Ministry of Energy, Mining, Water and Environment (MEMEE)
Agency of the Tensift Hydraulic Basin (ABHT)

No.

THE STUDY
ON
THE INTEGRATED WATER RESOURCES MANAGEMENT PLAN
IN
THE HAOUZ PLAIN
IN
KINGDOM OF MOROCCO

FINAL REPORT

MARCH 2008

JAPAN INTERNATIONAL COOPERATION AGENCY

PACIFIC CONSULTANTS INTERNATIONAL

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Exchange Rate (May 2007)		
US$ 1.00	=	DH 8.060
DH 1.00	=	US$ 0.124
US$ 1.00	=	Yen 121.84

PREFACE

In response to a request from the Government of Kingdom of Morocco, the Government of Japan decided to conduct a study on Study on the Water Resource Integrated Management Plan in the Haouz Plain and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr.Keiji MATSUMOTO of Pacific Consultants International. between September, 2006 and December, 2007.

The team held discussions with the officials concerned of the Government of Kingdom of Morocco and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Kingdom of Morocco for their close cooperation extended to the study.

March 2008

Ariyuki Matsumoto,

Vice President
Japan International Cooperation Agency

Mr. Ariyuki Matsumoto
Vice President
Japan International Cooperation Agency

March 2008

Dear Mr. Matsumoto,

Transmittal Letter

We are gland to submit the Final Report of "The Study on the Integrated Water Resources Management Plan in the Haouz Plain in Kingdom of Morocco".

The report incorporates the Master Plan for Integrated Water Resources Management in the Study Area of the Haouz Plain, and has been prepared in consideration of the advices and recommendations of relevant ministries of the Government of Japan and JICA, as well as the discussions with the Moroccan counterpart on the Draft Final Report and their comments on the report.

Currently in the Haouz Plain, the demand for water is increasing due to factors such as the introduction of modernized agriculture, development in tourist sectors and rapid increase of the urban population. Furthermore, observations indicate that the amount of precipitation in the Haouz Plain is decreasing in relation with the global climate change. Under such circumstances, the water balance in the Study Area, which has little rainfall and has been conventionally relying on groundwater resources, is in a critical state. In order to secure sustainable use of water and realize stable development in the area, practice of integrated water resources management is essential. In this regard, the preparation of a Master Plan for this purpose has been strongly required.

The implementation of the Master Plan for Integrated Water Resources Management in the Haouz Plain proposed in the report, will contribute to further development of the area by realizing efficient use of water resources which consist the basis of livelihood and economic activities, and by conserving the aquifer in the area. Moreover, through the implementation of this Study, technologies on development planning have been transferred to the counterparts of the Agency of the Tensift Hydraulic Basin. Sharing these technologies with other Hydraulic Basin Agencies will enable the planning of Integrated Water Resources Management in other areas suffering of similar problems in Kingdom of Morocco. We strongly believe that through such process, the implementation this Study will contribute to realizing sustainable water resources management throughout Kingdom of Morocco.

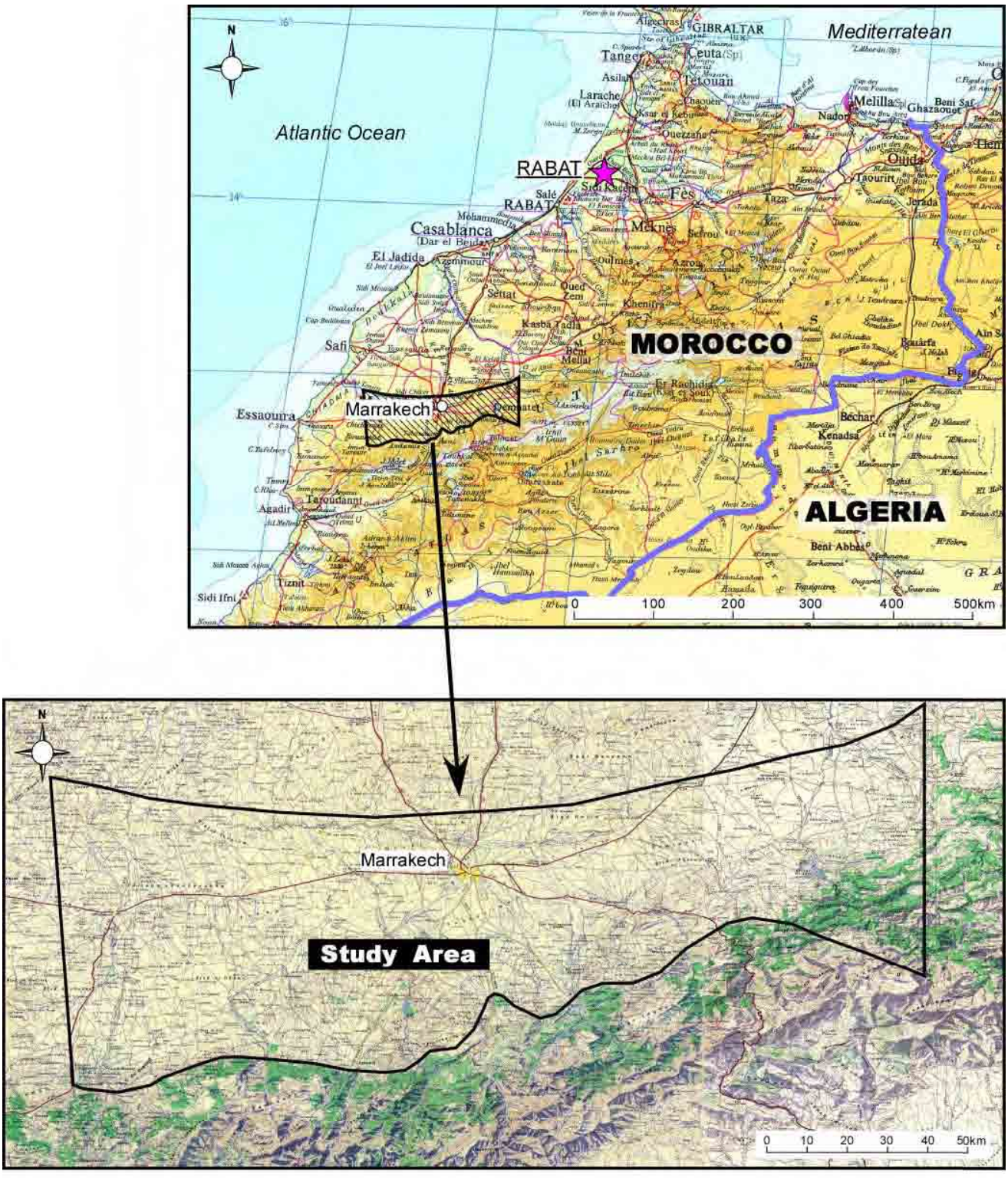
It is thus anticipated that this Master Plan should be put to implementation as soon as possible.

Taking this opportunity, we express our sincere thanks to the officials of your agency, the Ministry of Foreign Affairs and the Ministry of Land, Infrastructure, Transport and Tourism of the Government of Japan, and the Japan Bank for International Cooperation for their valuable advices and recommendations for the Study. We are also grateful to the officials of the Government of Kingdom of Morocco, particularly to the Agency of the Tensift Hydraulic Basin, and other public organizations involved in the Study for their devoted cooperation and support during the implementation of the Study in Kingdom of Morocco.

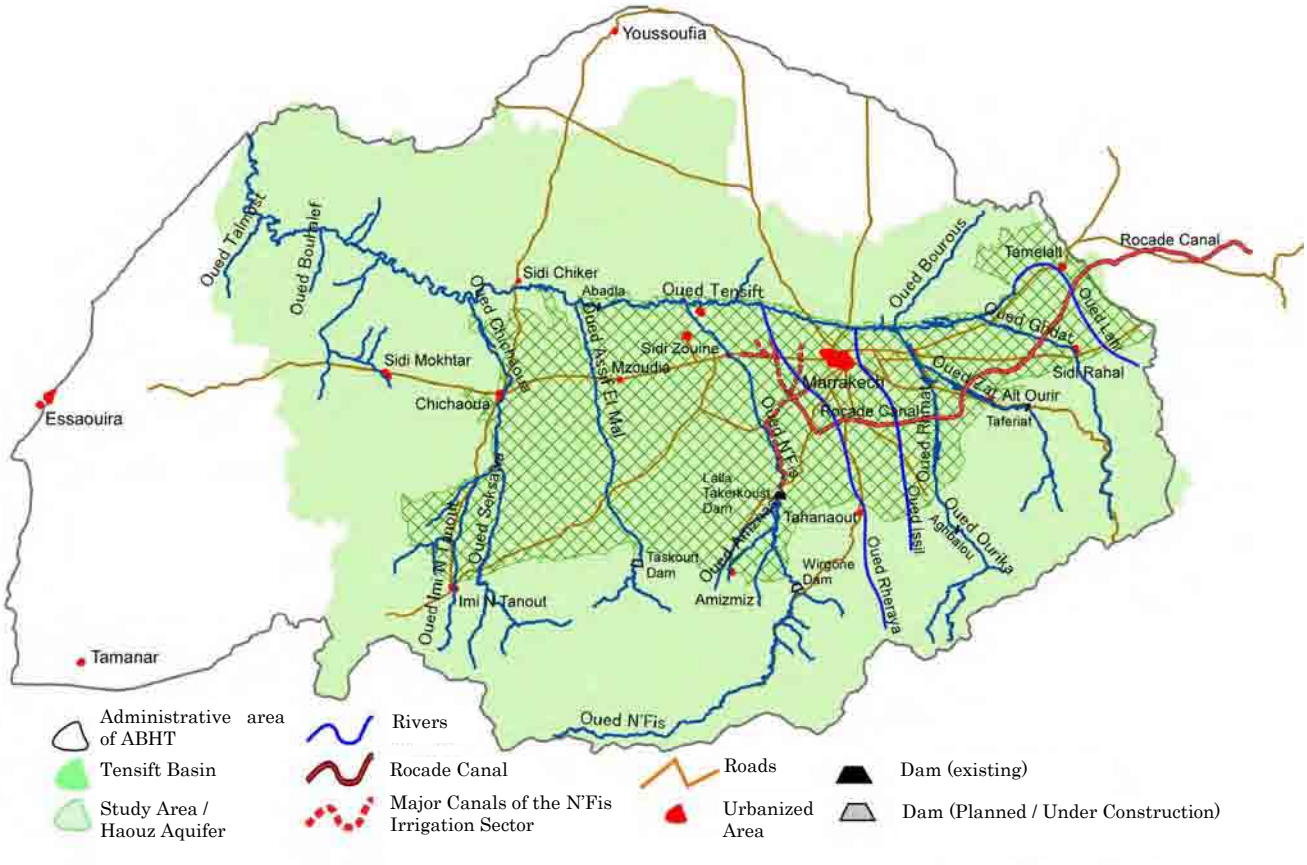
Sincerely Yours,

Keiji Matsumoto

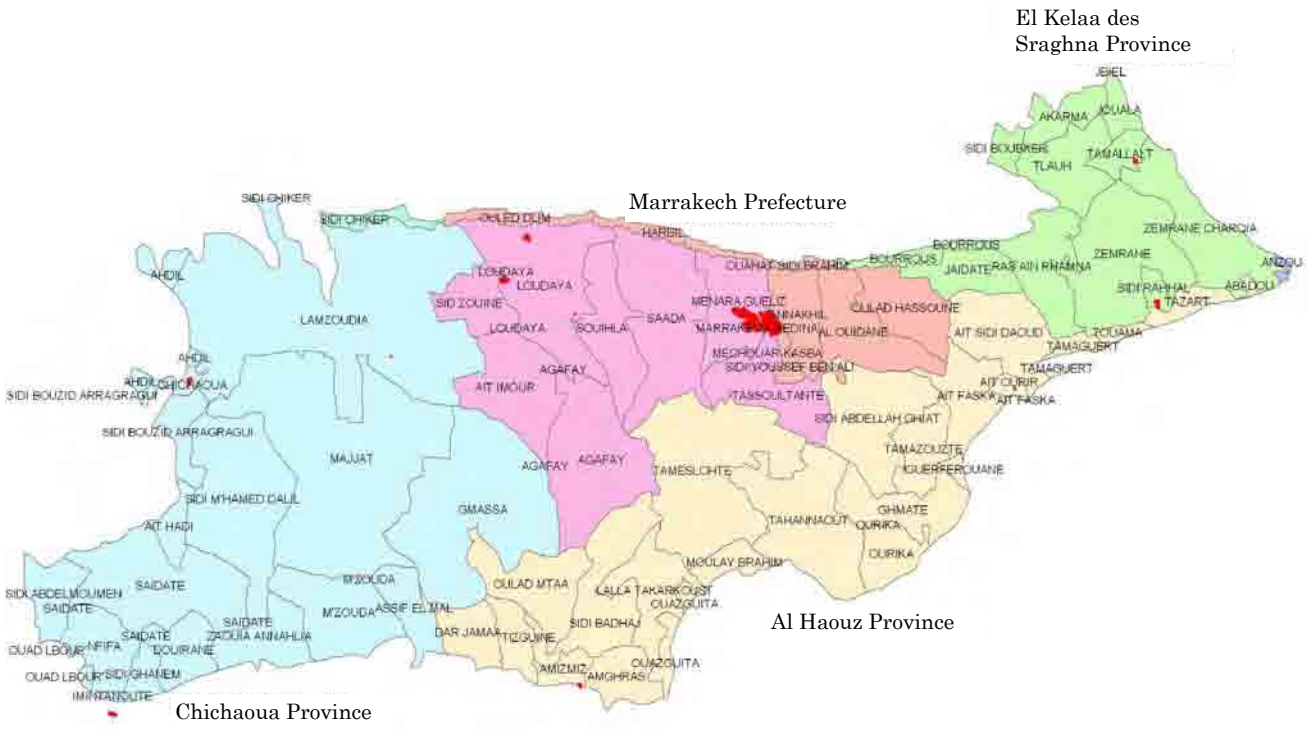
Team Leader
The Study on the Integrated Water Resources Management Plan in the Haouz Plain in Kingdom of Morocco



Location Map of the Study Area



Tensift Basin and the Study Area



Boundaries of Prefecture, Provinces and Communes in the Haouz Plain

	
View of the Study Area (1)	View of the Study Area (2)
	
View of the Study Area (3)	View of the Study Area (4)
	
Tensift River in the Rainy Season	Remains of Khattaras
	
Earthen Canals	Concrete Canals

	
High Atlas Mountains (Water Source Area)	Lala Takerkoust Dam
	
Rocade Canal	Olive farm
	
Olives	Olive farmers
	
Situation of Basin Irrigation	Situation of Drip Irrigation

	
Filter System for Drip Irrigation	Vegetables Cultivated by Drip Irrigation
	
Potable Water Treatment Facility near Marrakech	Greenbelts in Marrakech City
	
Golf Resort in the Study Area	Sewage Discharge Site
	
Sewage Treatment Plant under Construction	Setting up Automated Piezometers

	
Extraction of Groundwater Level Data	Supplementary Water Quality Survey
	
Coordination with GTZ Project	Stakeholder Meeting (1)
	
Stakeholder Meeting (2)	Stakeholder Meeting (3)
	
Discussion with Counter Parts	Signing of Minutes of Meeting

SUMMARY

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The Haouz Plain is a part of the hydraulic basin of the Tensift River, which is located in the mid-west part of the Kingdom of Morocco (hereinafter referred as “Morocco”). The Haouz Plain belongs to the arid area, where annual rainfall is 160 to 350 mm and average annual evaporation reaches 2,640 mm. Reduction of rainfall due to global climatic change is observed in the Tensift River Basin. In addition, the demand of water is increasing due to an expansion of modern irrigation practice with pump system as well as a significant increase of urban population in the recent years. Thus, the management of the water resources in the basin becomes more difficult year by year. The Haouz Plain has historically relied for the major part of its water resources on groundwater. The demand of this groundwater for large scale irrigation and tourism development and rapid population growth has been increasing significantly in the recent years. This has caused the depreciation of groundwater table close to over-exploitation.

Hence, in September 2003 the Government of Morocco requested the Government of Japan to perform a development study on “the Integrated Water Resources Management Plan in the Haouz Plain” (hereinafter referred to as “the Study”), with the objective to formulate strategies, master plan and action plan on the water resources management in the Haouz Plain. In response, Japan International Cooperation Agency (hereinafter referred to as “JICA”) dispatched the Project Formulating Mission in September 2005. Based on the results of discussion, the Scope of Works for the Study was agreed by both sides and it was decided to conduct the Study.

Based on the S/W, the JICA Study Team, headed by Mr. Keiji Matsumoto of Pacific Consultants International, has been dispatched to Morocco and conducted field surveys and studies in the Study Area since September 2006. The results of this Study is elaborated in this Report..

1.2 Objectives of the Study and Study Area

Objectives of the Study are as follows:

(1) To develop an integrated water resources management strategy, formulate the master plan for the integrated groundwater resources management, and formulate the action plan for effective use and conservation of the groundwater resources in the Haouz Plain.

(2) To lay the foundation for improving capability of ABHT for administrative management, through promoting coordination and involvement of concerned organizations in water resource management, and promoting sharing of understandings on the problems concerning water resources and water use.

(3) To improve skills and technologies of counterpart personnel mainly in the monitoring and analyzing groundwater, by the technical transfer through conducting the study, and formulating the master plan.

The Study Area covers the Haouz Plain located in the most upper basin of the Tensift River with an area of about 6,000 km^2 where about 1.61 million people are living.

1.3 Contents Scope and Process of the Study

Scope of the Study is divided into three stages: 1) formulation of the integrated water resources management strategy based on understanding present conditions and forecasting future conditions, 2) formulation of the master plan of integrated groundwater resources management and 3) formulation of the action plan based on the master plan.

CHAPTER 2 MOROCCO AND STUDY AREA

2.1 Morocco in Brief

(1) Administration

Morocco is divided into 16 regions, and subdivided into 62 prefectures/provinces, 162 districts and 1,497 communes.

In Morocco, the local government administrative subdivisions are prefectures and provinces, and they are supervised by the Ministry of Interior, also each chief of administration is appointed by the Minister of Interior. There are several subdivisions of the Regions of Morocco. Each prefecture and province is subdivided into districts (*cercles*, *sing. cercle*), municipalities (*communes*, *sing. commune*) or urban municipalities (*communes urbaines*, *sing. commune urbaine*), and arrondissements in some metropolitan areas. The districts are subdivided into rural municipalities (*communes rurales*, *sing. commune rural*). The municipalities and arrondissements should probably be thought of as fourth-level subdivisions, on the same level as the rural municipalities.

(2) Social and Economic Conditions of the Country

The total population of Morocco was 29,892,000 in 2004. Annual growth rate of population is 1.4% in 2004 although the growth rate is declining in recent years. The average of annual growth rate of these 10 years is 2.1% in the urban areas while the population in the rural areas is almost a level-off (an average of annual growth rate 0.6%), and the concentration of the population from the rural areas to the urban areas is remarkable. Moreover, the population inflow from the rural areas to the urban areas has become much greater in drought years, and has brought social unrest. Therefore, the Moroccan government is working for correction of the regional gap between rural areas and urban areas as one of the priority problems.

The major industry of Morocco is phosphate rock mining and processing, food processing, leather goods, textiles, construction, tourism, etc. as well as agriculture. GNI and GNI per capita in 2005 were US$ 52.3 billion and US$ 1,730 respectively. The labor force in 2004 totaled 9.8 million people, and the labor force by occupation is: agriculture 46%, industry 13% and services 41% in 2004. The unemployment rate is about 11%.

(3) National Development Plan

1) Five-year National Development Plan
   The 5-year National Development Plan (2000-2004) which was agreed officially in the National Assembly in August, 2000 is a social-economic development plan that established policy objectives, such as increase in the economic growth rate, improvement in the investment and saving rate, decrease of the unemployment rate, and increase of the literacy rate. Further, the reduction of poverty in the rural area was considered as a priority. The next Five-year National Development Plan (2007-2011 years) is said to be under preparation.

2) National Initiative for Human Development (INDH)
   National Initiative for Human Development (INDH; Initiative Nationale pour le Développement Humain) proposed the eradication of poverty and the correction of regional differential, Government and private sector cooperation. INDH was started in May, 2005. INDH was designed to reinforce the State's action and that of the local collectivities, without being a substitute for either the sectorial programs or the local socio-economic development plans.

(4) Privatization and Restructuring of Public Utilities

The current government has introduced a series of structural reforms in recent years. The most promising reforms have been in the liberalization of the telecommunications sector. The tender process in Morocco is becoming increasingly transparent. Many believe, however, that the process of economic reform must be accelerated in order to reduce urban unemployment below the current level which is more than 10%.

(5) Environmental Policies

Current environmental legislation in the Kingdom of Morocco is largely based on three Laws which were promulgated in 1993.

- Law No. 11-03 on protection and development of the environment
- Law No. 12-03 on Environmental Impact Studies
- Law No. 13-03 on the control of air pollution.

(6) Water Resources Development in Morocco

Average annual precipitation and evaporation is estimated at 150,000 Mm^3 and 121,000 Mm^3, respectively (FAO). This means around 29,000 Mm^3 is available water resource, and exploitable water is estimated around 20,000 Mm^3 which consists of 160,000 Mm^3 of surface water and 4,000 Mm^3 of groundwater.

Water resources development is one of the most important issues of the State. Based on the urbanization and rapid development of industry and irrigation sectors, water demand has increased rapidly. In order to fulfill the demand, the Government constructed more than 100 large-scale dams totaling 15,700 Mm^3 since 1960's. Also 13 of large scale canal systems and groundwater development facilities were constructed. Total of these additional water resources developments is estimated at 13,000 Mm^3 (around 65% of exploitable water resources).

(7) Water Resources Management Policy and Legal Framework

Water Law (Law No. 10-95)

Water Law, which was approved by the Government of Morocco in September, 1995, constitutes the legal basis for water resources development in Morocco. The Law is composed of 13 chapters and 123 articles:

Superior Council of Water and Climate (CSEC)

In Water Law 10-95, Superior Council for Water and Climate (CSEC) was assigned to formulate general guidelines of national policy concerning water and climate. The CSEC examines and formulates opinions on:

1) National strategy for enhancement of knowledge on climate and harnessing its impact on water resources development
2) National water plan
3) Integrated plan for water resources development in river basins, especially distribution of water among various demand sectors and regions, as well as arrangement for development, protection, and conservation of water resources.

Members of the CSEC are composed of the government, basin agencies, ONEP, ONE and ORMVA, elected consumer representatives, provincial or prefecture assemblies, and scientific experts.

(8) River Basin Integrated Water Management Plan

The master plan for water resources management defined in the Water Law

The Water Law (10-95) states that the administration for each river basin or a set of river basins has the duty for establishing an integrated master plan for water resources development. Such plan is required to define the following items:

1) Territorial limit of the river basin
2) Quantitative and qualitative evaluation and development of water resources and demand in river basin
3) Sharing plan of water among the various sectors in the basin. This plan will eventually specify a surplus of water quantities that can be subject to a transfer towards other basins.
4) General scheme of construction in river basin to insure conservation of water resources and their suitability to the needs.

The integrated master plan for water resources development was established for a period of 20 years,

and subject to review every five years. This plan is approved by a decree following the recommendation by CSEC. According to the law, the administration also has the duty to establish a national water plan on the basis of results and conclusions of the integrated master plan for water resources in each basin.

Implementation of Water Law 10-95

After the effectuation of Water Law 10-95, the Government started to reform the water policies, and implemented structural reform starting from establishment of ABHs and preparation of basin based master plans, etc. Progress of the water sector policy development and financial arrangement were not smoothly implemented.

Water Sector Policy Development Program (PPD-Eau)

Water Sector Policy Development Program (PPD-Eau), with the objectives of Improvement of Water Sector Governance and Operation, Reformation of Water Resources Management System, Improvement of Irrigation Project Operation System has been in operation between 2005 and 2009. The objectives and activities are as follows:

(9) Water Related Institutions

The following descriptions are as of August 2007. After the ministerial reforms in October 2007, the State Secretary in charge of Water and the environmental functions previously under the Ministry of Land Management, Water and Environment has been transferred to the current Ministry of Energy, Mining, Water and Environment. Similarly, the Provincial Directorates of Agriculture and the Regional Offices for Agriculture Development have been transferred to the Ministry of Agriculture and Maritime Fisheries from the previous Ministry of Agriculture, Rural Development and Maritime Fisheries.

Ministry of Land Management, Water and Environment (MATEE, Partially transferred to the Ministry of Energy, Mining, Water and Environment: MEMEE, after October 2007)

MATEE formulated for the land management, water resources and environmental protection in 2002 after the reformation of ministries. Under MATEE, two Secretaries General were installed: 1) Secretary General of MATEE who manages the Directorate General of Land Management, and Environment, and State Secretary to MATEE in charge of Water who manages the Directorate General of Water. At the same level of Secretaries General, seven Agency of Hydraulic Basin (ABH) and Moroccan Water Supply Organization.

1) Secretary of State in charge of Water (SEE)
   Under SEE, five directorates are installed: 1) Directorate of General of Hydraulic (DGH) for the general affaires, 2) Directorate of Hydraulic Installation (DAH), 3) Directorate of National Meteorology (DMN), 4) Directorate of Research and Planning of Water (DRPE) and 5) Directorate of General Technical Affairs. Water management policy is mainly in charge of DRPE at central government level.

2) Basin Water Management Agencies (ABH)
   Water Law (10-95) specifies the establishment of a basin agency in each river basin or a set of river basins. It is a public agency, endowed with individual legal entity and financial autonomy, however, its activities are supported by the Government in actual. Based on Decret No. 2-00-479, eight (8) hydraulic basin agencies were established. The contracts to transfer the authority from DGH were mostly signed up to now.

3) National Water Supply Organization (ONEP) and Marrakech Potable Water Distribution Enterprises (RADEEMA)
   ONEP is a public corporation with the characteristics of private enterprises. It has been established under Dahir No. 1-72-103, as a self support accounting body to inherit the functions of REI.

   Its main functions are to: prepare plans for potable water supply in the country, survey / install / manage potable water supply facilities, manage distribution of potable water distribution,

manage sewage treatment in towns and villages where requested, water quality monitoring and protection of water sources for water supply, and provide technical support for water quality monitoring.

RADEEMA is responsible for water supply, water distribution and sewage treatment in Marrakech city.

4) Functions for Environment under MATEE
Since its formulation within the Ministry of Habitat and Tourism, the legal authority of environmental issues has been shifted to various ministries / agencies. Currently, the Directorate of Environment, under the MATEE is the designated authority.

Ministry of Agriculture, Rural Development and Maritime Fisheries (MADRPM, Currently the Ministry of Agriculture and Maritime Fisheries, after October 2007)

Main Departments of MADRPM related to agricultural sector are: 1) Planning and Economic Affair (DPAE), 2) Education, Research and Development (DERD), 3) Crop Production (DPVCTRE), 4) Crop Protection (DPV), Livestock (DE), and 5) Public Administration Enterprises and Professional Organization (DEPAP). As far as irrigation is concerned, Directorate of Development and Management of Irrigation is the main department under the Rural Engineering Administration. As for fishery sector, MADRPM has 5 departments, i.e., 1) Marine Fisheries and Aquaculture (DPMA), 2) Marine Product Processing Industry (DIPM), 3) Cooperation and Legal Affaires (DCAJ), 4) Education and Vocational Training of Fisheries (DFMPS) and 5) Human Resource and General Affairs (DRHAG).

1) Provincial Directorate of Agriculture (DPA)
At the provincial level, 40 DPAs are installed under the MADRPM. They are mainly in charge of the small scale irrigation and rainfed agriculture areas. Large scale irrigation areas are covered by ORMVA.

2) Regional Authority for Agriculture Development Agency (ORMVA)
In addition to DPA, nine ORMVAs were established to manage the large scale irrigation project and to provide the agricultural support to the farmers in the individual project area. They are established as independent agencies under the supervision of MADRPM for technical matters and Ministry of Finance in financial affaires.

2.2 Outline of the Study Area

(1) General Conditions

The Study Area of the Haouz Plain covering about 6,000 km^2 is located on the left bank of the most upstream reaches of Tensift River. The Plain spreads in the alluvial plain on the foot of the High Atlas Mountains stretches between 7^o-09' and 8^o-55' west longitudes and between 31^o-09' and 31^o-55' north latitudes. The elevation of the Study Area is between 250 and 800 m above mean sea level. Center of the Plain is Marrakech.

The Marrakech - Tensift - Al Haouz region where the Study Area is located is composed of the Marrakech prefecture and 4 provinces: Al Haouz, El Kelaâ des Sraghna, Chichaoua and Essaouira, and includes 62 communes.

The Study focuses on the groundwater resources in the Haouz Plan. Then the Study is concentrated in the groundwater basin of the Haouz Plan. The Haouze groundwater basin spreads on the foot of High Atlas Mountains in the south, the Tensift River on the north, eastern boundary of the Tensift River Basin on the east and the Chichaoua River on the west. Therefore eastern part of the Haouz Plan and western boundary area along the Chichaoua river is excluded for the Study.

(2) Natural Conditions

Topography

The Haouz plain spreads mainly over the left bank of the middle to upper stream of the Tensift River and partly to the Oum er Rbia Basin, where the area is called Haouz Oriental, or the Eastern Haous. The central part of the plain around Marrakech is called Haouz Centaral and the western part is also called Mejiat Plain.

Climate and Hydrology

The climate of the Haouz Plain Area is arid continental type based on the Mediterranean climate. The annual mean temperature at Marrakech, which is located at the center of the Plain, is 19.9℃, and the monthly mean temperature varies from 11.9℃ in January to 28.7℃ in July. Comparatively high precipitation is observed along Atlas Mountain, and the rainy season starts on October and regularly continues to March or April. 86% of annual precipitation (equivalent to 216mm) is observed during the period of October to March in Marrakech, and in other areas too. The annual evaporation is 1,830mm at Lalla Takerkoust and 2,640mm at the center part of the Haouz Plain.

The discharge of the Tensift River and its tributaries starts to increase in November, following the start of rain ; the peak of discharge is observed in March to April, and generally a large amount of discharge continues to May. The discharge of these rivers area significantly fluctuates during year. More than 80% of total discharge is observed from November to May and the rivers are dried up from July to September during the dry season in the plain area including the Tensift River. (Table 2.2.5)

Geology and Hydrogeology

Geological structure and geological and hydrogeological features in the Tensift basin are show as follows.

Haouz Plain: Neogene to Quaternary alluvial deposit are mainly distributed in the Plain. Calcareous rocks are distributed around Chichaoua and its upper stream area, or the foot of the High Atlas. These formations are generally permeable and groundwater can be exploited. Some Paleozoic deposit areas are scattered in the central south of the Plain, southeast of Guemassa. This Paleozoic formation consists of schist, quartzite, limestone and so on, and is almost impermeable.

Essaouira-Chichaoua: Cretaceous to Eocene deposit forms the plateau. The formation consists of dolomite and marly limestone. It is permeable and groundwater has been abstracted for drinking and agricultural use of the residents in the area.

Jblit: Mainly consist of Paleozoic that is composed of schist, micaschist, quartzite, and limestone. The formation is almost impermeable and no aquifer occurs in it.

The High Atlas Mountains: The High Atlas Mountains in the Tensift basin consist of mainly Paleozoic and Precambrian partly. The areas where fissures or fractures developed may have permeability.

Vegetation and Soils

In the Study Area, vegetation coverage is generally poor, with 3/4 barely having no coverage. Vegetation types vary depending on elevation and soil. Evergreen oak forests (Aghana, Thuya, Red Juniper, etc.) spread around the Atlas Mountain range to the Rehamna hills. The area of forests in the area reaches up to 541,000ha.

The soil of the Marrakech Tensift Al Haouz Region has been developed in the alluvial deposit between the Paraeozoic relief of Jbilet and the Atlas mountains. The major soils of the area are as follows: 1) Isohumique siols (Fluvisols, Regosols, Lithisols under FAO Taxon) locally called “Requane” cover 75% of the area, 2) Cacimagnesic soils (Rendzinas, Yermosols, Xerosols) loccaly called “Biad “cover about 15% of the area. This type of soil is mainly found areas in the northwest of N’Fis, southeast of the central area and .north of El kelaa of Sraghna, and 3) Undeveloped soils locally called “Hach “cover a small potion of the area along the rivers of Haouz plain and in the and in the foots of the Atlas mountains, account for some 10% of the Region.

(3) Socio-Economic Conditions

Social and Economic Situations in the Study Area

The total population is 1,613,000 inhabitants and the Marrakech prefecture accounts for 63% of the whole population. Moreover, the urban population accounts 920,000 inhabitants which correspond to 57% of the whole population, and Marrakech prefecture occupies 89% of the total urban population.

Regional economy of the Marrakech - Tensift - Al Haouz region depends mainly on agriculture and

agro-industry, tourism, processing industry, handicrafts and in a small measure on fishing. The central place of the regional economy is Marrakech city which has approximately 795,000 inhabitants. The tourism plays an important role in regional economy. This sector has some secondary effects on other sectors as handicraft, construction and transportation.

Agriculture

The agricultural farms are characterized by the dominance of small parcels and the spatial dispersion of the parcels. In the zone of action of the ORMVAH, on 26,825 ha which are in the study area, farms of less than 5 ha account for 36% of the surface and 86% of the total number of exploitation. The main agricultural products in the Study Area are grain (wheat, barley) and orchids.

Law No2/84 of December 21, 1990 lays down the objectives as well as the constitution and function of Agricultural Water Users Associations (AUEA), who are represented in the Haouz Plain, as the more widespread form of farmer's organization. They have the objective to manage and to preserve the agricultural water infrastructure. In the irrigation development areas of the ORMVAH, part of the responsibilities and obligations of farming and maintenance for the infrastructures (secondary infrastructures and distribution networks) has been transferred to the AUEA.

Tourism

Marrakech city constitutes the first tourist destination of Morocco thanks to the wealth of its historic and cultural heritage. Marrakech-Medina was registered to the World Cultural Heritage of UNESCO in 1985. Tourist facilities are concentrated in Marrakech city.

(4) Present Water Uses

Water Related Institutions

1) Agency of the Tensift Hydraulic Basin (ABHT)
   ONEP is a public corporation with the characteristics of private enterprises. It has been established under Dahir No. 1-72-103, as a self support accounting body to inherit the functions of REI.

   Its main functions are to: prepare plans for potable water supply in the country, survey / install / manage potable water supply facilities, manage distribution of potable water distribution, manage sewage treatment in towns and villages where requested, water quality monitoring and protection of water sources for water supply, and provide technical support for water quality monitoring. The Tensift Regional Directorate in Marrakech is the organization representing the ONEP organizations in the Region.

2) Office of National Potable Water in Marrakech (ONEP)
   ONEP was established as an autonomous administrative body under the Ministry of Equipment and Transport in 1972. After a series of structural reforms of the government organizations, it is now under the jurisdiction of the Ministry of Land Management, Water and Environment. After the restructuring of the government agencies in January 2004, ONEP became the sole authority to supply water to urbanized communes in the rural areas.

3) Regional Agricultural Development Office of Haouz (ORMVAH)
   The Regional Agricultural Development Office of Haouz (ORMVAH) was established as a public institution with civil status and financing autonomy under the Ministry of Agriculture Rural Development and Maritime Fisheries in 1966, for the purpose of agricultural development and promotion of agriculture in the Haouz Area.

4) Provincial Direction of Agriculture (DPA)
   In the study area, the zone of action of DPA of Marrakech and Chichaoua include 11 and 14 Rural Communes, and extend over the total surface of 62,114 ha and 240,526 ha respectively.

5) RADEEMA
   RADEEMA is an independent public company responsible for supply of water and electricity and wastewater management in Marrakech in commercial base. The organization was

established by the City Council in 1971 under jurisdiction of the Ministry of Home Office and the Ministry of Economy to provide electricity service and distribute potable water.

6) Regional Inspection of Land Management, Water and Environment of Marrakech (IRATEE)
Under the MATEE, there are seven regional Regional Inspection of Land Management, Water and Environment (IRATEE), which handle the services of the Ministry at the regional Level. The main sectors that the IRATEE works on include management of sensitive areas, economy and tourism, infrastructures, social services, and environment.

Major Waterworks

1) Lalla Takerkoust Dam
The Lalla Takerkoust Dam wa constructed on 1935 and it was expanded by raising the dam height to cope with the increase of water demand, as a multipurpose dam for irrigation, power supply, drinking and industrial water. The dam supplies irrigation water to the N'Fis Irrigation Sectors of 24,200 ha in total in combination with the Rocade Canal, as well as to the improved seguia system area of approximately 10,000 ha. The water of the dam is also used for the drinking water supply to the Marrakech town area in combination with the Rocade Canal.

2) Other Dams under Construction
Wirgane Dam: The construction of the Wirgane Dam started at the beginning of 2005 and is scheduled to start its service in March 2008. The dam is located 20km upstream of the Lalla Takerkoust Dam in the N'Fis River, and it is expected to be operated in combination with it in order to reinforce the drinking and industrial water supply to the Marrakech town area and to improve the regulation capacity of the Lalla Takerkoust Dam.

Taskourt Dam: The construction of the Taskourt Dam, which is located in Chichaoua Province, is scheduled to start at the beginning of 2007. The dam will supply raw water for water supply and stable irrigation water to an area of 6,000 ha which is currently irrigated in a traditional manner.

3) Rocade Canal
The Rocade Canal is a hydraulic facility for the water transfer from the Oum Er Rbia basin to the Tensif Basin ; the transferred amount is designed as 300 million m3/year. The total length of the canal is approximately 120km and the flow capacity is 20m3/s.

4) Traditional Irrigation System (Seguia System)
Seguia originally was a traditional irrigation system taking water from natural rivers; however, the improved irrigation canal system connected to the dam and improved concrete pavement is also called as a seguia. The traditional irrigation system (SIT) and improved traditional system (STA) area were observed in the Study Area.

Domestic Water Supply

An amount of 3,000 l/s of raw water can be supplied to Marrakech for water supply, from surface and subsurface water resources. Water supply in Marrakech is produced by the water treatment facilities of ONEP and provided through the water distribution network of RADEEMA. After completion of the expansion project, the rated water treatment capacity will reach 3,000 L/s.

ONEP manages the water supply systems in 55 communes in the administration area of Region-2 Office. Out of 55 communes, the following 11 communes are located within the groundwater simulation boundary in the Study Area. All 11 communes use only groundwater sources and supply water to the communes after disinfection.

Localized piped water supply systems were installed in the rural communities under the assistance programs of the Ministry of Equipment and the Ministry of Agriculture, or by self-help of the communities. The population in the local communities was estimated to be approximately at 470,000 in 2005. Assuming 30 L/capita/day for water consumption in the local communities, the annual water demand is estimated at 5.2 M m^3/year.

Irrigation

In general, the irrigation system in the Morocco is categorized into two types: one is a large scale irrigation system. Among the three irrigation areas, the Haouz Central Area and a part of the Upper Tessaout Area belong to the Haouz Plain Area.

At moment, there is no GH irrigation system which has regulated water resources in the area jurisdiction of DPA Marrakech and Chichaoua. All irrigation systems in those DPAs are categorized into the PMH irrigation system including the traditional seguia system. In the DPA area, the irrigation areas with traditional and improved seguia system are categorized as three types: regular irrigation, seasonal irrigation and flood irrigation.

Although various irrigation methods are observed in the Study Area, the majority are basin irrigation for orchard trees and furrow irrigation for annual crops. In the large scale farms and a part of middle scale farms, drip irrigation system is also observed, however, the rate of extension is still low. In case of the drip irrigation, groundwater is widely used for the water source because of necessity of having a pump for the system and requirement of water quality to prevent clogging in tubes. Drip irrigation is used for orchard and vegetable crops in the field. Some sprinkler irrigation, such as pivot system and linear move system, is also observed in the modern farm land, however, the number is still small.

(5) Other Social Infrastructure

The length of the road network of the Marrakech - Tensift - Al Haouz region is 4,938 km in total, of which 63% are paved. The regional railway network extends 171 km, composed of two lines: one joins Marrakech to Casablanca, the other joins Ben Guerir to Youssoufla. Concerning air transportation, the region is endowed with two airports: Marrakech - Ménara and Essaouira.

CHAPTER 3 PRESENT CONDITION AND POTENTIAL OF THE WATER RESOURCES IN THE STUDY AREA

3.1 Previous Water Resources Development

In the Haouz Plain Area, the modern development of water resources were started on 1980's, which is represented by the development of the Rocade Canal Complex and piling up of the Lalla Takerkoust Dam. The Rocade Canal Complex was started from the beginning of 1980's and the Sidi Driss Dam had completed on 1984 and the Rocade Canal completed on 1985. By the completion of the construction of the Moulay Hassan I Dam on 1987, the Rocade Complex was completed. The development of irrigation sectors had been continued in parallel with the construction of the canal complex, the first section of irrigation sectors had been completed with Z1 Sector on 2000. The Lalla Takerkoust Dam is given an important role to supply water to the Marrakech urban area as well as supplying agricultural use in the centre of the Haouz Plain. The Dam was established on 1935, and it was piled up on 1980 to recover and increase its reservoir capacity to cope with the increase of water demand both for agriculture and drinking water and power supply. In relation to this Study, ABHT has carried out a study titled "Actualisation de l'Etat de Connaissance des Ressources en Eau dans les Bassins Hydrauliques de Tensift" in 2004 to evaluate the situation of water resources. The Master Plan prepared by ABHT is now being revised based on the results of this study.

3.2 Present Conditions of Surface Water

(1) Meteo-hydrological Network and their Data

ABHT has a rain gauging network composed of 20 stations within the Haouz Plain. In addition to the ABHT network, there are meteorological observation networks managed by ORMVAH and the National Meteorological Direction in and around the Haouz Plain. Also, the flow gauging stations of several rivers are operated by ABHT.

(2) Surface Runoffs

According to the Tensift River Water Resources Development Master Plan 2001, the Tensift basin had

1,124.5 Mm^3 of effective inflow including the transfer from Oum El Rbia River based on the historical data of 1935-1997. The inflow was re-evaluated in the *Actualisation de l'Etat de Connaissance des Ressources en* Eau *dans les* Bassins *Hydrauliques du Tensift 2004* as 1,067.8 Mm^3 with transfer based on the data 1970-2002 as shown below. The effective inflow into the Haouz Plain is estimated as 967.7 Mm^3 including transfer on average in the estimation.

(3) Water Supply from Dams

The total discharge of the Rocade Canal varied from 77.6 Mm^3 to 191.8 Mm^3 and the average was 150.1 Mm^3, which is equal to 43% of the designed discharge of 350 Mm^3. The deficit of the discharge is considered to be partly affected by the reduction of dam capacity by sedimentation; however, the main reason is considered to be the lack of precipitation in the catchment area of dam system. The lack of precipitation has been fixed in recent years and it has become a regular condition of the dam.

(4) Water Taken by Traditional Seguia System

The seguia systems taking water from natural rivers are important water sources for irrigation in the Study Area. Because the traditional seguia systems connected to rivers do not have any water regulation system, the amount of water intake by them is highly fluctuating every year. In accordance with the inventory survey in Etude hydrologique des prélèvements au fil de l'eau dans le basin Tensift, the average amount of water intake by traditional seguia system excluding the N'Fis sub-basin is 257.7 Mm^3 on average in 1985-2001, and the ratio of water intake to river discharge was from 50% to 63%, where the overall average is 54.3%.

(5) Sedimentation

As mentioned in the section 4.3.3, The sediment transport to dam is a serious problem for the water management of the Tensift Basin. According to the Actualisation de l'Etat de Connaissance des Ressources en Eau dans les Bassins Hydrauliques du Tensift 2004, the unit runoff of sedimentation of the N'Fis River is estimated as 240 ton/km^2/year at the Lalla Takerkoust, and it reduces the capacity of the Lalla Takerkoust Dam by 1.53 Mm^3/year. The sedimentation of the dam has so far resulted in a 20% decrease of the storage capacity of Lala Tekerkoust Dam; from 72.5 Mm^3 in 1981 to 56.1 Mm^3 in 2002.

(6) Floods and Flood Forecasting and Warning System

In and around the Study Area, the tributaries of Tensift Rivers have their catchments in the High Atlas Mountain area and they had suffered flood damage frequently in the valley area. The most severe flood was the one on August 1995 in which 55 villages in Ourika and other area was flooded. The Aghbalau Station of the Ourika Valley recorded 1,000 m^3/s, and the Tahanaout Station of the Rheraya River 680 m^3/s. The total damage amount was estimated at 70 MDH. The MATEE and JICA conducted the Master Plan Study on Flood Forecasting and Warning System for Atlas Region from March 2000 to December 2003, and some of the proposed flood forecasting and warning system was equipped, including automation of hydrological observation system at 5 flood watch station, etc., in the Pilot Project during the Study as well as the Master Plan was formulated.

(7) Water Quality

Water quality standards for surface water are defined under Decree No. 1275-01, promulgated in December 2002. Under these standards, water quality of surface water is categorized into 5 levels based on a variety of parameters: Excellent, Good, Average, Bad and Very bad. Water quality survey by ABHT in 2004-2005 indicates "average" to "good" for the majority of surveyed points. However, areas near major cities and towns indicated lower quality. These include:

3.3 Present Groundwater Conditions

(1) Hydrogeological Mechanism in the Haouz plain

The hydrogeological mechanism in the Haouz plain is quite well-known, understood from numerous geologic and piezometric investigations which took place since the beginning of the 20th century. The aquifer of the Haouz plain is formed by the Neogene to Quaternary deposits over the Palaeozoic and older formations of the Atlas/Jbeliat mountains. These heterogeneous deposits (form coarse gravels to consolidated conglomerate, and from siltite to clay), are permeable. The groundwater is developed in

the Haouz plain through khettaras since the 10th century.

(2) Groundwater Table and Groundwater Quality

From 2001, most of the piezometers show an important drawdown, from one meter to more than 10 m in one single year at some places. An important deficit in rainfall is recorded in 2001; this deficit impact together the direct recharge of the aquifer from the rain and the recharge from the surface irrigation water which both decrease and the groundwater abstraction which increase. This 2001 year seams to be the first one of a significant deficit in the groundwater balance and consequently of the reserve depletion. The calculation of the changes in the wet volume of the aquifer from the piezometric maps drawn for 1998 and 2002 shows that this figure is large: somewhere between 200 to 1 600 Mm^3, for an average porosity between 1 to 8% (according to the well tests reported by Bernert and Prost). The preliminary groundwater balance confirms that a deficit is recorder from the agricultural campaign 2000/01, but probably not during the 1993-2000 period, even though some local water depletion can be recorder some place to place.

Groundwater quality tests have been carried out regularly by ABHT for the production wells and monitoring wells. Findings of the groundwater quality tests for 2,349 samples indicate that in general, the status of groundwater quality in Haouz Plain is acceptable level. However, it shall be noted that some of the wells about 8% are contaminated and appropriate mitigation measures shall be taken.

(3) Groundwater Recharge and Natural Discharge

The process of inflow / outflow of groundwater into the aquifer of the Haouz Plain is summarized in the following.

Process of Inflow / Outflow of Groundwater into the Aquifer of the Haouz Plain

Process of Inflow / Outflow		Amount of Inflow / Outflow
Inflow	Direct inflow from precipitation	4% of the annual precipitation (38 – 110 Mm^3)
	Recharge of excess irrigation Water	Assumed from actual usage of irrigation water
	Recharge from rivers and seguias	25% of flow in rivers and seguias
	Inflow from the aquifers of the Atlas mountains	220Mm^3/year (varying depending on the groundwater level in the Haouz plain)
Outflow	Outflow from the lower end of the Haouz plain aquifer to lower aquifers	4-5.5Mm^3/year
	Outflow through rivers	81-142Mm^3/year - Occurs when groundwater level reaches the altitude of the riverbed - No outflow when groundwater storage is low

3.4 Groundwater Extraction in the Study Area

(1) Estimated number of wells

The wells pumped for the towns and small towns drinking water supply systems are well-known in the Haouz plain. But groundwater uptake for irrigation in agriculture, for livestock or for individuals in urban areas can only be estimated.

Based either on the drilling date recoded during the ABHT inventory or on the authorization data as it appears in the ABHT database of drilling request, the growth rate of boreholes and wells can be estimated to be about 4%/year from 1990. Based on the 2001 figure of wells in the PMH sector (14,348), the number of wells and boreholes can be estimated from 10,900 for the 1993/94 agricultural campaign to some 16,140 for the 2003/04 agricultural campaign. For the GH sector, much smaller than the PMH sector, and where the number of wells is much smaller, the total ratio of unregistered wells cannot be applied efficiently and the total number of wells can hardly be estimated. The approach of the groundwater abstraction will preferably be done based on the water demand.

(2) Groundwater abstraction for irrigation in agriculture

In the PMH sectors, the groundwater abstraction can be estimated from the number of wells and boreholes.

According to the 2001 survey, the abstraction systems are functioning for an average of 2,291 hours/year, with an average instantaneous yield measured at 8.81 m^3/hour. The annual average

abstraction per borehole is then 20,184 m^3/year. For the 15,520 wells and boreholes functioning in the PMH sector during the 2002/03 agricultural campaign, the total groundwater abstraction can be evaluated as 313.2 Mm^3. The estimated abstracted groundwater for the PMH sector should then be about 310 Mm^3 for the 2002/03 agricultural campaign, corresponding to an irrigated surface of about 82,700 ha, certainly with a growth rate equivalent with the growth rate of boreholes: 4% per year.

In the GH sectors, the net groundwater abstraction (total groundwater abstraction minus excess irrigation water re-infiltrated to the aquifer) can be estimate from crop water consumption.

The average crop water requirement in GH sectors was estimated to 6 300 m^3/ha/year. The crop water consumption will be taken from the ETR values rather than from the water requirement. Part of this evapo-transpiration is covered by rain. The same 82% ratio as for PMH sectors can be consider to estimate the efficient rainfall from the annual rainfall. The figures of surface water volumes were extracted from the ORMVAH database. For the Tessaout amont sector, an estimate of the surface water distributed over the Tensfit basin was made based on Fadil investigations. Apart from the efficient rainfall and surface water contributions, the remaining part of the ETR is provided by the net groundwater abstraction.. From 1993 to 2004, the estimated groundwater abstraction for irrigation in the GH sectors varies from 26.0 Mm^3 during the 1995/96 agricultural campaign to 129.8 Mm^3 during the 2001/02 agricultural campaign.

(3) Groundwater abstraction for drinking water supply

The Marrakech drinking water supply partly comes from groundwater, abstracted in 9 different places. The groundwater abstracted in 2003 for the drinking water supply of Marrakech, the six (6) main towns of the Haouz plain and the rural population may be evaluated as 14.9 Mm^3.

(4) Groundwater abstraction for livestock water supply

According to the ORMVAH statistics, there are some 116,000 cattle and 599,000 sheep in the Haouz plain. The water demand of this livestock is estimated to 1.5 Mm^3/year, probably roughly half provided by the surface water. The groundwater abstraction for livestock supply can then be estimated to about 0.8 Mm^3/year. As a first estimate and at the present scale, this figure can be consider as totally constant.

(5) Additional groundwater abstraction (urban sectors)

The annual amount of groundwater abstracted beneath Marrakech city for the irrigation of grassy areas can be estimated to about 7.3 Mm^3 in year 2003.

3.5 Present Conditions of Irrigation and Water Saving Irrigation

(1) Irrigation Water Demand

The present water demand for irrigation based on the actual water sufficient level of crops in the field is estimated 1,061 Mm^3/year for 175,704 ha of irrigated area. On the other hand, the potential water demand at the present condition in the study area is estimated with following assumptions:

- No irrigation area is newly developed in the GH areas. The fallowing area due to lack of irrigation water, which is approximately 6,300 ha, is taken account of area to be irrigated for estimating water demand.
- For the PMH area, the area actually irrigated at present is taken into account as irrigation area for estimating water demand.
- It is understood that the water demand of crops is not satisfied at present due to lack of irrigation water. Thus, increase of water demand by increasing water application to crops is forecast instead of expanding the irrigation area.

Under these conditions, the potential water demand for irrigation is estimated 1,459 Mm^3/year for 182,023 ha of irrigated area.

Estimated Present Water Demand for Irrigation

Area	Present Water Demand		Potential Water Demand	
	Irrigation Area (ha)	Water Demand at Main Canal / Well (Mm^3/year)	Irrigation Area (ha)	Water Demand at Main Canal / Well (Mm^3/year)
ORMVA	137,689	836	144,008	1,158
-GH	40,514	242	46,833	371
-PMH	97,175	593	97,175	787
DPA Marrakech	8,896	52	8,896	69
DPA Chichaoua	29,118	174	29,118	232
Total	175,704	1,061	182,023	1,459

The water demand for irrigation is set as 1,260 Mm^3, of which irrigated area is increasing to 203,377 ha in 2020 from 175,704 ha at present. In addition to above forecasting, the maximum water demand for irrigation, that is whole irrigation developed area of GH areas are under irrigation and whole irrigation area receive full water which satisfy the water sufficient of crop is also set as 1,720 Mm^3, of which irrigated area is increasing to 209,696 ha in 2020 from 182,023 ha of the potential water demand.

Irrigation Area and Water Demand Forecasting for Irrigation

Area	Water Demand in 2020		Maximum Water Demand in 2020	
	Irrigation Area (ha)	Water Demand at Main Canal / Well	Irrigation Area (ha)	Water Demand at Main Canal / Well
ORMVA	156,568	961	162,887	1,324
-GH	40,514	242	46,833	371
-PMH	116,054	719	116,054	953
DPA Marrakech	10,954	69	10,954	92
DPA Chichaoua	35,855	229	35,855	304
Total	203,377	1,260	209,696	1,720

(2) Water Saving Irrigation

The merit of drip irrigation is very popular among farmers, however, the expansion of the drip irrigation does not proceeded significantly.

In order to promote the expansion of drip irrigation, the government gives subsidy for introducing drip irrigation system to farmers. The ratio of subsidy is 40% for equipment and 30% for well and pump at present, and the ratio is intended to increase to 60% for both equipment and well pump.

3.6 Water Users Association (AUEA) and Farm Household Survey and Water Related Issues

Out of the issues identified in the AUEA and Farm Household Survey, those related to agricultural practices are summarized below. The environment surrounding agriculture contains various problems including low productivity of agricultural products, deficiency of agricultural infrastructure/machinery, increased price of agricultural input as well as decrease in marketing price, thus causing a difficult situation for the farm households.

Major Issues Relating to Agricultural Practices

Issues regarding AUEA		
Rank	Issues	%
1	Decrease in price of commodities	89.3
2	Lack of irrigation water	85.7
3	Low income	82.1
4	Lack of rainfall	82.1
5	Increased price of seeds/seedlings	78.6
6	Lack of storage facilities	78.6
7	Lack of means of transportation	78.6
8	Lack of agricultural machinery	75.0
9	Decrease in agricultural productivity	75.0
10	Lack of opportunities for training	75.0
11	Lack of opportunities for selling products	71.4
12	Lack of agricultural infrastructure	67.9
13	Lack of financial resources (loans/subsidies)	64.3
14	Lack of agricultural technology	57.1
15	Lack of guidance by govt. organizations	50.0
16	High cost for irrigation	46.4

Issues regarding Farm Households		
Rank	Issues	%
1	Low income	91.4
2	Increased price of seeds/seedlings	82.8
3	Lack of agricultural machinery	82.8
4	Decrease in price of commodities	81.0
5	Lack of irrigation water	79.3
6	Decrease in agricultural productivity	77.6
7	Lack of storage facilities	75.9
8	Lack of opportunities for selling products	74.1
9	Lack of means of transportation	70.7
10	High cost for irrigation	69.0
11	Lack of agricultural infrastructure	65.5
12	Lack of financial resources (loans/subsidies)	65.5
13	Lack of rainfall	63.8
14	Lack of opportunities for training	63.8
15	Lack of agricultural technology	56.9
16	Lack of guidance by govt. organizations	51.7

Almost all of the surveyed AUEAs had a set of official regulations for their activities and claimed that they have held general meetings. However, half of the surveyed AUEAs have not held their general meetings after the year 2005.

Almost all of the surveyees (94%) expressed their consent in regard of educational activities to raise awareness on water saving. Items such as strengthening subsidies for drip irrigation, minimizing irrigation water through the introduction of xerophilous / value added crops were also generally welcomed (88%). However, in many cases, introduction of new crops were only welcomed if they were to bring higher productivity / benefit. The "water police" defined under the Water Law, was also positively responded (82%) in regard that it may prevent excessive / unauthorized pumping of groundwater to realize sustainable management of groundwater and improve fairness in water use.

On the other hand, 67.4% of the surveyees opposed towards raisin the price of water fee. Further more, 66.3% opposed to charging water fees for groundwater use, while 57% opposed to installation of water meters on wells. In general, there were large oppositions towards actions involving increased of burden for the farmers.

3.7 Re-use of Treated Sewage and Drainage Water of Marrakech

(1) Present Conditions of Sewage and Drainage of Marrakech Town

Sewage and Drainage System in Marrakech Town

Sewer system in Marrakech is the so-called combined sewer system to collect both storm water and wastewater from the houses and buildings by reinforced concrete pipes. Collected sewage is discharged at 3 outfalls (Azib Ayadi, El Azzouzia and Issil) on the shore of the Tensift river and it causes water pollution. The total length of the combined sewer system reaches approximately 1,400 km and is connected at about 106,000 points to cover 82 % of the city area.

Assuming 80 % of the quantity of water consumption is discharged as sewage and the coverage area of sewers is 82%, the sewage quantity discharged to the Tensift River is estimated as 62,000 m^3/day.

Construction Plan of Sewage System in Marrakech Town

Development project of sewerage system is being implemented by RADEEMA to construct sewage treatment plant at Azib Ayadi in the Tensift River side including the rehabilitation of existing sewers and the intercept facilities and sewers. The project was awarded to the joint venture of DEGEAMONTE, France and SOGEA, Morocco in 2004.

(2) Possibility of Re-use of Treated Sewage Water

The concentration level of SS and BOD5 of the treated sewage of Phase 1 treatment process is rather high and water is still aggressive in nature to consider about wastewater reclamation. Treated sewage from the Phase 2 treatment process will reach the allowable level and is expected to be re-used for irrigation and similar level water use.

3.8 Analysis of the Water Balance

(1) Previous Studies on Groundwater Balance

The first groundwater balance analysis was conducted early in the 70's, for Central and Oriental Haouz. For this part of the aquifer, it gives a total annual entry of 280 Mm^3, equivalent to the output.

The last groundwater modeling work was conducted in 2004 over the aquifer extension in the Tensift basin. It gives detailed results for the 2000/01 season. The total annual entry to the aquifer was then estimated as 425 Mm^3, while for an output of 704 Mm^3, mainly constituted in abstraction

(2) Methodology of Groundwater Modeling and Simulations

The groundwater flow simulations, using a mathematical model, will produce an evaluation of the future groundwater levels and impacts for the development options. This will be used as material for discussion in Stakeholder Meetings and for the preparation of the Master / Action Plan.

(3) Present Conditions in Groundwater Balance

Assessment of the groundwater balance can be done for the last ten years, based on a first estimate of each of the inflow and outflow topics. For this first estimate, it is assumed that any excess water can be drained to the rivers within one year, which may be wrong in such a large porous aquifer, and that no drainage occurs when the reserve is realized, which does not take into account the spatial distribution of the deficits and the potentially local excess (the 2001 simulation shows that some drainage could still occurs in 2000/01, despite the 279 Mm^3 deficit estimated by the model).

(4) Current water demand

As a result of examination of water demand and available water resources including estimation of groundwater abstraction, the total water use in the Study Area is estimated 735 Mm^3/year and irrigation use occupies 92% besides water supply and other use 8%. By water sources, the water use of the Study Area relies on 45% on groundwater, 41% on the surface water source in the Area, and 14% on the surface water transferred from the Oum El Rbia Basin.

The estimates of water demand discussed above are summarized as follows.

Summary of Estimates for Water Demand

(Unit: Mm^3)

Item	Current Water Consumption	Current Potential Water Demand	Estimated Water Demand in 2020/21	Estimated Water Demand in 2020/21 (maximum demand)
Water Demand	**1,147**	**1,544**	**1,389**	**1,588**
1. Irrigation	**1,061**	**1,459**	**1,260**	**1,459**
(1) ORMVAH	835.6	1,158.0	960.8	1,158.0
1) GH	242.2	370.9	242.2	370.9
2) PMH	593.4	787.1	718.6	787.1
(2) DPA Marrakech	51.8	69.2	69.4	69.2
(3) DPChichaoua	173.7	231.5	229.3	231.5
2. Water Supply	**76.5**	**76.5**	**100.3**	**100.3**
1) Marrakech : RADEEMA	58.9	58.9	77.3	77.3
2) 11 Communes under ONEP	3.5	3.5	4.7	4.7
3) Rural areas: Communes other than those under ONEP	14.1	14.1	18.4	18.4
3. Others (Urban Areas)	**9.2**	**9.2**	**28.8**	**28.8**
1) Golf Cources	2.5	2.5	19.4	19.4
2) Others (Gardens, Hotels)	6.7	6.7	6.7	6.7

(5) Available Amount of Water Resources

The plan for integrated water resources management plan for the Tensift basin (2001) examines 12 new dam sites, and proposes 7 dams (with the total capacity of 200 million m^3) to be constructed by 2011. Wirgane dam is already under construction. The construction of Taskourt dam is also planned to start next year. However, at this point, there are no provisions for the other remaining dams to be implemented.

The results of the examination of water balance for the period of 1993/94 to 2003/04, the total annual water use is estimated at 942 Mm^3 of which 93% is used for irrigation and 7% for other sectors. 54% of the water is obtained from groundwater, while 36% and 11% are taken from surface water and through inter-basin water diversion from the basin of Oum Er Rbia.

Estimation of Water Balance in the Study Area (average of 1993/94-2003/04)

(Unit: Mm3)

Supplied Amount			Used Amount		
Water from Dam: Lalla Takerkoust Dam (including a part of water from Mouay Yossef Dam	135	14.3%	Irrigation	880	93.3%
River Water	201	21.4%	Water Supply	55	5.8%
Inter Basin Transfer (Water from Oum Er Rbia Basin transferred through Rocade Canal)	101	10.7%	Others (Urban)	8	0.9%
Groundwater Abstraction	505	53.6%			
Total Suplied	942		Total Used	942	

According to the examination, the available water resources are summarized as shown bellow:

(Unit: Mm^3)

Water Source	Period	
	2008-2009	2010-2020
1. Surface Water	518	522
(1) Dam	145	169
1) Lalla Takerkoust Dam	82	82
2) Wirgane Dam	17	17
3) Taskourt Dam	0	24
4) Moulay Youssef Dam*1	46	46
(2) Rivers (Seguia)	252	233
(3) Inter-Basin Water Diversion from the Basin of Oum Er Rbia through the Rocade Canal*2	120	120
2. Groundwater	564	

Note: *1: A part of Skhrat and Bouida Areas were taken into consideration.

*2: Annual Flow estimated at 114Mm^3 with transportation loss (6Mm^3/year).

*3: Amount of available groundwater is based on the results of simulation

3.9 Groundwater Simulation in the Haouz Plain and Zoning

(1) Groundwater Simulation in the Haouz Plain

Underground water simulation it did in order in the future to presume the available water resource quantity in the Haouz Plain. Scenario of two kinds below was set at the time of the execution of simulation.

Continuation Scenario: It is the scenario that acts as basis of the exam. It is assumed that the situation where the present water use will continue and the preventive measures won't be taken.

Maximum Demand Scenario: For the critical situation, it is assumed that the situation where 100% of the quantity of necessary water will be used by every sector. (For the water supply, the measures to take, as the prevention of the water leakage, etc. are already considerations in the forecasting of the demand in water.)

The Table below gives the values of each of the indicators for the scenarios.

Indicators values obtained from groundwater flow simulations (simulated period from 2006/07 to 2020/21)

			Continuation	Maximum Demand
Indicates related to Groundwater	Surface "Change50"(ha)		29,000	97,000
	Groundwater Balance (Mm^3)	Whole period	-1,310	-3,440
		2006/07	-39	-126
		2020/21	-121	-263
Economic Indicators	Average depth of the groundwater table (m): 41.4m at present		41	48
	(Economic Impact: Million dh)		(3,757)	(7,605)
	Dried out aquifer surface (ha)		9,100	44,000
	(Economic Impact: Million dh)		(448)	(2,166)
	Number of dried out boreholes		1,805	6,883
	(Economic Impact: Million dh)		(253)	(964)
	Number of people losing jobs		4,306	20,821

(2) Regional Characteristics and Measures for Groundwater and Management

For managing groundwater in the Haouz Plain, it is necessary to have two aspects, the one is aspect of global water balance in the whole aquifer, and another is the aspect of regionalized water use such as regional characteristics and situation of aquifer, socio-economic importance and position of groundwater in the region, and regional demand and its characteristics. These regional characteristics shall be considered in setting regional priority, formulating and selecting countermeasures in region, and conducting appropriate regional water management. In the Study, the Haouz Plain was divided into several zones based on the concept described below.

Marrakech water supply well field capture zone	None of the groundwater development scenarios significantly modify the captures zones of the Marrakech well fields: the capture zone of the N'Fis well field extend to the South along the N'Fis oued, and then reach the Amizmiz sector; a unique capture zone may be defined for the Issil, Aguedal, Ourika, Menara and Drain well fields, which reach Tahanaout Southward. These two sectors are strategic areas for the Marrakech City water supply. They should be protected regarding the quality and regarding the quantity
Marrakech City sector	The groundwater development beneath the Marrakech City sector was important in the last 10 years. It is expected to significantly increase in the near future: up to 15 golf courses projects are identified for a total water demand of over 19 MCM/year, dozens of hotels with gardens and pools are constructed every year, the Municipality services increase the irrigated grassy areas along the main streets, many individuals drill their own well for the swimming pool supply
Lower N'Fis Left Bank PMH sector (Special Risk area)	Whatever is the development scenario, a Special Risk area may be identify in the lower N'Fis Left Bank PMH sector. The extension of this sector differs from one scenario to another but all the simulations shows that most of this sector will faced a dramatic drawdown and will certainly dried out.
Irrigation sector in risk area	The sectors where the expected drawdown within the next 15 years will be significant and where the groundwater is used for agriculture may be called Risk Area regarding the abstraction capacity. Indeed, some major economic negative impacts are expected in the agricultural sector in case of significant drawdown. This Risk Area will nearly cover the whole Haouz plain in case of important increase of the groundwater abstraction (Maximum Demand scenario) and then all of the GH sectors will face large negative impacts. In case of a continuation of the present groundwater abstraction development (Continuation scenario), the Risk Area will cover the N'Fis GH sectors. The PMH sectors located in the lower part of the Haouz plain are in the Risk Area. This risk area is set from oued El Mal at the West to Marrakeck at the East in case of a continuation of the present groundwater abstraction development (Continuation scenario).
Other irrigation sector	Everywhere else, the Haouz plain will face a drawdown within the next 15 years limited from 0.1 m/year to 0.5/ m/year. None of the tested development scenarios lets expect a null (or positive) change in the water table.

CHAPTER 4 STRATEGY OF THE INTEGRATED WATER RESOURCES MANAGEMENT

4.1 Strategies for Integrated Water Resources Management

(1) Basic Concept of Integrated Water Resources Management Strategies

The objective of the integrated water resources management is to realize sustainable water use in the Haouz Plain, where is severely limited in the water resources. In order to achieve that, it is considered that the recovering and maintaining the balance of water demand and supply, especially in groundwater, which is in the condition of over exploitation or very close to over exploitation at the moment, is indispensable. The approaches from both sides of the supply side (water resources) and the demand side (water users) are necessary to be applied to improve the present condition of the water balance.

From the aspect of water resources, it is required to make maximum and effective usage of water sources under maintaining the appropriate groundwater management. The usage of water shall include both of maintaining existing water source and development of new source as well as reuse of wasted water. From the aspect of water users, it is necessary to manage and reduce the demand to meet the available water resource, as well.

In order to manage and reduce the amount of water use, all water users in whole sectors shall give full effort to economization of water use. Preventing ineffective use and loss will contribute to improve water balance through water saving activities. To compensate the cost for effort to reduce the demand, it is necessary to introduce aspect of the value adding and cost saving of water use (valorization) as well as the aspect of efficiency of water use. Both aspects of economization and valorization shall be considered as a combination to achieve realistic results of reducing water demand and use. Based on above idea, the 6 basic strategies are proposed to the IWRM as shown in the right figure:

4.2 Strategy for Surface Water Sources Development and Management

(1) Strategy for Surface Sources Development

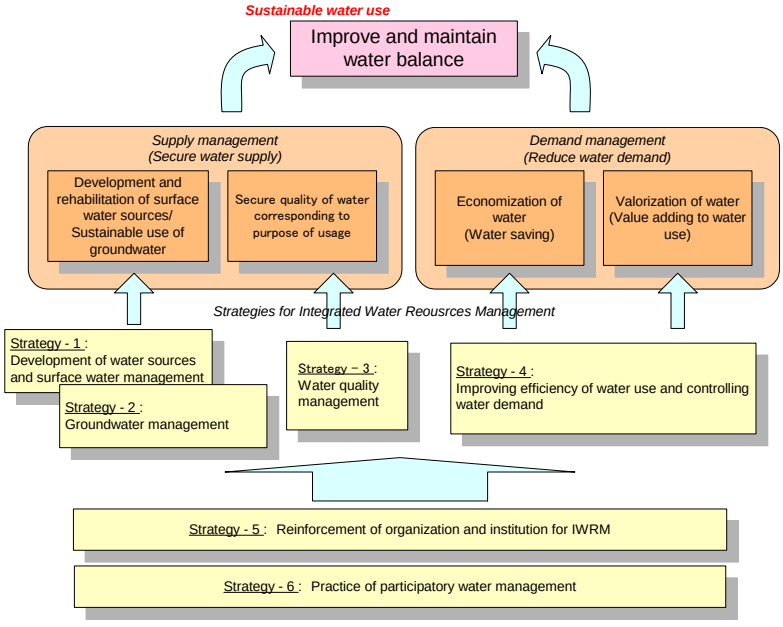
Rehabilitation/Enhancement of Existing Facilities

Because the possibility of development of new water resources is limited in the Haouz Plain, it is important to maintain the existing water resources adequately and use them sustainable.

- Maintaining the function of the Lalla Takerkoust Dam
- Effective use of river water

Development of New Water Sources

Even several dam projects were propose in the Integrated Water Resources Development Plan of the Tensift Basin (2001), only two dams, that is Wirgane Dam and Taskourt Dam, were decided to construct (or started to construct) due to most of proposed dam sites had a technical or socio-economic reason. Thus, improvement of water balance by developing new dam water other than above two dams is not expected in the Haouz Plain in the short and mid-term.



Basic Strategies of Integrated Water Resources Management

(2) Strategy for Maximum Use of Surface Water Resources

Artificial groundwater recharge

The groundwater has an important role in the potentiality of the water resources in Morocco. The artificial recharge of groundwater, which consists in infiltration of the fluvial waters to restore the aquifer, is placed in the integrated water resources management of surface and groundwater. On the other hand, the potential for artificial groundwater recharge is largely controlled by the situation of the rivers. Increase of groundwater recharge through artificial groundwater recharge is expected to contribute to the recovery of groundwater tables in specific areas.

Preservation of the Catchment Area

In order to increase the watershed conservation in the upstream of the urban or agricultural zones that require a lot of water, it is necessary to afforest and to practice a program of prevention for the erosion. It is necessary to examine the management of the catchment area in collaboration with the authorities concerned by the environmental preservation or the forest protection.

Effective use of runoff water flow out of Tensift river

The effective use of surface water resources, through the activities as the maintenance of the functions of the existing dams, the moderation of the drains by the preservation of the catchment areas, the artificial recharge of the groundwater with the restraint of water on the river bed, etc., will result the reduction of flows out toward the downstream. This reduction of flow will maintain and the improve of the water balance of the Haouz plain.

Water harvesting

As for countermeasures to increase the efficiency of the natural recharge of pluvial waters to the groundwater, it is possible to adopt the method of water harvesting by means of collecting channel such as dug shaft or tanks, as well as the artificial recharge of the groundwater and the preservation of the catchment areas.

(3) Development of Reclaimed Water of Sewage

Estimated Sewage Generation Amount

Sewage generation amount in the Study Area is estimated by 80 % of the water demand and tabulated. In 2020, the sewage generation amount in Marrakech is estimated at 45.2 Million m^3/year or 124,000m^3/day. If all the amount of generated sewage will be reclaimed, it will rise in expectation for new water resources.

Reclaimed Water of Treated Sewage in Marrakech

Sewerage development project of Marrakech by RADEEMA schedules to start operation of primary sewage treatment in 2008 with the rated capacity of 90,720 $m^{3/}$day and start operation of the secondary treatment in 2010 together with the tertiary treatment to pump up reclaimed water to the Tensift riverside palm garden and the nearby golf course & resort areas for landscape irrigation water.

Sewage water treatment out of Marrakech

The scale of sewage treatment plant in development by ONEP in the rural urban areas is small and treated water quality will become an issue of sanitation as it is used for the reclaimed water. It is not economical to formulate the plan for utilization of treated sewage intensively.

Water Resource Development from Desalination

In regard of desalination for the new water resources of Marrakech located inland is very disadvantageous conditions in technical and economical point of views. It will be an appropriate disposition to exclude the seawater desalination for new water resources development from the study objective item of the Master Plan targeted up to the year 2020.

(4) Strategy for Surface Water Resources Management

Reinforcement of surface water monitoring system

The main use of river waters are intakes by seguias as irrigation water. A structure to collect and accumulate information of water use by, with the participation of AUEAs, shall be formulated. Further

more, such data on water use shall be promptly shared with ABHT, the water resource management authority.

Improvement of hydrological observation network

In order to obtain accurate understandings on the situation of the aquifer in the Haouz Plain, and to manage groundwater in an appropriate manner, it is important to conduct accurate observations of the discharge of the rivers, which are the sources of water to the aquifers. The current observation network of ABHT is sufficient for understanding the discharge at the level of small catchments, but this should be further strengthened through installation of new observation points and renewing of observation apparatus (introduction of automatic gauges).

4.3 Strategy for Groundwater Management

(1) Registration Management of Groundwater Intake Facilities

On the premise that water is national property and share righteously to the people, ABHT shall have management obligation to collect and grasp all the information of water intake facilities and water users for fulfilling the duties. Moreover, the sample survey revealed the existence of 31% of unregistered wells and the information of the increase ration of the number of wells in 2003 and 2004, the present total numbers of wells are estimated at in the range of 17,000 to 18,000. The current number of registered wells and the contents of the registration are not adequate to realize the effective groundwater management.

(2) Determination of Available Groundwater Volume through Scientific Means

In case the pumping control is enforced, the control groundwater level, pumping volume, control period, control area, etc. must be determined based on the scientific means. For that purpose, the latest data shall be prepared always in carrying out the groundwater analysis. Collection of the information of hydrogeology, groundwater level of monitoring wells, satellite image maps and/or aerial photos will be the basic conditions to structure the accurate groundwater simulation model. After obtained the available groundwater amount and control amount determined from the result of groundwater analysis, the test operation for pumping control area and the period will be arranged. Analysis of groundwater level changes will be made for the test period for adjustment of the pumping control as required and shit to the actual enforcement of pumping control.

(3) Establishment of Institutional Mechanism for Equitable Groundwater Distribution

The system will have to be established in order to ensure an equitable distribution of the ground waters which takes account of the type of water use. Concrete actions will have to be implemented to achieve this objective. On the legislative level, the application texts has to be elaborated and be published so that can be finalized the legal basis of : the workers framing of the wells digging and the ground water use monitoring and control by the water police. On the other hand, on the institutional level, a series of the action must be committed: the installation of the council framework together of the local concerned actors, the system establishment for the royalties collecting by ABHT, the progressive competences transfer to the local communities on the ground water management and local capacities reinforcement, and also reinforcement of the personnel of ABHT in charge of the ground water management.

(4) Scenario for Implementation of Groundwater Management Program and Groundwater Management Manual

The scenario for implementing the groundwater management program will be decided based on the prescribed schemes to establish the effective aquifer management and formulate the management plan for the normal year and the drought year.

Annual groundwater utilization plan for normal year will be prepared based on the preparedness of groundwater intake facilities resulted in the registration management, scientific mean groundwater simulation, estimation of available groundwater amount, righteous water allocation, appropriate pumping control level & amount, annual groundwater management policies, etc. prescribed schemes to establish the effective aquifer management and formulate the management plan for the normal year and the drought year. The annual groundwater utilization plan will be implemented through basic

acceptance of the relevant agencies, water users association, the representatives of farmers and other water users. Observation for the approaching to the predetermined draught year groundwater level will be carried out from the information of groundwater level of the monitoring wells. The draught year measures will be taken for the enhancement of pumping control or suspending pumping and the control area based on the status of observation.

4.4 Strategy for Water Quality Management

(1) Construction of Facilities for Domestic Sewage

The first sewage treatment plant of Marrakech is under construction by RADEEMA and scheduled to start operation the primary treatment in 2008 followed by the operation of secondary treatment by biological treatment start in 2010.

ONEP is implementing the sewerage facility development projects in the rural areas. The sewage treatment plant constructed by ONEP in Sidi Moktar has started operation since November 2006 and the plant is operated with low influent flow without meeting with the design flow due to the low ratio of sewer connection to the houses. The sewerage development projects in the future shall be implemented by studying carefully the case of the Sidi Moktar.

(2) Construction of Facilities for Factory & Business Wastewater

Drainage from the restaurants as the other type of business activities cause of probable problems and the drainage from every factory and business establishment including hotels as prescribed will be obligated to meet the receiving wastewater quality standard determined for connection to the sewer system through the preliminary treatment facilities equipped by themselves. Factory effluent standards are in force only for sugar factory, pulp factory and paper & cardboard factory as of today and the effluent standards for the other type of industries have not yet been enforced. Urgent legislative measure is required toward prohibiting the factory and business establishments without equipped with the preliminary treatment facilities to discharge drainage to the public water receiving body. Survey shall be carried out hereafter to investigate for the actual status of drainage from the factory and business establishments to promote stipulation and enforcement of the effluent standards.

(3) Construction of Facilities for Other Wastewater

Land development projects bring about increase of run-off factor and cause of increase of storm-water flow in the area. Outflow of excavated earth during the construction work will cause of increase of turbidity in the rivers. The measures by means of constructing a retardation pond for controlling of flood flow and settling of turbidity element in the pond is a considerable factor for discussion as the land development projects will be implemented.

(4) Reduction of Water Pollutants by Non-structural Measures

It is recommendable to control generation of water pollutants and reduce water pollution loading in the river basin. In other words, the above method means to ask the polluters for practicing environment-friendly life and business activities.

(5) Formulation of Water Quality Monitoring System among Supervisory Agencies, Water Polluters and Residents

The system for water quality monitoring and measures for water pollution in the river basin shall be structured with the enhancement of linkage among the relevant government agencies concerned with conservation of water environment, municipalities and water users, namely water polluters.

4.5 Strategy for Improving Efficiency of Water Use and Controlling Water Demand

(1) Strategy for Improving Efficiency of Water Use and Controlling Water Demand in Agricultural Sector

<u>Increase of conveyance efficiency by improvement of canal system</u>

1) Improvement of traditional seguia system
   There are more than 1,000 km length of traditional seguia network in the Haouz plain, and the

94% of total length is equipped by earth canal of which percolation loss is significant do that the average conveyance efficiency is estimated to be approximately 50% at present. The improvement of seguias should be done avoiding such negative impacts to the water balance. In order to do so, the function of seguias for groundwater recharge should be clarified through carefull examination, and seguia improvement should be carried out together with strict control of groundwater exploitation.

2) Extension of Secondary Canal in GH Sector
Even though the canal system is modernized in the GH sector under ORMVAH, the loss after the division work of the main canal is significant due to the unimproved secondary canals. Thus, it is necessary to improve canals in the distance of secondary and tertiary canals from the division work to the inlet of the field. Improvement of the secondary and tertiary canal by extension of pipelines in the beneficiary area of pressurized system is considered as a precondition of expansion of drip irrigation in those area, and it is necessary to be carried out in combination with the program of spread of drip irrigation in order to maximize the effect of reduction of irrigation demand.

Increase of application efficiency by expansion of drip irrigation

1) Introduction and spread of drip irrigation
To reduce irrigation water will contribute to reducing irrigation cost as well as to improving regional water balance by reducing water demand for irrigation. Drip irrigation shall be promoted actively as a measure of reducing irrigation water demand in the Haouz plain.

2) Accumulation/distribution of technical information for water saving irrigation
With regard to the techniques of irrigation and farming practice for water saving, the information will be distributed extensively, especially for small and middle scale farmers, to make know the merits, the means of the introduction and the cultivation techniques for the drip irrigation in order to motivate the users to introducing drip irrigation system. Besides, the relative organizations conduct the technical development and the accumulation of the relative technical information of the water saving irrigation as well as the extension and enlightening to the users.

Value adding to water use (Valorization of water use)

1) Selection of water saving crop/variety
To carry out selection and adaptation of crop/variety and development of cultivation techniques.

2) Distinguishing irrigation crops and non irrigation crops
To concentrate irrigation into the high economic value crops and to promote rain fed cultivation of cereals and feed crops.

3) Irrigation planning based on the available water resources / adequate water distribution in the filed level
In case of necessity from the view point of water balance, the water deficit (water stress) of crops shall be allowed in farming practice.

(2) Strategy for Water saving in Water Supply Sector

Water Leakage Control of Water Supply Facilities

From the table, about one third of water is estimated for the unaccounted amount from 2003 to 2005, which is equivalent to 17.8 to 22.7Mm^3 water loss per year for the total of RADEEMA and ONEP water supply systems. Presumably, the very high 40 % unaccounted water ratio is caused by the distribution pipe network, service pipes, water meters, water taps, etc. It will be a very effective scheme to reduce water purification amount and water intake amount as well by decreasing the water leakage ratio to a half through the implementation of effective water leakage control m

Saving Water in Water Supply

Considering the current tourism boom of Marrakech, the increase of water use by tourists will not be denied in the future. Saving water campaigns at the hotels will become important. There are 10 hotels

in Marrakech of which number of hotel rooms are more than 300 rooms as of 2006. If the hotels positively construct the tertiary treatment facilities and use the reclaimed water for landscape irrigation within the hotel compound and the neighboring street garden, water consumption amount decrease considerably. For the water management administration side concerned, the financial special measures shall be considered as the hotels and other water users construct the water reclamation facilities.

Water Saving of Other Sectors

In Marrakech city, there are city parks, green zones, street trees belt, etc. as about 400 ha (ABHT, 2006), and these are the relaxing places for the residents. The City (Commune Urbaine Marrakech) has taken charge of management for these. It is said that the wells (groundwater) are used for watering of the plants mainly. The consideration of excessive watering on the city park and green area / garden plant is basically similar to the agricultural production. It can be said that the water is saved by the watering with drip and sprinkler compared with furrow irrigation, flood irrigation and watering by hose.

4.6 Strategy for Reinforcement of Organizational and Institutional Framework

(1) Clarification of the Roles and Responsibilities of the Stakeholders and Reinforcement of Consultation Frameworks

Indeed, for the sustainable management and the rational use of the water resources in the Haouz plain, all stakeholders concerning water will have to take part in the water management with its various aspects, in particular the framework installation for follow-up and monitoring of the water resources, the enlightenment activities for awareness-raising to water saving, the introduction or the reinforcement of the water users organizations and the dissemination of the water saving techniques.

Thus, to carry out the sustainable management and the rational use of the water resources with participation of various stakeholders, stakeholders themselves at the beginning have to clarify and recognize their role and responsibility for these resources management. Then, a mechanism to concert, to make the decision and to implement concrete actions of the water resources management should be established on the basis of the role and the responsibility of each stakeholder.

(2) Activation of the Prefectural and Provincial Committees of Water

The Water Law and the decree No 2-97-488 of February 4 are envisioned the creation of the Prefectural and Provincial Commissions of Water (CPPE) and their compositions and operations. It is very important to establish the water resources management system with the participation of the local actors as well as the local communities (at the provincial level) to the planning and the implementation of the water resources management, the action of the management system establishment at the provincial level will be undertaken through the organization of CPPE and its activation.

(3) Reinforcement of the Implementation of the Water Police and the Competence Transfer to the Provincial Level

To realize the control of illicit water use by the water police, the ABHT should firstly provide the necessary human and material means and proceed to the implementation of the actions of the water police in the whole of the action zone of the agency. To achieve the goal of the actions of the water police, such as the prevention of the illicit water use and the water resource protection, a close cooperation with the local communities (Region, Province and Commune) and the gradual competences transfer of the water police to the local communities are indispensable.

(4) Adequate Water Pricing and Royalties Collection

The adoption of the tariffication to the water resource, particularly the underground resource intake, will have to be considered in an equitable way and differentiated according to the criteria defined such as the volume of water intaken, the effort for the water saving introducing the adequate technique or the type of water use developed. For example, new tariffcation of use of groundwater will be applied initially to the large scale water users (large farms and tourist sector). The possibility of extending tariffication application to the other users will be applicable gradually. Also the large water consumers will have to be penalized in the tariffication.

(5) Financial Strengthening of ABHT

In the water law, the financial resources of ABH are composed of the royalties to collect from the water users and DPH users, and public debt, state subsidy, donation, and so on. ABHT is expected to be managed to operate self-sustained organization as an independent administrative organization in the future. Securing of the income source becomes even more important to strengthen a financial base.

(6) Capacity Development of ABHT on Water Resources Management

For the sustainable management and rational use of the water resources in the Haouz plain, the establishment of the water resource management system under the close collaboration with the various stakeholders is indispensable. Also the function of the ABHT must be operational as the federator of the water resources management. Administrative system improvement and reinforcement for the water resources management, through the actions for the capacity reinforcement of the ABHT in the technical and institutional level, must be done as soon as possible.

(7) Legislative System Establishment for Effective Implementation of the Water Law

Water legislation is not sufficiently recognized and applied by the users. To respect and accomplish the legal system concerned the water management, the reconnaissance to the users on the water legal system must be promoted to the users by the large diffusion of the information related the Water Law and its application texts. And also the necessary application texts have to be elaborated and approved for the effectiveness of the Water Law.

4.7 Strategy for Participatory Water Resources Management

(1) Reinforcement of the Actions of Enlightenment for Water Saving and Water Resources Conservation

The saving water and the water management campaign have been implemented by the concerned structures especially in the agriculture and tourism sectors, but each executes individually as a function of their competence particularly finance capacity. The activities of the enlightenment for the saving water and the water resources conservation must be preceded strategically to the multiple concerned stakeholders based on the elaborated communication plan.

(2) Activation and Reinforcement of Capacities of Water User's Associations, Competence Transfer for Water Management

The Agricultural Water Users Associations (AUEA) plays an important part of the irrigation water distribution and the hydro-agricultural equipments management. In fact, the irrigation for agriculture dominate 92% of the total water demand in the Haouz plain, the AUEA have to play an important role to the water resources management such as the federator of the farmers. To promote the saving irrigation water, the AUEA as the principal actors of the water use must participate actively to the management and the saving of the irrigation water by the drip irrigation practice.

(3) Contract for Groundwater Management and Use

A participation of all stakeholders is indispensable for the sustainable management and use of the water resources in the Haouz plain.

The contract for the ground water management that the ABHT aims to realize is a participatory and contractual framework for the water resources management. It defines the utilization conditions and the action for the ground water management engaged by the ensemble of intervenient in the water domain including the users. The elaboration of the dossiers of the contract will be examined at the consultation framework, and finally approved and signed at the Basin Committee level: The contract of the ground water management will insure the concrete actions implementation by the responsibility and the engagement of the stakeholders.

4.8 Scenarios for Integrated Water Resources Development and Management

(1) Water Allocation Plan

For the adequate allocation of limited water resources, considering the priorities of each sector, the water allocation plan will be set and the measures for the reduction of water demand will be taken in

each sector having this setting for value of objective.

Since the drinking water is indispensable as basic human needs, the source of drinking water should be assured above all. The demand in drinking water in 2020 is estimated in 100.3 Mm3, of which 77.3 Mm^3 for the Marrakech city will depend on 8 Mm^3 of the groundwater and 69 Mm^3 of the surface waters supplied by the Rocade Canal and the Lalla Takerkoust-Wirgane Dam. To the commune level in rural area, the demand in drinking water is estimated in 23 Mm^3 whose whole quantity will be taken in the groundwater.

The water demand of golf courses will have increase from 2.5 Mm^3 at present to 19.4 Mm^3 in 2020. The water demand for golf courses irrigation will depend on the treated wastewater after the beginning of the supply by the project of development of RADEEMA.

The water demand of irrigation is estimated currently in 883 Mm^3 and is increased to 1,046 Mm^3 in 2020. The quantity of surface waters to distribute for the irrigation in 2020 is estimated in 233 Mm^3 of the river water and seguias, 210 Mm^3 of the dam water and transferred of the outside of the basin, either in 443 Mm^3 to the total. The rest of the irrigation demand will depend on the groundwater. The amount of available water from the point of sustainable groundwater management is set at 564 Mm^3 in the case where Major Actions are taken, based on the results of the groundwater simulation. Maximum efforts shall be made to reduce water demand in order to realize water use based on this level which enables sustainable roundwater management.

(2) Scenarios for the Integrated Water Resources Management

In addition to the 2 scenarios examined in 4.2 (continuation and maximum demand), integrated water management scenarios were examined taking into regard the scenarios for improvement and maintaining of water balance, the scenarios for water source development, and the scenarios for water demand reduction. 2 additional scenarios with different levels were examined and simulations were done for both of them.

Detailed hypothesis for the main parameters of the four scenarios

	Scenarios			
	Continuation	**Maximum Demand**	**Basic Actions**	**Major Actions**
Irrigated areas GH PMH	40.514 ha 135.190 ha in 2006/07 162.863 ha in 2020/21	46.883 ha 135.190 ha in 2006/07 162.863 ha in 2020/21	40.514 ha 135.190 ha in 2006/07 162.863 ha in 2020/21	40.514 ha 135.190 ha Up to 2020/21
Drip irrigated surfaces GH N'Fis right bank Other sectors PMH	 - - 0 ha	 - - 0 ha	 17.500 ha in 2011 11.500 ha in 2017 62.000 ha in 2020	 17.500 ha in 2011 11.500 ha in 2017 47.000 ha in 2020
Water stress conditions	18%	0%	18%	18%
Growth rate of PMH irrigated by groundwater	2%	2%	2%	0%
Surface water availability (MCM/year)	501 up to 2007/08 518 up to 2009/10 522 up to 2020/21	501 up to 2007/08 518 up to 2009/10 522 up to 2020/21	501 up to 2007/08 518 up to 2009/10 522 up to 2020/21	501 up to 2007/08 518 up to 2009/10 522 up to 2020/21
Golf courses water demand	Up to 15 golf courses from 2015 (19.7 MCM/year)		Covered by 19.4 MCM treated wastewater from 2014	
Rainfall	282 mm/year			
Flood infiltration rate	about 25%, based on flood regime			
Regionalized allocation of surface water resources	-	-	Shift 6Mm^3 from Lalla Takerkoust dam to Rocade canal for Marrakech Water Supply	
Artificial groundwater recharge	-	-	14.3 m^3 as total of 4 rivers	

(3) Outline of the scenario results

The evaluation of the results of each scenario is summarized as follows:

Summary of the scenario results (simulated period from 2006/07 to 2020/21)

			Continuation	Maximum Demand	Basic Actions	Major Actions
Indicates related to Groundwater	Surface "Change50"(ha)		29,000	97,000	3,690	-6,214
	Groundwater Balance (Mm^3)	Whole period	-1,310	-3,440	-696	-289
		2006/07	-39	-126	-35	-35
		2020/21	-121	-263	-70	-21
Economic Indicators	Average depth of the groundwater table (m): 41.4m at present		41.4	48.4	38.7	37.3
	(Economic Impact: Million dh)		(3,757)	(7,605)	(1,918)	(1,606)
	Dried out aquifer surface (ha)		9,100	44,000	3,714	3,589
	(Economic Impact: Million dh)		(448)	(2,166)	(183)	(177)
	Number of dried out boreholes		1,805	6,883	414	283
	(Economic Impact: Million dh)		(253)	(964)	(58)	(40)
	Number of people losing jobs		4,306	20,821	1,758	1,699

CHAPTER 5 MASTER PLAN OF INTEGRATED GROUNDWATER MANAGEMENT

5.1 Object of the Master Plan

The Master Plan for the Integrated Groundwater Management aims at the realization of the appropriate management of the groundwater which is necessary to guarantee the utilization of the water resources continuously and stably on the inhabitant's life and the agricultural production, in consideration of supply and demand of the groundwater in the Haouz plain.

5.2 Targets of the Master Plan

The target year of the Master Plan is established in 2020, taking into consideration of the Integrated Water Resources Management Strategies and the target year of the National Water Resources Plan which is preparing by the Morocco Government. Because of that, this can't be said as the general long-term plan. Furthermore, as for the projects and activities which continue for a long duration and the interim review year for the main project and activity are set at 2012 and 2015 respectively.

To realize the improvement and maintenance of the water balance in the Haouz plain, the scenario (Major Action Scenario) examined in the former chapter is realized. In other words, the equilibrium of water balance of the groundwater is attained by the target year, 2020.

5.3 Strategies to Attain the Master Plan Object

Based on the Integrated Water Resources Management Strategies shown in the preceding chapter, the Master Plan is elaborated mainly the groundwater management which aims at improvement and sustainability of the water balance in the Haouz plain, and the basic concepts are composed of the followings:

1) New water resources development and surface water management plan,
2) Groundwater management plan, including the regulation of extraction in consideration of the balance of demand and supply in the Haouz plain,
3) Water quality management plan,
4) Plan for appropriate groundwater distribution and use, which could obtain consensus among various stakeholders,
5) Plan for organizational and institutional strengthening for the management of water resources, and
6) Participatory water resources management plan through the participation of the stakeholders

The components which composes the Master Plan are as the followings.

Components of the Master Plan

Plan Field	Program / Project
Surface Water Sources Development and Surface Water Resources Management Plan	Artificial Groundwater Recharge Project
	Reclaimed Water Supply Project
	Hydrological Observation Network Reinforcement Project
Groundwater Management Plan	Program for Groundwater Facility Registration Management
	Program for Scientific Estimation of Available Groundwater
Water Quality Management Plan	Program for Water Quality Monitoring
Water Demand Reduction Plan	Program for Drip Irrigation Introduction and Dissemination
	Program for Seguia and Water Management Improvement
	Program for Accumulation and Distribution of Technical Information for Water Saving Farming and Irrigation
	Water Supply Leakage Control Project
	Program for Water Saving Dissemination
Organizational and Institutional Improvement Plan	Program for Water Resources Management Capacity Development of ABHT
	Program for Legal and Institutional Frameworks Improvement for Water Law Implementation
	Program for Water Police System Enhancement
	Program for Appropriate Pricing and Effective Collecting of Water Royalty
Participatory Groundwater Management Plan	Program for Formulation of Collaboration and Decision – Making Framework for Water Resources Management
	Program for Activation and Capacity Development of Water Users Association
	Program for Public Awareness on Water Saving and Conservation

5.4 Contents of the Master Plan

The programs and projects which compose the Master Plan are as follows:

(1) Surface Water Sources Development and Surface Water Resources Management Plan

Artificial Groundwater Recharge Project

Implementing agency:	ABHT
Objectives of the project:	Recharge groundwater by infiltrating stocked water in the river bed.
Outline of the project:	Implementation of artificial groundwater recharge has various aims such as long term retention of water, maintaining and upraising groundwater level, and decreasing groundwater pumping costs. Infiltration of water from the soil surfaces may be named as a standard method for groundwater recharge, which can be further divided into recharge by in-river facilities or by facilities along side the rivers. The « Programme de recharge artificielles des nappes (PRN) » prepared in 2003 proposes an in-river structure based on factors such as the advantage in efficient utilization of surface water and natural conditions in the area. A pilot projects shall be implemented in R'dat river. Based on the results of the pilot project, artificial recharge shall be implmented in Rerhaya, Ourika and Zat by 2020.
Cost Estimation:	Total cost estimated 106.0 Million DH.

Reclaimed Water Supply Project

Implementing agency:	RADEEMA
Objectives of the project:	Supply reclaimed water of treated sewage of Marrakech to the Tensift riverside palm garden and golf course & resort areas for irrigation water for the alternative water sources of groundwater and surface water.
Outline of the project:	Currently, RADEEMA is planning the installation of treatment facilities for wastewater from Marrakech city. Treated wastewater is not necessarily applicable for all purposes in regard of it quality. However, with an appropriate purpose matching its quality, it can serve as an important new source of water contributing to the water balance in the Haouz Plain. Supplying treated wastewater on charge to the golf courses in and around Marrakech city can contribute not only to offering an alternative water source to the city, but also to recovering the costs for operation and management. Major contents of the Project are as follows: a. Phase-1 Reclaimed Water Utilization Facilities Construction Project: Provide 52 600m3/day of treated wastewater to 8 golf courses for irrigation water. b. Future Reclaimed Water Utilization Plan: Provide treated waste water to the following 6 golf courses.
Cost Estimation:	Total cost estimated 636.5 million DH.

Hydrological Observation Network Reinforcement Project

Implementing agency:	ABHT
Objectives of the project:	Improving the accuracy of assessment of natural recharge of the Houaz aquifer from the High Atlas
Outline of the project:	The existing hydrological observation network oh ABHT is equipped necessary function to grasp the active runoff of major tributaries of the Tensift river, and had accumulated information effectively. However, during establishing and calibrating the new groundwater simulation model of the Haouz aquifer in the Study, it was found that taking account discharge of some of small sub-basins which had not been observed would contribute to improve the model accuracy. Thus, 2 sites, are proposed to equipped the water gauge in order to reinforce the observation network. The major activities to be carried out in this project are as follows. a) Selection of the site, b) Installation of watermarks, c) River surveying and preparation of HQ-curve, and d) Preparation of ledger, obtaining observers
Cost Estimation:	Total cost estimated 3.0 million DH.

(2) Groundwater Management Plan

Program for Groundwater Facility Registration Management

Implementing agency:	ABHT
Objectives of the project:	Utilizing the registration data for grasping the status of groundwater utilization and for the basic data of groundwater analysis.
Outline of the project:	In order to maintain sustainable use of groundwater resources, it is essential to precisely understand the current groundwater balance, and to appropriately manage the resource based on its overall quantity. At present, many of the wells in the Haouz Plain are not registered, viz the amount of groundwater extraction is not understood. The procedure for well registration shall be strictly noticed and applied to new wells. The registration status of existing wells shall also be surveyed, and registration shall be promoted. In parallel, the registration procedure shall be simplified to enable efficient and prompt registration of wells. The major activities to be carried out in this program are as follows. a) Execution of application, approval and registration for construction and renovation of wells, b) Updating and preparation of database of existing registered/unregistered wells, c) Monitoring of utilization status of wells, and d) Preparation of database of groundwater intake facilities other than wells
Cost Estimation:	Total cost estimated 5.7 million DH.

Program for Scientific Estimation of Available Groundwater

Implementing agency:	ABHT
Objectives of the project:	Determination of available groundwater amount, pumping control water level and volume based on the groundwater analysis
Outline of the project:	In order to maintain sustainable use of groundwater resources, it is essential to precisely understand the current groundwater balance, and to control the amount of groundwater uptake determined from the view of sustainable groundwater management. Though groundwater simulation has been carried out in this Study, there is need for further collection and analysis of information for more accurate evaluation of the availability of groundwater resources. Based on such information, the amount of available groundwater for sustainable groundwater management shall be defined. The major activities to be carried out in this program are as follows. a) Accumulation of new hydrogeological data in the upper part of the aquifer, b) Accumulation of cultivation land information, c) Accumulation of new deep hydrogeological data, d) Accumulation of data on water level, e) Accumulation of database of groundwater users, f) Staff reinforcement and capacity building for groundwater analysis, g) Performing scientific mean groundwater analysis, h) Determination of available groundwater amount, pumping control water level and amount, and i) Preparation of groundwater management manual
Cost Estimation:	Total cost estimated 18.2 million DH.

(3) Water Quality Management Plan

Program for Water Quality Monitoring

Implementing agency:	ABHT
Objectives of the project:	Monitoring for maintaining the water quality meeting with the various types of water use
Outline of the project:	The management of water quality is also an important factor for sustainable use of groundwater resources. Currently, there are 76 measurement points (26 rivers, 6 reservoirs/canals, 3 wells, etc.) for water quality in the Haouz Plan. These points (in location and in number) shall be reconsidered and confirmed in the view of understanding the water quality of the whole Haouz Plain. Furthermore, a water quality monitoring plan shall be developed based on these measurement points, along with the formulation of a monitoring structure. The major activities to be carried out in this program are as follows. a) Review and set up of water quality monitoring sites, b) Preparation of improvement plan of water quality monitoring, c) Implementation of water quality test based on the present system, and mplementation of water quality test based on new system
Cost Estimation:	Total cost estimated 44.5 million DH.

(4) Water Demand Reduction Plan

(Agricultural Sector Water Demand Reduction Plan)

Program for Drip Irrigation Introduction and Dissemination

Implementing agency:	ORMVAH, DPA Marrakech, DPA Chichaoua, ABHT
Objectives of the project:	To Contribute to the improvement of the global water balance through the reduction of water demand for the irrigation as well as the reduction of the irrigation water use in the filed by t introducing and spreading drip irrigation.
Outline of the project:	Basin irrigation is a standard method for irrigation largely practiced in the Haouz plain. A portion of water used for basin irrigation evaporates into the air or percolates into the ground. Introduction of drip irrigation will raise the efficiency of water used for irrigation, and at the same time will reduce the invalid loss of water into the air. The major activities to be carried out in this

	program are as follows. a) tension of pipeline and outlet, b) bsidies for installing drip irrigation, c) pports for Procedures of Subsidy and Establishment of Consultation Desk, d) ministrative guidance through authorization of well construction, and e) tension and guidance of water saving irrigation
Cost Estimation:	Total cost estimated 2,715 million DH.

Program for Seguia and Water Management Improvement

Implementing agency:	Water User's Associations (WUA), ORMVAH, DPAs
Objectives of the project:	To use the surface water efficiently through maintaining and improving seguias, as well as to improve water management in irrigation through grasping the actual conditions of the water in seguia system
Outline of the project:	Majority of the seguias is left as an earthen structure. Such seguias have low transport efficiency, losing a significant portion of water into the ground. Concrete lining is an effective method to reduce such loss and to raise the efficiency of the canals. However, the improvement of all seguias which will add up to a huge length will require a massive financial input. Thus surveys to determine seguias with high priority should be conducted and an overall improvement plan shall be prepared. Also, management and maintenance of seguias as well as monitoring of water use shall be realized with the participation of users. The major activities to be carried out in this program are as follows. a) Survey for the clarification of the groundwater recharge function of seguias, b) Strengthening of Activities of WUAs for Operation and Maintenance of Seguias, and c) Establishment of Monitoring System for Water Use in Seguis System by WUAs
Cost Estimation:	Total cost estimated 2.0 million DH.

Program for Accumulation and Distribution of Technical Information for Water Saving Farming and Irrigation

Implementing agency:	ORMVAH, DPA Marrakech, DPA Chichaoua, INRA, Of other institutes of research,
Objectives of the project:	To valorize (economic value adding) water through the development of the techniques of the water saving farming and irrigation, the accumulation of the technical information and the extension and distribution to users.
Outline of the project:	In order to introduce drip irrigation at the on-farm level, it is essential that the farmers practice cultivation methods matching the characteristics of the water saving measure. Introduction of water saving methods that will limit or reduce farm incomes will not be accepted by the farmers and this is not practical. In this regard, information on agricultural technology such as selection of varieties and cultivation methods, for improving profitability shall be accumulated and disseminated together with measures for water saving irrigation. The major activities to be carried out in this project are as follows. a) Development of the techniques of the water saving irrigation and accumulation of the technical information, b) Development of the techniques of the water saving farming and selection of crop/variety, and c) Extension and enlightening of water saving farming and irrigation
Cost Estimation:	Total cost estimated 19.5 million DH.

(Water Supply Sector Water Demand Reduction Plan)

Water Supply Leakage Control Project

Implementing agency:	RADEEMA & ONEP
Objectives of the project:	To reduce water intake amount through decreasing the water leakage ratio and the amount in the water supply systems
Outline of the project:	The loss from urban water supply networks reaches a rate of 38% (2005), indicating the possibility that a significant portion of the water is lost through leakage from the network. Emergency repair works shall be carried out for such leakage in parallel with the preparation of an overall improvement plan which shall be carried out by an annual budget. The major activities to be carried out in this project are as follows. a) Urgent water leakage control measures, b) Water leakage control measures by decreasing water distribution pressure, c) Formulation of water leakage control plan, d) Formulation of improvement plan to structure efficient water distribution network, e) Regular water leakage survey and repair works, and f) water distribution network improvement work
Cost Estimation:	Total cost estimated 403.0 million DH.

Program for Water Saving Dissemination

Implementing agency:	RADEEMA, ONEP and Wilaya
Objectives of the project:	Reduction of total water consumption by decreasing the unit water consumption rate (water consumption per capita per day) through water saving activities
Outline of the project:	At present, the water consumed by households and commercial facilities in urban areas holds less that 10% of the total water consumption. However, regarding the expected expansion of urban areas and possible economic development of the area, water consumption for such sector shall not be neglected. Approaches will be made to reduce the unit volume of water consumption of individuals as well as raising the awareness on the importance of water resources mainly through educational campaigns. The major activities to be carried out in this program are as follows. a) Development of water saving campaign through mass-medias, b) Holding water saving seminars for water users in urban area, and c) Holding water saving seminars for water users in rural area
Cost Estimation:	Total cost estimated 31.0 million DH.

(5) Organizational and Institutional Improvement Plan

Program for Water Resources Management Capacity Development of ABHT

Implementing agency:	ABHT
Objectives of the project:	Function of the ABHT as a federator of the water resources management is reinforced
Outline of the project:	For the sustainable management and rational use of the water resources in the Haouz plain, the establishment of the water resource management system under the close collaboration with the various stakeholders is indispensable. The improvement and the reinforcement of the administrative system of the water resources management, through the actions of the capacity reinforcement of the ABHT which are technical level and also institutional level must be carried out. The major activities to be carried out in this program are as follows. a) Capitalization and diffusion of the information on the water resources, b) Reinforcement of the consultation and the cooperation with the concerned stakeholders on the water resources management, c) Function of the authorization procedure of the DPH, d) Reinforcement of the control of the illicit water use, Royalty collection, e)Reinforcement of the monitoring and the evaluation of the water resources, and f)Reinforcement of the water quality control
Cost Estimation:	Total cost estimated 5.0 million DH.

Program for Legal and Institutional Frameworks Improvement for Water Law Implementation

Implementing agency:	ABHT is a principal organization for this program implementation in collaboration with the local communities and the structures concerned on the water resources management
Objectives of the project:	The function of the Water Law is improved and reinforced by the legal countermeasures
Outline of the project:	Water legislation is not sufficiently recognized and applied by the users. And moreover, the Water Law defines the water police that have to control the unauthorized digging wells and intake water and also the illicit water use and water pollution little function. To respect and accomplish the legal system concerned the water management, the reconnaissance to the users on the water legal system must be promoted to the users by the large diffusion of the information related the Water Law and its application texts. And also the necessary application texts have to be elaborated and approved for the effectiveness of the Water Law. The major activities to be carried out in this program are as follows. a) Elaboration and application of the necessary texts of application for the effective implementation of the Water Law, b) Improvement of the authorization procedure for the digging and the water intake of the wells, and the authorization observance, and c) nformation on the Water Law 10-95 and the legal texts relating to the water
Cost Estimation:	Total cost estimated 6.5million DH.

Program for Water Police System Enhancement

Implementing agency:	ABHT is a principal organization for this program implementation. This program aims to establish a ground water management system and a illicit water use surveillance system by the user's participation at the local communities level through the competence transfer to the local communities in particular to the provinces and the communes.
Objectives of the project:	Establishment of the monitoring system of the illicit water use and the coordination system between the users aiming at the equitable water use
Outline of the project:	The water police currently does not have the capacity to carry out the actions envisaged in the Water Law. To realize the control of illicit water use by the water police, the ABHT should firstly take the initiative for the implementation of the water police. Taking account of the human and the financial capacity of the ABHT and also its wide action zone, it is not realistic that the ABHT carries out alone the actions of the water use control. To achieve the goal of the actions of the water police, such as the prevention of the illicit water use and the water resource protection, a close cooperation with the local communities (Region, Province and Commune) and the gradual competences transfer of the water police to the local communities are indispensable. It is prospective that the illicit water use will be reduced by the establishment of control networks through the actions of the water police at the communal level. The major activities to be carried out in this program are as follows. a) Information on the activities of the water police to the stakeholders in particular to the local authorities, b) Implementation of the water police by the ABHT, and c) Competences transfer of the water police activities to the local communities, and Establishment of the water use control networks
Cost Estimation:	Total cost estimated 29.6 million DH.

Program for Appropriate Pricing and Effective Collecting of Water Royalty

Implementing agency:	ABHT is a principal organization for this program implementation in collaboration with the local communities (region, provinces and communes), local authorities, MATEE/SEE, ORMVAH and DPAs.
Objectives of the project:	Realization of the rational water use and the saving water by collection of the ground water management royalty
Outline of the project:	Water is a public property and cannot be the subject of private appropriation described clearly in the Water Law. All users using the surface and underground water resources in the DPH have the obligation to pay a royalty for water use. The adoption of the tariffication to the water resource, particularly the underground resource intake, will have to be considered in an equitable way and differentiated according to the criteria defined such as the volume of water intaking, the effort for the water saving introducing the adequate technique or the type of water use developed. Thus, the big aversion of the users to the royalty payment in particular of ground waters is foreseeable, it is necessary circumspect discussion and efforts to obtain the comprehension and the approval of the water users by the communication and publicity campaigns. In this program, the adoption of the adequate and equitable tariffication and the promotion for comprehension obtain to the ground water management royalty payment will be aimed in order to realize the sustainable ground water management and the water saving. In this program, the adoption of adequate and equitable tarification and the promotion of comprehension obtaining of the royalty payment for the ground water management will be aimed to carry out the sustainable ground water management and the water saving. The major activities to be carried out in this program are as follows. a) Examination and consultation on the water pricing and the collecting modality, b) Elaboration and proclamation of the texts of application related to the water pricing and the collection modality, c) Explanations and information to the users and relevant organizations at the local level on the new water pricing, d) Development of the royalty collection system, and e) Establishment of the ground water resources management fund by the water royalty
Cost Estimation:	Total cost estimated 10.3 million DH.

(6) Participatory Groundwater Management Plan

Program for Formulation of Collaboration and Decision - Making Framework for Water Resources Management

Implementing agency:	ABHT is a principal organization for this program implementation in collaboration with the local communities, the governmental services and the private sectors.
Objectives of the project:	The participatory water resources management system is established
Outline of the project:	Indeed, for the sustainable management and the rational use of the water resources in the Haouz plain, all stakeholders concerning water will have to take part in the water management with its various aspects, in particular the framework installation for follow-up and monitoring of the water resources, the enlightenment activities for awareness-raising to water saving, the introduction or the reinforcement of the water users organizations and the dissemination of the water saving techniques. Thus, to carry out the sustainable management and the rational use of the water resources with participation of various stakeholders, stakeholders themselves at the beginning have to clarify and recognize their role and responsibility for these resources management. The major activities to be carried out in this program are as follows. a) Establishment of the Tensift Basin Committee, b) Establishment of the Thematic Commissions, c) Constitution of the water management system at the

	provincial level by the enhancement of the Prefectural and Provincial Commissions of Water (CPPE), and d) Competences transfer of the water resources management at the communal level
Cost Estimation:	Total cost estimated 7.0 million DH.

Program for Activation and Capacity Development of Water Users Association

Implementing agency:	ORMVAH, DPA of Marrakech and Chichoua
Objectives of the project:	Realization of the management and the allocation of water resources by the water users organization
Outline of the project:	Activation of AUEAs, which are the main actors for irrigation agriculture will contribute in fair distribution of irrigation water, strengthen the capacity of water resources management at the end-user level, and will also contribute in formulating a recepient body for the introduction of water saving techniques and educational campaigns. The actions of the reinforcement of the organizational and technical capacities of the AUEA which are the principal actors of agricultural irrigation are as follows: a) Trainings to the executive committee members of the AUEA for the reinforcement of organizational and financial management capacities, b) inancial capacities reinforcement of the AUEA by the contributions of members, c) Improvement of the information diffusion system by the organization of general assembly of the AUEA, d) Relationship reinforcement with the ORMVAH and the DPAs, e) Training for the agricultural techniques in order to save the water (drip irrigation, varieties draught resistant), and f) Exchange with the advanced AUEA on the saving water activities
Cost Estimation:	Total cost estimated 2.0 million DH.

Program for Public Awareness on Water Saving and Conservation

Implementing agency:	ABHT is a principal organization for this program implementation in collaboration with the concerned stakeholders of the water resources management in the Haouz plain such as the local communities (region and provinces), the governmental services and the private sectors.
Objectives of the project:	Development of the consciences of the water users for the sustainable management and use of the water resources
Outline of the project:	The saving water and the water management campaign have been implemented by the concerned structures especially in the agriculture and tourism sectors, but each executes individually as a function of their competence particularly finance capacity. Thus, results of the campaigns haven't been satisfied because impacts to water users have been little significant. It is possible to pass message on the importance of the saving water and the water resources conservation through the enlightenment activities for the resources management considering the diversity of the stakeholders by the multiple mean of the communication and media. The major activities to be carried out in this program are as follows. a) Elaboration of the plan for enlightenment and communication, and b) Implementation of the enlightenment and the communication activities on the water resources management
Cost Estimation:	Total cost estimated 41.5 million DH.

5.5 Implementation of Integrated Groundwater Management Master Plan

(1) Institutional Arrangement of the Master Plan Implementation

The strategies of the integrated groundwater management master plan aim to allocate the limited water resources fairly and effectively and to make water use sustainable keeping supply and demand in balance in the Haouz Plain. In order to implement securely the strategies as already described with

the basic concept, it is indispensable that the implementation framework clarifies the responsibility of the organization as shown in the figure below. ABHT will naturally take a leading part and additionally the understanding and cooperation with the other related organizations should be essential to achieve the plan.

(2) Implementation schedule and Costs of the Master Plan

The detailed schedule and costs of the projects proposed in the master plan is shown in Table S-1.

5.6 Evaluation of the Master Plan

(1) Project Benefits

The beneficiaries by the realization of the appropriate management of the groundwater as the main object of the Master Plan which is necessary to guarantee continuously and stably the utilization of the water resources on the inhabitant's life and the agricultural production, are city inhabitants, regional industry including the tourism sector, agricultural producer, etc. The tangible benefits which can be estimated are analyzed quantitatively in the possible range with the economic evaluation and the financial evaluation for the agricultural sector which consumes most of the water resources and tourism sector. The intangible benefits are analyzed qualitatively for the socio-economic effects.

The tangible benefits of the agriculture sector derived by the implementation of the Master Plan refer to the difference of economic loss expected between with-project (Scenario of Major Actions) condition and without-project (Scenario of Continuation) condition through the whole period of the Master Plan. In other words, because of the implementation of the Master Plan, it is understood the decrease of economic loss. It is calculated by average depth of the groundwater table, dried out aquifer surface, number of dried out boreholes and number of unemployed persons (it is economized applying the minimum wage of the agriculture sector.) when are appraised on the consideration of the scenarios.

Economic Loss and Project Benefit (MDH)

Item	Indexes	Without Project	With Project	Project Benefit
Fall of the groundwater level (/1,000 m^3)	0.0025	4,673	1,998	2,675
Dried out aquifer surface (/ha)	0.049	448	177	271
Dried out borehole (/well)	0.140	253	40	213
Unemployed person (/ha) (/person)	0.473 0.027	116	46	70
Total		5,490	2,261	3,229

The difference (Project Benefit) between with project and without project conditions is estimated 3,229 MDH for the whole project period.

According to the World Travel & Tourism Council (WTTC), tourism industry of Morocco in 2007 is expected to generate USD 13,767.6 million of economic effects (total demand). Morocco's tourism economy (direct and indirect impact) in 2007 is expected to account for 17.9% of GDP and 15.5% of total employment. This sector is expected to grow 4.0% in 2007 and by 4.0% per annum, in real terms, between 2008 and 2017. On the other hand, the truism sector of Marrakech region occupied 35% of all country by the tourist night number of hotels in 2006. Appling the same ratio, the 2007 economic effect of the tourism sector in the Marrakech region is estimated approximately USD 4.8 billion (38.7 billion DH).

The Master Plan considers the distribution of water for tousim sector, etc., and will not hamper the growth of the tourism sector, of which the government attaches priority. Thus the distribution of water will not largely impact the trend of the growing tourism sector in Marrakech. Based on the assumption that the 4% growth rate in the tourism sector will further continue, the total production in the year 2020 will be approximately 1.7 times more than that of 2007. With the assumption that the securing of water will contribute as 3% of this growth, the accumulated benefit between 2007 and 2020 will reach some 637 million USD (5,054 MDH). This accounts for some 51% of the total implementation cost of the Master Plan (4,086 million USD).

(2) Project Costs

The total project cost of the Master Plan is estimated approximately 4,086 MDH (Table S-1), the annual mean of 13 years of the implementation period is approximately 314 MDH. Among these, the Reclaimed Water Supply Project, the Program for Drip Irrigation Introduction and Dissemination and the Water Supply Leakage Control Project that will contribute directly to the improvement of the water balance of the groundwater as the object of the Master Plan, are existing plans, they were budgeted by each executing agencies, and some part of the projects was already started.

On the other hand, the Program for Drip Irrigation Introduction is the project which the beneficiaries of farmers bear a part of project cost; the 60% of the total cost is bone by the farmers and 40% is supported from the government). In addition, the Reclaimed Water Supply Project is the project which is expected the income from the sale of reclaimed water. Therefore, all of the project cost does not become the burden of the executing agencies. Thus the actual cost to be burdened by the relevant agencies is lower than the total project cost, making it easier for implementation.

(3) Viewpoint of Economic Evaluation

When the project cost and the project benefit of the Master Plan are compared, the tangible benefit from the sectors of agriculture (3,229 MDH) and tourism (5,054 MDH) count up to 8,283 MDH, which is more that twice of the implementation cost (4,086 MDH). Considering the object of the Master Plan, the sufficient project benefit will expect with the implementation of the Master Plan. Because of that, it is considered that the implementation of the Master Plan will contribute sufficiently to the achievement of the object of the Master Plan from the viewpoint of economic evaluation.

(4) Viewpoint of Financial Evaluation

The total project cost for the 11 projects which ABHT will become the executing agency is approximately 277 MDH, and the annual mean of 13 years in the implementation period is approximately 21 MDH. This amount is lower in comparison with the annual budget of ABHT at 2007, which is approximately 64 MDH, and the budget of the Action Plan 2004-2007: annual mean of the total cost was 42.7 MDH. Therefore, it is considered to be appropriate as investment in the projects related to the water resource management, and the fiscal burden ability of ABHT is appraised as sufficient.

By the burden of farmers who consume 90% or more of the water resource, participation ability to the Master Plan is appraised from the viewpoint of the financial evaluation. Increase of the production cost when the water saving measure is not done and when the irrigation system of water saving type is introduced (60% of drip irrigation facility cost, etc.) are compared. The production cost with the implementation of the program (34,556 DH/ha) is approximately 8% lower than the production cost without project implementation. Therefore, it is considered that that not only there is no burden increase and no reduction in the farmer’s income, the profit of farmers will increase through cost reduction by the introduction of the water saving irrigation system. Therefore, acceptance ability of project by farmers is appraised sufficiently. Furthermore, according as increase of the proportion of the government subsidy to the irrigation facilities (actually 40%), the project benefit of the farmers will be augmented more.

(5) Socio-economic Effects

The executive effects of the Master Plan, besides the direct tangible benefits which are mentioned in the previous section, will generate also secondary or indirect intangible benefits. Secondary and indirect benefits are important in appraising the propriety of project execution, as principal intangible benefits are as follows:

- Income through the Tourism Industry
- Creation of job opportunities through the development of the Tourism Industry
- Secondary benefits derived from the Tourism Industry, such as handicrafts, construction, distribution, food and services.

(6) Environmental and Social Considerations (Environmental and Social Impact Assessment)

Though the realization of the Master Plan may affect the social and natural environment at a certain extent through controlled groundwater extraction and water saving agriculture methods, such effect can be minimized by implementing appropriate mitigation measures.

(7) Comprehensive Evaluation

By the implementation of the Master Plan, the appropriate management of the groundwater which is necessary to guarantee continuously and stably the utilization of the water resources on the inhabitant's life and the agricultural production will be realized. As a result, the equilibrium of water balance of the groundwater in the Haouz plain will be achieved by 2020 of the target year. Moreover, the implementation of the Master Plan will be expected to contribute to the life stability of the inhabitant in the object area, guaranty of economic activity and acquisition of employment opportunity, consequently, it is expected that contributes greatly to the regional economy. Furthermore, as a influence effect, it is foreseen that it will decrease the further fall of the groundwater level.

From the above, it can be said that the implementation of the Master Plan is sufficiently appropriate due to the results of the economic analysis and financial analysis that were appraised by the tangible benefit that are obtained from the damage reduction of the agriculture sector and the economic growth in the tourism sector, which will be prioritized for water distribution, by the improvement of the fall of the groundwater level. And the socio-economic effects that were analyzed as intangible benefits could also be sufficiently expected. Moreover, as major adverse environmental and social impacts were not identified in its assessment The risks for the implementation are also considered manageable. On the one hand, the Master Plan is also viable in terms of technical feasibility and is proper plan even in the organizational management aspect. Thus, the implementation of the Master Plan is evaluated to be valid.

Reference: Direct Contribution of Major Projects / Programs to the Groundwater Balance and their Economic Contribution

The direct contribution of the Major Projects (Artificial Groundwater Recharge Project, Reclaimed Water Supply Project and Program for Drip Irrigation Introduction and Dissemination) to the balance of the aquifer is summarized in the following.

Direct Contribution of Major Projects on Groundwater Balance

Project	Type of Contribution	Annual Contribution at Target Tear (Mm^3/year)	Accumulated Contribution during Master Plan Period (Mm^3)	Implementation Cost (MDH)	Cost for Improving Groundwater Balance (DH/m^3)
Artificial Groundwater Recharge	Development of new sources	14.3 (13.4%)	95 (10.8%)	106	1.12
Reclaimed Water Supply	Development of new sources	19.2 (18.0%)	211 (24.1%)	637	3.01
Drip Irrigation Introduction and Dissemination	Reduction of water demand	73.0 (68.5%)	572 (65.2%)	2,715	4.74
Total		107 (100%)	878 (100%)		

The water developed / saved by the implementation of the Major Projects have the following economic values.

(1) Artificial Groundwater Recharge Project

This project will be implemented in order to secure the sources of potable water supply. The water newly developed can be compared with the raw water developed by dams. With the unit price of raw water from dam set as 2.58 DH/m^3 (Great Dam Connection Concept Report), the economic benefit will be 244 MDH (2.58 DH/m^3 x 94.5Mm^3). The economic Internal Rate of Return (IRR) of the project based on the benefit and project cost (106 MDH) is 41.4% for the 13 year implementation period.

(2) Reclaimed Water Supply Project

This project will be implemented to cope with the water demand of the tourism sector in Marrakech, particularly for the water to maintain golf courses and gardens. In this regard, the water newly developed can be compared with the water cost burdened by the tourism sector (Hotels, 8.58 DH/m^3, RADEEMA). The unit price is set as half of the water fee for Hotels (4.29DH/M^3). With the

assumption that the project life is 22 years (duration of operation: 20years, construction 2 years), the economic benefit will be 1,647 MDH (4.29DH/m^3 x 384 Mm^3 x 20 years). The IRR of the project based on the benefit and project cost (990 MDH) is 14.1% for the 22 year project life.

(3) Program for Drip Irrigation Introduction and Dissemination

This program is implemented to efficiently utilize water resources in the agriculture sector. The reduction in water demand can be compared with the potential value of newly developed water. If the unit price of the value of water is set at 4.13 DH/m^3 (summer vegetables and winter vegetables), the economical benefit from the program will be 2,362 MDH (4.13 DH/m^3 x 572Mm^3). Furthermore, in regard of the pumping cost reduced through the introduction of drip irrigation, an additional 1,447 MDH (unit pumping cost x amount pumped: 2.53 DH/m^3 x 572Mm^3) can be regarded. This will total up to 3,809 MDH as the economical benefit. The IRR of the project based on the benefit and program cost (2,715 MDH) is 13.7% for the 13 year implementation period.

CHAPTER 6 Action Plan

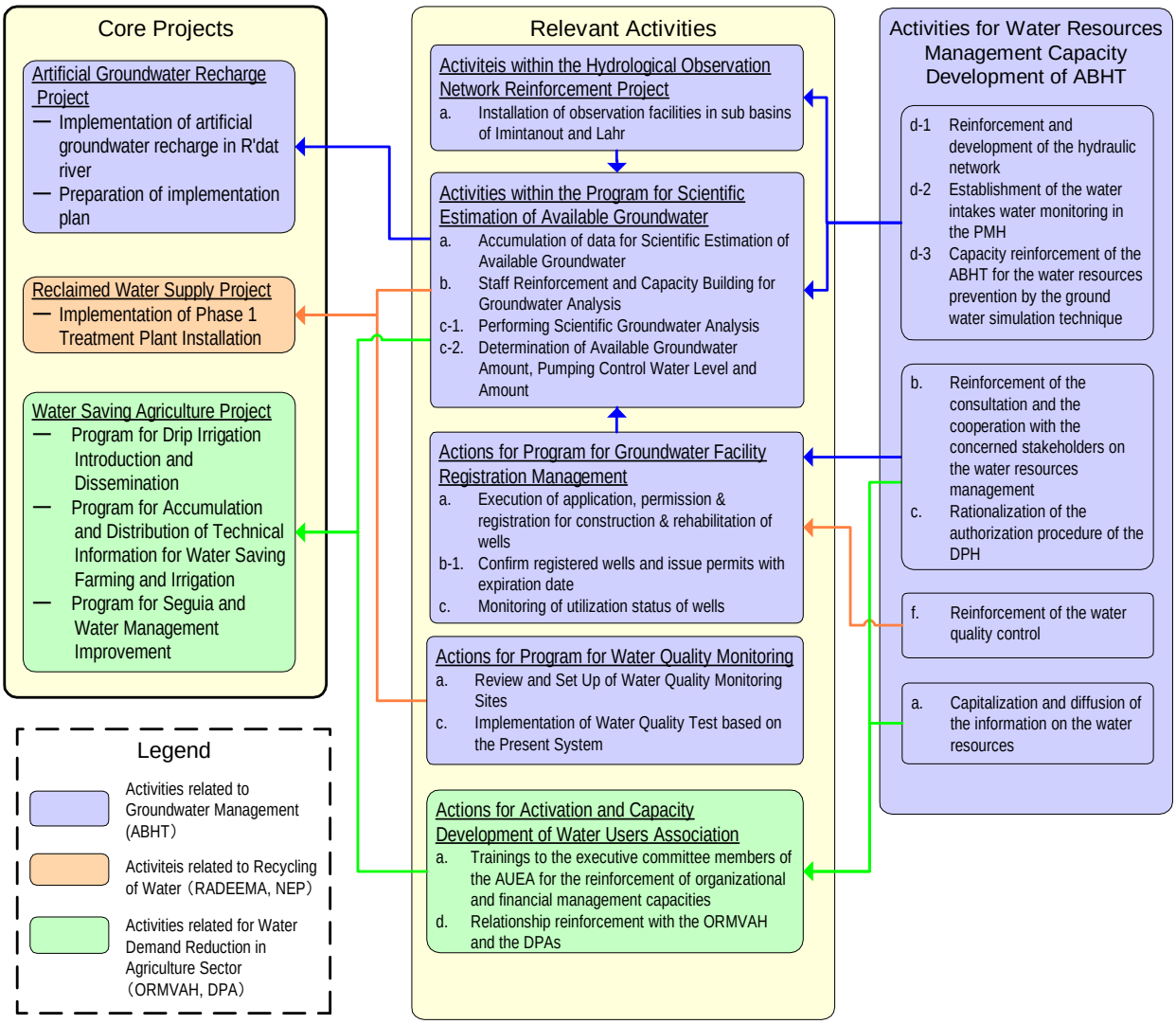
6.1. Understanding of the Master Plan as a whole and selection of Programs / Projects for the Action Plan

The activities, implementing agencies and stakeholders of the Master Plan cover a wide range, where each of the activities are mutually related in order to realize sustainable groundwater use. The action plan targets the implementation of "Core Projects", which are the Projects and Programs that directly contribute to the improvement of the balance of groundwater. Therefore, the Action Plan consists of activities of the Core Projects and other projects / programs to implement the Core Projects, which are to be implemented with in 5 years after the start of the Master Plan.

1) Activities needed to be implemented urgently in order to accomplish the goals of the Master Plan
   - ✧ Artificial Groundwater Recharge and relevant activities
   - ✧ Reclaimed Water Supply and relevant activities
   - ✧ Water Saving Agriculture (Program for Drip Irrigation Introduction and Dissemination, Program for Seguia and Water Management Improvement, Program for Accumulation and Distribution of Technical Information for Water Saving Farming and Irrigation) and relevant activities.
2) Activities required for the effective and efficient implementation of the Master Plan
   - ✧ Water Resources Management Capacity Development of ABHT and relevant activities
   - ✧ Activities within the Hydrological Observation Network Reinforcement Project, relevant to the Core Projects.
   - ✧ Activities within the Program for Scientific Estimation of Available Groundwater, relevant to the Core Projects.
   - ✧ Activities within the Program for Groundwater Facility Registration Management, relevant to the Core Projects.
   - ✧ Activities within the Program for Water Quality Monitoring, relevant to the Core Projects.
   - ✧ Activities within the Program for Activation and Capacity Development of Water Users Association, relevant to the Core Projects.
3) Activities required for the implementation structure of the Action Plan
   - ✧ Program for Formulation of Collaboration and Decision - Making Framework for Water

Resources Management

- The relations of the Core Projects and relevant activities are shown in the following figure. Furthermore, the list of relevant programs are shown in Table 6.1.1.



Core Projects and Relevant Activities

6.2 Contents of the Action Plan

The Action Plan for each sector, consisting of components of the Core Projects and relevant activities to be implemented by the year 2012, which is the review period, is as follows

(1) Action Plan for Groundwater Management

1) Actions for Artificial Groundwater Recharge Project
   a. Artificial Recharge Project in R'Dat river (pilot project)
   b. Preparation of implementation Plan

2) Actions for Hydrological Observation Network Reinforcement Project
   a. Installation of observation facilieits in the sub-basins of Imintanout River and Lahr River

3) Actions for Program for Groundwater Facility Registration Management
   a. Execution of application, permission & registration for construction & rehabilitation of wells
   b. Inventory & preparation of database of registered and unregistered wells
   c. Monitoring of utilization status of wells

d. Inventory & preparation of database of groundwater intake facilities other than wells

4) Actions for Program for Scientific Estimation of Available Groundwater
   a. Accumulation of data for Scientific Estimation of Available Groundwater
   b. Staff Reinforcement and Capacity Building for Groundwater Analysis
   c. Performing Scientific Groundwater Analysis

5) Actions for Program for Water Quality Monitoring
   a. Review and Set Up of Water Quality Monitoring Sites
   b. Preparation of Improvement Plan of Water Quality Monitoring
   c. Implementation of Water Quality Test based on the Present System
   d. Implementation of Water Quality Test based on New System

6) Actions for Program for Water Resources Management Capacity Development of ABHT
   a. Capitalization and diffusion of the information on the water resources
   b. Reinforcement of the consultation and the cooperation with the concerned stakeholders on the water resources management
   c. Rationalization of the authorization procedure of the DPH
   d. Reinforcement of the monitoring and the evaluation of the water resources
   e. Reinforcement of the water quality control

7) Total Estimated Cost: 55.5MDH

8) Possible Financial Sources
   The total cost for the Action Plan for Groundwater Management is 55.53 MDH with the annual expenditure of some 10 MDH. In regard of the scale of activities carried out by ABHT, it may be said that the cost for this Action Plan is not extremely large. In regard of financial aspects, the Action Plan may be carried out within the Moroccan budget. On the other hand, many of the activities involve technical aspects such as decisions based on the situation of water resources and results of analysis. Furthermore, strengthening of the technical capacity of ABHT holds an integral part of the activities. In this regard, it may be more efficient for the strengthening of ABHT to be carried out through technical assistance schemes from donor countries.

(2) Action Plan for Reclaimed Water Supply

1) Actions for Reclaimed Water Supply Project
   a. Installation of Water Treatment Plant (Phase 1)

2) Total Estimated Cost: 354.1MDH

3) Possible Financial Sources
   Currently, RADEEMA is planning / implementing a project for sewerage treatment in Marrakech. This project is already aiming at selling treated water to the golf courses. Depending on the price of the treated waste water, the cost for installation of the tertiary treatment and distribution facilities can be covered from with the water selling. The cost for this Action Plan is 354.1 MDH and is considerably large. However, this is not extremely high compared o the operation scale of RADEEMA, and it is assumed that it is possible to be carried out through Morrocan Budget or by Loans from other doner countries.

(3) Action Plan for Water Efficient Agriculture

1) Actions for Program for Drip Irrigation Introduction and Dissemination
   a. Defining Priority Area for and Introduction Plan for Drip Irrigation (PMH sector in left bank of N'Fis)
   b. Defining Priority Area for and Introduction Plan for Drip Irrigation (PMH sector irrigated by groundwater)
   c. Subsidies for Installing Drip Irrigation
   d. Supports for Procedures of Subsidy and Establishment of Consultation Desk
   e. Extension and Guidance of Water Saving Irrigation

2) Actions for Program for Accumulation and Distribution of Technical Information for Water Saving Farming and Irrigation
   a. Development of the techniques of the water saving irrigation and accumulation of the technical information
   b. Development of the techniques of the water saving farming and selection of crop/variety
   c. Extension and enlightening of water saving farming and irrigation

3) Actions for Program for Seguia and Water Management Improvement
   a. Survey for the clarification of the groundwater recharge function of seguias
   b. Strengthening of Activities of WUAs for Operation and Maintenance of Seguias
   c. Establishment of Monitoring System for Water Use in Seguias System by WUAs

4) Actions for Activation and Capacity Development of Water Users Association
   a. Trainings to the executive committee members of the AUEA for the reinforcement of organizational and financial management capacities
   b. Relationship reinforcement with the ORMVAH and the DPAs

5) Total Estimated Cost: 1,321.7MDH

6) Possible Financial Sources
   The cost for the Action Pplan for Water Demand Reduction in the Agriculture Sector is 1,321.7. The majority of this massive budget is required for the introduction of drip irrigation system to priority areas. In regard of its importance to water balance and the economic benefits to farmers (section 5.6.7), the introduction of drip system may be implemented by Moroccan budget or by loans from other donor countries. On the other hand, other programs with relevantly small costs and significant technical aspects, can be implemented by Moroccan budget or through technical assistance schemes from other donor countries.

6.3 Implementation Structure of the Action Plan

The activities of indicated in the Action Plans will be basically carried out within the framework of the Master Plan. In other words, the Action Plan will be implemented by individual implementing agencies with close coordination with ABHT. On the other hand, a framework for consultation and decision making among stakeholders including implementing agencies, relevant agencies and residents shall be formulated to enable smooth implementation of the Action Plan.

(1) Formulation of Collaboration and Decision - Making Framework for Water Resources Management

The framework for consultation and decision making for the implementation of the Actio Plan is basically the same with that indicated in the “Program for Formulation of Collaboration and Decision – Making Framework for Water Resources Management” under the Master Plan (Section 5.4.6 (1)). Out of this framework, the activities required for the smooth implementation of the Core Projects and relevant activities indicated in the Action Plan in summarized. However, it should be noted that other activities within the framework should also be implemented as required.

   a. Establishment of the Tensift Basin Committee
   b. Establishment of the Thematic Commissions

(2) Implementation Schedule of the Action Plan

The schedule for the Action Plans mentioned in this Chapter, including the Formulation of Collaboration and Decision - Making Framework for Water Resources Management is summarized in the Table S-2.

(3) Implementation Cost of the Action Plan

The Cost for the Action Plans mentioned in this Chapter, including the Formulation of Collaboration and Decision - Making Framework for Water Resources Management is summarized in Table S-3.

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

The Master Plan is consisted of five plan fields such as Surface Water Sources Development and Surface Water Resources Management Plan, Groundwater Management Plan, Water Quality Management Plan, Water Demand Reduction Plan, Organizational and Institutional Improvement Plan and Participatory Groundwater Management Plan, and 18 components with the target year of 2020. The components, i.e., programs and projects are interrelated, and shall be implemented systematically. The pillars of the Master Plan are the "Surface Water Sources Development and Surface Water Resources Management Plan" and "Water Demand Reduction Plan", which directly contribute to the improvement of the water balance, and these Plans are regarded as the "Core Projects".

On the other hound, the agency shouldering the central role in the management of the water resources in the Haouz Plain is ABHT, standing in the position to manage and supervise the implementation of the Master Plan in coordination with the agencies in charge of the implementation of the individual programs and projects formulating in the Master Plan. Therefore, it is indispensable to implement supporting activities to ensure the capacity of ABHT, which is the managing / supervising agency of the Master Plan, is priority required in order to implement the core projects effectively, and to achieve the object of the Master Plan.

By the implementation of the Master Plan, the appropriate management of the groundwater which is necessary to guarantee continuously and stably the utilization of the water resources on the inhabitant's life and the agricultural production in the Haouz Plain will be realized. Consequently, the equilibrium of water balance of the groundwater will be achieved, and the improvement and maintenance of the water balance become possible. Furthermore, depending on the execution of the Action Plan proposed in the Master Plan, it is foreseen that it will decrease the further fall of the groundwater level. And, will largely contribute to the Integrated Water Resources Management in the Haouz Plain as a participatory water resources management plan through the participation of the stakeholders. Thus, it is important for this Master Plan for the Integrated Groundwater Management to be immediately implemented.

Finally, to achieve the sustainable water resources management, the important issues to approach more aggressive in the future are as follows:

1) Capacity development which aims to improve the organizational capability and management of the executing agencies.
2) Appropriate contents of the projects by the participation of stakeholders.
3) Cooperation and collaboration among multiple sectors such as agriculture, tourism, health and sanitation, regional development, etc.
4) Voluntary activities by local authorities, farmers, urban residents, NGO, etc.
5) Partnership between public sector and private sector.

7.2 Recommendations

The following recommendations are made for the smooth implementation of Integrated Water Resources Management.

(1) Implementation of the Master Plan with close coordination among relevant agencies

The Master Plan shall be implemented with close coordination among the relevant agencies and other stakeholders. Relevant agencies shall also implement its individual activities under the framework of such coordination.

As seen in the active discussions in the Technical Committees held during this Study, the coordination of concerned agencies including local administration is currently in a favorable situation. Such situation shall be maintained for the implementation of the Master Plan. Furthermore, as described in the Action Plan, a permanent structure of coordination among stakeholders should be established by clarifying the roles and responsibilities of the regional government, ministerial agencies and other stakeholders regarding water resources management.

(2) Initiate measures for new water resources at an early stage in order to cope with increased water demand in the future

The Master Plan aims to secure the water balance by the target year of 2020 by enabling coexistence of agriculture and tourism through maximum and efficient use of available water resources. Thus the measures proposed do not consider the continuous increase in water demand after the target year.

By 2020, there will be small room for further development of water resources in the area, and there is need to initiate necessary investigations to prepare measures for the increasing demand. The government of Morocco is currently conducting a study on the possibilities of inter-basin water diversion to the Haouz Plain. The results of such studies shall be realized at an early stage.

(3) Considerations to the vulnerable in implementing the Master Plan

The Master Plan proposes the regulation of groundwater extractions in PMH sectors and the capture zone for the water supply boreholes of ONEP. Information of such regulation shall be clearly noticed to the people who may be negatively effected, and implementation of the regulation shall be carried out with due considerations for these people.

The water royalties proposed in the Master Plan shall also be examined with considerations on the capacity of the vulnerable for payment.

Introduction of water saving irrigation is currently carried out with government subsidies. However, the many of the small scale farm households cannot apply this to their fields because they do not have the resource to pay their portion of the cost. Access to water saving irrigation methods should be improved through establishment of credit systems for such purposes.

(4) Structural studies on water saving agriculture in dry areas

Agricultural technologies are being studied and disseminated by the Ministry of Agriculture and Marine Fisheries. However, this is not necessarily resulting in an efficient way. Studies not only on water saving irrigation in dry areas, but also on improvement of farm economy such as introduction of high-profitable / high water-stress tolerant varieties shall be further studied.

(5) Technical assistance from other donor agencies

Currently, the German Technical Cooperation (GTZ) is carrying out activities centering capacity development in ABHT. The implementation of the Study for Integrated Water Resources Management in the Haouz Plain by JICA also provided technical transfer to the engineers of ABHT. Such schemes for technical cooperation and funding by foreign government agencies such as JICA and JBIC should be efficiently used for the smooth implementation of the Master Plan.

Table S.1 Schedule and Cost of the Components of the Master Plan (1/2)

	Project and Implementation Items	Implementing Agency	Year 2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Surface Water Sources Development and Surface Water Resources Management Plan	Artificial Groundwater Recharge Project	ABHT													
	Preparation works (pilot project & formal project)														
	General design (pilot project & formal project)														
	Detailed design (pilot project & formal project)														
	Construction (pilot project & formal project)														
	Maintenance works & Evaluation (pilot project & formal project)														
	Reclaimed Water Supply Project	RADEEMA													
	Reclaimed water supply planning, design, tender & contract														
	construction of tertiary treatment plant and water distribution facilities														
	Commissioning and adjustment of reclaimed water supply facilities														
	Operation of reclaimed water supply facilities														
	Hydrological Observation Network Reinforcement Project	ABHT													
	The selection of the new observation facilities establishment place														
	The establishment work (water level gauge establishment, vertical crossing measurement and HQ curve preparation) of the new observation														
	Observation using the new observation facilities														
	Improvement for existing and new observation facilities (Introduction of the self-water gauge)														
Groundwater Management Plan	Program for Groundwater Facility Registration Management	ABHT													
	Execution for application, permission & registration for construction & rehabilitation of wells														
	Inventory & preparation of database of registered and unregistered wells														
	Monitoring of utilization status of wells														
	Inventory & preparation of database of groundwater intake facilities other than wells														
	Computer set for database of groundwater intake facilities														
	Program for Scientific Estimation of Available Groundwater	ABHT													
	Accumulation of new hydrological data in the upper part of the aquifer														
	Accumulation of cultivation land information														
	Accumulation of new deep hydro geological data														
	Accumulation of data on water level														
	Accumulation of database of groundwater uses														
	Staff reinforcement & procurement of groundwater analysis tools														
	Performing scientific mean groundwater analysis														
	Determine available pumping volume., control Pumping volume														
	Preparation of groundwater management manual														
Water Quality Management Plan	Program for Water Quality Monitoring	ABHT													
	Review of water quality sampling point and determination														
	Formulation of water quality monitoring improvement plan														
	Continuation of present water quality monitoring operation														
	Implementation of new water quality monitoring operation														
	Vehicle for water sampling and O&M cost														
Water Demand Reduction Plan	Program for Drip Irrigation Introduction and Dissemination	ORMVAH													
	N'Fis perimeter with pressure water supply on right river side (Irrigation area : 16,102ha)														
	PMH irrigation area (Irrigation area : 56,000ha)														
	Other GH irrigation area (irrigation area : 10,000ha)														
	Program for Seguia and Water Management Improvement	ORMVAH													
	Study for clarifying the function of groundwater recharge from seguias														
	Reinforcement of the canal cleaning, maintenance control activities by water users association														
	The maintenance of the monitor ring system of water volume of seguia intake and paddy field by water users association														
	Program for Accumulation and Distribution of Technical Information for Water	ORMVAH													
	The development of the water saving irrigation technology and the accumulation of the technical information														
	The development of the water saving cultivation technology and the selection of the kind, list of articles														
	Diffusion, enlightenment activities about the water saving agriculture & water saving irrigation														
	Water Leakage Control Project	RADEEMA/ ONEP													
	Preparation of water leakage control plan														
	Preparation of water distribution network efficiency improvement plan														
	Regular water leakage detection survey & repair works														
	Water distribution network improvement works														
	Program for Water Saving Measures	RADEEMA/ ONEP													
	Public information using Mass-medias														
	Water saving seminar to the urban water user														
	Water saving seminar to the rural water user														

Table S.1 Schedule and Cost of the Components of the Master Plan (2/2)

		Implementing Agency	Year											
			2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Organizational and Institutional Improvement Plan	Program for Water Resources Management Capacity Development of ABHT	ABHT													
	Materials, data joint ownership, one former control and materials room establishment														
	Information joint ownership from related organization, transmission system maintenance														
	Web site building and information sending to stakeholder														
	Reinforcement of the consultation and the cooperation with the concerned stakeholders on the water resources management														
	The simplification and speed up of the application procedure and the permission														
	Business ability reinforcement for the charge department office of the permission and examination														
	Development of royalty collection system														
	Water resources control plan , execution, monitoring and improvement in the evaluation ability														
	Program for Legal and Institutional Frameworks Improvement for Water Law	ABHT													
	To enhance the actual effect of the water law, the maintenance of the necessary statute and the execution of detailed regulations														
	The improvement of the procedure concerned with an application for well digging & intake water permission and the thoroughness of the place permission items observance														
	Public relations about the water law and that related bill														
	Program for Water Police System Enhancement	ABHT													
	Information on the activities of the water police to the stakeholders in particular to the local authorities														
	Elaboration of the term of references and the text of application to fix the modality of the water police implementation														
	The adoption of water police works, staff member, and training														
	Securing of the executing materials and financial treatment														
	The execution of the watching activities for the water supply														
	Water police business training for the in charge person of the local administrated organization														
	The escalating execution of water police works by the local administration organization														
	The execution of the illegal watching activities for the water supply by AUEA														
	Program for Appropriate Pricing and Effective Collecting of Water Royalty	ABHT													
	An examination about the setup of the water fee and method of collection														
	Elaboration and proclamation of the texts of application related to the water pricing and the collection modality														
	Holding of the explanation meeting to the user and relevant organizations at the local level about the water fee and that way of paying it and public relations														
	Building of the water fee levy system														
	The establishment of the water resources control fund														
Participatory Groundwater Management Plan	Program for Formulation of Collaboration and Decision - Making Framework for Water Resources Management	ABHT													
	The establishment and conference of Tensift basin control committee														
	The establishment and conference of the subcommittee by the subject														
	The establishment of the prefecture water committee (CPPE) and activation														
	The establishment and conference of the commune water control committee														
	The partial assignment of the water resources control authority to the commune														
	Program for Activation and Capacity Development of Water Users Association	ORMVAH /DPA													
	The organization management of the target association office and reinforcement training of control ability for the financial affairs														
	Financial capacities reinforcement of the AUEA by the contributions of members														
	Improvement of the information diffusion system by the organization of general assembly of the AUEA														
	Relationship reinforcement with the ORMVAH and the DPAs														
	The diffusion training of the water saving irrigation technology														
	Inspection and opinion exchange in the excellent activities and advanced AUEA														
	Program for Public Awareness on Water Saving and Conservation	ABHT													
	The plan decision of the enlightenment and communication														
	Local authority, water resources control understanding to the local government and the tradition village autonomy organization														
	The diffusion enlightenment of water saving agriculture														
	Illegal digging of the wells and the prevention of intake water														
	The common knowledge of the water law and the related legal system														
	Understanding and common knowledge for charge of groundwater use														
	Repression of water consumption at the hotel and resort facilities														
	Using reclaimed water at the golf courses														
	School education (a curriculum about the control of water resources and the preservation)														
	The poster preparation and notice which made problem and water saving about the water resources as a theme														
	Water control and water saving contest														
	The enlightenment of water saving in the mosque using worship														
	The enlightenment of the water resources control and using water saving through Mass-medias														

Table S.2 Summary of Costs for Integrated Groundwater Resources Management Master Plan

Plan Field	Title of Programs / Projects	Execution Agency	Project Cost (MDH)
Surface water sources development and management	Artificial Groundwater Recharge Project	ABHT	106.0
	Reclaimed Water Supply Project	RADEEMA	636.5
	Hydrological Observation Network Reinforcement Project	ABHT	3.0
Groundwater management	Program for Groundwater Facility Registration Management	ABHT	5.7
	Program for Scientific Estimation of Available Groundwater	ABHT	18.2
Water quality management	Program for Water Quality Monitoring	ABHT,	44.5
Water demand reduction	Program for Drip Irrigation Introduction and Dissemination	ORMVAH, DPA, ABHT	2,715.0
	Program for Seguia and Water Management Improvement	Water Users Association, ORMVAH, DPA	2.0
	Program for Accumulation and Distribution of Technical Information for Water Saving Farming and Irrigation	ORMVAH, DPA, INRI	19.5
	Water Supply Leakage Control Project	RADEEMA, ONEP	403.0
	Program for Water Saving Dissemination	RADEEMA, ONEP, Willaya	31.0
Organizational and institutional improvement	Program for Water Resources Management Capacity Development of ABHT	ABHT	5.0
	Program for Legal and Institutional Frameworks Improvement for Water Law Implementation	ABHT	6.5
	Program for Water Police System Enhancement	ABHT	29.6
	Program for Appropriate Pricing and Effective Collecting of Water Royalty	ABHT	10.3
Participatory integrated water resources management	Program for Formulation of Collaboration and Decision - Making Framework for Water Resources Management	ABHT	7.0
	Program for Activation and Capacity Development of Water Users Association	ORMVAH, DPA	2.0
	Program for Public Awareness on Water Saving and Conservation	ABHT	41.5
Total	Whole Master Plan	Whole Related Agencies	4,086.3
Sub-total	Programs / Projects of ABHT	ABHT	277.3

Table S-3 Implementation Schedule of the Action Plan

	2008	2009	2010	2011	2012
Actions for Artificial Groundwater Recharge Project					
a. Artificial Recharge Project in R'Dat river (pilot project)	■	■	■	■	■
b. Preparation of implementation Plan				■	
Actions for Hydrological Observation Network Reinforcement Project					
a. Installation of observation facilieits in the sub-basins of Imintanout River and Lahr River		■	■	■	■
Actions for Program for Groundwater Facility Registration Management					
a. Execution of application, permission & registration for construction & rehabilitation of wells	■	■	■	■	■
b. Inventory & preparation of database of registered and unregistered wells	■	■	■		
c. Monitoring of utilization status of wells	■	■	■	■	■
d. Inventory & preparation of database of groundwater intake facilities other than wells					■
Actions for Program for Scientific Estimation of Available Groundwater					
a. Accumulation of data for Scientific Estimation of Available Groundwater	■	■	■	■	■
b. Staff Reinforcement and Capacity Building for Groundwater Analysis	■				
c. Performing Scientific Groundwater Analysis		■	■	■	■
Actions for Program for Water Quality Monitoring					
a. Review and Set Up of Water Quality Monitoring Sites	■				
b. Preparation of Improvement Plan of Water Quality Monitoring		■			
c. Implementation of Water Quality Test based on the Present System	■	■			
d. Implementation of Water Quality Test based on New System			■	■	■
Actions for Program for Water Resources Management Capacity Development of ABHT					
a. Capitalization and diffusion of the information on the water resources	■	■	■	■	■
b. Reinforcement of the consultation and the cooperation with the concerned stakeholders on the water resources management	■	■	■	■	■
c. Rationalization of the authorization procedure of the DPH			■	■	■
e. Reinforcement of the monitoring and the evaluation of the water resources		■		■	
f. Reinforcement of the water quality control			■	■	■
Actions for Reclaimed Water Supply Project					
a. Installation of Water Treatment Plant (Phase 1)	■	■	■	■	■
Actions for Program for Drip Irrigation Introduction and Dissemination					
a. Defining Priority Area for and Introduction Plan for Drip Irrigation (PMH sector in left bank of N'Fis)		■	■	■	■
b. Defining Priority Area for and Introduction Plan for Drip Irrigation (PMH sector irrigated by groundwater)	■	■	■	■	■
c. Subsidies for Installing Drip Irrigation	■	■	■	■	■
d. Supports for Procedures of Subsidy and Establishment of Consultation Desk	■				
e. Extension and Guidance of Water Saving Irrigation	■	■	■	■	■
Actions for Program for Accumulation and Distribution of Technical Information for Water Saving Farming and Irrigation					
a. Development of the techniques of the water saving irrigation and accumulation of the technical information	■	■	■	■	■
b. Development of the techniques of the water saving farming and selection of crop/variety	■	■	■	■	■
c. Extension and enlightening of water saving farming and irrigation	■	■	■	■	■
Actions for Program for Seguia and Water Management Improvement					
a. Survey for the clarification of the groundwater recharge function of seguias	■	■			
b. Strengthening of Activities of WUAs for Operation and Maintenance of Seguias	■	■	■	■	■
c. Establishment of Monitoring System for Water Use in Seguias System by WUAs	■	■	■	■	■
Actions for Activation and Capacity Development of Water Users Association					
a. Trainings to the executive committee members of the AUEA for the reinforcement of organizational and financial management capacities		■		■	
b. Relationship reinforcement with the ORMVAH and the DPAs	■	■	■	■	■
Formulation of Collaboration and Decision – Making Framework for Water Resources Management					
a. Establishment of the Tensift Basin Committee		■		■	
b. Establishment of the Thematic Commissions	■	■	■	■	■

Tabl S-4 Summary of Costs for the Action Plan

Unit: Million DH

		2008	2009	2010	2011	2012	Remarks
Actions for Artificial Groundwater Recharge Project							
a. Artificial Recharge Project in R'Dat river (pilot project)		2.50	4.00	4.00	5.50	2.00	
b. Preparation of implementation Plan					4.50		
Cost subtotal	17.00	2.50	4.00	4.00	10.00	2.00	
Actions for Hydrological Observation Network Reinforcement Project							
a. Installation of observation facilieits in the sub-basins of Imintanout River and Lahr River			0.5				
Cost subtotal	0.5		0.5				
Actions for Program for Groundwater Facility Registration Management							
a. Execution of application, permission & registration for construction & rehabilitation of wells		0.12	0.12	0.12	0.12	0.12	
b. Inventory & preparation of database of registered and unregistered wells		1.10	1.00	1.00			
c. Monitoring of utilization status of wells		-	-	-	-	-	To be implemented through normal works of ABHT
d. Inventory & preparation of database of groundwater intake facilities other than wells						1.00	
Cost subtotal	4.70	1.22	1.12	1.12	0.12	1.12	
Actions for Program for Scientific Estimation of Available Groundwater							
a. Accumulation of data for Scientific Estimation of Available Groundwater		2.90	1.50	1.50	0.50	0.50	
b. Staff Reinforcement and Capacity Building for Groundwater Analysis		4.10					
c. Performing Scientific Groundwater Analysis			0.60	0.10	0.60	0.10	
Cost subtotal	12.40	7.00	2.10	1.60	1.10	0.60	
Actions for Program for Water Quality Monitoring							
a. Review and Set Up of Water Quality Monitoring Sites		-					To be implemented through normal works of ABHT
b. Preparation of Improvement Plan of Water Quality Monitoring			-				
c. Implementation of Water Quality Test based on the Present System		0.58	0.58				
d. Implementation of Water Quality Test based on New System				3.94	3.94	3.94	
Cost subtotal	12.98	0.58	0.58	3.94	3.94	3.94	
Actions for Program for Water Resources Management Capacity Development of ABHT							
a. Capitalization and diffusion of the information on the water resources		0.077	0.072	0.077	0.077	0.072	
b. Reinforcement of the consultation and the cooperation with the concerned stakeholders on the water resources management		-	-	-	-	-	To be implemented through normal works of ABHT
c. Rationalization of the authorization procedure of the DPH				0.24	0.24	0.24	
e. Reinforcement of the monitoring and the evaluation of the water resources			1.34		0.01		
f. Reinforcement of the water quality control				-	-	-	To be implemented through actions for water quality monitoring
Cost subtotal	2.45	0.077	1.412	0.317	0.317	0.322	
Actions for Reclaimed Water Supply Project							
a. Installation of Water Treatment Plant (Phase 1)		3.50	185.33	94.67	35.30	35.30	Budget for tertiary plant and distribution network only, because current project covers the secondary treatment level.
Cost subtotal	354.10	3.50	185.33	94.67	35.30	35.30	
Actions for Program for Drip Irrigation Introduction and Dissemination							
a. Defining Priority Area for and Introduction Plan for Drip Irrigation (PMH sector in left bank of N'Fis)		96.70	193.40	193.40	193.40	193.40	
b. Defining Priority Area for and Introduction Plan for Drip Irrigation (PMH sector irrigated by groundwater)		88.40	88.30	88.30	88.30	88.30	
c. Subsidies for Installing Drip Irrigation		-	-	-	-	-	To be implemented through normal works

		2008	2009	2010	2011	2012	Remarks
d. Supports for Procedures of Subsidy and Establishment of Consultation Desk		-					To be implemented through normal works
e. Extension and Guidance of Water Saving Irrigation		-	-	-	-	-	To be implemented through normal works
Cost subtotal	1311.90	185.10	281.7	281.7	281.7	281.7	
Actions for Program for Accumulation and Distribution of Technical Information for Water Saving Farming and Irrigation							
a. Development of the techniques of the water saving irrigation and accumulation of the technical information		0.50	0.50	0.50	0.50	0.50	
b. Development of the techniques of the water saving farming and selection of crop/variety		0.50	0.50	0.50	0.50	0.50	
c. Extension and enlightening of water saving farming and irrigation		0.50	0.50	0.50	0.50	0.50	
Cost subtotal	7.50	1.50	1.50	1.50	1.50	1.50	
Actions for Program for Seguia and Water Management Improvement							
a. Survey for the clarification of the groundwater recharge function of seguias		1.00	1.00				
b. Strengthening of Activities of WUAs for Operation and Maintenance of Seguias		-	-	-	-	-	To be implemented by efforts of WUAs
c. Establishment of Monitoring System for Water Use in Seguias System by WUAs		-	-	-	-	-	To be implemented by efforts of WUAs
Cost subtotal	2.00	1.00	1.00				
Actions for Activation and Capacity Development of Water Users Association							
a. Trainings to the executive committee members of the AUEA for the reinforcement of organizational and financial management capacities			0.13		0.13		
b. Relationship reinforcement with the ORMVAH and the DPAs		-	-	-	-	-	To be implemented through normal works
Cost subtotal	0.26		0.13		0.13		
Formulation of Collaboration and Decision – Making Framework for Water Resources Management							
a. Establishment of the Tensift Basin Committee			0.05		0.05		
b. Establishment of the Thematic Commissions		0.04	0.04	0.04	0.04	0.04	
Cost subtotal	0.30	0.04	0.09	0.04	0.09	0.04	
Total Cost	1,731.59	202.52	479.46	388.89	334.20	326.52	

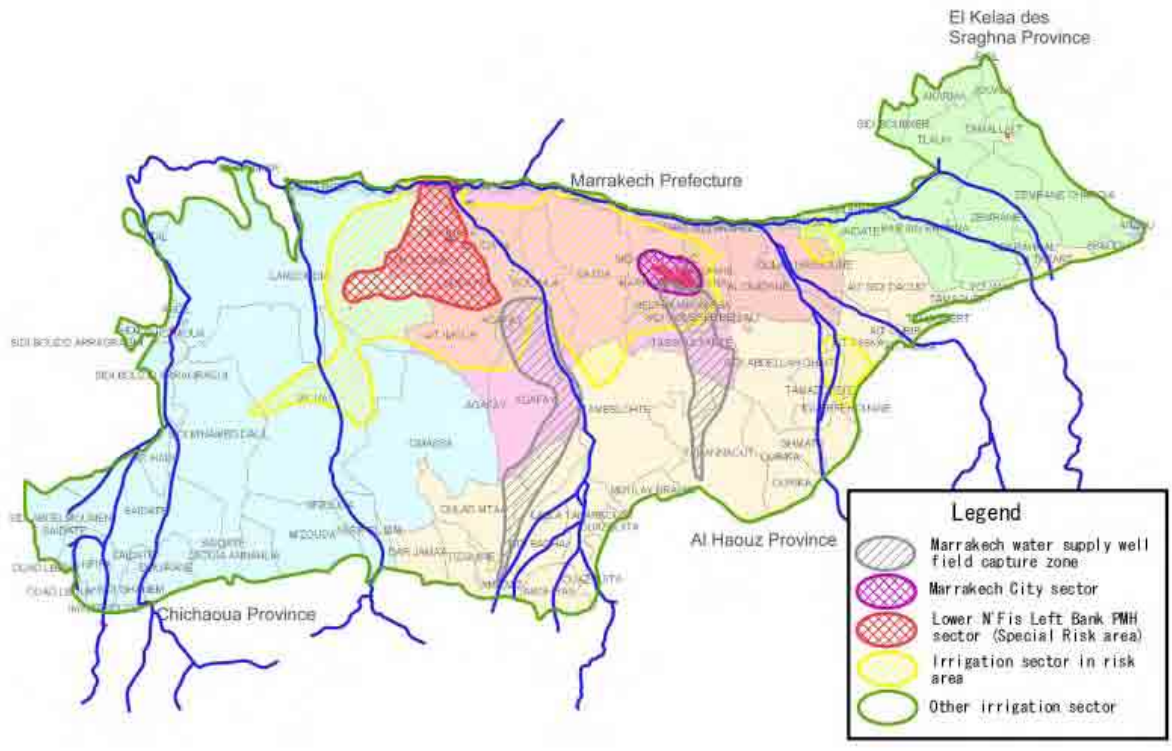


Figure S-1 Zoning of the Haouz Plain Based on Results of Simulation

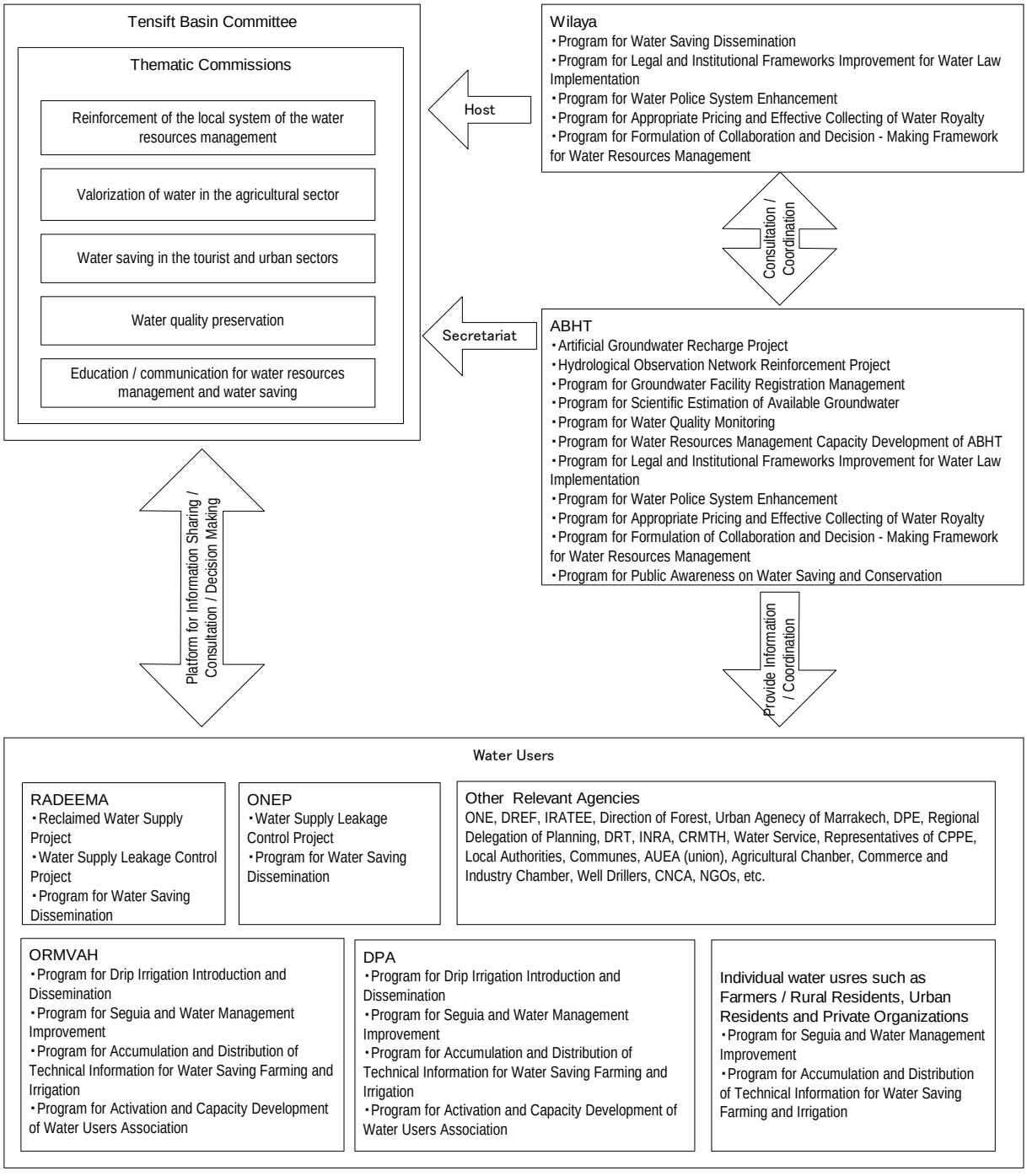


Figure S-2 Implementation Structure of the Integrated Groundwater Resources Management Master Plan

THE STUDY
ON
THE INTEGRATED WATER RESOURCES MANAGEMENT PLAN
IN
THE HAOUZ PLAIN IN THE KINGDOM OF MOROCCO

MAIN REPORT

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ABBREVIATIONS

Abbreviation	English	French
ABH	Agency of Hydraulic Basin	Agence du Basin Hydraulique
ABHT	Agency of the Tensift Hydraulic Basin	Agence du Basin Hydraulique du Tensift
AUEA	Agricultural Water Users Association	Associations des Usagers des Eaux Agricoles
CMV	Agricultural Development Center	Centres de Mise en Valeur Agricole
CSEC	Superior Council for Water and Climate	Conseil Supérieur de l'Eau et du Climat
CTIEV	Center of Irrigation Technique, Experimentation and Extension	Centre de Technique d'Irrigation, d'Expérimentation et de Vulgarisation
DAH	Directorate of Hydraulic Management (Installation)	Direction d'Aménagement Hydraulique
DGH	Directorate of General Hydraulic	Direction Générale de l'Hydraulique
DPA	Provincial Department of Agriculture of the Ministry of Agriculture, Rural Development and Fisheries	Direction Provinciale de l'Agriculture
DPH	Public Hydraulic Domain	Domaine Public Hydraulique
DRPE	Direction of Water Research and Planning of MATEE	Direction de la Recherche et de la Planification de l'Eau
EIA/EIE	Environmental Impact Studies	Etude d'Impact sur l'Environnement
ESC/CES	Environmental and Social Considerations	Considération environnementale et sociale
GH	Large Scale Irrigation Systems	Grande Hydraulique
GIRE/IWRM	Integrated Water Resources Management	Gestion Intégrée des Ressources en Eaux
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit	Agence Allemande de Coopération Technique
IEE	Initial Environmental Examination	investigation environnementale initiale
INDH	National Initiative for Human Development	Initiative Nationale pour le Développement Humain
IRATEE	Regional Inspection of Land Management, Water and Environment of Marrakech	Inspection Régionale de l'Aménagement du Territoire de l'Eau et de l'Environnement
JBIC	Japan Bank for International Cooperation	Banque Japonaise de Coopération Internationale
JICA	Japan International Cooperation Agency	Agence Japonaise de Coopération Internationale
MADRPM	Ministry of Agriculture, Rural Development and Maritime Fisheries	Ministère de l'Agriculture, du Développement Rural et Pêches Maritimes
MAPM	Ministry of Agriculture and Fisheries	Ministère de l'Agriculture et la Pêches Maritimes
MATEE	Ministry of Land Management, Water and Environment	Ministère de l'Aménagement du Territoire, de l'Eau et de l'Environnement
MEMEE	Ministry of Energy, Mining, , Water and Environment	Ministère de l'Energie, des Mines, , de l'Eau et de l'Environnement
ONE	National Office of Electricity	Office National d'Electricité
ONEP	National Office of Drinking Water	Office National de l'Eau Potable
ORMVAH	Regional Office of Agricultural Development of Haouz	Offices Régionaux de Mise en Valeur Agricole
PANE	National Action Plan for Environment	Plan d'Action National pour l'Environnement
PMH	Small ad Medium Irrigation Systems	Petite et Moyenne Hydraulique
PNA	National Sewage Development Plan	Plan National d'Assainissement
PNEP	National Potable Water Development Plan	Plan National d'Economie de l'Eau Potable
PPD-Eau	Water Sector Policy Development Program	Programme de Développement de la Politique du Secteur d'Eau
RADEEMA	Marrakech Regional Water and Electricity Distribution Company	Régie Autonome de Distribution d'Eau et d'Electricité de MARRAKECH
SAU	Useful Agricultural Surface	Superficie Agricole Utile
SEE	State Secretary in charge of Water	Secrétariat d'Etat Chargé de l'Eau

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The Haouz Plain is a part of the hydraulic basin of the Tensift River, which is located in the mid-west part of the Kingdom of Morocco (hereinafter referred as “Morocco”). The Haouz Plain belongs to the arid area, where annual rainfall is 160 to 350 mm and average annual evaporation reaches 2,640 mm. Reduction of rainfall due to global climatic change is observed in the Tensift River Basin. In addition, the demand of water is increasing due to an expansion of modern irrigation practice with pump system as well as a significant increase of urban population in the recent years. Thus, the management of the water resources in the basin becomes more difficult year by year. The Haouz Plain has historically relied for the major part of its water resources on groundwater. The demand of this groundwater for large scale irrigation and tourism development and rapid population growth has been increasing significantly in the recent years. This has caused the depreciation of groundwater table close to over-exploitation.

Hence, in September 2003 the Government of Morocco requested the Government of Japan to perform a development study on “the Integrated Water Resources Management Plan in the Haouz Plain” (hereinafter referred to as “the Study”), with the objective to formulate strategies, master plan and action plan on the water resources management in the Haouz Plain. In response, Japan International Cooperation Agency (hereinafter referred to as “JICA”) dispatched the Project Formulating Mission in September 2005. Based on the results of discussion, the Scope of Works for the Study was agreed by both sides and it was decided to conduct the Study.

Based on the S/W, the JICA Study Team, headed by Mr. Keiji Matsumoto of Pacific Consultants International, has conducted field surveys and studies from September 2006 to December 2007. And, the results of the Study are elaborated in this report.

1.2 Objectives of the Study and Study Area

1.2.1 Objectives of the Study

Objectives of the Study are as follows:

(1) To develop an integrated water resources management strategy, formulate the master plan for the integrated groundwater resources management, and formulate the action plan for effective use and conservation of the groundwater resources in the Haouz Plain.

(2) To lay the foundation for improving capability of ABHT for administrative management, through promoting coordination and involvement of concerned organizations in water resource management, and promoting sharing of understandings on the problems concerning water resources and water use.

(3) To improve skills and technologies of counterpart personnel mainly in the monitoring and analyzing groundwater, by the technical transfer through conducting the study, and formulating the master plan.

1.2.2 The Study Area

The Study Area covers the Haouz Plain located in the most upper basin of the Tensift River with an area of about 6,000 km^2 where about 1.61 million people are living. The actual target area for groundwater management is the groundwater basin of the Haouz Plain (Haouz Aquifer) with the area of 6,149 km^2, as shown in the Map in the beginning of this report.

1.2.3 Study Implementation Framework

As stated in the S/W and M/M of the Study, ABHT/MATEE[*1] organized and chaired the steering committee at the central level and the technical committee at the local level, and also arranged the counterpart team to coordinate the Moroccan institution for smooth implementation of the Study.

1.3 Contents of the Study

1.3.1 Contents of the Study

Scope of the Study is divided into three stages: 1) formulation of the integrated water resources management strategy based on understanding present conditions and forecasting future conditions, 2) formulation of the master plan of integrated groundwater resources management and 3) formulation of the action plan based on the master plan as shown in the figures below:

(1) Stage 1: Formulation of Strategies on Integrated Water Resources Management

After several sectoral and thematic field inspections and reviewing the existing data/information previous studies, the direction of the integrated water management in the Haouz Plain will be complied as the strategy of the integrated water resourced management. The strategies should clarify how to distribute and manage the limited water resources in the Study Area, effectively and appropriately. Also, the zonal water usage and integrated water resources management plan will be prepared based on the regional conditions/characteristics.

(2) Stage 2: Formulation of Master Plan

In the 2nd Stage, the management plan of the integrated groundwater resources in the Study Area will be studied and used to formulate the master plan. In order to use the groundwater sustainably, the plans will aim to reduce amount of water used by various water use sectors. Also plan for capacity development and institutional strengthening on management of groundwater by ABHT including monitoring systems will be proposed.

(3) Stage 3: Formulation of Action Plan

The high priority or urgency activities / programs among the components of the master plan will be selected and their details including activities and inputs will be described for implementation.

1.3.2 Process of the Study

The Study has been carried out based on the agreed S/W and M/M between the Morocco side and the Japanese side dated on September 27, 2005. The Study consisted of two phases: the first phase was the data collection and basic study (approximately 7 months), and the second phase was formulating the master plan and action plan (approximately 11 months).

1.3.3 Participation of Stakeholders

The utilization of the water resources in the Haouz plain is multi-faceted and complex. Actors of the water use and its management (governmental services, irrigation associations, farmers, agro-industrial companies, tourism sectors, research institutes, projects and ONG), and moreover their social and economic structures also are very diversified. Thus, for the rational use and the preservation of the water resources, the water users will have to participate in water management in various phases, as the enlightened conscience of water conservation, the organization of water users and their reinforcement or introduction, and of the popularization of water conservation techniques.

Meetings with Stakeholders were held within the Study, with the purpose of sharing the understandings on the status of water resources and its management, which is essential for the formulation of an Integrated Water Resources Plan. The results of such meetings were incorporated into the output of the Study.

[*1] The counterpart organization has been transferred to the Ministry of Energy, Mining, Water and Environment (MEMEE) due to ministerial reforms in October 2007.

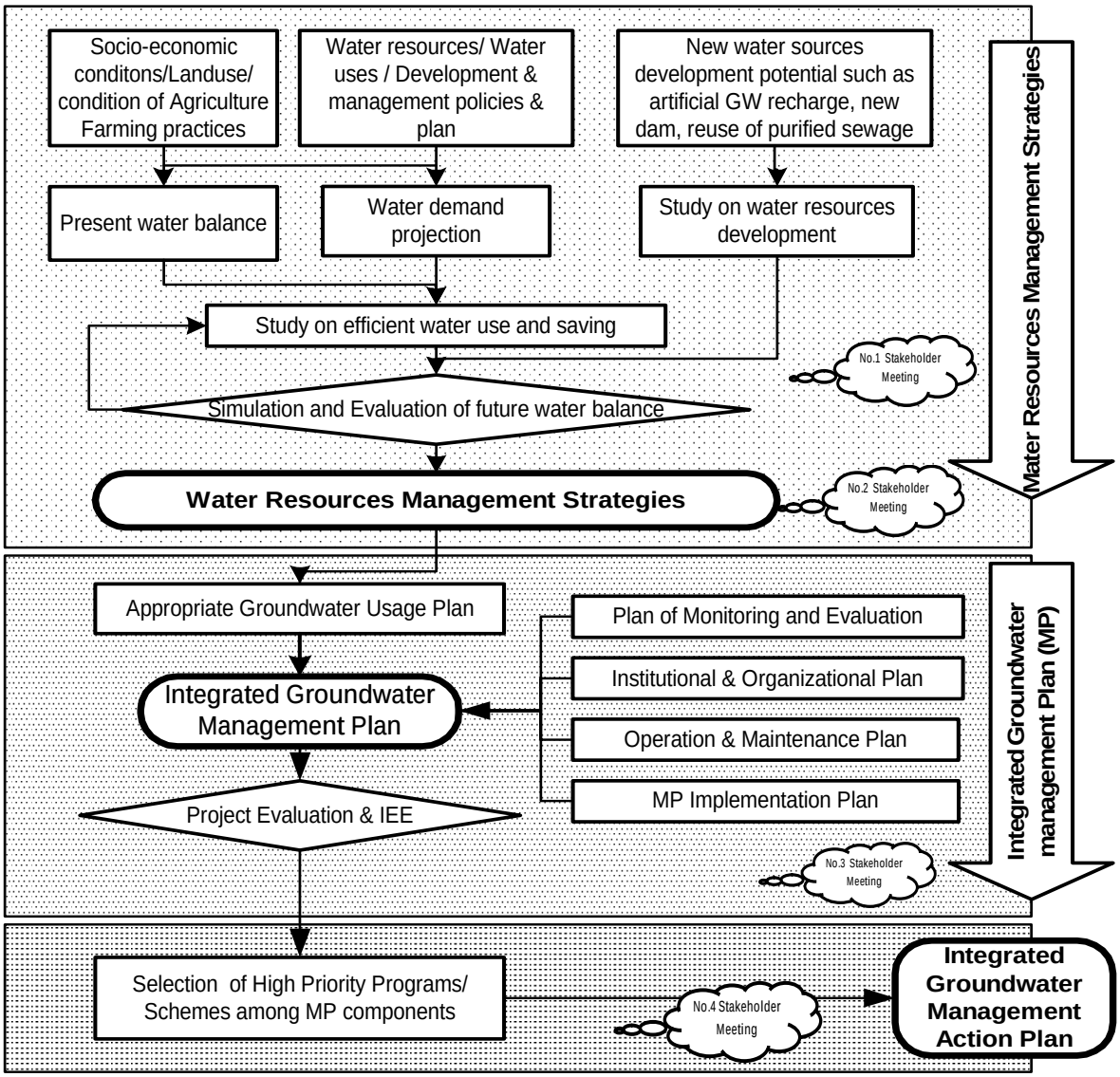


Figure 1.3.1 Work Flow of the Study

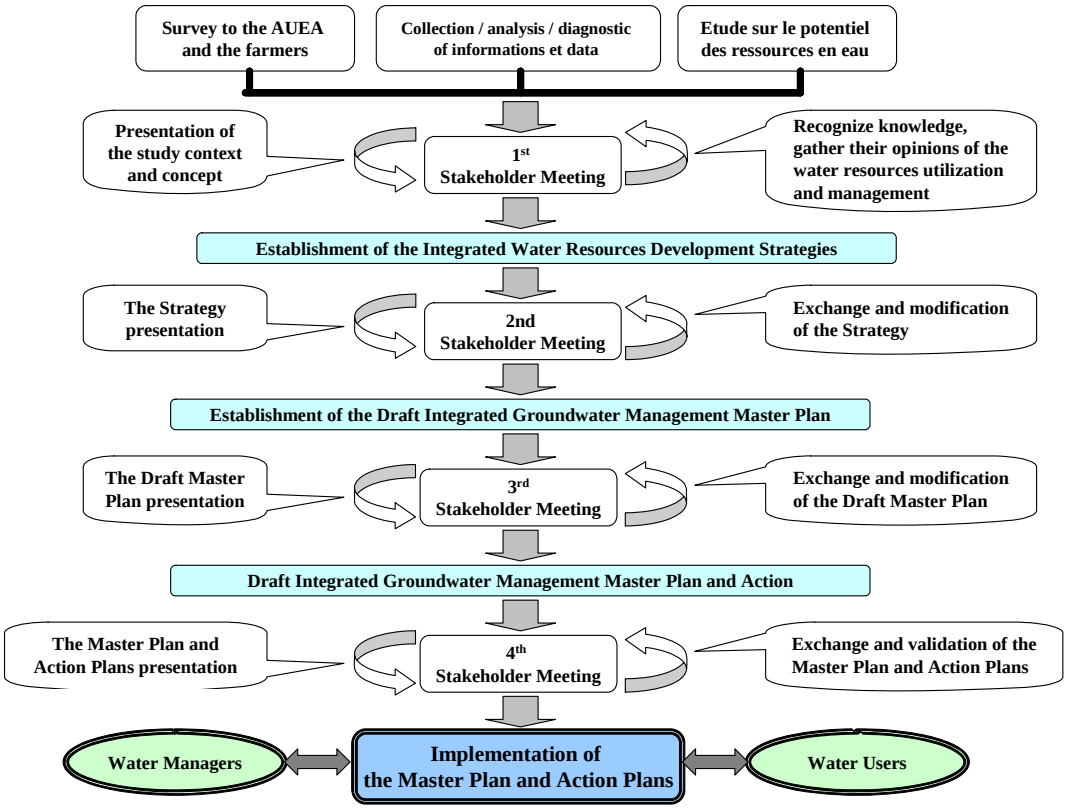


Figure 1.3.2 Participation Process of the Stakeholders in the Establishment of the Master Plan for the Integrated Groundwater Management

CHAPTER 2 MOROCCO AND STUDY AREA

2.1 Morocco in Brief

2.1.1 Administration

(1) General

Morocco is divided into 16 regions, and subdivided into 62 prefectures/provinces, 162 districts and 1,497 communes. Central and local government administrations can be summarized as follows:

Central and Local Government Administrations

Level of Administration	Head of Administration		Congress
Central Government	Prime Minister, Ministers, Cabinet		National Assembly
Region	Wali		Regional Council
Province Prefecture	Governor		Provincial (Prefectural) Council
Cercle	Super Caid	Bacha	
Municipality Commune	Caid		Municipality Council Rural Commune)
Douar, Ksar	Mqdem		Traditional Autonomy

(2) Central Level Administration

The Parliament consists of an upper house or Chamber of Counselors (270 seats; members elected indirectly by local councils, professional organizations, and labor syndicates for nine-year terms; 1/3 of the members are renewed every three years) and a lower house or Chamber of Representatives (325 seats; 295 by multi-seat constituencies and 30 from national lists of women; members elected by popular vote for five-year terms).

After the 2002 Parliamentary elections, reformation of the ministries was implemented at the central government level. At present, there are 21 ministries.

(3) Local Level Administration

In Morocco, the local government administrative subdivisions are prefectures and provinces, and they are supervised by the Ministry of Interior, also each chief of administration is appointed by the Minister of Interior. There are several subdivisions of the Regions of Morocco. Each prefecture and province is subdivided into districts (*cercles*, *sing. cercle*), municipalities (*communes*, *sing. commune*) or urban municipalities (*communes urbaines*, *sing. commune urbaine*), and arrondissements in some metropolitan areas. The districts are subdivided into rural municipalities (*communes rurales*, *sing. commune rural*). The municipalities and arrondissements should probably be thought of as fourth-level subdivisions, on the same level as the rural municipalities.

2.1.2 Social and Economic Conditions of the Country

(1) Social Conditions

The Kingdom of Morocco is a constitutional monarchy, known as the Maghreb together with Tunisia and Algeria, and it is the most westerly of the North African countries. Morocco faces to the Atlantic Ocean at the western end and to the Mediterranean Ocean at the north end. Strategically situated with both coastlines, Morocco is just 14 km from Europe, across the Strait of Gibraltar. Most people live in the west of the Atlas Mountains, a range that insulates the country from the Sahara Desert. Casablanca is the center of commerce and industry, which is the 2nd largest international trading port in Africa.

The total population of Morocco was 29,892,000 in 2004 (Annuaire Statistique du Maroc 2005, HCP, 2006). Most Moroccans are Sunni Muslims of Arab, Berber, or mixed Arab-Berber stock. The Arabs arrived in Morocco in the 7th and 11th centuries and established their culture there. Most of the 100,000 foreign residents are French or Spanish. Annual growth rate of population is 1.4% in 2004 although the growth rate is declining in recent years. The average of annual growth rate of these 10

years is 2.1% in the urban areas while the population in the rural areas is almost a level-off (an average of annual growth rate 0.6%), and the concentration of the population from the rural areas to the urban areas is remarkable. The social infrastructures such as education, health, etc. and the economic infrastructures such as transportation, communication, etc. concentrate in the urban areas, and thus have expanded the socio-economic difference with the rural areas. Moreover, the population inflow from the rural areas to the urban areas has become much greater in drought years, and has brought social unrest. Therefore, the Moroccan government is working for correction of the regional gap between rural areas and urban areas as one of the priority problems. In addition, the population of below 20 years old accounts for 42% of the total, and so the problems of education and employment will impact the future.

Classical Arabic is Morocco's official language, but the country's distinctive Arabic dialect is the most widely spoken language in Morocco. French, which remains Morocco's unofficial third language, is taught universally and still serves as Morocco's primary language of commerce and economics; it also is widely used in education and government. Many Moroccans in the northern part of the country speak Spanish. English is rapidly becoming the foreign language of choice among educated youth along with popularization of internet, while still far behind French and Spanish in terms of number of speakers. English is taught in all public schools from the fourth year on.

(2) Economic Conditions

Morocco has rich resources, including the world's largest phosphate reserves, a large tourist industry and growing manufacturing sector. However, agriculture remains as the backbone of the economy. King Mohammed VI has encouraged political and economic reform, the expansion of civil rights, and the elimination of corruption. The appointment of Prime Minister Driss Jettou in 2002 bolstered prospects for free-market reforms, privatization, enhancement of the private sector, and liberalization of social laws. During 2004, the government also sold some of its shares of the state telecommunications company and the largest state-owned bank.

Morocco has ratified various free trade agreements with its principal economic partners. These include: the Euro-Mediterranean free trade area agreement with the European Union with the objective of integrating Morocco into the European Free Trade Association in about 2012; the Agadir Agreement, signed with Egypt, Jordan, and Tunisia, within the framework of the installation of the Arab Zone of Free Exchange; the US-Morocco Free Trade Agreement with USA which came into force in January 1, 2006 and lately the agreement of free exchange with Turkey.

The major industry of Morocco is phosphate rock mining and processing, food processing, leather goods, textiles, construction, tourism, etc. as well as agriculture. GNI and GNI per capita in 2005 were US$ 52.3 billion and US$ 1,730 respectively (World Development Indicators Database, WB April 2006). GDP in 2005 was US$ 51.7 billion, and the annual growth at same year was 1.6%. The proportions of each sector in GDP are : 13% agriculture, 31% industry and 56% services. Agriculture and fishery sector produces wheat, barley, citrus fruits, vegetables, olives, livestock, and fishing. The annual inflation rate (GDP deflator) was 1.8% in 2005.

Principal Economic Data

Year	2000	2004	2005
GNI, Atlas method (current US$)	34.0 billion	46.9 billion	52.3 billion
GNI per capita, Atlas method (current US$)	1,220	1,570	1,730
GDP (current US$)	33.3 billion	50.0 billion	51.7 billion
GDP growth (annual %)	1.0	4.2	1.6
Inflation, GDP deflator (annual %)	1.5	1.5	1.8
Agriculture, value added (% of GDP)	13.8	15.9	13.3
Industry, value added (% of GDP)	31.9	30.4	31.2
Services, etc., value added (% of GDP)	54.2	53.8	55.5
Exports of goods and services (% of GDP)	31.4	33.1	34.4
Imports of goods and services (% of GDP)	37.6	39.3	43.1
Gross capital formation (% of GDP)	23.6	25	25.6

Source: World Development Indicators Database, April 2006

The amount of the exports totaled US$ 9.78 billion and the imports totaled US$ 17.5 billion in 2004, thus a favorable balance of trade of US$ 7.7 billion. The principal export commodities are ready-to-wear-clothes, hosiery articles, phosphoric acid, phosphates, fertilizers, etc. and major partners are : France 33%, Spain 17%, UK 7%, Italy 5% and USA 4%. The principal import commodities are crude petroleum oil, fabrics, machine and miscellaneous appliances, iron and steel blooms and pieces, wheat, etc. and major partners are : France 18%, Spain 12%, Italy 7%, Germany 6% and Russia 6% (Morocco in Figures 2004, HCP, 2006). Remittances from overseas migrant workers is the principal foreign currency acquisition source.

The labor force in 2004 totaled 9.8 million people, and the labor force by occupation is: agriculture 46%, industry 13% and services 41% in 2004. The unemployment rate is about 11% (Morocco in Figures 2004, HCOP, 2006).

2.1.3 National Development Plan

(1) Five-year National Development Plan

The 5-year National Development Plan (2000-2004) which was agreed officially in the National Assembly in August, 2000 is a social-economic development plan that established policy objectives, such as increase in the economic growth rate, improvement in the investment and saving rate, decrease of the unemployment rate, and increase of the literacy rate. Further, the reduction of poverty in the rural area was considered as a priority.

As concrete measures to attain these goals, developments were proposed for the following areas: 1) human resources and social development (education, vocational training, technology and investigation, culture, health, employment, social protection and social development), 2) production sectors development (agriculture and forest, industry, handicraft, energy, mining and tourist) and 3) social-economic infrastructures development (land planning, urban planning, residence maintenance, environment preservation, transportation, communication, posts and information technology).

The next Five-year National Development Plan (2007-2011 years) is said to be under preparation.

(2) National Initiative for Human Development (INDH)

National Initiative for Human Development (INDH; Initiative Nationale pour le Développement Humain) was sponsored by His Majesty of Mohammed VI, and it proposed the eradication of poverty and the correction of regional differential, Government and private sector cooperation. INDH was started in May, 2005. INDH was designed to reinforce the State’s action and that of the local collectivities, without being a substitute for either the sectorial programs or the local socio-economic development plans. INDHhas four main premises:

1) Target rural and urban poverty zones under difficult living conditions
2) Social upgrading and sustainable human development cannot rely on the specific assistance or charity action
3) The choice for opening to the world can be only a collective endeavor, not a retreating into oneself
4) Lessons drawn from past experiments attest to the relevance of the target steps, and integrated local development, as much as participatory planning, community ownership, and integration of sectorial actions.

Four priority programs in the first phase are listed and then discussed below.

1) Rural poverty reduction program: To improve the poverty ratio in the poorest communes in the rural areas
2) Urban social exclusion reduction program: To strengthen social bonds between urban populations to improve quality of life
3) Precarious livelihood reduction program: To support the socially vulnerable and discriminated to adapt to society
4) Institutional change program: To support the programs mentioned above

Principles of action in these program are as follows:

1) Actions for rural poverty and urban exclusion reduction:
   - Economic integration through revenue generating activities
   - Widening access to proximity equipment and basic social services
   - Social, cultural and sports animation

2) Actions for precarious livelihood reduction:
   - Provision of direct assistance but moving towards social integration
   - Taking charge of welfare recipients in social reception centers

3) Actions for institutional change:
   - Strengthening of human capital and local governance
   - Strengthening inter-ministerial coordination

DH 10 billion is being budgeted over 5 years, for the period 2006-2010, for INDH priority programs as follows:

- Rural poverty reduction program: DH 3.5 billion,
- Urban exclusion reduction program: DH 3.5 billion,
- Precarious livelihood reduction program: DH2.5 billion,
- Institutional change program: DH 0.5 billion.

2.1.4 World Bank Country Assistance Strategy

The Country Assistance Strategy (CAS) is the World Bank's work plan that guides its operations in a country, usually for a period of three years. It describes the country's economic and social performance, its main development challenges, and a summary of the government's development strategy.

CAS for the period 2005-09, is to help Morocco meet its key development challenges : notably,

1) Accelerate employment-generation and sustainable economic growth
2) Reduce poverty and marginalization.

To achieve and sustain these goals, a series of institutional reforms are needed to improve the transparency, accountability, and inclusiveness of the public sector. This CAS reflects differences from the past: the overarching objective of poverty reduction and the underpinning objective of governance are both more fully integrated in the country program, and in addition, the environment for reform has matured. The main difference between this CAS period and the previous one (2001-04), is the more favorable political, and bureaucratic environment within which to implement institutional reforms. A greater sense of urgency prevails, and this has generated political will at the top levels of leadership as well as within civil society. The CAS focuses on four objectives:

1) Improve competitiveness and the investment climate
2) Increase access to basic services by poor and marginalized groups
3) Improve the efficiency of the education system
4) Improve water management and access to water services and sanitation.

2.1.5 Privatization and Restructuring of Public Utilities

Morocco's economy is considered a liberal economy governed by the economics of supply and demand although certain economic sectors still remain in the hands of the government. The decentralization/regionalization law passed by the legislature in March 1997, and 16 new regions and many new provinces have been created although full details and scope of the reorganization are limited.

The current government has introduced a series of structural reforms in recent years. The most promising reforms have been in the liberalization of the telecommunications sector. This process started with the sale of a second GSM license in 1999. In 2001, the process continued with the privatization of 35% of the state operator Maroc Telecom. Morocco has announced plans to sell two fixed licenses in 2002. Morocco has also liberalized rules for oil and gas exploration and has granted concessions for many public services in major cities. The tender process in Morocco is becoming increasingly transparent. Many believe, however, that the process of economic reform must be

accelerated in order to reduce urban unemployment below the current level which is more than 10%.

In Morocco, production of potable water was developed by private enterprise around 1914. However, concessions held by French operators were not renewed at the country's independence. In Casablanca, as an exception, two private companies (ELYO and Lyonnaise des Eaux) were granted a 30-years concession in 1997 and it still produces a large part of potable water supply. Furthermore, SEPR supplies 30% of the potable water in Greater Casablanca.

2.1.6 Environmental Policies

(1) Environmental Legislation

Current environmental legislation in the Kingdom of Morocco is largely based on three Laws which were promulgated in 1993.

1) Law No. 11-03 on protection and development of the environment

The law aims to enact the basic rules and the general principles of the national policy in the field of protection and the development of environment. Their aim is:

- To protect the environment against all forms from pollution and degradation whatever the origin
- To improve the framework and the living conditions of people
- To lay down the basic orientations of the legislative, technical framework and finance concerning the protection and the management of the environment
- To set up particular responsibilities guaranteeing compensation for damages caused to the environment and compensation for any victims.

The law, consisting of seven chapters and 80 articles, dictates the basic direction to be taken for the protection of living environment, natural environment and resources, and for the prevention of pollution and harmful effects. Chapter 5 and 6 of the law dictates the process of environmental impact studies and legislative procedures for its evaluation, which is in relation to Law on Environmental Impact Studies

2) Law No. 12-03 on Environmental Impact Studies

In line with the Law on protection and development of the environment, the Law on Environmental Impact Studies dictates the obligations of Environmental Impact Studies (EIE) to obtain authorization of projects listed in its Appendix. The law, comprising of four chapters and 20 articles largely refers the following issues:

1. Definition of environment as well as EIE
2. The obligation of EIE to obtain authorization of projects subject to EIE under the Appendix in the Law
3. Objectives of EIE are: a) to predict and evaluate in rational manner, the possible impact of the project to the environment, b) to avoid, reduce or substitute negative impacts, c) to enhance and improve the positive impacts, and e) to inform the concerned population of the negative impacts.
4. The contents that should be incorporated in the EIE
5. The mission of the National Committee and Regional Committees for EIE, which are largely: a) to examine the EIE, b) to deliver opinions on the environmental acceptability of the projects, and c) to involve the public in the procedures of EIE.
6. The preparation of a decree specifying the procedures of the Law
7. Defining the period of validity of the EIE to five years for the realization of the project

The preparation of the Government Decree to specify the requirements and procedures for EIE is still underway. Under such circumstances, the procedures for EIE tend to vary depending on the individual projects. According to MATEE, the general procedures taken are as follows:

1) Confirmation of necessity of conducting EIE in the course of obtaining administrative authorization for the project by the investor.

2) When EIE is found necessary, the investor conducts EIE at his own expense.
3) The investor submits the results of EIE to National / Regional Committee(s) on EIE.
4) National / Regional Committee(s) on EIE examine the impact study and determine if the project is acceptable from the viewpoint of environment.
5) National / Regional Committee(s) prepare a report on the EIE, including the decision whether:
   - the project is acceptable without modification or additional measures for mitigation of environmental impact
   - the project is acceptable only with modification and / or additional measures for mitigation of environmental impact
   - the project is not acceptable
6) Decision of authorization of the project is made by National / Regional Committee(s) on EIE taking into account the acceptability of the project.

The Regional Committees for Impact Studies are also at the stage of preparation. The National Committee is currently the only authority to provide the decision whether the project is environmentally acceptable or not. However, training of relevant government personnel for Regional Committees has been started in Marrakech and Casablanca as pilot cases. With the approval and issuance of the "Decree on the composition and the procedure of the national committee and the regional committees of the impact studies on environment (provisional title)", in the near future, these committees are expected to start performing their tasks.

3) Law No. 13-03 on the control of air pollution.

The law on control of air pollution aims at the prevention and the fight against the emissions of the atmospheric pollutants likely to attack the health of the man, to fauna, the ground, the climate, the cultural inheritance and the environment in general. The law dictates legal obligations for individuals and organizations that emit pollutants into the atmosphere.

(2) Environmental Policies

Within the framework of laws and regulations, the Ministry of Energy, Mines, Water and Environment (MEMEE) is in charge of elaborating and implementing the policy of the government.

The main strategic documents prepared by MEMEE are as follows:

1) National Strategy for the Protection of Environment and Sustainable Development (SNPEDD)

The SNPEDD was elaborated in 1995 to integrate and strengthen environmental concerns and economic development activities, with the target year of 2020. The main principles of the plan are: a) strengthening of legal framework and institutional capacities, b) end-of-pipe approach, and c) policy integration. Within the plan, cost/benefits analysis for development activities are to be carried out and discussions made on the mid-long term benefits which will be realized by protecting the environment.

Major activities elaborated in the plan include:

1. Studies on the state of environment
2. Preparation of an inventory of environmental projects
3. Formulation of a National Action Plan for Environment
4. Preparation of a database and information management system on environment
5. Studies on biodiversity, greenhouse gas emissions and desertification
6. Preparation of regional and local environmental monographs

2) National Action Plan for the Environment (PANE)

Based on the SNPEDD, PANE has been prepared in 1998. The plan consists of 7 programs / 165 activities, with the aim of implementing the strategies set under the SNPEDD (i.e., Conservation and sustainable management of water resources, Conservation and sustainable management of ground resources, Conservation and sustainable management of renewable energies, Conservation and sustainable management of the natural environment, Prevention of the natural disasters and major technological risks, Improvement of the urban and peri-urban environment, and Management and

environmental communication.). The programs refer to conservation and sustainable management of natural environment and resources, as well as prevention of hazards and improvement of living environment in urban and peri-urban areas. The strategic objectives of the PANE are:

1. To ensure rational management of natural resources, through implementation of a comprehensive solution
2. To integrate environmental concerns in the definition of the policies, programs and projects set up in each principal sector of the development
3. To support the implication, clarification of responsibility and participation of public as well as the investors in management of resources and securing of quality of living environment
4. To support the development of an effective partnership between the actors concerned in environmental issues and sustainable development
5. To develop human resources and the institutional capacity allowing a better knowledge of the state of the environment and its management.

2.1.7 Water Resources Development in Morocco

(1) Water Resources in Morocco

Average annual precipitation and evaporation is estimated at 150,000 Mm^3 and 121,000 Mm^3, respectively (FAO). This means around 29,000 Mm^3 is available water resource, and exploitable water is estimated around 20,000 Mm^3 which consists of 160,000 Mm^3 of surface water and 4,000 Mm^3 of groundwater.

(2) Previous Water Resources Development

Water resources development is one of the most important issues of the State. Based on the urbanization and rapid development of industry and irrigation sectors, water demand has increased rapidly. In order to fulfill the demand, the Government constructed more than 100 large-scale dams totaling 15,700 Mm^3 since 1960's. Also 13 of large scale canal systems and groundwater development facilities were constructed. Total of these additional water resources developments is estimated at 13,000 Mm^3 (around 65% of exploitable water resources).

(3) Shifting the water development to water management

As stated above, the Government policies for water resources development gave high priority to the water resources development by construction of dams and mobilization of water resources, and management of demand was set as a secondary priority. After the Water Law was issued in 1995, the Government gave the high priority to integrated water resources management on river basin basis based on the participation of stakeholders.

2.1.8 Water Resources Management Policy and Legal Framework

(1) Water Law (Law No. 10-95)

Water Law, which was approved by the Government of Morocco in September, 1995, constitutes the legal basis for water resources development in Morocco. The Law is composed of 13 chapters, listed below, and 123 articles:

1) Domain Public Hydraulic (DPH): To define the water as public properties
2) Vested right holders in DPH shall be re-registered their right within 5 years after the law effectuation, and transfer of water rights
3) Conservation and protection of DPH
4) Superior Council for Water and Climate (CSEC), national water development plan, basin water management by Basin Hydraulic Agencies (ABH) and integrated water management plan and water charges
5) Permission and approval system for utilization of DPH including rights and obligations
6) Water quality conservation, pollution control and water quality standards
7) Domestic water
8) Development natural water and its sale
9) Management and utilization of water for agriculture including water pollution, limitation of irrigation water
10) Control regulation of water usage during drought

11) Water demand projection, inventory of water resources, flood control, etc.
12) Formulation of water committees at provincial and commune level for the participation of local people to the water management and conservation
13) Water Police for inspecting the illegal water use and definition of fines and procedure of legal trials

(2) Superior Council of Water and Climate (CSEC)

In Water Law 10-95, Superior Council for Water and Climate (CSEC) was assigned to formulate general guidelines of national policy concerning water and climate. The CSEC examines and formulates opinions on:

1) National strategy for enhancement of knowledge on climate and harnessing its impact on water resources development
2) National water plan
3) Integrated plan for water resources development in river basins, especially distribution of water among various demand sectors and regions, as well as arrangement for development, protection, and conservation of water resources.

Members of the CSEC are composed of the government, basin agencies, ONEP, ONE and ORMVA, elected consumer representatives, provincial or prefecture assemblies, and scientific experts.

(3) Other Water Related Law and Regulations

1) Irrigation

For irrigation, many regulations (Decrets) and Law were issued such as regulation on the Irrigation Water Distribution (1969), Water Users Association Law (Loi No. 02-84), agreement between the Government and water users association on the demarcation of role of irrigation O&M (1979) and regulations concerning water fee (1983 – 1997). These were mostly issued before issuing the Water Law; therefore, their review and updating are under way.

2) Environment and Water Quality

The Environmental Protection and Improvement and Law of Environmental Impact Study are the base of environmental conservation and protection in Morocco. The water quality standards for evaluation method, water quality of surface, irrigation, and potable water were issued by the Decrets and gazette during 1997 to 2002. Also, Regulation of the usage of treated wastewater was issued in 1997 and 2002.

2.1.9 Integrated Water Management Plan by River Basin

(1) The master plan for water resources management defined in the Water Law

The Water Law (10-95) states that the administration for each river basin or a set of river basins has the duty for establishing an integrated master plan for water resources development (Plan Direcuteur d'Aménagement Intégrés des Ressources en Eau: PDAIRE). Such plan is required to define the following items:

1) Territorial limit of the river basin
2) Quantitative and qualitative evaluation and development of water resources and demand in river basin
3) Sharing plan of water among the various sectors in the basin. This plan will eventually specify a surplus of water quantities that can be subject to a transfer towards other basins.
4) General scheme of construction in river basin to insure conservation of water resources and their suitability to the needs.

The integrated master plan for water resources development was established for a period of 20 years, and subject to review every five years. This plan is approved by a decree following the recommendation by CSEC. According to the law, the administration also has the duty to establish a national water plan on the basis of results and conclusions of the integrated master plan for water resources in each basin.

Integrated Master Plans for water resources in respective river basin / set of river basins, are as follows:

1) Integrated Master Plan for Moulouya River basin that was approved by CSEC in 1990
2) Integrated Master Plan for Sebou, Bouregreg and Oum Er Rbia River basins that was approved by CSEC in 1992
3) Integrated Master Plan for Northern Morocco basins that was approved by CSEC in 1993
4) Integrated Master Plans for Tensift River, Souss-Massa River basins were approved by CSEC in 2001, and
5) Guir, Ziz, Rheriss and Draa River Basins are in final stage for their study.

Establishing these plans mainly aims to evaluate water demand from different sectors such as potable and industrial water, irrigation and hydropower generation, and to determine optimal integrated scheme of the water resources development.

Allocation of water resources is fixed in the plans to cover demand of different sectors up to 2020 as shown below. Such demand is to be met by local water resources or transferred from resources within or outside of the river basin.

Allocation of Water Resources (Mm^3/year)

River Basin	Potable Water		Irrigation		Maintenance Flow	
	1990	2020	1990	2020	1990	2020
Northern Morocco	110	305	385	925	-	-
Moulouya	75	160	1,170	1,525	-	-
Sebou	230	663	1,550	3,398	-	60
Bouregreg	386	1,270	164	440	-	30
Oum Er Rbia	300	425	1,750	2,230	-	60
Tensift	150	355	1,850	2,740	-	-
Souss-Mass	50	155	915	870	-	-
Guir, Ziz, Rheriss and Draa	23	55	1,326	1,445	-	-
Total	1,324	3,388	9,110	13,573	-	150

Source: Synthese des Plans Directeurs d'Amenagement Integre des Eaux des Differents Bassins du Royaume

(2) Water Sector Policy Development Program

1) Implementation of Water Law 10-95

After the effectuation of Water Law 10-95, the Government started to reform the water policies, and implemented structural reform starting from establishment of ABHs and preparation of basin based master plans, etc. Progress of the water sector policy development and financial arrangement were not smoothly implemented. The World Bank, EU and other donor countries provided the technical and financial assistances for the policy reform/development.

2) Water Sector Policy Development Program (PPD-Eau)

World Bank issued the Country Assistance Strategy for Morocco in June 2005. In the strategy, the World Bank indicates two broad objectives : 1) Accelerate growth and job creation, and 2) Reduce poverty and exclusion. These objectives shall be achieved by four strategic objectives: 1) improve competitiveness and the investment climate, 2) increase access to basic services by the poor and marginalized, 3) improve education system's efficiency, and improve water management and access to water and sanitation service. Based on the 4th strategic objectives, Water Sector Policy Development Program (PPD-Eau) has been in operation between 2005 and 2009. The objectives and activities are as follows:

Objective 1: Improvement of Water Sector Governance and Operation
- 1.1 Assuring the consistence of sectoral policies
- 1.2 Allocation of budget to the high priority sub-sector

Objective 2: Reformation of Water Resources Management System
- 2.1 Strengthening ABH
- 2.2 Extension of water fee collection system
- 2.3 Water Pollution Control
- 2.4 Protection of Aquifer
- 2.5 Protection of water resources and budget allocation

2.6 Water demand survey in the Tensift basin and coastal area
2.7 Improvement of law and regulation concerning water

Objective 3: Improvement of Irrigation Project Operation System
3.1 Efficient use of irrigation water
3.2 Improvement of irrigation water fee collection at the domain public hydraulic(DPH) and strengthening maintenance of irrigation facilities
3.3 Strengthening ORMVA
3.4 Reformation of ORMVA: entrusting management of irrigation system
3.5 Improvement of downstream of Dam by PPP

Objective 4: Improvement of Water Supply and Sewage Policies
4.1 Strengthening the control and reformation of water charge: considering improvement of performance of executing agencies, financial autonomous, and dissemination of consumers
4.2 Formation of National Sewage Development Plan (PNA)
4.3 Improvement of water access for the poor in urban and rural area
4.4 Support the improvement of the access to water supply and sewage in rural area
4.5 Implementation of National Plan for Potable Water (PNEP)

2.1.10 Water Related Institutions

The following descriptions are as of August 2007. After the ministerial reforms in October 2007, the State Secretary in charge of Water and the environmental functions previously under the Ministry of Land Management, Water and Environment has been transferred to the current Ministry of Energy, Mining, Water and Environment. Similarly, the Provincial Directorates of Agriculture and Regional Offices for Agriculture Development have been transferred to the Ministry of Agriculture and Maritime Fisheries from the previous Ministry of Agriculture, Rural Development and Maritime Fisheries.

(1) Ministry of Land Management, Water and Environment (MATEE)

1) Organization of MATEE

MATEE formulated for the land management, water resources and environmental protection in 2002 after the reformation of ministries. Under MATEE, two Secretaries General were installed: 1) Secretary General of MATEE who manages the Directorate General of Land Management, and Environment, and State Secretary to MATEE in charge of Water who manages the Directorate General of Water. At the same level of Secretaries General, seven Agency of Hydraulic Basin (ABH) and Moroccan Water Supply Organization.

2) Secretary of State in charge of Water (SEE)

Under SEE, five directorates are installed: 1) Directorate of General of Hydraulic (DGH) for the general affaires, 2) Directorate of Hydraulic Installation (DAH), 3) Directorate of National Meteorology (DMN), 4) Directorate of Research and Planning of Water (DRPE) and 5) Directorate of General Technical Affairs. Water management policy is mainly in charge of DRPE at central government level.

DRPE consists of 4 divisions: 1) Planning and Management of Water for the studies, planning, and management by sub-division of Master Plan and Water Management, 2) Water Resources, 3) Water Quality for the water quality monitoring, control of water pollutants and improvement of water qualities, 4) Water Legislation for the legal arrangement of water resources and of Domain Public Hydraulic (DPH).

3) Basin Water Management Agencies (ABH)

Water Law (10-95) specifies the establishment of a basin agency in each river basin or a set of river basins. It is a public agency, endowed with individual legal entity and financial autonomy, however, its activities are supported by the Government in actual. Based on Decret No. 2-00-479, eight (8) hydraulic basin agencies were established: namely, 1) Moulouya, 2) Loukkos, 3) Sebou, 4) Bouregreg and Chaouia, 5) Oum Er Rbia (1997), 6) Tensift,7) Souss Massa, and 8) Guir, Ziz, Rhersis

and Draa. The contracts to transfer the authority from DGH were mostly signed up to now.

Such basin agencies are in charge of the following:

- Elaboration of an integrated master plan for water resources development relevant to its action zone
- Making sure that the integrated master plan for water resources development is implemented inside its action zone
- Giving permission and concession to use hydraulic domain scheduled in the integrated master plan for water resources development in its action zone
- Provision of financial support and service, notably technical assistance, to both public and private bodies that make requests, either to prevent the pollution of water resources or to equip or use the public hydraulic domain.

4) National Water Supply Organization (ONEP) and Marrakech Potable Water Distribution Enterprises (RADEEMA)

ONEP is a public corporation with the characteristics of private enterprises. It has been established under Dahir No. 1-72-103, as a self support accounting body to inherit the functions of REI. ONEP is in charged in implementation of the Rural Water Supply Program (PAGER), which is to increase the access to the potable water up to 90% by the year 2007. ONEP has been working in the field of rural water supply from January 2004. Furthemore, the revision of legislation in 2000 has made it possible for ONEP to manage sewage treatment services in towns and villages among request.

RADEEMA is a public corporation providing electricity, distributing water and management sewage treatment in the City of Marrakech.

5) Functions for Environment under MATEE

Since its formulation within the Ministry of Habitat and Tourism, the legal authority of environmental issues has been shifted to various ministries/agencies. Currently, the Directorate of Environment, under the MATEE is the designated authority. The field of Environment is one of the three major tasks of MATEE. However, the actual functions for environmental management are separately performed under the four directions of MATEE. The main tasks of MATEE related to environmental field are to:

1. Elaborate and implement environmental policies within the framework of laws and regulations
2. Conserve the natural environment and to prevent degradation of the environment of which obstructs sustainable development
3. Implement appropriate measures to monitor and manage the state of environment
4. Prevent pollution or hazards which may affect the health of the public

Currently, the institutional framework for activities at the regional level is being actualized based on the system formulated in the year 2000. The environmental section (although not officially defined as an administrative unit of MATEE) under the Regional inspection of Land Management, Water and Environment (IRATES) of Marrakech, has been conventionally performing regional activities such as liaison with Wilaya/provinces, collection of environmental data and consulting investors on procedures for Environmental Impact Studies. The provisional organizational structure is now being finalized in MATEE and is expected to be realized in the near future.

Furthermore, with the planned promulgation of the “decree on the composition and the procedure of the national and regional committee on environmental impact studies (provisional title)”, is expected to further enhance the activities of the regional inspection.

(2) Ministry of Agriculture, Rural Development and Maritime Fisheries (MADRPM)

1) Organization of MADRPM

Main Departments of MADRPM related to agricultural sector are: 1) Planning and Economic Affair (DPAE), 2) Education, Research and Development (DERD), 3) Crop Production (DPVCTRE), 4) Crop Protection (DPV), Livestock (DE), and 5) Public Administration Enterprises and Professional Organization (DEPAP). As far as irrigation is concerned, Directorate of Development and Management

of Irrigation is the main department under the Rural Engineering Administration. As for fishery sector, MADRPM has 5 departments, i.e., 1) Marine Fisheries and Aquaculture (DPMA), 2) Marine Product Processing Industry (DIPM), 3) Cooperation and Legal Affaires (DCAJ), 4) Education and Vocational Training of Fisheries (DFMPS) and 5) Human Resource and General Affairs (DRHAG).

MADRPM formulated the"2020 Rural Development Strategy" with the objective to reduce the poverty in the rural area based on three principals: 1) decentralization on order to development based on the needs of the people, 2) integration among sectors, and 3) effective participation of stakeholders in the process of planning and implementation.

2) Provincial Directorate of Agriculture (DPA)

At the provincial level, 40 DPAs are installed under the MADRPM. They are mainly in charge of the small scale irrigation and rainfed agriculture areas. Large scale irrigation areas are covered by ORMVA.

3) Regional Authority for Agriculture Development Agency (ORMVA)

In addition to DPA, nine ORMVAs (Doukkala, Gharb, Haouz, Loukkos, Ouarazazate, Souss-Massa, Tadla, Mouloya and Tafilalet) were established to manage the large scale irrigation project and to provide the agricultural support to the farmers in the individual project area. They are established as independent agencies under the supervision of MADRPM for technical matters and Ministry of Finance in financial affaires.

2.2 Outline of the Study Area

2.2.1 General Conditions

(1) Location

The Study Area of the Haouz Plain covering about 6,000 km^2 is located on the left bank of the most upstream reaches of Tensift River. The Plain spreads in the alluvial plain on the foot of the High Atlas Mountains stretches between 7^o-09' and 8^o-55' west longitudes and between 31^o-09' and 31^o-55' north latitudes. The elevation of the Study Area is between 250 and 800 m above mean sea level. Center of the Plain is Marrakech.

(2) Administration

The Marrakech - Tensift - Al Haouz region where the Study Area is located is composed of the Marrakech prefecture and 4 provinces: Al Haouz, El Kelaâ des Sraghna, Chichaoua and Essaouira, and includes 62 communes (17 urban communes and 51 rural communes, 6 communes of Al Haouz are classified both types).

(3) The Haouz Plain and Study Area

The Study focuses on the groundwater resources in the Haouz Plan. Then the Study is concentrated in the groundwater basin of the Haouz Plan. The Haouze groundwater basin (area: 6,149 km^2) spreads on the foot of High Atlas Mountains in the south, the Tensift River on the north, eastern boundary of the Tensift River Basin on the east and the Chichaoua River on the west. Therefore eastern part of the Haouz Plan and western boundary area along the Chichaoua river is excluded for the Study.

(4) Tensift River Basin and ABHT Command Area

1) The Tensift River Basin

The Tensift River is a seasonal river which originates in the High Atlas Mountains and flows 260 km from east to west, ending at to the Atlantic Ocean at Souira Kédima. Its major tributaries in the Study Area are the R'dat, Zat, Ourika, Issil, Moulay Brahim, N'Fis, Asif El-Mel, and Chichaoua rivers.

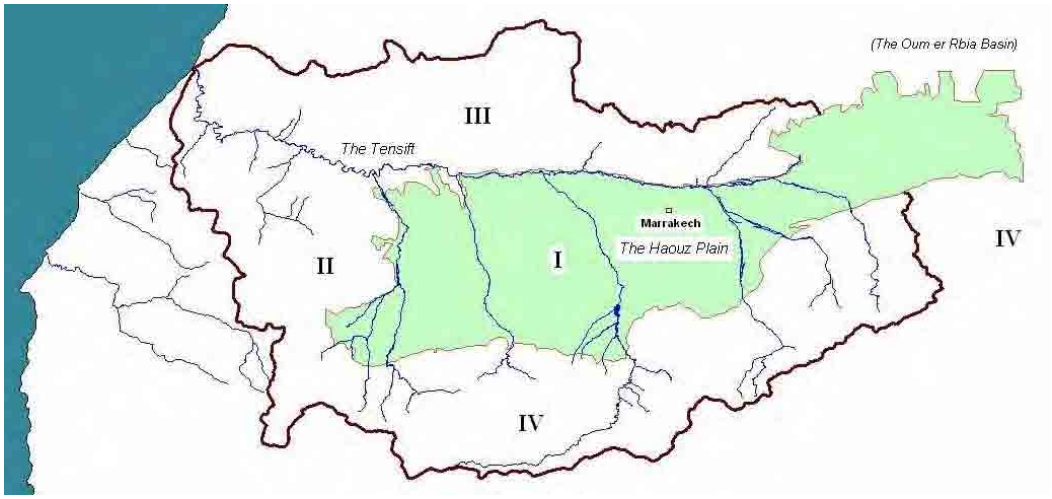
2) ABHT Command Area

Area of coverage under ABHT is 24,800 km2 which consists of the Tensift River basin and Bahira basin at the north-east and Essaouira area on the southwest. The area is divided into five geographical units; 1) High Atlas Mountains Unit, 2) Haouz Plain Unit, 3) Mejjate Unit, 4) Jbilet Unit, and 5) Essaouira Unit.

2.2.2 Natural Conditions

(1) Topography

The Haouz plain spreads mainly over the left bank of the middle to upper stream of the Tensift River and partly to the Oum er Rbia Basin, where the area is called Haouz Oriental, or the Eastern Haous. The central part of the plain around Marrakech is called Haouz Centaral and the western part is also called Mejiat Plain. In the Haouz Plain, the main stream of the Tensift starts at the eastern part with the altitude of about 550m and runs to the west with the altitude of about 250m, the inclination of which is 3/1000. The Tensift Basin is divided to four (4) regions by geomorphologic units, namely I: Haouz Plain, II: Essaouira – Chichaoua, III: Jbilet, IV: High Atlas, as shown in the following.



The Haouz Plain and the Drainage Basin of the Tensift

1) Haouz Plain: I

The Haouz Plain is bordered by the Tensift River and the Jblit Mountains on the north, the Chichaoua River and its upper stream, the Amznas, on the west and the foot of the High Atlas Mountains on the south to the east. The plain slopes gently from the northwest to the southeast. Altitude varies from around 250m on the northwest end of the plain, where the confluence of the Tensift and the Chichaoua, to 800m on the south to the east end. The inclination of the plain's surface is a degree of 1/100-150 on the northern part and gradually rises southwards.

2) Essaouira-Chichaoua: II

The Essaouira-Chichaoua area is the undulating plateau distributed on the east of Haouz Plain with the altitude of 400 to 800m in general. The Tensift flows on the north and the west border contacts a coastal plain facing the Atlantic Ocean, and the south tends toward the Western High Atlas.

3) Jblit: III

Jblit is the low mountainous region, the altitude of which varies from 300 to the highest point of 1000m, spread over 170km from the Mouissate terrain on the west to the Central High Atlas on the east. The surface of the region gradually rises toward the north from the right bank of the Tensift and slope down toward the Bahira Plain over the ridge.

4) The High Atlas Mountains: IV

The mountain range of the Atlas extends west and east on the south of the Haouz Plain. The row of mountains comprises the summits over 3000m including the highest peak of the Atlas, Jbel Toubkal, 4167m. The tributaries of the Tensift flow from the valleys of the mountains.

(2) Climate and Hydrology

The climate of the Haouz Plain Area is arid continental type based on the Mediterranean climate. The annual mean temperature at Marrakech, which is located at the center of the Plain, is 19.9℃, and the monthly mean temperature varies from 11.9℃ in January to 28.7℃ in July. At Lalla Takerkoust, which is located at the foot of the Atlas Mountain, the annual mean temperature is 18.0℃, the monthly mean of January is 11.4℃ and of July is 26.6℃. At Sidi Rahal, which is the east end of the Central Haouz, the annual mean temperature is 18.8℃, the monthly mean of January is 12.0℃ and of July is 27.7℃. Comparatively high precipitation is observed along Atlas Mountain, which is located in the south and south-east part of the Plain, where average annual precipitation is 259mm at Lalla Takerkoust and 535mm at Aghbalou. In the plain area, the average annual precipitation observed is comparatively low: 176mm at Abadla and 216mm at Marrakech. The rainy season starts on October and regularly continues to March or April. 86% of annual precipitation (equivalent to 216mm) is observed during the period of October to March in Marrakech, and in other areas too. The annual evaporation is 1,830mm at Lalla Takerkoust and 2,640mm at the center part of the Haouz Plain (Table 2.2.1 and Table 2.2.2).

The rainfall in the Study Area shows a gradual decrease when examined in a long span, where the rainfall in Marrakech has decreased 0.18%/year in average. Sidi Rahal, which is located in the eastern part of the area also shows an average decrease of 0.21%/year. Serious droughts have hit the area in the past decade. This can be seen in the average rainfall in Marrakech and Sidi Rahal, where the long term average since 1970 was 220mm and 349mm respectively, has shown a significant drop to an average of 204mm and 319mm in the past 10 years (Figure 2.2.1, Figure 2.2.2 and Table 2.2.3)

The Tensift River Basin, where the Haouz Plain is located, has its south boundary along Atlas Mountain, and the Tensift River that is a major river of the Basin runs through the Plain from the east to the west, and discharges to the Atlantic Ocean. The total length of the Tensift River is 260km and the area of basin is 19,800km^2. The Study Area is locatedoin the left bank of the Tensift River upstream from the conjunction of the Chichaoua River. The major tributaries of the Tensift River concerning the Study Area are Chichaoua River, Assif El Mal River, N'Fis River, Rheraya River, Rhmat River, and Ghdat River from west to east. The upstream of the Tensift River is called the Lagr River. (Table 2.2.4, Figures 2.2.3, and 2.2.4)

The discharge of the Tensift River and its tributaries starts to increase in November, following the start of rain ; the peak of discharge is observed in March to April, and generally a large amount of discharge continues to May. The discharge of these rivers area significantly fluctuates during year. More than 80% of total discharge is observed from November to May and the rivers are dried up from July to September during the dry season in the plain area including the Tensift River. (Table 2.2.5)

(3) Geology and Hydrogeology

Geological structure and geological and hydrogeological features in the Tensift basin are show as follows. (Table 2.2.6)

1) Haouz Plain

Neogene to Quaternary alluvial deposit are mainly distributed in the Plain. Calcareous rocks are distributed around Chichaoua and its upper stream area, or the foot of the High Atlas. These formations are generally permeable and groundwater can be exploited. Some Paleozoic deposit areas are scattered in the central south of the Plain, southeast of Guemassa. This Paleozoic formation consists of schist, quartzite, limestone and so on, and is almost impermeable.

2) Essaouira-Chichaoua

Cretaceous to Eocene deposit forms the plateau. The formation consists of dolomite and marly limestone. It is permeable and groundwater has been abstracted for drinking and agricultural use of the residents in the area.

3) Jblit

Jblit Mountains mainly consist of Paleozoic that is composed of schist, micaschist, quartzite, and limestone. The formation is almost impermeable and no aquifer occurs in it.

4) The High Atlas Mountains

The High Atlas Mountains in the Tensift basin consist of mainly Paleozoic and Precambrian partly. The areas where fissures or fractures developed may have permeability.

(4) Vegetation and Soils

In the Study Area, vegetation coverage is generally poor, with 3/4 barely having no coverage. Vegetation types vary depending on elevation and soil. Evergreen oak forests (Aghana, Thuya, Red Juniper, etc.) spread around the Atlas Mountain range to the Rehamna hills. The area of forests in the area reaches up to 541,000ha.

The vegetation in around the southern Atlas mountains forms an important part of the ecological resources of Morocco. Conservation of vegetation in the area, along with the palm tree oasis in Marrakech and the Alghana forests in Essauira should be considered. Vegetation coverage by agricultural plants has a rather large variety, including grains, olive, apricot, orange, roses, apple and pasture. As for Al Haouz province, 75.6% of the total cultivated area (604,000ha) is covered by tree plantations, while the remaining area is covered by non-tree crops.

The soil of the Marrakech Tensift Al Haouz Region has been developed in the alluvial deposit between the Paraeozoic relief of Jbilet and the Atlas mountains. The major soils of the area are as follows.

1） Isohumique siols (Fluvisols, Regosols, Lithisols under FAO Taxon) locally called “Requane” cover 75% of the area.
2） Cacimagnesic soils (Rendzinas, Yermosols, Xerosols) loccaly called “Biad “cover about 15% of the area. This type of soil is mainly found areas in the northwest of N’Fis, southeast of the central area and .north of El kelaa of Sraghna.
3） Undeveloped soils locally called “Hach “cover a small potion of the area along the rivers of Haouz plain and in the and in the foots of the Atlas mountains, account for some 10% of the Region.

2.2.3 Socio-Economic Conditions

(1) Social and Economic Situations in the Study Area

1) Population

The total population is 1,613,000 inhabitants and the Marrakech prefecture accounts for 63% of the whole population. Moreover, the urban population accounts 920,000 inhabitants which correspond to 57% of the whole population, and Marrakech prefecture occupies 89% of the total urban population.

On the other hand, the percentage of urban population for each prefecture/province are : 80% in the Marrakech prefecture, 12% in the Al Haouz province, 29% in the El Kelaâ des Sraghna province, and 18% in the Chichaoua province. The average of population density of the Study Area is 195 inhabitants/km^2, and the population density of each prefecture/province is as follows: 620 inhabitants /km^2 in the Marrakech prefecture, 124 inhabitants/km^2 in the Al Haouz province, 124 inhabitants/km^2 in the El Kelaâ des Sraghna province and 54 inhabitants/km^2 in the Chichaoua province. (Table 2.2.7)

2) Regional Economy

Regional economy of the Marrakech - Tensift - Al Haouz region depends mainly on agriculture and agro-industry, tourism, processing industry, handicrafts and in a small measure on fishing. The central place of the regional economy is Marrakech city which has approximately 795,000 inhabitants.

The useful agricultural area is 1.4 million ha which represents a quarter of the useful agricultural area of the country. The main agricultural products are cereals, legumes and vegetables. Fruit-culture depends on the olives that cover 126,000 ha and they play an important role in regional economy ; the region is the top producer of olives on a national level. The forest covers the area of 491,000 ha and

provides an indispensable income complement on the regional level (Le Maroc des Régions 2005, HCP 2006).

The tourism plays an important role in regional economy. This sector has some secondary effects on other sectors as handicraft, construction and transportation. The region possesses major assets for the development of the tourism such as: accommodation that represents 25% of the capacity of hotel beds of the country, transportation, and a varied cultural heritage consisting of tourist sites and the historic monuments essentially localized in Marrakech city.

The most important industrial units operate in the sectors of agro-processing, chemistry, and textiles and leather. With 387 companies, representing 5% of the total number of the industrial establishments, the region contributes up to 4% for national permanent employees and 3% for national production. The production value in 2003 reached more 5.7 billion DH, and grew 4% in relation to 2002 (Table 2.2.8). The agro-food industry has the biggest weight in the region, with 60% of the regional production. The unemployment rate of the region is 6.5% which is lower than the average of the country (10.8%).

(2) Agriculture

1) Land Use

The Study Area is divided into three areas based on the administration organization of irrigation and agriculture (i.e., DPA Marrakech, DPA Chichaoua and ORMVAH), and the Study Area consists of a part of their jurisdictions. The management area of DPA Marrakech consists of 32 rural communes, of which 10 rural communes are in the Study Area. 29% of the DPA Marrakech Area is occupied by arable land, of which 32% is irrigable land. In the area of the DPA Chichoua, 13 rural communes are in the Study Area an also the DPA covers 35 rural communes. the arable land occupies 23% of total and 42% of that is irrigable area. The grazing land and fallow land occupies 61%, which is comparatively higher than other areas. ORMVAH manages 69 rural communes and 32 of them are in the Study Area. Arable land occupies 73% of the total and irrigable area is 66% of the arable land. The ORMVAH area is a highly developed agricultural area in the Plain. (Table 2.2.9)

2) Status of Land Resources

The Government of Morocco classifies the land into five categories as follows: the Melk, the Collective, the Habous, the Guich and the State Domain. Each is discussed below.

The Melk corresponds to the private lands, having a collateral value relating to their property, that the farmers can use for investment. This status facilitates the loans at the bank because the owner mortgages his lands to guarantee loans. The collective lands are managed by the assembly of the sages. The distributed lands do not have value-added by their owner. The Habous is the land under the supervision of the Minister for Habous and Islamic Affaires. The Guich is one of land forms of domanial origin, whose title was given, formerly, with certain communities and tribes, as the reward of their military services. These lands, placed under the supervision of the Ministry of the Interior, are classified as private domains of the State and are often small parcels. It is remarkable that Guich is more common in the province of Marrakech, since this status does not make it possible for farmers to access Agricultural credit because the bank does not accept the mortgage of the lands as a loan guarantee. The State Domain is a public domain managed by the government.

In addition, the agricultural farms are characterized by the dominance of small parcels and the spatial dispersion of the parcels. In the zone of action of the ORMVAH, on 26,825 ha which are in the study area, farms of less than 5 ha account for 36% of the surface and 86% of the total number of exploitation. On the other hand, the farms of more than 20 ha present 2% of the total farms and cover 24% of the total surfaces. That does not favor good land utilization with limited infrastructures and insufficiency of public and private investment. (Figure 3.3.1 and Table 3.3.4)

3) Agricultural Production

The agriculture sector plays a very important part in the economy of the Marrakech-Tensift-Al Haouz region. The useful agricultural surface (SAU) estimated in the study area is 469,279 ha. The irrigated surface accounts for 53.5% (251,034 ha) of the SAU, of which 56,970 ha of the Large Scale Irrigation

Systems (GH) improved and headed by the ORMVAH, and 194,073 ha of the surface irrigated in the Small and Medium Irrigation Systems (PMH).

The principal agricultural productions mainly consist of cereal cultivations (wheat, barley) and of arboriculture. The surfaces of the cereal cultivation and arboriculture in the study area are respectively 244,608 ha and 92,517 ha which are 4.3% and 11.1% respectively compared to the total national surface. Arboriculture, in particular olive cultivation which widely covers 67,000 ha in the study area, plays an important part in the economy of the region. (Table 2.2.10)

4) Livestock Production

Livestock breeding constitutes one of the most important income sources of the population of the region; it plays a considerable part in the economic development of the region. Total number of livestock in the study area is about 1,161,513 heads. The ovine is most dominant, then the bovine and the goats ; these are respectively, 73%, 14% and 12% of the livestock number in the study area. (Table 3.3.6)

Thus, this area has a pastoral vocation based on extensive livestock breeding, in particular ovine. Known degradation continues due of the severe climatic conditions, overgrazing and deregulated cultivation.

5) Agriculture Extension and Supporting System

The ORMVAH; DPA of Marrakech and Chichaoua are the principal structures for leading and of support to the farmers in the study area.

The ORMVAH is a responsible for the whole of the irrigation development areas, in particular in Large Scale Irrigation Systems (GH)) of the Haouz Plain. On the other hand, the intervention zone of DPA extends over their provinces except the zone of action of the ORMVAH.

Principal attributions of the ORMVAH and DPA are as follows:

- Development and the management of irrigation development areas and water resources for agriculture use
- Agricultural techniques spreading and the vocational training
- Organization and the leading of the farmers and stockbreeders
- Development of vegetal and animal production
- Development of allied industry in agricultural sector.

The Center of Technique of Irrigation, Experimentation and Spreading (CTIEV) at Saâda created by the ORMVAH in 1990, in the Central Haouz irrigation development areas (N'Fis), has two principal objectives:

- Experimental work and the demonstration of irrigation techniques in order to make the new irrigation methods used in the Center known to farmers
- Technical assistance to farmers who are interested to try new irrigation systems.

6) Rural and Farmers Organization

Associations of irrigation (Agricultural Water Users Associations, AUEA)

Law No2/84 of December 21, 1990 lays down the objectives as well as the constitution and function of Agricultural Water Users Associations (AUEA), who are represented in the Haouz Plain, as the more widespread form of farmer's organization. Before the promulgation of this law, the irrigation associations had been created by the initiative of users in the study area. After the promulgation of the law of 1990, the ORMVAH and DPA carried out the conversion from existed associations to AUEA, also with the creation of new AUEA, in the GH and the PMH. They have the objective to manage and to preserve the agricultural water infrastructure. In the irrigation development areas of the ORMVAH, part of the responsibilities and obligations of farming and maintenance for the infrastructures (secondary infrastructures and distribution networks) has been transferred to the AUEA. (Table 3.3.7)

Agricultural cooperatives

Various existing agricultural cooperatives in the study area play an important part for the agricultural

development of the region. The major agricultural cooperatives in the study area are: the dairy cooperatives, the producer's cooperatives in particular the olive products and the pastoral products, the apiculture cooperatives, and the cooperatives of the Land Reform.

7) Agro-industry

Agro-industry plays a major role from an economic as well as social stand point by providing regional production value and employment. Although the agro-food industry has the biggest weight in the region economy, most facilities of agro-industry are medium and small scale. There is total of 129 agro-industry establishments in the service area of ORMVAH. (Table 3.3.8)

(3) Tourism

1) Accommodations

Marrakech city constitutes the first tourist destination of Morocco thanks to the wealth of its historic and cultural heritage. Marrakech-Medina was registered to the World Cultural Heritage of UNESCO in 1985. Tourist facilities are concentrated in Marrakech city.

One million tourists per year visited to the Marrakech - Tensift - Al Haouz region and spent 4.3 million nights in 2004 in hotels which corresponds to 33% of the country total. There are 397 accommodations in total in 2004 which corresponds to 41% of the country total, and the capacity of beds of the accommodations is 30,000 which correspond to 25% of the country total. Moreover, the occupancy rate of in hotels is from 50% to 60% in these years. (Table 3.3.9 to 12)

2) Park lands

The park lands of the Royal domain occupy 580 ha of which 500 ha are the Agdal gardens and 80 ha of the Ménara gardens. The park lands inside Marrakech city total 935 ha of which 510 ha are hotel gardens and 30 ha are INRA gardens (Alimentation en Eau Potable et Industrielle de la Ville de Marrakech, ABHT, 2006).

3) Golf Course

The existing golf courses (Royal, Amelkis and Palmeraie) are situated in the southeast of Marrakech city. The golf course projects are allowed withdrawals of water. These golf courses are:

- ASSOUFID project with 220 ha
- PALM Golf project with 170 ha
- ATLAS GOLF AND RESORT "GROUP ALAIN CRENN" project with 282 ha.

Other golf course projects under validation (agreement in principle is given by the ad hoc commission) for withdrawal authorizations of water are:

- LATSIS GROUP project with 140 ha
- "JARDINS DE L'ATLAS" project with more than 148 ha
- DOMAIN ROYAL PALM project with 250 ha
- The TRITEL project with 220 ha
- STRATEGIC PARTNERS project

(4) Industries

The Wilaya of Marrakech monopolizes the essential industrial activities: it intervenes 80% in industrial employment and 70% in industrial production. The region includes an important industrial unit known as the Cement factory of Marrakech (CIMAR) that has a capacity of production of 450,000 tons (Le Maroc des Régions 2005, HCA 2006). In the Marrakech - Tensift - Al Haouz region 9 industrial zones are located as follows:

- Marrakech: Azli, Sidi Ghanem, Al Mssar, Harbil, Sidi Ghanem III
- El Kelâa des Sraghna: Sidi Bouathman, Ennakhil
- Chichaoua: Ennasr
- Essaouira: Industrial district of Essaouira

The region contains a substantial mining potential of phosphates with reserves estimated at 48 billion m^3 of barite, zinc, lead, salt and copper.

2.2.4 Present Water Uses

(1) Water Related Institutions

Major water sector related institutions and their major roles are indicated in Figure 2.2.6. These institutions are outlined in the following.

1) Agency of the Tensift Hydraulic Basin (ABHT)

Founded by decree No 2-00-479 of November 14, 2000 and, pursuant to article 20 of the Water Law (loi 10-95 sur l'eau), the Agency of the Tensift Hydraulic Basin (ABHT) is the new organization for water service. The Agency of the Tensift Hydraulic Basin is managed by an administrative board comprised by all of the actors for water: intellects, professional associations, user groups, industrialists, farmers, public establishments, and ministry departments, who decide on plans, programs, and projects together for water resource development in this hydraulic basin. In addition to its role of coordinator of all actors for the water management, The Agency of the Tensift Hydraulic Basin has the mission to evaluate, plan, develop and manage the water resources in the zone of action as follows:

1. To elaborate the master plan for integrated water resources development in the zone of action.
2. To monitor the application of the master plan for integrated water resources development in the zone of action.
3. To issue the authorizations and concessions of utilization in the public hydraulic domain envisaged in the master plan for integrated water resources development in the zone of action.
4. To provide all financial assistance and render services, in particular of technical assistance, to public or private persons who request it, that can be for the water resources pollution prevention, or for development or utilization of the public hydraulic domain.
5. To realize all piezometric and flow measurements, also the hydrological, hydro-geological, planning, and water management studies, from the quantitative point of view as well as from the qualitative point of view.
6. To realize all quality measurements and to apply the dispositions of this law and the current laws related to the water resources protection and the water quality restoration, in collaboration with the governmental authority in charge of the environment.
7. To propose and carry out the adequate countermeasures, according to the regulations in particular, in order to ensure the water supply in the case of declared water shortage in accordance with Chapter X of the Water Law, or to prevent the risk of floods.
8. To manage and control the use of the mobilized water resources.
9. To realize the infrastructures necessary to prevention and fight against floods in collaboration with the local communities.
10. To maintain a register of the recognized rights of water and concessions and authorizations of taking away of water that have been granted.

<u>Organization and human resource</u>

ABHT is established by the water low of 1995 and it is one of the Agencies of Hydraulic Basin (ABH) which is a public institution with the juridical personality based on self-sustenance. ABHT designates assessment of the water resources of the Tensift River, elaboration of programs/projects, and management of the water resources as duty, and it's activity was started in April, 2002. ABHT is composed of 4 divisions such as the water resources development, the hydraulic property, the information and communication system, and the human resources and financials.

After the establishment of ABHT the number of staff members has decreased from 74 to about 40, and it contributed to the cost reduction. However, securing and training of the human resources are important for the improvement of executive ability and the fulfillment of services in the future. At present, the human resources are not enough to the activity amount, and it is supposed that approximately ten persons are to be supplemented. Objects of this supplement are

information/communication, account and computer such as specialized fields.

The pumping regulation of groundwater was started in 2004, and several water polices take charge of the prosecution of the illegal groundwater user who isn't doing the well registration. However, effective activity can't be done because this prosecution is an additional activity to the daily duty. Furthermore, the water quality analysis is another activity and it is being carried out regularly.

Budget

The budget amount of ABHT in 2007 is DH 63,964 thousand. In 2003 and 2004 it increased about 100% in comparison with the previous year, and in 2005 and 2006 about 50% of the increasing rate was shown in comparison with the previous year. And, the increasing rate of 18% with the previous year is shown in 2007. As annual revenue, own revenues of service and subsidy of the State are occupied 22% and 31% respectively. The former shows the tendency of increase in amount and in rate, and the latter's rates shows a tendency of decrease. The year investment occupies about 90% of the annual expenditure.

Budget of ABHT (DH)

REVENUES	2002	2003	2004	2005	2006	2007
Own revenues of service		528,404.00	5,674,800.00	7,260,000.00	10,000,000.00	13,800,000.00
Various and accidental revenues		12,000.00				
Estimable revenues of the previous service		1,048,341	2,950,277.96	4,801,481.88	11,443,049.86	10,462,945.00
Excess of the returns achieves on the execute payments to the previous service		5,659,170.82	8,041,859.31	14,213,994.63	12,424,564.54	20,200,866.71
Subsidy of State to the title of service of the previous year non unblocked					10,500,000.00	8,500,000.00
Subsidy of State to the title of service	6,000,000.00	6,000,000.00	8,500,000.00	10,500,000.00	10,000,000.00	11,000,000.00
Total	6,000,000.00	13,247,916.00	25,166,937.27	36,775,476.51	54,367,614.40	63,963,811.71

EXPENDITURES	2002	2003	2004	2005	2006	2007
Expenditures of staff		1,634,630.60	1,524,449.60	1,392,200.00	1,180,700.00	1,843,700.00
Expenditures of materials and various expenses	0.00	2,249,845.40	2,316,427.28	2,990,188.95	2,676,824.77	4,110,950.70
Expenses of the year investment	6,000,000.00	9,363,440.00	21,326,060.39	32,393,087.56	50,510,089.63	58,009,161.01
Credit reserves	0.00	0.00	0.00	0.00	0.00	0.00
Total	6,000,000.00	13,247,916.00	25,166,937.27	36,775,476.51	54,367,614.40	63,963,811.71

Source: Financial Division

Approximately DH 7milion of a subsidy (personnel expenses) is expended from the government (Ministry of Finance & Privatization) as staff member's salary besides the budget of ABHT.

Income from royalties

The individual source of revenue of ABHT is mainly the income from extraction permission of construction aggregate material at river beds and the water sales of potable water and irrigation water. Though the income from extraction permission occupies about half, the rate shows a tendency of decrease comparatively. Water sales were started in 2004. Besides, there are DPH (Public Hydraulic Property) use fee, water sales fee for electricity generation and industrial use, permission fee of water-intake, and so on. The total amount of royalty income in 2006 was about DH 18 million. The increasing rate was shown about 80% in comparison with the previous year.

Income from royalties

Items	2002	2003	2004	2005	2006
Extraction of materials	1,121,478.00	1,265,640.00	5,317,521.00	6,176,375.00	8,795,842.50
Rate	79%	78%	66%	61%	49%
Occupation of the DPH	179,409.42	170,000.00	320,509.27	109,877.54	3,858,742.66
Rate	13%	10%	4%	1%	22%
Energy Water	126,173.36	188,980.00	290,840.00	145,020.00	193,655.40
Rate	9%	12%	4%	1%	1%
Irrigation Water	0	0	804,879.73	2,058,654.92	2,016,572.08
Rate	0%	0%	10%	20%	11%
Potable water	0	0	1,046,895.07	1,220,345.23	2,611,694.46
Rate	0%	0%	13%	12%	15%
Concession authorizations	0	0	312,600.00	377,600.00	457,800.00
Share	0%	0%	4%	4%	3%
Total	1,427,060.78	1,624,620.00	8,093,245.07	10,087,872.69	17,934,307.10

Source: Financial Division

The unit prices of the main royalties are as follows: extraction permission of the construction aggregate material is DH 0.5 / m^3 (gravel), water for electricity generation is DH 0.02 / kwh, water for industrial and irrigation is DH 0.02 / m^3, and potable water is DH 0.04 / m^3 from 2005, though it was DH 0.02 / m^3 before.

Unit price of Royalties (2006)

Items	Amount (DH)	Rate (%)	Unit price (DH)	Volume
Extraction permission of construction material	8,795,842.50	49	0.5 (/ m^3, gravel)	17,591,685 m^3
DPH use fee	3,858,742.66	22	based on the list	-
Electricity generation water	193,655.40	1	0.02 (/kwh)	9,682,770 kw
Irrigation water (ORMVA, Private)	2,016,572.08	11	0.02 (/m^3)	100,828,604 m^3
Potable water (ONEP, OCP, etc.)	2,611,694.46	15	0.02 (/m^3, 2004) 0.04 (/m^3, from 2005)	65,292,362 m^3
Industrial water	contained in the above	-	0.02 (/m^3)	-
Water-intake fee	457,800.00	3	500~1,000 (/cases)	-
Total	17,934,307.10	100		

Source: Financial Division

2) Office of National Potable Water in Marrakech (ONEP)

ONEP is a public corporation with the characteristics of private enterprises. It has been established under Dahir No. 1-72-103, as a self support accounting body to inherit the functions of REI. The Tensift Regional Directorate in Marrakech has jurisdiction over the offices in Safi, Essaouira, El-Kelaâ des Saraghna, Chichaoua and Marrakech. The main roles and the functions of ONEP at present are summarized as follows.

1. Plan and Study for assuring to supply drinking water in the country.
2. Operation and Management for production of water and distribution of drinking water for access and consumption of the people.
3. Control of water quality for production and distribution of drinking water, and water pollution control in addition to assistance for monitoring of water quality.
4. Participation in studies and projects in cooperation with the agencies/departments of the interested ministries.

In addition to the main roles and functions mentioned above, ONEP conducts activities summarized as follows.

1. Supply water to the remote rural areas adjoining to the existing water service areas.

2. Appropriate water tariff system to extend and develop the service of water in the small urban centers.
3. Training and cooperation for participants in the fields of technical and financial matters in cooperation with international organizations.
4. Raising awareness of the people for water economy through schools, audiovisual media, holiday camps, sporting and cultural events.
5. Development of new technology such as desalination and demineralization conducted especially in the south provinces.
6. Wastewater treatment to avoid negative impacts of domestic and industrial wastewater on water sources.
7. Improvement of water quality using the decentralized laboratories managed by the central laboratory to achieve regular and sustainable water quality testing to assure the required water quality for water supply.

ONEP operates 9 Regional Offices scattered all over the country. In the Haouz Plain, Tensift Office is set up in Marrakech for management of the services to Safi, Essaouira, El. Kalaa des Saraghna, Ouarzazate, Chichaoua, Zagora and Marrakech Prefecture. Currently, Tensift Office operates the water supply system in 55 communes with approximately 750 staff members.

3) Regional Agricultural Development Office of Haouz (ORMVAH)

The Regional Agricultural Development Office of Haouz (ORMVAH) was established as a public institution with civil status and financing autonomy under the Ministry of Agriculture Rural Development and Maritime Fisheries in 1966, for the purpose of agricultural development and promotion of agriculture in the Haouz Area. The roles of the ORMAVH are:

1. Studying and executing irrigation system and agricultural development projects
2. Extending new agricultural techniques, professional training
3. Organization of farmers and management of the agrarian reform sector
4. Increasing crop and animal production
5. Promoting the agro-industrial sector.

ORMVAH covers 663,000 ha of the plain area of the Haouz area, which spreads to 4 provinces: Marrakech, Al Haouz, El Kelaa des Sraghna, and a part of Azizal, and includes 69 rural communes. (Table 3.4.1)

ORMVAH has the responsibility for management of all water resources for irrigation including irrigation system and facilities in its jurisdiction area. As its activities in water management, ORMVAH has carried out technical extension service to farmers, collection of water fee, permission of well construction, regulation of illegal water take, etc., as well as operation and maintenance of irrigation system. As for the water sources, the operation and maintenance of dam facilities are carried out by ABHT, and ORMVAH takes responsibility for the one of canal systems after the dams. ORMVAH has the responsibility for the operation of Rocade Canal as well. ORMVAH prepares the water distribution plan in the irrigation sectors and requests water discharge from the dams to ABHT.

ORMVAH established 31 Agricultural Development Center (CMV) in its jurisdiction area for the purpose to give effective service for the water management and extension service to farmers. The CMVs have responsibility for management of irrigation facilities, extension service to farmer, collection of water fee in their administration area. The CMVs arrange the water use plan in the irrigation sectors in cooperation with the water users associations, and the water use plans of sectors are compiled to the water distribution plan after the adjustment of the headquarters of ORMVAH finally. After coordination with ABHT, water is distributed based on the plan.

ORMVAH conducts research and development of water use technology for effective water use in the field. The Technical Extension Center (CTE) located in Saada has the responsibility for technical development as well as conducting technical extension of irrigation.

4) Provincial Direction of Agriculture (DPA)

In the study area, the zone of action of DPA of Marrakech and Chichaoua include 11 and 14 Rural Communes, and extend over the total surface of 62,114 ha and 240,526 ha respectively.

The Provincial Directions of the Agriculture of Marrakech and Chichaoua have the principal duties as follows:

1. Hydro-agricultural developments in the Small and Medium Irrigation Systems (PMH) and pastoral land developments
2. Promotion of agricultural investment
3. Leading farmers and stockbreeders
4. Popularization of agricultural techniques and technology transfer to farmers and stockbreeders
5. Training and literacy education for rural populations
6. Promotion of women in rural areas.

Concerning agricultural water management, the Development Service is in charge of hydro-agricultural development in the PMH. In the zone of intervention of DPA of Marrakech, 22 PMH of 3,635 ha are arranged and rehabilitated by the Project of Integrated Rural Development centered on the Small and Medium Irrigation Hydraulics (DRI-PMH).

The number and the area of the PMH in each intervention zone of DPA are summarized in Table 3.4.2.

5) RADEEMA

RADEEMA is an independent public company responsible for supply of water and electricity and wastewater management in Marrakech in commercial base. The organization was established by the City Council in 1971 under jurisdiction of the Ministry of Home Office and the Ministry of Economy to provide water and electricity service.

In 2005, RADEEMA supplied water to 87 % or 748,000 of the population in Marrakech after providing purified water from ONEP. Also, RADEEMA launched an environmental conservation project since 1998 and the development project of sewerage facilities has just started in August 2006 for the works to renovate the existing sewers, install intercept sewers and construct primary sewage treatment system at the river basin of the Tensift in the north-west suburbs of the city.

To perform public services for water, electricity and sewage, RADEEMA employs about 1000 staff , of which some 300 are assigned to provide water related services.

6) Regional Inspection of Land Management, Water and Environment of Marrakech (IRATEE)

Under the MATEE, there are seven regional Regional Inspection of Land Management, Water and Environment (IRATEE), which handle the services of the Ministry at the regional Level. The main sectors that the IRATEE works on include management of sensitive areas, economy and tourism, infrastructures, social services, and environment. The IRATEE Marrakech, with its 14 permanent staff (3 administrative and 11 specialists), has been carrying out its activities since the year 2000. Currently, the organizational structure of IRATEE is being reviewed in the central level. The IRATEE Marrakech carries out its activities through a collaborative approach by three technical teams (land management, environment, urban study, and planning). In addition, an administrative cell manages administrative and financial issues. In addition, IRATEE Marrakech has a branch cell in Laattaouia with one staff member, making liaison for local issues.

(2) Major Waterworks

1) Lalla Takerkoust Dam

The Lalla Takerkoust Dam wa constructed on 1935 and it was expanded by raising the dam height to cope with the increase of water demand, as a multipurpose dam for irrigation, power supply, drinking and industrial water. The dam supplies irrigation water to the N'Fis Irrigation Sectors of 24,200 ha in total in combination with the Rocade Canal, as well as to the improved seguia system area of approximately 10,000 ha. The water of the dam is also used for the drinking water supply to the

Marrakech town area in combination with the Rocade Canal. The major parameters of the dam are:

1. River Basin: Tensift Basin - N'Fis Sub-basin
2. Catchment Area: 1,707 km^2
3. Active Capacity: 72.5 Mm^3 (currently reduced to 56.1 million m^3 in 2002 due to sedimentation.)
4. Regulation Volume: 85 Mm^3

2) New Dam Development Plans

Wirgane Dam

The construction of the Wirgane Dam started at the beginning of 2005 and is scheduled to start its service in March 2008. The dam is located 20km upstream of the Lalla Takerkoust Dam in the N'Fis River, and it is expected to be operated in combination with it in order to reinforce the drinking and industrial water supply to the Marrakech town area and to improve the regulation capacity of the Lalla Takerkoust Dam. The major parameters of the dam are:

River Basin: Tensift Basin - N'Fis Sub-basin

1. Catchment Area: 1,200 km^2
2. Active Capacity: 70 Mm^3
3. Supplemental Regulation Volume: 17 Mm^3

Taskourt Dam

The construction of the Taskourt Dam, which is located in Chichaoua Province, is scheduled to start at the beginning of 2007. The dam will supply stable irrigation water to an area of 6,000 ha which is currently irrigated in a traditional manner. The major parameters of the dam are:

River Basin: Tensift Basin – Al Mal Sub-basin

1. Catchment Area: 520 km^2
2. Active Capacity: 25 Mm^3
3. Regulation Volume: 24 Mm^3

3) Rocade Canal

The Rocade Canal is a hydraulic facility for the water transfer from the Oum Er Rbia basin to the Tensif Basin ; the transferred amount is designed as 300 million m^3/year. The water source of the Canal is the Moulay Hassan I Dam and Sidi Driss Dam in the Lakdar River of the El Rbia Basin, with total active capacity of 246.3 million m^3 (245 million m^3 for the Maoulay Hassan I and 1.3 for the Sidi Driss). The total length of the canal is approximately 120 km and the flow capacity is 20 m^3/s. In the design, the Canal takes 350 million m^3 of water from the dam complex and 296 million m^3 of water is to be transferred to the Tensift Basin to be supplied to the irrigation sectors in the Haouz Central and drinking water to Marrakech town area, as well as supplying irrigation water in the Oum Er Rbia Basin, with 33 million m^3 to the small and medium irrigation sectors of the Ladar basin of 4,000 ha and 21 million m^3 to a part of the Lower Tessaout Irrigation Sectors though B1 and B2 canal systems.

4) Traditional Irrigation System (Seguia System)

Seguia originally was a traditional irrigation system taking water from natural rivers; however, the improved irrigation canal system connected to the dam and improved concrete pavement is also called as a seguia. The seguia system is categorized according to the level of improvement. The traditional irrigation system (SIT) and improved traditional system (STA) area were observed in the Study Area.

According to the inventory survey of sguia systems in the Haouz Plain (Etude hydrologique des prélèvements au fil de l'eau dans le basin du tensift, 2003), there are 163 seguia systems in the Study Area. 31% of the systems have partial concrete structure; however, the length of concrete canal is only 6% of the total length and the majority are earth canals as shown in Table 2.2.12.

(3) Domestic Water Supply

1) Water Supply in Marrakech

Water supply in Marrakech is produced by the water treatment facilities of ONEP and provided through the water distribution network of RADEEMA.

At 17 km away from the city, the water treatment plant started operation in 1983. Present rated capacity is 1,600 L/s. Construction work is in progress at the adjacent area of the existing plant to construct 1,400 L/s water treatment processes. Half of the water treatment facilities are expected to start operation in July 2007 and the other half to be completed in 2010. After completion of the expansion project, the rated water treatment capacity will reach 3,000 L/s.

Three water intake facilities convey raw water to the water treatment plant. Most of the raw water is conveyed from Rocade Canal by 2km gravity flow pipeline. Moulay Brahim Stream that runs in Bouzougharo about 25 km away from the water treatment plant to the South is the water source of subsurface water. Subsurface water is collected by under-drain facilities that convey the flow of approximately 200 L/s to the water treatment plant as long as the water is available especially in wet season. Standby water intake facilities are located at Station-9 about 25 km away from the water treatment plant to the South-West. The water intake facilities of Station-9 divert irrigation water of ORMVA and convey 200 to 250 L/s raw water to the water treatment plant especially in summer season on request. The intake facilities suspended operation at the end of October for about 10 days due to work to remove sediments in the canal. Currently in Marrakech, there are 16 shallow wells and 19 deep wells extracting less than 300 l/s (in contrary with the original plan of 1800 l/s).

There are two distribution reservoirs operated by RADEEMA. One is located nearby the water treatment plant with the capacity of 37,500 m^3. The other distribution reservoir having the storage capacity of 55,000 m^3 is located in the South suburbs of Marrakech. Water is supplied to the consumers in Marrakech through gravity flow system. Water consumption, water production and water intake volumes are 34.6 Mm^3/year, 56.1 Mm^3/year and 58.9 Mm^3/year respectively in 2005. The water supply records shows that the domestic water consumption accounts for more than 86 % of the total water consumption and the supply of water to industries including hotels is 9 %. (Table 3.4.5)

2) Rural Water Supply Systems

ONEP manages the water supply systems in 55 communes in the administration area of the Tensift Regional Directorate. Out of 55 communes, the following 11 communes are located within the groundwater simulation boundary in the Study Area: (1) Sid Zouine, (2)Loudaya, (3) Tahannaout, (4) Ait Ourir, (5) Tameslohte, (6) Ghmate, (7) Abdallah Ghiat, (8) Lalla Takarkoust, (9) Chichaoua, (10) Tamallalt, and (11) Sidi Rahhal

All 11 communes use only groundwater sources and supply water to the communes after disinfection. Table 2.2.14 shows the water consumption of 11 communes estimated by ONEP. In total, the commune consumed 4.0 Mm^3/year with the largest portion of water, 2.9 Mm^3/year (73%) was used for the domestic water consumption in 2005.

3) Community water Supply

Localized piped water supply systems were installed in the rural communities under the assistance programs of the Ministry of Equipment and the Ministry of Agriculture, or by self-help of the communities. The houses using these water supply systems obtain water from the wells dug by themselves or from the half-underground water storage tank pumping up water from the nearby well. The population in the local communities was estimated to be approximately at 470,000 in 2005. Assuming 30 L/capita/day for water consumption in the local communities, the annual water demand is estimated at 5.2 Mm^3/year.

ONEP, in collaboration with DGH has been promoting the PAGER project, which has been started in 1995 to supply water in the remote areas to achieve the water supply coverage ratio of 92% by 2007; however, the development is delayed due to budget constraints.

4) Water Quality of Domestic Water

RADEEMA measures distribution water quality regularly at the inlet to the distribution network and the tap water in the network. Table 2.2.15 shows the water quality test results only for the major water quality parameters shown in comparison with the drinking water standard determined by ONEP for purified water quality. The test result shows that the water quality passed well within the Recommended Maximum Level of ONEP's Drinking Water Standard.

(4) Irrigation

1) Irrigation System in the Area under ORMVAH

In general, the irrigation system in the Morocco is categorized into two types: one is a large scale irrigation system (Grande Hydraulique: GH) and a small and medium scale irrigation system (Petite et Moyenne Hydraulique: PMH) (Table 2.2.16). The GH system has dam or other regulated water resources and is equipped with improved canal system. The ORMVAH has been developed complex GH irrigation systems over the plain area of the Marrakech, Al Haouz and El Kekaa des Sraghna provinces. In the jurisdiction area of the ORMVAH, there are three major irrigation areas : the Haouz Central Irrigation Area, the Upper Tessaout Irrigation Area and Lower Irrigation Area from west to east. The Haouz Central Irrigation Area is supplied water by the Rocade Canal which takes its water source to Moulay Hssan I Dam and Sidi Driss Dam in the Lakdar River and by the Lalla Takerkoust Dam in the N'Fis River. The Upper Tessaout Irrigation Area relies for its water source on the Moulay Yossef Dam in the Tessaout River, and the Lower Tessaout Irrigaition Area relies on the T2 Canal which is supplied water by the Bin El OUdane Dam. Among these irrigation areas, the Haouz Central Area and a part of the Upper Tessaout Area belong to the Haouz Plain Area. The original scheme and distribution plan of the irrigation system in the ORMVAH area are schematically shown in Fig.2.2.7 and Fig. 2.2.8.

2) Irrigation in the Area under DPAs

At moment, there is no GH irrigation system which has regulated water resources in the area jurisdiction of DPA Marrakech and Chichaoua. All irrigation systems in those DPAs are categorized into the PMH irrigation system including the traditional seguia system. In the DPA area, the irrigation areas with traditional and improved seguia system are categorized as three types: regular irrigation, seasonal irrigation and flood irrigation. The irrigation system by regular water is continuously able to take water from the river, and the irrigation system by seasonal water is able to use water during a programmed period of the year. Usually both systems have a small dam for intake in the river. On the other hands, the irrigation system by flood water supply does not have an intake dam facility in the river and is able to take water only during the period when the water level in the river is high (Table 2.2.17).

3) Traditional Irrigation System

The area and amount of water intake in seguia systems in a part of the Study Area is summarized in Table 2.2.18. This table does not include the Chichaoua and Al Mal sub-basin. The water intake by seguia system of the N'Fis River includes the discharge of improved irrigation system (STA) taking water from the Lalla Takerkoust Dam.

4) Irrigation Method at the Field

Although various irrigation methods are observed in the Study Area, the majority are basin irrigation for orchard trees and furrow irrigation for annual crops. Water management at the field level is made manually by riding and dredging water course and furrow. In the large scale farms and a part of middle scale farms, drip irrigation system is also observed, however, the rate of extension is still low. In case of the drip irrigation, groundwater is widely used for the water source because of necessity of having a pump for the system and requirement of water quality to prevent clogging in tubes. Drip irrigation is used for orchard and vegetable crops in the field. Some sprinkler irrigation, such as pivot system and linear move system, is also observed in the modern farm land, however, the number is still small.

(5) Consumption of Water Supply by User Types

As for the water consumption ratio by water user groups calculated from the water consumption in

2005. Domestic water use accounts for the majority of water consumption in the Study Area as a whole. More than 85 % of water is consumed by the domestic water users in Marrakech while 81 % of water is used in the service areas of 17 communes operated by ONEP. Water consumption ratio by the government offices, institutional buildings, schools, office buildings, etc. is about 12 % and the second largest consumer. Water consumption ratio by the industrial is 3 % in Marrakech and 6 % in 17 communes in 2005. However, the water consumption ratio of industrial water users including hotels in 2003 is about 8 %. These figures shall be confirmed in the course of the Study. (Table 2.2.19)

2.2.5 Other Social Infrastructure

(1) Transportation

The length of the road network of the Marrakech - Tensift - Al Haouz region is 4,938 km in total, of which 63% are paved. In March 2007, the highway which was operating from Rabat to Settat has been extended to the northern vicinities of Marrakech, and the section between Marrakech and Agadir is now under construction. The regional railway network extends 171 km, composed of two lines: one joins Marrakech to Casablanca, the other joins Ben Guerir to Youssoufla. Concerning air transportation, the region is endowed with two airports: Marrakech - Ménara (the 1st tourist airport of the country) and Essaouira (Le Maroc des Régions 2005, HCP 2006).

(2) Electricity

The net production of electricity by hydraulic plants of the region in 2004 is 57.9 million KWh which accounts for 3.6% of the whole country.

Table 2.2.1 Average Annual Precipitation in the Haouz Plain

Items	Sidi Rahal	Aghbalou	Tahanaout	Lalla Takerkoust	Marrakech	Abadla	Chichaoua	Sidi Bouathamane	Iloudjane
Altitude (m)	690	1,070	925	630	460	250	340	820	757
Annual Precipitation (mm)	349	535	368	259	216	176	185	345	339
Data	1970/71-2005/06							1989/90-2005/06	

Source: ABHT

Table 2.2.2 Mean Temperature and Precipitation in the Study Area

Station	Altitude (m)	Items	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Average, Annual
Sidi Rahal	690	Mean Tempereture (^{o}C) (1935-2001)	24.2	19.9	15.9	12.6	12.0	13.3	14.8	15.9	18.7	22.7	27.7	27.3	18.8
		Precipitation (mm) (1970-2005)	10.1	33.4	43.4	36.3	46.6	41.9	47.7	47.5	24.9	8.2	2.8	5.7	349
Lalla Takerkoust	630	Mean Tempereture (^{o}C) (1935-2001)	22.9	18.8	14.8	12.7	11.4	13.1	14.6	15.7	18.8	21.1	26.6	25.7	18.0
		Precipitation (mm) (1970-2005)	9.1	25.1	33.4	24.3	29.9	31.4	34.6	38.5	19.1	7.4	3.6	2.4	259
Marrakech	470	Mean Tempereture (^{o}C) (1935-2001)	25.3	21.1	16.3	12.8	11.9	13.8	16.1	18.0	21.2	24.5	28.6	28.7	19.9
		Precipitation (mm) (1970-2005)	5.2	16.3	25.5	22.4	26.4	26.1	39.6	29.8	10.5	5.1	1.0	2.1	216

Source: Temperature - Etude d'Actualization des Ressources en Eau de Surface de la Zone d'Action l'Agence du Basiin Hydraulique du Tensift
Source: Precipitation - ABHT

Table 2.2.3 Comparison of Annual Precipitation between Different Periods

Location	Average of 70/71-05/06 (1)	Average of Last 10 years (95/96-05/06) (2)	(2)/(1)
Marrakech	220 mm	204 mm	92%
Sidi Rahal	349 mm	319 mm	92%

Source: ABHT

Table 2.2.4 River System and Subbasin of Tensift River

Tensift River Basin		Left Bank of Tensift River upstream from Chichaoua Basin		Inflow Point to Haouz Plain Aquifer
Sub-basin	Area (km2)	Major Tributaries	Area (km2)	
Tensift Basin downsteam from the confluence of Tiroula River	1,494			
Tensift Basin between the confluences of Tiroula River and Chichaoua River	2,129			
Chichaoua Basin	2,453	Chichaoua, Imintanout River, Seksawa River	2,453	at Iloudjane
Tensift Basin between the confluence of Chichaoua River and N'fis River	5,166	Assif Al Mal River	3,122	at Sidi Bouathmane
N'fis Basin	2,212	N'fis River	2,212	at Lalla Takerkoust
Tensift Basin between the confluences of N'fis River and Rhmat River	2,417	Rheraya River	1,588	at Tahanaout
Tensift Basin upsteram from the confluence of Rhmat River	3,930	Rhmat River, Ourika River, Zat River, Ghdat River, Lagh River	3,490	at Aghbalou, Taferiat and Sidi Rahal
Total	19,800		12,866	
*: Areas were calculated based on the GIS databse of ABHT.				
**: Total area of the Tensif River Basin was defined as 19,800 km2.				
Source: ABHT GIS Database adjusted.				

Table 2.2.5 Monthly and Annual Mean Discharge of Tensift River and Its Major Tributaries

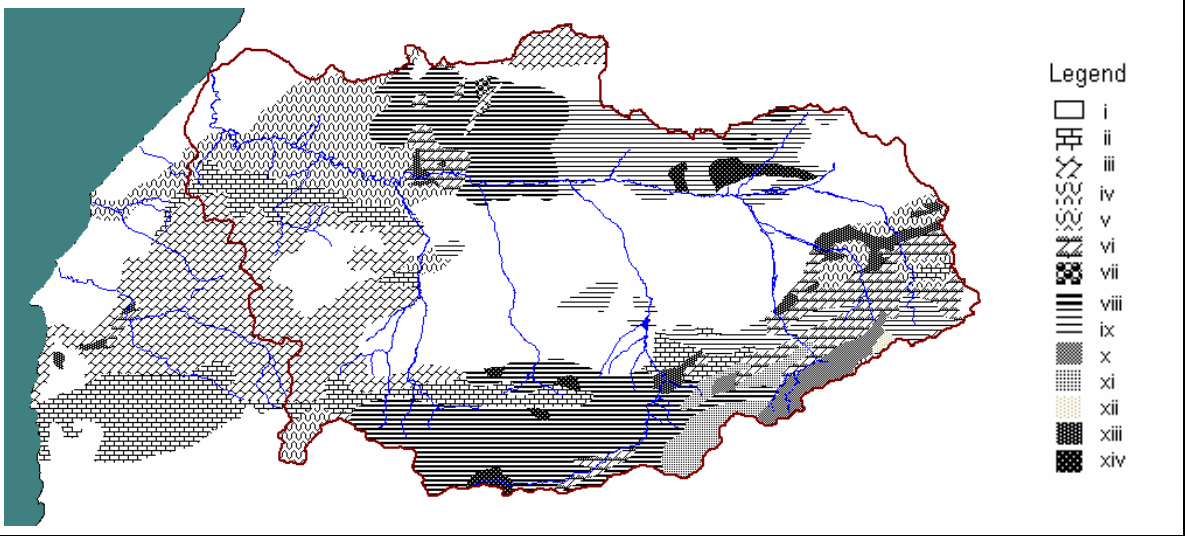
Unit : Mm^3

Station	River	Data	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Annual	Runoff during Nov-May
Talmest	Tensift	*1	1.13	12.99	15.65	18.68	21.08	19.93	31.74	36.61	24.75	5.18	0.17	0.16	188.1	90%
Abadla	Tensift	*2	1.10	7.03	10.56	12.24	16.82	16.52	27.91	32.77	23.08	5.08	0.47	0.48	154.1	91%
Sidi Rahal	R'Dat	*2	1.06	4.14	5.76	5.48	8.68	9.16	15.58	12.31	7.98	2.12	0.66	0.74	73.7	88%
Aghbalou	Ourika	*2	3.87	6.12	6.43	8.63	9.53	12.09	30.42	36.73	31.15	11.70	3.13	2.89	162.7	83%
Tahanaout	Rherhaya	*2	0.89	2.06	2.35	2.25	2.71	3.49	5.78	7.89	8.69	4.94	1.67	1.08	43.8	76%
Lalla Takerkoust	N'Fis	*1	1.90	8.97	12.52	20.32	18.36	20.12	29.29	26.30	15.74	7.12	2.19	1.78	164.6	87%
Sidi Bouothmane	Assif El Mal	*3	0.54	3.50	1.57	3.17	2.31	3.09	5.12	5.23	2.83	1.49	0.36	0.65	29.9	78%
Chichaoua	Chichaoua	*4	0.40	2.01	1.19	2.18	3.27	2.46	3.08	2.22	1.61	0.93	0.23	0.09	19.7	81%

*1: Average from 1970/71-2003/04, *2: Average from 1970/71-2005/06, *3: Average 1985/86-2005/06, *4:Average from 1970/71-2004/05

Data of 1989/90 was rejected due to its pecuriarity. Source: ABHT

Table 2.2.6 Geological and Hydrogeological Features in the Tensift Basin



Legend No.	Geological features	Hydrogeological features	Main Distributed Area in the Tensift Basin
i	Neogene and Quaternary deposit of the coastal plain, and Neogene and continental Quaternary sediment filling internal basins and plateaus	Moderate-High permeability, Main aquifer in Haouz Plain	Haouz Plain (Essaouira-Chichaoua)*
ii	Jurassic to Cretaceous of internal synclinal basin (Cretaceous and Eocene)	Permeable	(Essaouira-Chichaoua)*
iii	Secondary and tertiary deposit, plain or small fold in hard zones in central plateaus	Permeable, Aquifer in Essaouira-Chichaoua Plateau	Essaouira-Chichaoua
iv	Jurassic deposit, plain or small fold in hard zones in central plateaus (Dolomite and calcic marl)	Very low permeability	Jblit
v	Secondary fold of the High Atlas, especially Lias and Jurassic (dolomite, marl and occasionally sandstone)	Moderate-Low permeability, Deep aquifer	High Atlas
vi	Permian-Triassic (sandstone, conglomerate and red clay)	Very low permeability	High Atlas (Jblit)*
vii	Autunien (lower Permian) (conglomerate, sandstone and red clay)		(Jblit)*
viii	Paleozoic: Cambrian-Ordovician-Silurian (schist, micaschist, quartzite, limestone)		Jblit, High Atlas
ix	Paleozoic: Carboniferous (schist, micaschist, quartzite, limestone)		Jblit (Haouz Plain, High Atlas)*
x	Precambrian II-III geo-synclinal (flysch) and granite (Marocanides)	Moderate-Low permeability with fissures/fractures	(High Atlas)*
xi	Precambrian III (or lower Low-Cambrian)		
xii	Precambrian III (or lower Low-Cambrian) : volcanic rock (rhyolite, ignimbrite, andesite)		
xiii	Basaltic dolerite: upper Triassic	Very low permeability	(Jblit, High Atlas)*
xiv	Granite: Hercynian (Late Paleozoic)		

Source: ABHT *): Area in parentheses = distributed partly

Table 2.2.7 Population of the Study Area

Province	Commune	Population	% of the whole S. A.	Number of Urban	% of the whole Urban	Urban Rate in Province	Population Density (per km2)
Marrakech	16	1,023,514	63%	816,293	89%	80%	620
Al Haouz	20	277,377	17%	32,086	3%	12%	124
E.K. Sraghna	10	132,993	8%	38,765	4%	29%	124
Chichaoua	16	179,032	11%	32,694	4%	18%	54
Total	62	1,612,916	100%	919,838	100%	57%	195

Source: Recensement Général de la Population et de l'Habitat 2004, Haut Commissariat au Plan, 2005

Table 2.2.8 Industrial Production by Sector

(Unit: million DH)

Sector	2002	2003	
Agro-food industry	3,410	3,436	60%
Textile and leather industry	500	604	11%
Chemical and parachimique industry	1,452	1,571	27%
Mechanical and metallic industry	122	110	2%
Electric and electronic industry	20	17	0%
Total	5,504	5,738	100%

Source: Le Maroc des Régions 2005, HCP, 2006

Table 2.2.9 Land Use of ORMVAH and DPA Managed Area

Items	DPA Marrakech		DPA Chichaoua		ORMVAH			
					Whole area		Concerned communs	
Number of Communes Rurals	32		35		69		32	
Surface Area (ha)	600,000		687,200		648,394		372,565	
Land Use								
-SAU (ha)	173,016	29%	160,000	23%	489,564	76%	272,948	73%
-Forest (ha)	216,092	36%	110,000	16%	22,656	3%	20,946	6%
-Pastures and uncultivated (ha)	210,892	35%	417,200	61%	136,174	21%	78,671	21%
Total (ha)	600,000	100%	687,200	100%	648,394	100%	372,565	100%
Irrigation								
-Non-Irrigation (ha)	117,916	68%	92,012	58%	211,819	43%	92,779	34%
-Irrigation (ha)	55,100	32%	67,988	42%	277,745	57%	180,169	66%

Remarks : Data includes outside of the Study Area.
Sources:
Monographie de la Zone DPA de Marrakech, 2005
Monographie Agricole de la Province de Chichaoua, 2006
Monographie Commune Rural, 2003-2004, ORMVAH

Table 2.2.10 Agricultural Surface and Production in the Study Area

Province	Marrakech *1		Al Haouz *1, 2		El Kélâa Sraghna *1		Chichaoua	
	Area (ha)	Production (QX)	Area (ha)	Production (QX)	Area (ha)	Production (QX)	Area (ha)	Production (QX)
Cereals	44,410	347,652	65,926	567,928	59,627	1,153,007	74,645	473,299
whistle-berry	1,280	44,770	132	2,201	84	7,694	571	93,213
Forages	6,185	2,954,560	3,219	717,840	2,313	2,065,360	749	495,540
Vegetables	3,570	609,255	2,116	437,460	2,589	660,430	1,140	205,125
Arboriculture	43,296	2,344,109	20,046	553,020	15,239	243,397	13,936	409,425

Sources: *1: Data by ORMVAH (Monograph of rural commune, Data of 2003/2004)
*2: Data by DPA Marrakech *3: Data DPA Chichaoua

Table 2.2.11 Number of Livestock and Traction Animals in the Study Area

Province	Number of livestock				Number of traction animals		
	Bovine	Ovine	Goats	Camels	Horses	Mules	Asses
Al Haouz	47,429	210,033	42,096	103	951	3,202	22,138
Chichaoua	22,892	263,946	65,975	244	552	2,756	15,916
El Kelâa Sraghna	60,268	253,441	29,697	60	1,879	4,360	22,881
Marrakech	35,084	125,458	4,765	22	380	668	9,415
Total	165,673	852,878	142,533	429	3,762	10,986	70,350

Source: Ministry of Agriculture, Rural Development and Fishery Maritime (2000): General Agricultural Census, Results by communes

Table 2.2.12 Number of Seguias and Conditions

Sub-basin	Number of Canals			Length of Canal (km)		
	Partially Concrete	Earth Canal	Total	Concrete Lining	Earth Canal	Total
Assif El Mal	3	13	16	1.5	140.5	142.0
Chichaoua	2	11	13	6.3	35.7	42.0
N'Fis	6	25	31	20.5	223.9	244.4
Ourika	19	11	30	6.3	163.2	169.5
R'Dat	1	26	27	0.3	124.0	124.3
Rheraya	3	12	15	0.5	119.5	120.0
Zat	17	19	36	30.2	193.3	223.5
Total	52 31.0%	116 69.0%	168	65.5 6.2%	1,000.2 93.8%	1,065.7

Source: Etude hydrologique des prelevements au fil de l'eau dans le bassin du Tensift, 2003

Table 2.2.13 Status of Water Supply Service (Marrakech-2005)

Population (x 1,000)	859.5
Served Population (x 1,000)	747.8
Annual Water Consumption (M.m^3/year)	
Domestic : House Connection	29.16
Domestic : Public Taps	0.45
Govt. Office, Institutional Bldgs., Schools, Office Bldgs., etc.	4.09
Industries including hotels	0.89
Total Annual Water Consumption (M.m^3/year)	34.59
Annual Average Water Production (M. m^3/year)	56.12
Annual Average Water Intake (M. m^3/year)	58.93
Estimated Water Loss Ratio (%)	38

Data Source : RADEEMA modified by the Study Team

Table 2.2.14 Status of Water Supply Service (11 Communes of ONEP-2005)

Population (x 1,000)	97.6
Annual Water Consumption (M.m^3/year)	
Domestic : House Connection	1.64
Domestic : Public Taps	0.06
Govt. Office, Institutional Bldgs., Schools, Office Bldgs., etc.	0.26
Industries including hotels	0.10
Others	0.04
Total Annual Water Consumption (M.m^3/year)	2.10
Annual Average Water Production (M. m^3/year)	3.30
Annual Average Water Intake (M. m^3/year)	3.46
Estimated Water Loss Ratio (%)	36

Data Source : ONEP modified by the Study Team

Table 2.2.15 Distribution Water Quality in Marrakech (2006)

Parameters	unit	RADEEMA Test Results for the Major Water Quality Parameters		ONEP Standard Recommended Max. Value (VMA)
		Minimum	Maximum	
Turbidity	NTU	0.35	1.20	5
pH	-	7.35	7.90	9.2
Nitrate	mg/L	5.52	9.10	50
KMnO4 consumption	mg/L	0.25	0.80	-
Iron	mg/L	0.28	0.3	0.3
Arsenic	mg/L	< 0.003		0.05
Cadmium	mg/L	< 0.001		0.005
Lead	mg/L	< 0.005		0.05
Conductivity	µS/cm	600	900	2,700
Chloride	mg/L	44	150	750
Calcium	mg/L	74	115	-

Data Source: RADEEMA

Table 2.2.16 Sectors of Haouz Central Irrigation System

Location	Sectors	Area (ha)	Designed water demand (Mm3/y)	Actural rerouce
N'Fis Right Bank	N1-1	21,100	46.5	Lalla Takerkoust Dam
	N1-2, N2, N3		112.6	Rocado Canal
			12.2	Groundwater
N'Fis Left Bank	N4	3,160	22.5	Lalla Takerkoust Dam
	Improved Seguia	10,000	12.9	Lalla Takerkoust Dam
Haouz Central	H2	4,621	46.0	Rocado Canal
	R1	3,795	38.8	Rocado Canal
	CV	1,600	14.3	Rocado Canal
	R3	2,868	29.1	Rocado Canal
	Z1	1,460	15.2	Rocado Canal
Pump Sector	N5	800	7.0	Pump
	R1 Downstream	720	6.8	Pump
	Z7	1,005	9.0	Pump
Total		**41,129**	**372.9**	

Source: Etude des schemas d'interconnexion des grande barrages

Table 2.2.17 Irrigable Area and Distribution of Irrigation Type

(Unit : ha)

DPA	Number of Commue Rurals	Physical Area	SAU	Rainfed Field	Irrigable Field	Irrigation Type		
						by regular water	by seasonal water	by flood water
Marrakech	10	110,152	49,892	34,842	15,050	4,820	3,916	6,314
Chichaoua	13	317,536	139,444	94,959	44,485	9,810	13,565	21,110
Total	23	427,689	189,336	129,801	59,535	14,630	17,481	27,424

The data covers Commune Rurals concerned to the Study Area.
Source: ORMVAH, DPA

Table 2.2.18 Area and Amount of Water Use of Seguia Systems in Study Area

Sub-basin	Area (ha)	Amount of Water (1000m3)	Unit water use (m3/ha)	Data
N'Fis	38,800 *1	95,550 (16,804) (6,7801) (10,945)		Average of 1985-2003 (Continous) (Seasonal) (Flood)
Ourika	25,299	93,142	3,682	Average of 1985-2001
R'Dat	31,085	44,806	1,441	Average of 1985-2001
Rheraya	10,465	26,046	2,489	Average of 1985-2001
Zat	19,872	49,474	2,490	Average of 1985-2001
Total *2	125,521	309,018		

*1: Estimated by unit water use of 2,462m^3/ha

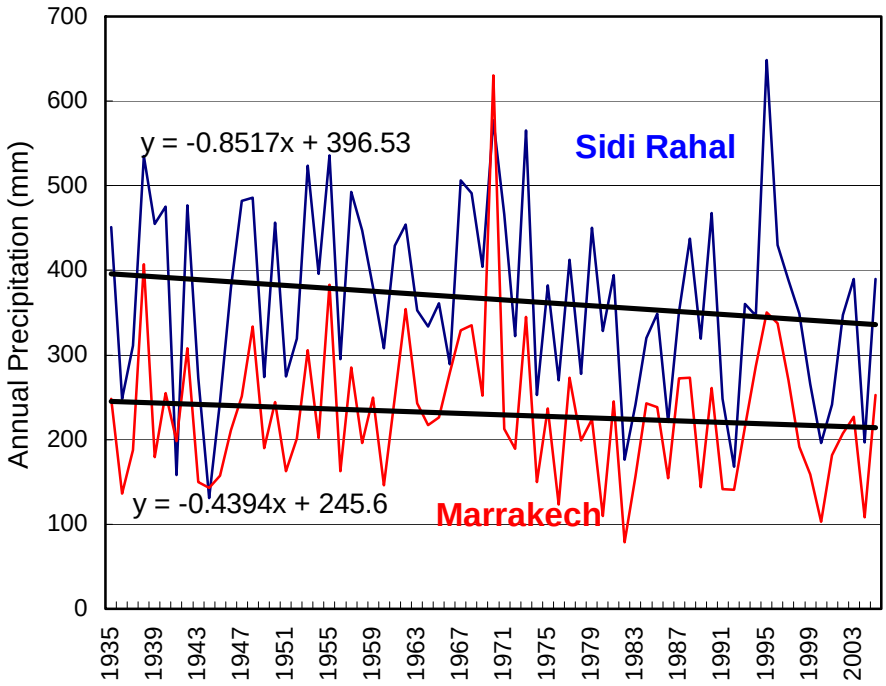
*2: Subbasin of Assif El Mal and Chichaoua are not included due to lack of data.

Source: Etude hydrologique des prelevements au fil de l'eau dans le bassin du Tensift, 2003

Table 2.2.19 Water Consumption by User Types (2005)

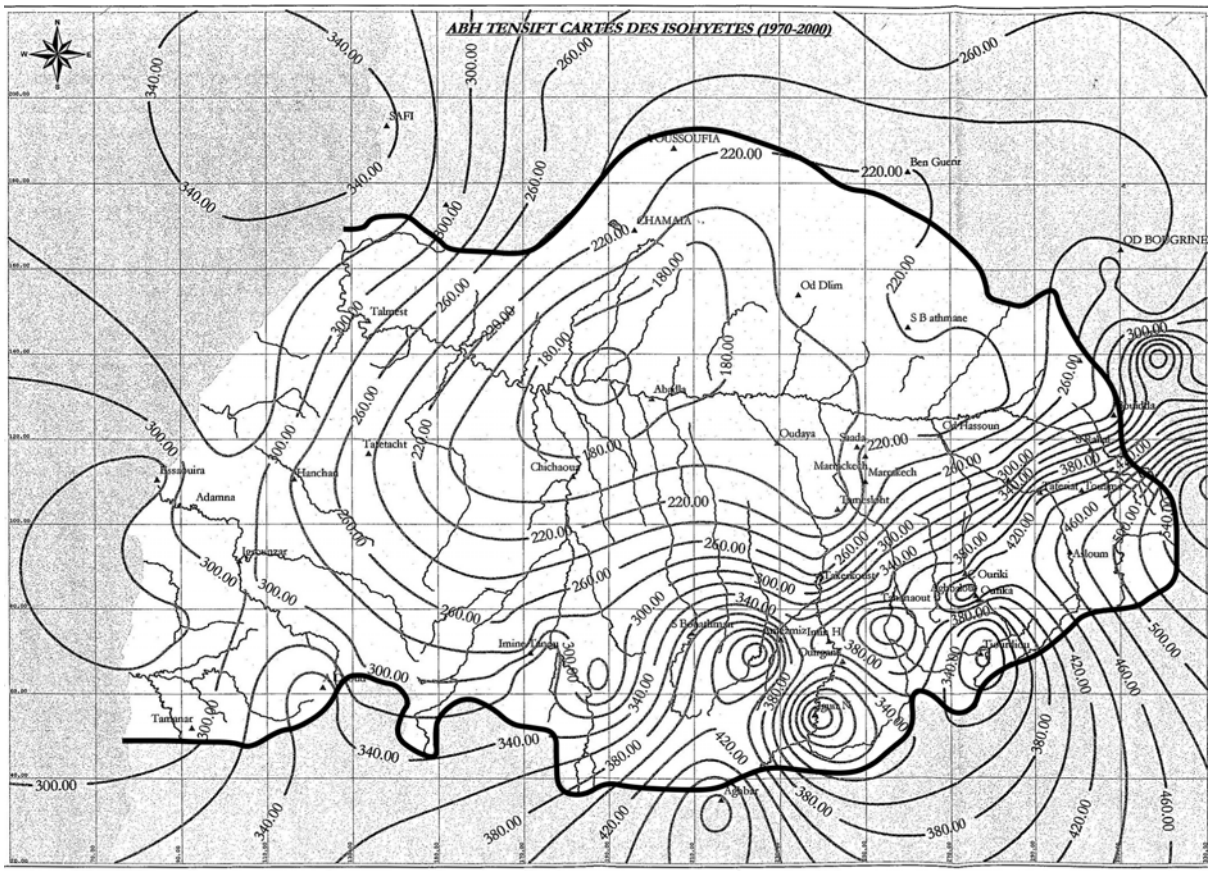
Marrakech (RADEEMA) and 17 Communes (ONEP)	Water Consumption 2005	Ratio by User Groups (%)	
Annual Water Consumption (M.m3/year)			
Domestic : House Connection	30.80	84.0	-
Domestic : Public Taps	0.51	1.4	-
Govt. Office, Institutional Bldgs., Office Bldgs., etc.	4.34	11.8	-
Industries including hotels	1.00	2.7	-
Others	0.04	0.1	-
Total	36.69	100	-
Marrakech (RADEEMA)			
Annual Water Consumption (M.m3/year)			
Domestic : House Connection	29.16	84.3	79.5
Domestic : Public Taps	0.45	1.3	1.2
Govt. Office, Institutional Bldgs., Office Bldgs., etc.	4.09	11.8	11.1
Industries including hotels	0.89	2.6	2.4
Others	0.00	0.00	0.0
Total	34.59	100	94.3
17 Communes (ONEP)			
Annual Water Consumption (M.m3/year)			
Domestic : House Connection	1.64	78.2	4.5
Domestic : Public Taps	0.06	2.7	0.2
Govt. Office, Institutional Bldgs., Office Bldgs., etc.	0.26	12.4	0.7
Industries including hotels	0.10	5.0	0.3
Others	0.04	1.7	0.1
Total	2.10	100	5.7

Data Source : ONEP and RADEEMA



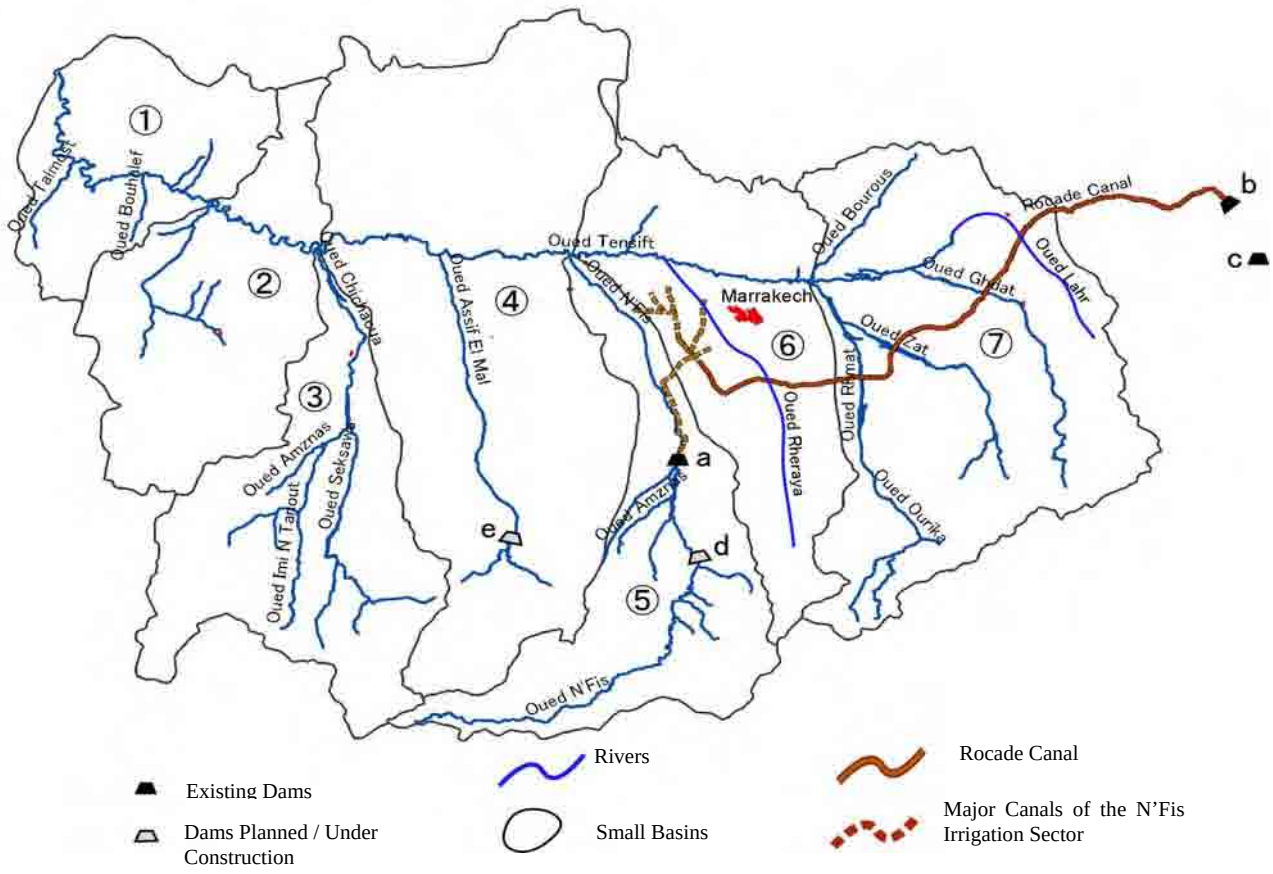
Source: ABHT

Figure 2.2.1 Long Term Change of Precipitation in the Study Area



Source: Etude d'Actualization des Ressources en Eau de Surface de la Zone d'Action l'Agence du Basiin, ABHT

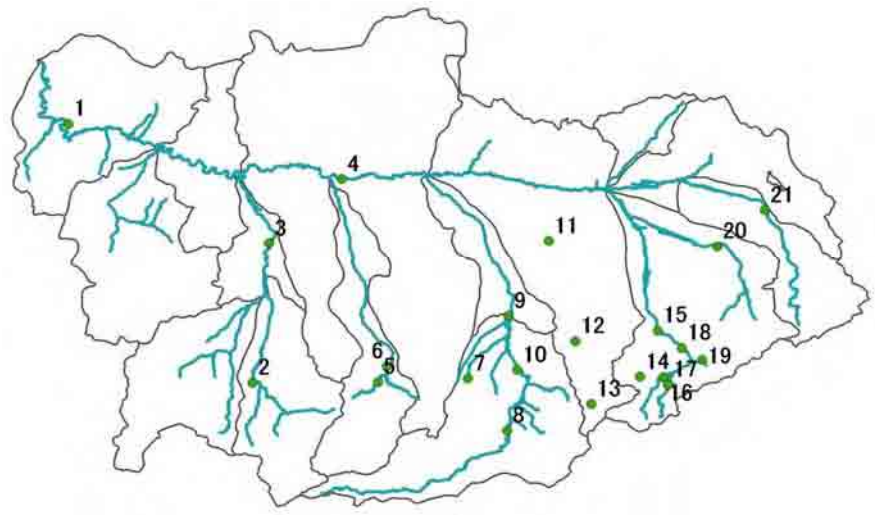
Figure 2.2.2 Isohyetal Line in the Tensift Basin (Average of 1970-2000)



Small Basins		Dam Sites	
①	Down Stream Side of Tiroula River	a	Lalla Takerkoust Dam
②	Between Tiroul and Chichaoua Rivers	b	Sidi Driss Dam
③	Basin of Chichaoua River	c	Moulay Hassan I Dam
④	Between Chichaoua and N'fis Rivers	d	Wirgane Dam
⑤	Basin of N'fis River	e	Taskourt Dam
⑥	Between N'fis and Rhmat Rivers		
⑦	Upstream Side of Rhmat River		

Source : ABHT

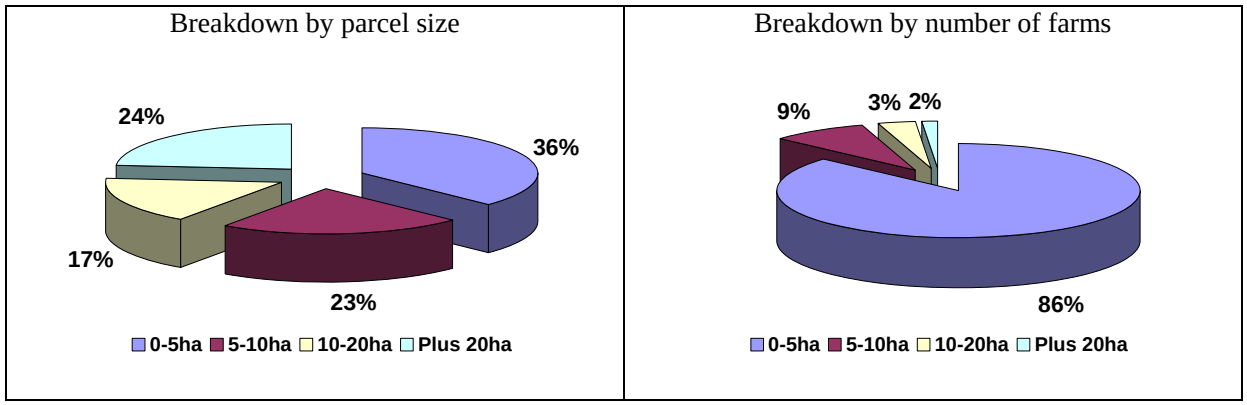
Figure 2.2.3 River System of Tensift Basin



No.	Station	Rainfall	Flow
1	TALMEST	○	○
2	ILOUDJANE	○	○
3	CHICHAOUA	○	○
4	ABADLA	○	○
5	TASKOURT	○	○
6	SIDI BOUATHMANE	○	○
7	SIDI HSAIN	○	○
8	IGUIR NKOURIS	○	○
9	L.TAKERKOUST	○	–
10	IMIN EL HAMAM	○	○
11	MARRAKECH	○	–
12	TAHANAOUT	○	○
13	AREMD	○	○
14	AGOUNS	○	–
15	AGHBALOU	○	○
16	TIOURDIOU	○	○
17	AMENZAL	○	○
18	TAZITOUNT	○	○
19	TOURCHT	○	○
20	TAFERIAT	○	○
21	SIDI RAHAL	○	○

Source: ABHT

Figure 2.2.4 Observation Network operated by ABHT



Source: Data from SGRID, ORMVAH

Figure 2.2.5 Farm Scale by Area and Number of Farms in the Study Area (ORMVAH Zone)

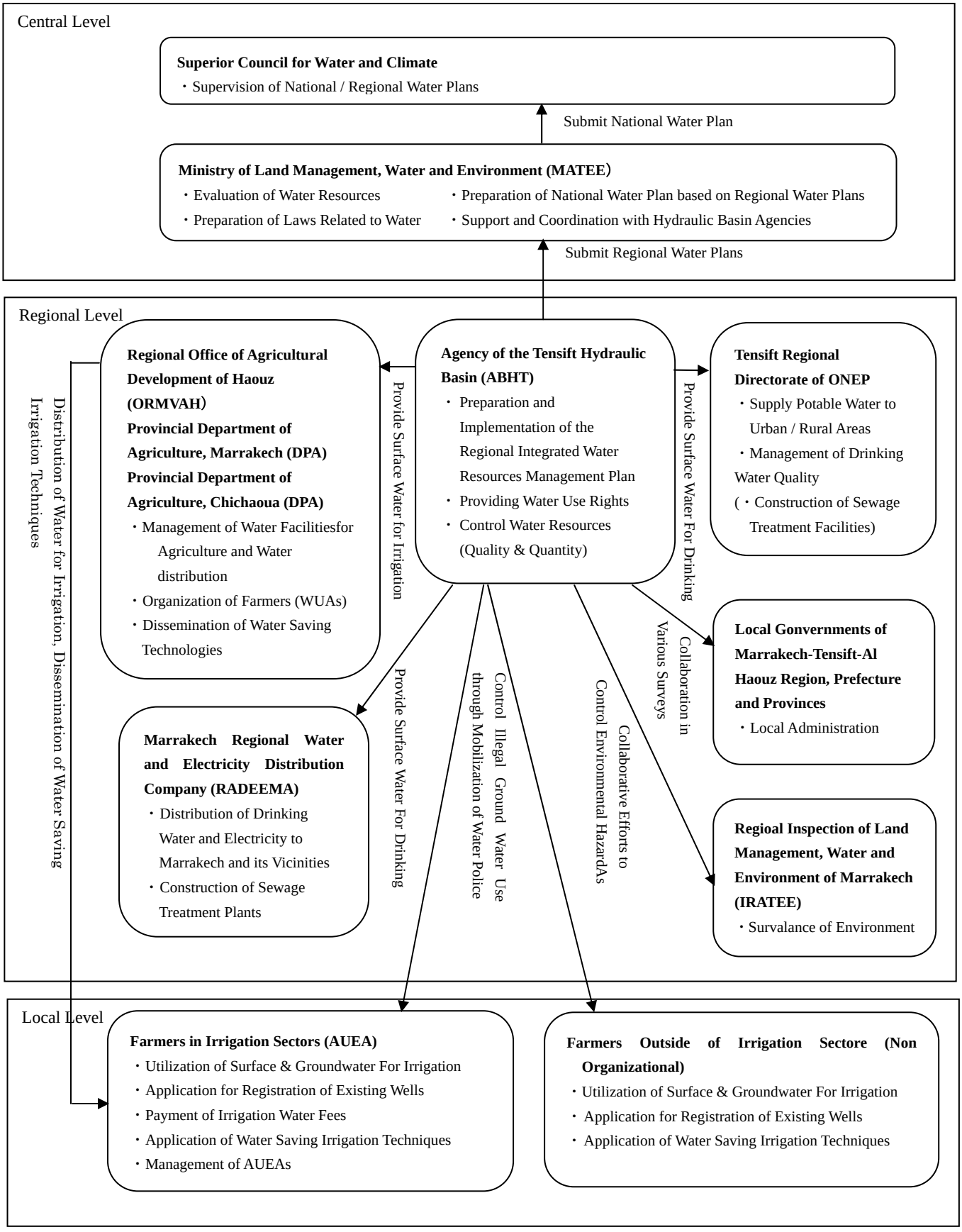
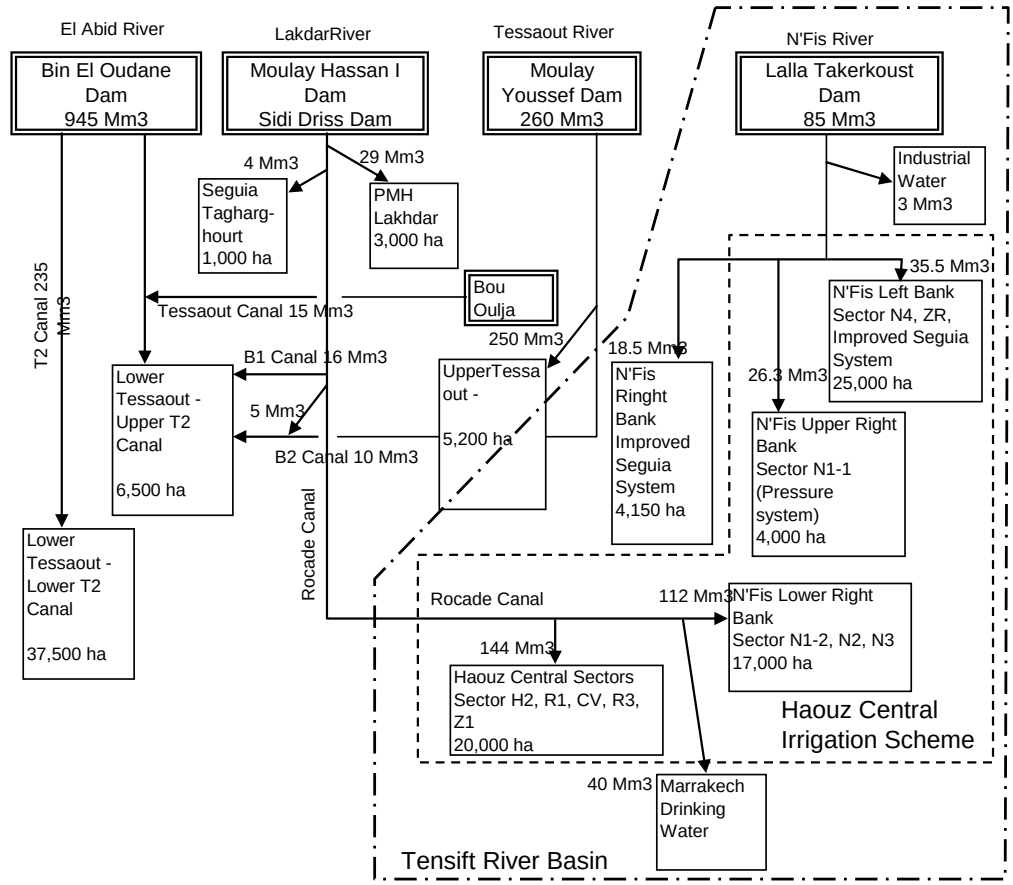


Figure 2.2.6 Major Water Related Institutions and Their Roles



Source: ORMVAH

Figure 2.2.7 Original Plan of ORMVAH Irrigation Scheme

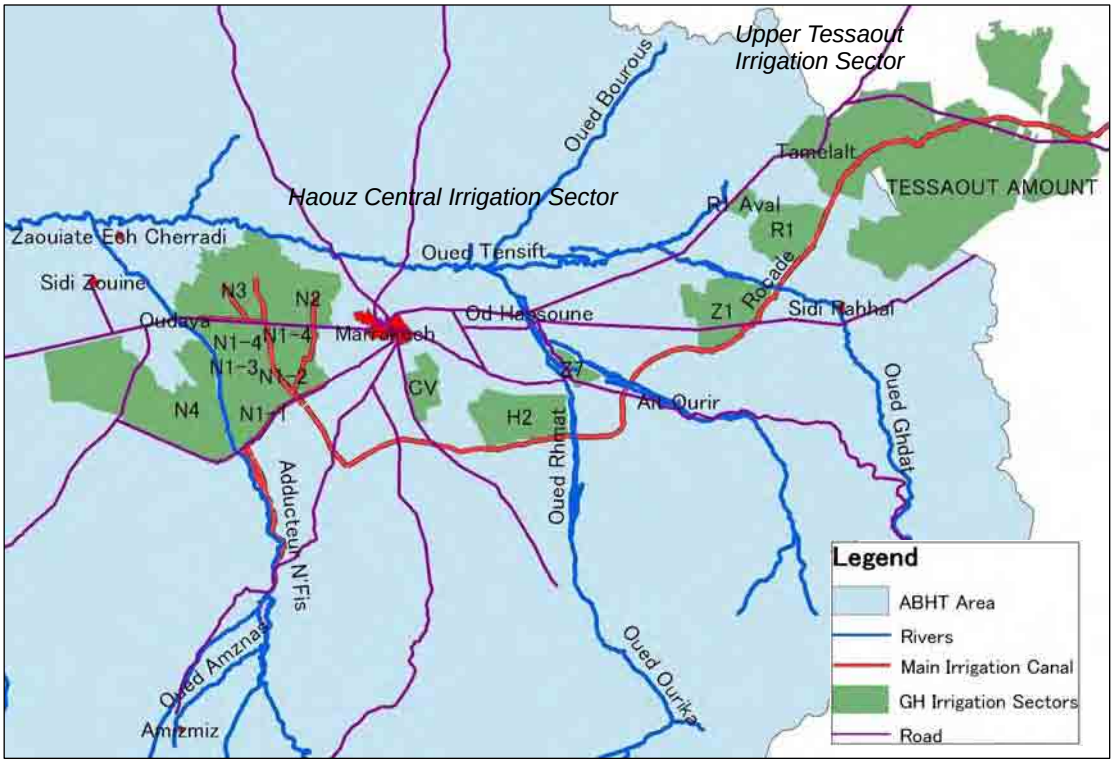


Figure 2.2.8 GH Irrigation Sectors of ORMVAH

CHAPTER 3 PRESENT CONDITION AND POTENTIAL OF THE WATER RESOURCES IN THE STUDY AREA

3.1 Previous Projects and Studies on Water Resources Development

3.1.1 Water Resources Development Projects

In the Haouz Plain Area, the modern development of water resources were started on 1980's, which is represented by the development of the Rocade Canal Complex and piling up of the Lalla Takerkoust Dam. The Rocade Canal Complex was started from the beginning of 1980's and the Sidi Driss Dam had completed on 1984 and the Rocade Canal completed on 1985. By the completion of the construction of the Moulay Hassan I Dam on 1987, the Rocade Complex was completed. The development of irrigation sectors had been continued in parallel with the construction of the canal complex, the first section of irrigation sectors had been completed with Z1 Sector on 2000. The Lalla Takerkoust Dam is given an important role to supply water to the Marrakech urban area as well as supplying agricultural use in the centre of the Haouz Plain. The Dam was established on 1935, and it was piled up on 1980 to recover and increase its reservoir capacity to cope with the increase of water demand both for agriculture and drinking water and power supply. In relation to this Study, ABHT has carried out a study titled "Actualisation de l'Etat de Connaissance des Ressources en Eau dans les Bassins Hydrauliques de Tensift" in 2004 to evaluate the situation of water resources. The Master Plan prepared by ABHT is now being revised based on the results of this study.

3.1.2 Water Resources Development Studies

(1) The Tensift River Basin Management Plan

The 9th session of the Moroccan Superior Council for Water and Climate published the Tensift river basin management plan (« Plan Directeur pour le Développement des Ressources en Eau des Bassins du Tensift », Conseil Supérieur de L'eau et du Climat, 9ième session). This very detailed document aims to define the optimal mobilisation plan of the water resource over the whole Tensift and Ksob basins and some additional Atlantic basins. It gives, for the covered areas (including the Haouz plain), a detailed assessment of the resources. Several scenarios of development were studied and a development plan was proposed, with an economic analysis and an environmental assessment.

(2) The Integrated Hydrogeological Study in the Tensift River Basin

The integrated hydrogeological study for the estimate of the water resources of the Tensift River Basin (« Etude de synthèse hydrogéologique pour l'évaluation des ressources en eau souterraine du bassin hydraulique du Tensift ») was conducted from 2002 to 2003 by ANTEA and ANZAR consulting firms for the DRH. Most of the available documents describing the geological or hydrogeological prospecting or the hydrogeological behaviour of Haouz plain aquifer were consulted and integrated. Complementary field surveys were conducted (groundwater abstraction, water table level, etc.), an exhaustive GIS was developed, and the mathematical model of the aquifer (developed in 1972 and 1986) was updated to transient mode.

This document gives a perfect understanding of the aquifer system behaviour and of the water balance limits. All the hypothesis used to construct the water balance are detailed in the final document and can now be revised or discussed (re-infiltration of irrigation water in excess, direct rainfall infiltration, participation of rainfall in the crop water demand, aquifer parameters –especially porosity, etc.).

Regarding the water management plan, this study demonstrates that the present development involves all of the water collected by the Haouz unit, and that there are very few opportunities to increase this development with this limited resource.

(3) The Pilot Study of Artificial Groundwater Recharge in the N'Fis River

A pilot study of artificial recharge was conducted in 1984 and 1985 in the Haouz plain (« Expérimentation d'un dispositif de recharge artificielle dans le cadre du Projet de Développement des Ressources en eau de l'Afrique du Nord - Projet PNUD Rab 80/011 »). Two sites were selected for

the experiment: along the Zat River, where the floods are not controlled, and along the N'Fis River, controlled by the Lalla Takerkoust dam.

The Zat River experiment couldn't be conducted efficiently: a very low flood level in 1984 prevented any significant recharge and a large flood in 1985 destroyed the experimental works.

The N'Fis experimental device consisted of a series of infiltration basins. In 1984, some 1.26 Mm^3 of surface water were infiltrated to the aquifer in 43 days, and some additional 0.35 Mm^3 in 16 days were infiltrated in 1985. Technical constraints (i.e. mainly topographic and hydraulic constraints) were evidenced. Technical and economic studies were conducted, demonstrating interest for a combination dam/artificial recharge device.

(4) Survey on Artificial Recharge in Morocco

The Survey on artificial recharge in Morocco was conducted by the DRPE in 2003. This document describes the theoretical bases of the artificial recharge. It gives a brief description of the three projects conducted in Morroco: the Chorf Al Akab aquifer recharge, for the Tanger water supply, still functioning since 1958; the Souss aquifer recharge along the rivers, from 1991; and the Haouz aquifer experiments conducted in 1984 and 1985.

The authors propose a program of artificial recharge over 20 areas in the whole country, with an implementation schedule and the corresponding annual budgets. For the Haouz aquifer, the proposed project plans an artificial recharge of some 50 Mm3/year.

(5) Study on Actualization of Surface Water Resources in ABHT Area

The Study on the Actualization of Surface Water resources in ABHT Area («Etude d'actualisation des ressources en eau de surface de la zone d'action de l'Agence du Bassin Hydraulique du Tensift») was conducted by CID Consultant and the Report on Sub-mission I.1 Assessment and Actualization of Precipitation Data («Critique et actualisation des données pluviométriques») was issued on February 2005. In the Mission I.1, precipitation data was collected and assessed so that historical precipitation data of 1935 to 2002 was prepared for future analysis. Two kinds of isohyets graph (i.e., data of 1935-2003 and of 1970-2000) was prepared in the Mission as well as various meteorological analysis was conducted based on the historical data. This report gives information on precipitation in the ABHT action area and it is considered as one of most basic and valuable data source for studying hydrology in the area.

(6) Study on Large Dam Connection Scheme among the Tensift, Lakhdar and Tessaout Basin

The Study on the Large Dam Connection Scheme among the Tensift, Lakhdar and Tessaout Basin («Etude des schémas d'interconnexion des grands barrages des bassins : Tensift, Lakhdar et Tessaout») was conducted by INGEMA Consultants under the contract with Direction of Hydraulic Management (DAH) and the final report was submitted on March 2005. The objective of the study is examining the interconnection of existing large dams and possibility of new dam sites technically and economically, in order to cope with increase of water demand in the region and solve deficit of water resources. As a conclusion of the study, the following comments were pointed out:

- Abandon of Ait Segmine Dam Project due to large scale negative socio-economic impact to the region.
- Recommendation of implementation of the interconnection of N'Fis and Lakdar Basin.
- Recommendation of implementation of the interconnection of Tessaout and Lakdar Basin,
- The advantages of Ait Ziat Dam Project including combination with Tinzilliyt Dam was mentioned.
- The advantages of Tiyoughza Dam and Wirgane Dam Project was mentioned.

(7) Other Major Studies

The ABHT submitted in April 2006 an internal document about the drinking and industrial water supply of Marrakech city (« Alimentation en eau potable et industrielle de la ville de Marrakech »). This document proposes a detailed assessment of the present situation of the water demand in Marrakech city and the forecast needs up to 2020. It includes an overview of the possible development

of the water resource: groundwater, artificial recharge, surface water, irrigation optimalisation and wastewater conversion. The document assumes the water demand at 2020 in Marrakech and its vicinities as 79 – 129 Mm3 for potable and industrial water supply, and 30Mm3 for golf courses, large scale resort development and gardening, etc.

3.2 Present Conditions of Surface Water

3.2.1 Meteo-hydrological Network and their Data

ABHT has a rain gauging network composed of 20 stations within the Haouz Plain. The stations and their data availability are listed in Table 3.3.1. In addition to the ABHT network, there are meteorological observation networks managed by ORMVAH and the National Meteorological Direction in and around the Haouz Plain. The flow gauging stations of several rivers are operated by ABHT too. The stations and the data availability are shown in Table 3.2.2.

3.2.2 Surface Runoffs

According to the Tensift River Water Resources Development Master Plan 2001, the Tensift basin had 1,124.5 Mm^3 of effective inflow including the transfer from Oum El Rbia River based on the historical data of 1935-1997. The inflow was re-evaluated in the *Actualisation de l'Etat de Connaissance des Ressources en* Eau *dans les Bassins Hydrauliques du Tensift 2004* as 1,067.8 Mm^3 with transfer based on the data 1970-2002 as shown below. The effective inflow into the Haouz Plain is estimated as 967.7 Mm^3 including transfer on average in the estimation. (Table 3.2.3)

3.2.3 Water Supply from Dams

The actual record of the discharge of the Rocade Canal in the last 10 years is summarized in Table 3.2.4. The total discharge of the Canal varied from 77.6 Mm^3 to 191.8 Mm^3 and the average was 150.1 Mm^3, which is equal to 43% of the designed discharge of 350 Mm^3. The deficit of the discharge is considered to be partly affected by the reduction of dam capacity by sedimentation; however, the main reason is considered to be the lack of precipitation in the catchment area of dam system. The lack of precipitation has been fixed in recent years and it has become a regular condition of the dam. It is necessary to take into account of this climatic change and deficit of dam discharge. It is also necessary to set a reasonable design discharge of the Canal during examining the water balance of the Haouz Plain Area. This will be examined in successive work in the Study.

The record of discharge of the Lalla Takerkoust Dam is summarized in Table 3.2.5. It shows that the dam supplies 86% of design discharge on average. In consideration of the severe drought in 2000/2001 and 2001/2002, the average value is comparatively verified. However, the Lalla Takerkoust Dam is affected by the sedimentation and it has lost more than 20% of the storage capacity in the past 20 years. The decrease of storage capacity affects the effective outflow of the dam and it is expected to become unable to bypass in near future.

3.2.4 Water Taken by Traditional Seguia System

The seguia systems taking water from natural rivers are important water sources for irrigation in the Study Area. Because the traditional seguia systems connected to rivers do not have any water regulation system, the amount of water intake by them is highly fluctuating every year. In accordance with the inventory survey in Etude hydrologique des prélèvements au fil de l'eau dans le basin Tensift, the average amount of water intake by traditional seguia system excluding the N'Fis sub-basin is 257.7 Mm^3 on average in 1985-2001, and the ratio of water intake to river discharge was from 50% to 63%, where the overall average is 54.3% (Table 3.2.6). Relying to this average ratio, the amount of water intake by the traditional seguia systems was estimated as shown in Table 3.2.7, in order to examine the water balance in this stage.

3.2.5 Sedimentation

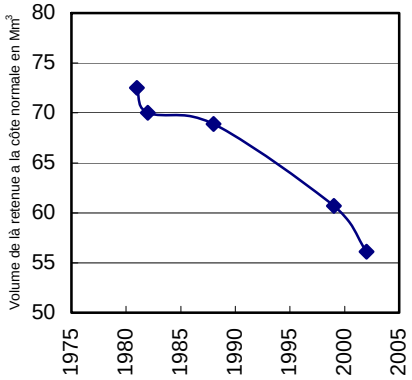
As mentioned in the section 4.3.3, The sediment transport to dam is a serious problem for the water management of the Tensift Basin. According to the Actualisation de l'Etat de Connaissance des Ressources en Eau dans les Bassins Hydrauliques du Tensift 2004, the unit runoff of sedimentation of

the N'Fis River is estimated as 240 ton/km^2/year at the Lalla Takerkoust, and it reduces the capacity of the Lalla Takerkoust Dam by 1.53 Mm^3/year. The sedimentation of the dam has so far resulted in a 20% decrease of the storage capacity of Lala Tekerkoust Dam; from 72.5 Mm^3 in 1981 to 56.1 Mm^3 in 2002.

Sediment Transportation of Tensift Basin

Specific Station	River Name	Catchment Area (km2)	Sediment Runoff (ton/km2/year)
Lalla Takerkoust	N'Fis	1,692	240
Tahanaout	Rheraya	225	185
Taferiat	Zat	516	440
Sidi Rahal	R'dat	569	3,015

Source: Actualisation de l'Etat de Connaissance des Ressources en Eau dans les Bassins Hydrauliques du Tensift, ABHT, 2004



Source: ABHT

Transition of Storage Capacity of Lalla Takerkoust Dam

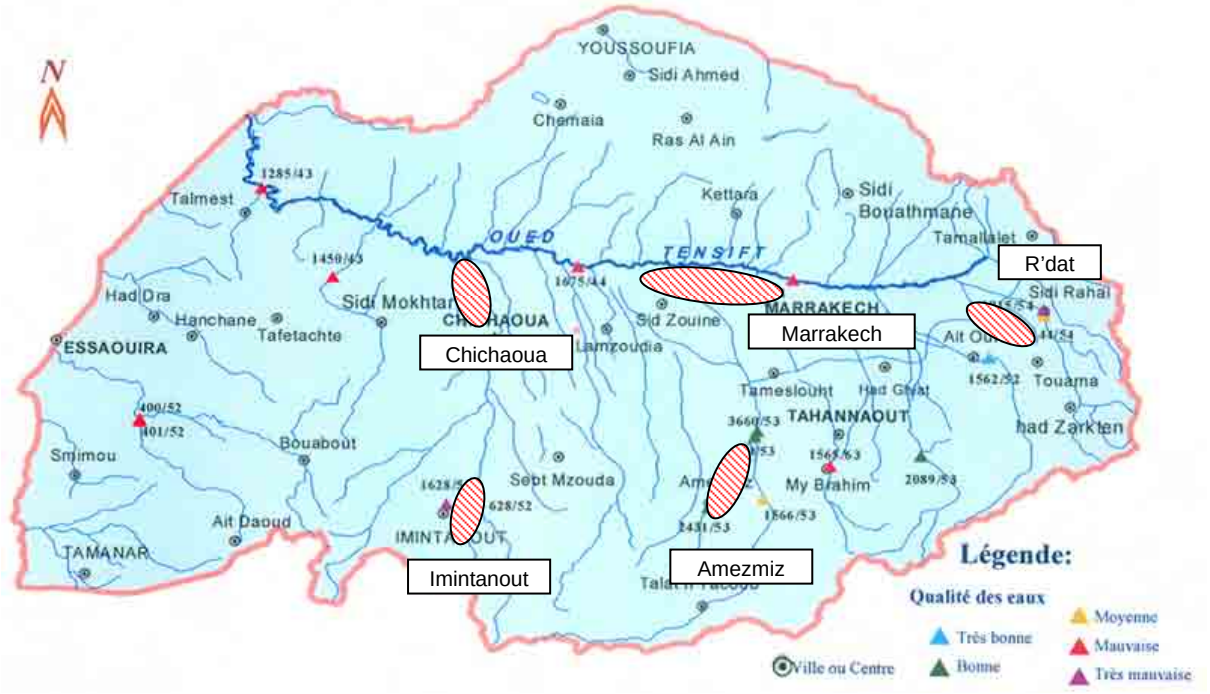
3.2.6 Floods and Flood Forecasting and Warning System

In and around the Study Area, the tributaries of Tensift Rivers have their catchments in the High Atlas Mountain area and they had suffered flood damage frequently in the valley area. The most severe flood was the one on August 1995 in which 55 villages in Ourika and other area was flooded. The Aghbalau Station of the Ourika Valley recorded 1,000 m^3/s, and the Tahanaout Station of the Rheraya River 680 m^3/s. The total damage amount was estimated at 70 MDH. The MATEE and JICA conducted the Master Plan Study on Flood Forecasting and Warning System for Atlas Region from March 2000 to December 2003, and some of the proposed flood forecasting and warning system was equipped, including automation of hydrological observation system at 5 flood watch station, etc., in the Pilot Project during the Study as well as the Master Plan was formulated.

3.2.7 Water Quality

Water quality standards for surface water are defined under Decree No. 1275-01, promulgated in December 2002. Under these standards, water quality of surface water is categorized into 5 levels based on a variety of parameters: Excellent, Good, Average, Bad and Very bad. Water quality survey by ABHT in 2004-2005 indicates "average" to "good" for the majority of surveyed points (Table 3.2.8). However, areas near major cities and towns indicated lower quality. These include:

Tensift river:	discharges of waste water of the city of Marrakech.
Imintanout river:	downstream of the center of Imintanout
R' dat river:	downstream of the center of Sidi Rahal
Amezmiz river:	downstream of the rejections of the center of Amezmiz;
Chichaoua river:	downstream of the center of Chichaoua;



Source: ABHT

Surface Water Quality in the Haouz Plane (2004-2005)

Table 3.3.8 indicates water quality of selected survey sites. The classification of water quality (River water) is done based on 6 items. For sites categorized into "bad" and "very bad", majority of the reason was the amount of Chemical Oxygen Demand (DCO) and total Phosphorous. Other items showed rather good results for most of the samples.

On the other hand, turbulence of water by suspended soil also affects the water quality of major rivers including that of Rocade Canal by pressuring the process for treatment of drinking water and filling dams with sediments

3.3 Present Groundwater Conditions

3.3.1 Hydrogeological Mechanism in the Haouz plain

The hydrogeological mechanism in the Haouz plain is quite well-known, understood from numerous geologic and piezometric investigations which took place since the beginning of the 20th century. The aquifer of the Haouz plain is formed by the Neogene to Quaternary deposits over the Palaeozoic and older formations of the Atlas/Jbeliat mountains. These heterogeneous deposits (form coarse gravels to consolidated conglomerate, and from siltite to clay), are permeable. The groundwater is developed in the Haouz plain through khettaras since the 10th century.

This aquifer is recharged from the rain and from the rivers entering the plain. It can also be recharge from the surrounding aquifer systems (see section 3.2.3). It then discharge naturally to the Jurassic limestone in the north of Chichaoua and by drainage to the rivers. The details of the natural recharge and discharge mechanisms are describe in section 4.4.3.

3.3.2 Groundwater Table and Groundwater Quality

<u>Existing groundwater observation well network</u>

In addition to the private wells and boreholes, hundreds of piezometers have been drilled by the former DRH (current ABHT), particularly since 1983. The piezometric campaigns beneath the Haouz aquifer are nowadays conducted by for four (4) organisations:

1) The Wilaya provincial services of water are in charge of some piezometers in the Mejate plain

area. The last campaign was conducted in June 2005. Eleven (11) water level measures were performed.

2) The Haouz provincial service of water is in charge of some piezometers in the Central Haouz plain area. Campaigns are regularly conducted and the last one was conducted in August 2006. Nine (9) water level measures were performed.
3) The HYDRAUMET company is contracted by ABHT to survey every two months some twenty one (21) piezometers beneath the whole aquifer, including five (5) covered by the Wilaya and five (5) covered by the Provincial service.
4) ABHT is surveying the five (5) piezometers equipped with automatic data loggers, recording EC, water temperature and pH as well as groundwater level.

In addition to these "regular" surveys, piezometric campaigns can be conducted (usually by consultants) for a specific study, as in 2002[1]. Due to the poor number of piezometers measured in the "regular" campaigns, these large campaigns are the only ones which gives enough information to draw a piezometric map. According to Razoki et al. (2000[2]) an optimized piezometric network of the aquifer should include some 110 piezomters, including those in the Oriental Haouz area (outside the Tensift river basin). Additional piezometers to the current network are clearly necessary, including at least:

1) Downstream, beneath the northwestern part of the aquifer (sector of Ain Beïda/Sidi Chirek), the hydraulic gradient controlling the aquifer discharge is far for being precisely known: the closer piezometer to the aquifer border is 20 Km far. To improve the gradient knowledge, an additional piezometer is necessary somewhere around Oulad Mbarek, north of Ain Beida.
2) Upstream, beneath the southern part of the aquifer, in the sector of Zgaggma/Zawia south of Gamassa, the flow entry needs to be precise. Additional piezomters in this sector are necessary in order to better understand the potential flux from this border of the Atlas Mountains.
3) In the extreme East limit of the Central Haouz plain, the piezometric information is poor, especially the position of the piezometric crest between this part of the aquifer and the oriental Haouz. Two additional piezometers should be constructed along this limit.

To date, the topographic information of the piezometers (coordinates and elevation) is given by the topographic maps scale 1:50,000. The piezometric maps are drawn using this information, with an error of about 5 m (the topographic line equidistance is 10 m). All the piezometers included in the measurement campaign, including private wells and boreholes, should be precisely levelled in order to draw precise piezometric maps. An updated database of the whole piezometric network is under construction for the ABHT.

Installation of additional automatic groundwater gauges through this Study

Installation of piezometers equipped with automatic data loggers are being done through this Study; in several wells, which are regarded important for monitoring of groundwater level in the Study Area. There are two major aims in the installation of these piezometers

1) To ensure, for this minimal network, the permanence of the measurements, whatever may be the availability of the staff in charge of the measures, the contracting conditions (in case of externalization of the measures), or the terrains conditions (flooding).
2) To ensure the ability of the ABHT to conduct by itself, with its own staff, a series of measures on a minimal network and improve the monitoring of groundwater by reducing the time for this operation.

The selection of a minimal automatic network has been maid aiming to give the best regional distribution of the measures, specifically including measures beneath: upstream and downstream sectors, rapid changing zones (important abstraction or recharge zones) and no flow limits.

The wells of which the piezometers are equipped were selected within the existing observation

[1] Etude de synthèse hydrogéologique pour l'évaluation des ressources en eau souterraine du bassin hydraulique du Tensift. (2004) ANTEA-ANZAR for ABHT

[2] Razoki B., Er-Rouane S., El Hebil A. (2000) Piézométrie et optimisation du réseau de contrôle de la nappe plio-quaternaire du Haouz (Marco) Bull. Hydro. 18, Neuchâtel

network of ABHT.

In this way, the installation of 10 new gauges (SEBA brand as the 5 existing ones) has been carried out in the Haouz plain, in addition to the 5 existing automatic data loggers. The piezometers selected for being installed with automatic data loggers are as follows (location indicated in Figure 3.3.1):

1) On the western border of the aquifer, piezometers N° 1580/52 in the south and 1753/53 in the north.
2) On the southern border , piezometers N° 2826/53, 2715/53 and 2700/53 Eastward (in addition to 1580/52 and the two already equipped with automatic data logger 3834/53 and 3849/53)
3) On the extreme east of the aquifer, piezometer N° 3139/53.
4) In the N'Fis sector, piezometers N° 3664/53 and 4151/44 (Associated with the already automatic 3849/53, these three piezometers give a slice of this sector identified as a large abstraction one)
5) Along the northern border of the aquifer, piezometers N° 4403/44 and 4402/44 (in addition to 4151/44).

Selected Piezometers to be Equipped with Automatic Data Logger

IRE	Coordinates		Depth (m)	Water thickness (m)	Probe length	Proposed probe
	X	Y				
1753/53	188,350	114,503	69.6	29.8	62	3 bars
1580/52	183,800	85,000	73.0	14.6	65	2 bars
2826/53	204,000	88,000	107.0	32.0	100	5 bars
2700/53	254,450	99,050	70.8	16.9	64	3 bars
3139/53	292,500	118,300	120.0	55.0	81	3 bars
3664/53	223,550	117,650	68.6	23.1	61	3 bars
4151/44	210,000	125,040	80.0	56.0	58	5 bars
4402/44	273,200	119,100	98.0	67.0	56	5 bars
4403/44	232,500	124,500	90.0	50.0	82	5 bars
2715/53	245,000	103,050	85.0	60.4	64	5 bars

Groundwater table deterioration

Figure 3.3.2 describes the changes in the water table from 1965 for few selected piezometers. According to the oldest water table measurements beneath the plain, the groundwater depletion was first observed in the beginning of 70's, mainly in the central part of the aquifer (see IRE 2941/44 and IRE 2162/44) where it could reach some 1 m/year. In the Mejate plain in the western end of the area, this drawdown was also recorded, but in a quite small rate, not reaching 0.1 m/year.

This depletion continued up to beginning of the 90's. It could even stop earlier beneath the irrigated perimeters[3] where the water table locally rises up. Then, and up to 1998, most of the piezometers show inter-annual changes around an average value, reflecting a total steady-state of the aquifer (Figure 3.3.3).

This steady-state mode is confirmed with the comparison of the piezometric maps drawn for 1986 and 1998 (Figure 3.3.4 and 3.3.5). From these maps, a calculation of the changes in the wet volume of the aquifer shows that this figure is nearly null (the wet volume of the aquifer even seams to lightly increase between 1986 and 1998).

From 2001, most of the piezometers show an important drawdown, from one meter to more than 10 m in one single year at some places (see IRE 0385/53). An important deficit in rainfall is recorded in 2001; this deficit impact together the direct recharge of the aquifer from the rain and the recharge from the surface irrigation water which both decrease and the groundwater abstraction which increase(see section 3.3.3). This 2001 year seams to be the first one of a significant deficit in the groundwater balance and consequently of the reserve depletion. The calculation of the changes in the wet volume of the aquifer from the piezometric maps drawn for 1998 and 2002 (Figure 3.3.5 and 3.3.6) shows that

[3] Abourida A., Errouane S., Leduc c., Chehbouni G. (2004) Impact de la modernisation agricole sur l'évolution piézométrique de la nappe phréatique du Haouz (Maroc central). Proceeding of Modernisation de l'Agriculture Irriguée Symposium held in Rabat, April 2004

this figure is large: somewhere between 200 to 1 600 Mm^3, for an average porosity between 1 to 8% (according to the well tests reported by Bernert and Prost[4]). The preliminary groundwater balance (see section 3.8.3) confirms that a deficit is recorder from the agricultural campaign 2000/01, but probably not during the 1993-2000 period, even though some local water depletion can be recorder some place to place[5].

Groundwater quality

Table 3.3.1 shows the groundwater quality standard prepared by ABHT and proposed to the Ministry for final approval.

Groundwater quality tests have been carried out regularly by ABHT for the production wells and monitoring wells. The groundwater quality test data analyzed for the period from 1991 to 2004 is summarized in Table 3.3.2 in comparison with the provisional groundwater quality standard. Findings of the groundwater quality tests for 2,349 samples are summarized as follows:

- Conductivity ranges in the level of "good-medium" except for the remarkable numbers of samples shows the concentration in the level of "very bad".
- Oxidizable matter is rather low for most of the samples.
- Chloride ranges in the level of "excellent – medium" except of the remarkable numbers of samples shows the level of "very bad".
- Nitrogen in the form of Ammonia and Nitrates shows the tendency in the level of "excellent – medium". Decomposition of nitrogen is in progress in most of the wells.
- Faecal coliform ranges in the level of "excellent – good"

More than 90 % of the test samples grouped in the level of "excellent – medium" and the status of groundwater quality in Haouz Plain is acceptable level. However, it shall be noted that some of the wells about 8% are contaminated and appropriate mitigation measures shall be taken.

3.3.3 Groundwater Recharge and Natural Discharge

The process of inflow / outflow of groundwater into the aquifer of the Haouz Plain is summarized in the following.

Process of Inflow / Outflow of Groundwater into the Aquifer of the Haouz Plain

Process of Inflow / Outflow		Amount of Inflow / Outflow
Inflow	Direct inflow from precipitation	4% of the annual precipitation (38 – 110 Mm^3)
	Recharge of excess irrigation Water	Assumed from actual usage of irrigation water
	Recharge from rivers and seguias	25% of flow in rivers and seguias
	Inflow from the aquifers of the Atlas mountains	220Mm^3/year (varying depending on the groundwater level in the Haouz plain)
Outflow	Outflow from the lower end of the Haouz plain aquifer to lower aquifers	4-5.5Mm^3/year
	Outflow through rivers	81-142Mm^3/year - Occurs when groundwater level reaches the altitude of the riverbed - No outflow when groundwater storage is low

(1) Natural recharge of the aquifer

The aquifer natural recharge process is probably the most difficult parameter to evaluate. At least, five types of aquifer recharge can operate in the same time:

- Direct infiltration of the rain.
- Beneath the irrigated areas, infiltration of irrigation water in excess (both coming from surface water or groundwater).
- Preferential infiltration along the river bed and the traditional seguia network, during the flood periods.

[4] Bernert G., Prost J-P (1975), Le Haouz de Marrakech et le bassin du Mejjate *in* Ressource en Eau du Maroc Tome 2, Plaines et bassins du Maroc Atlantique. DRE, Rabat

[5] It is important to precise here that a piezometric drawdown is not necessary the illustration of a groundwater balance deficit.

- Lateral flow from the atlas mountains geological formations.
- Ascending leakage from the eo-cretaceous aquifers underlying the Plio-quaternary series of the Haouz plain aquifer.

Direct infiltration of the rain: The part of the direct infiltration of the rain is recognized by most of the authors as limited, and possibly negligible. Using isotopic techniques, Abourida et al.[6] show that most of the natural groundwater recharge comes from the infiltration of rainfall at some 1200 to 1900 m of altitude, far from the altitude of the Haouz plain (250 to 800 m). The authors couldn't quantify the part of direct rainfall infiltration over the plain, but it can be considered that this figure is less than 10 to 20% of the total inflow to the aquifer.

The last groundwater modeling study[1] estimates the direct rainfall infiltration over the Mejate plain of about 6% of the total rainfall. Over the Central Haouz plain, the authors do not repeat this ratio but estimate a total value for recharge, dominated by the infiltration of the excess irrigation water. If the 6% is hardly applicable for the whole plain (it may then represent more than 25% of the total inflow of the aquifer), a total value of 4% of rainfall can probably be applied over the 6 149 Km² of the plain: it gives an annual value of 40 to 110 Mm^3.

Estimate of the Direct Rainfall Infiltration from 1993 to 2004

	Agricultural campaign										
	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04
Average rainfall over the plain (mm)	289	304	446	380	298	251	223	153	214	262	299
Volume of direct rainfall infiltration (Mm^3)	71.0	74.9	109.7	93.5	73.2	61.8	54.9	37.6	52.7	64.4	73.5

For a total inflow of about 465 Mm^3/year (see section 3.9.3 – Groundwater balance), an estimate of 40 to 110 Mm^3/year of direct rainfall infiltration is consistent with the order of magnitude given here before (average of 70 Mm^3, for 15% of the total inflow).

Infiltration of irrigation water in excess: According to the authors of the last groundwater modelling study[1], the major part of the infiltration over the Central Haouz plain comes from the irrigation water in excess, this irrigation water coming from both surface water and groundwater. This hypothesis is shared by Abourida et al. (2003[7]). These authors show the recovery of the groundwater levels beneath the N'Fis irrigated perimeter when the surface irrigation water distributed in this perimeter reach the largest values. They conclude of an important recharge beneath this site. Another cause could nevertheless explain the piezometric level recovery: a diminution of the groundwater abstraction when surface water is provided for irrigation. It is probable that both phenomena occur at the same time.

The volume of the infiltration of irrigation water in excess is certainly excessively difficult to estimate. Beneath the irrigated perimeters, it is potentially more efficient to evaluate the net abstraction, i. e. the growth groundwater abstraction beneath these perimeters minus the local infiltration of surface water (see section 3.5.1 - Existing well inventory and abstracted volumes).

Preferential infiltration along the river bed during the flood periods: The riverbeds are mainly constituted of coarse materials, favouring an infiltration of the flood water. Bernert and Prost (1971[4]) evaluate the preferential infiltration along the oueds and along the traditional seguia system of the Central Haouz plain to 183.3 Mm^3 for an average year. This figure represents an average of 20 to 30% of the yield of the rivers then entering the system.

The authors of the 2004 water balance[8] estimate that some 30% of the yield of the rivers entering the system minus the volume diverted for irrigation may reach the aquifer, for a total value of about

[6] Abourida A, Leduc C., Errouane S., Blavoux B – Apport de la géochimie à l'étude de la recharge de la nappe du Haouz (Maroc central), under review

[7] Abourida A., Razoki B., Errouane S., Leduc c., Prost J-P. (2003) Impact de l'irrigation sur la piézométrie du secteur N'Fis au Haouz Central de Marrakech (Maroc). Hydrology of the Mediterranean and Semiarid regions. Proceedings of an international symposium held at Montpellier, April 2003

[8] 2004, ABHT internal document

65.2 Mm^3 in 2004. The difference comes from the traditional seguia system, not taken into account in this estimate; for this work, it was considered as part of the return flow from irrigation water.

As a first estimate, an average ratio 25% of the flood water can be considered for the infiltration along the riverbed and the traditional seguia system. The changes in the preferential infiltration along the riverbeds during the flood periods can be estimated for each agricultural campaign, as given in Table 3.3.3.

Lateral flow from the Atlas Mountains and ascending leakage from the Eo-cretaceous aquifers underlying the Plio-quaternary series of the Haouz plain aquifer: Several estimates of the inflow coming from the aquifers surrounding the Haouz plain were made, often very different from one to another.

Bernert and Prost (1971[4]) estimated the lateral inflow for the Central Haouz to 45.2 Mm^3 for an average year. This work, modified in 2003[1] and extended to the Mejate plain, gives some 152 Mm^3 (including 67 Mm^3 at south and south-east of the Mejate plain) and the last groundwater modeling study[1] concludes of a value close to 221 Mm^3 in 2000/01 (including 86 Mm^3 at south and south-east of the Mejate plain). According to the piezometric maps and specially those drawn for 1972 before the development of the irrigated areas and the closer to natural conditions, a large amount of the aquifer flow comes from the southern limit of the Central Haouz part of the aquifer; it is facilitated there by major colluvial structures. There is no indication that the lateral inflow south and south-east of the Mejate plain is higher. The last two estimates, which give a lateral inflow beneath the Central Haouz plain from 1,3 to 1,6 times larger than beneath the Mejate plain, certainly reflect the distribution of these flows, the border of the aquifer being there approximately 1,7 times longer than the Mejate's. The total lateral inflow should then be about 180 to 230 Mm^3/year.

According to the ABHT 2004 estimate, the major part of this inflow is located at the river's entrance in the plain. The authors estimate a lateral inflow of about 17,5 Mm^3/year: 4.0 Mm^3 for the Central Haouz and 13.5 Mm^3 for the Mejate plain. These figures, abnormally low (especially for the Central Haouz part) should be compare to an estimate of the infiltration of irrigation water which reaches 250 Mm^3/year, certainly largely overestimated.

For these three studies, the potential ascending leakage from the Eo-cretaceous aquifers underlying the Plio-quaternary series of the aquifer of the Haouz plain is not integrated in the balance. In the study for 1972[4], the aquifer recharge from the Lias reservoir (including the oriental Haouz sector) was estimated to 50.5 Mm^3/year. In the study for 1987[9], an estimate of the inflow from Cenomanian-turonian aquifer gives some 9.5 Mm^3/year.

The total inflows from the surrounding aquifers certainly reach some 190 to 290 Mm^3. As a first estimate, some 220 Mm^3/year will be considered at the present stage. This figure should lightly increase with the drawdown of the water table which increase the hydraulic gradient.

(2) Natural discharge of the aquifer

The piezometric maps drawn for 1986, 1998 and 2002 (Figures 3.3.3 to 3.4.6) show that the groundwater flow converges toward the north-western limit of the aquifer, the Sidi Chiker sector, where the calcareous substratum is outcropping. The Jurassic limestones are very certainly in hydraulic continuity with the alluvial deposits of the Haouz plain. Here, a large evaporation takes place in the low-flow channel of the Tensift River, locally recognized as a perennial part of the River (according to locals, the river never became dry). The total outflow in this sector can be estimated using two ways:

1) Along the 15 000 m of this perennial part of the Tensift River, the low-flow channel is about 30 m large, as an average. The evaporation in this area is estimated to 2 700 mm/year[4]. The total evaporation in this area should be about 1.2 Mm^3/year.

   Local sub-surface water abstraction for irrigation purpose should be add to this figure. This

[9] Etude du Plan Directeur Intégré d'Aménagement des Eaux du Bassin du Tensift (1987), ABHT internal document.

abstraction is roughly 4.3 Mm^3 for the 2002/2003 season, estimated using the total ETR[10] calculated in Sidi Chiker sector (a strip of 2 km large along the river). This ETR values, calculated from the vegetal mass, do not take into account the evaporation in the riverbed.

The total discharge of the aquifer in this area should then be about 5.5 Mm^3/year.

2) Another estimate can be obtained from the piezometric map, using the Darcy law. The outflow (Q) in Sidi Chiker sector is equal to the flow along the 250 m piezometric line: $Q = \partial h.K.D.L$,

where dh is the hydraulic gradient, here 5‰ (constant for each piezometric map), K is the Darcy Coefficient (known as permeability), probably as low as 3.10-5 m^2/s, D the wet aquifer thickness, here about 40 m, and L the length of the piezometric line, about 22,000 m.

According to these parameters, the outflow should then also be about 4 Mm^3/year. However, this estimate is very sensitive to the aquifer transmissivity (K.D), imprecisely known in this sector.

The groundwater discharge in Sidi Chiker sector is probably about 4 Mm^3/year, and certainly no more than 8 Mm^3/year, without major changes during the last 20 years.

The other (and often major) natural discharge of the aquifer is the drainage by the rivers. This phenomena occurs when the water table reach the elevation of the river beds, along the downstream part of the rivers.

The amount of drainage for the Tensift system in the Central Haouz was estimated in the study for 1971[4] using mathematical simulation to a total of 106.6 Mm^3/year for an average year. The detail per river is given in the following.

Estimate of the Average Aquifer Drainage from Mathematical Simulation
(BERNERT and PROST, 1975[4])

River	Flow
Oued R'Dat	5.0 Mm^3/year
Oued El-Hajar	13.4 Mm^3/year
Oued N'Fis	14.4 Mm^3/year
Oued Tensift	73.9 Mm^3/year
Total	106.6 Mm^3/year

Extension of this simulation[1] gives a total of 142 Mm^3/year drained by the whole Tensift basin (including the Mejate plain). This average figure is certainly significantly changing from one year to the other according to the level of the aquifer recharge. The 2002 mathematical model[1] shows that it comes down to 81 Mm^3/year in 2001/2002. It can even become nil if the water table is depleted up to below the riverbed elevation.

3.4 Groundwater Extraction in the Study Area

3.4.1 Existing Well Inventory

The wells pumped for the towns and small towns drinking water supply systems are well-known in the Haouz plain. But groundwater uptake for irrigation in agriculture, for livestock or for individuals in urban areas can only be estimated.

The ABHT is currently preparing a massive inventory of the wells in the rural communes, but the first partial results clearly demonstrate that a large part of private wells are still hidden to the authorities: in the 22 rural communes where the surveys where conducted from 2003, the total number of surveyed wells is 7598, 13% less than the number of authorised wells as it appears in the ABHT database (see details in Table 3.4.1).

[10] An estimate of the Evapo-transpiration was conducted within the SudMed Project in partnership with the ABHT: ETR data, 500 m resolution

An estimate of the number of wells in the rural areas can be found from the 2001 survey[11]. The ratio of unauthorized wells and boreholes were not directly surveyed but found with cartographic work based on the 1151 wells and boreholes (constructed before 2001, date of the last records in the ABHT drilling request database) positioned with GPS. As the position of authorized wells and borehole is not known with a better precision than 500 m, any surveyed well or borehole closer than 500 m from an authorized well was assumed appropriate for this estimate. This work gives a total of 16% of unauthorized wells. The same operation conducted over the wells located during the ABHT exhaustive inventory (5,232 wells constructed up to 2001 and correctly located within the Haouz plain) gives a ratio of 46% of unauthorized wells. The difference in the two figures comes from the location of the data collection associated with the unequal spatial distribution of unauthorized wells; the 2001 survey was conducted over the whole plain but the exhaustive inventory was only conducted for 22 rural communes, including some where few authorizations are recorded. The ratio of unauthorised wells is certainly between 16 and 46%. At this point, it is estimated to be 31% at the present stage.

This ratio can be applied to estimate the number of wells over large areas. For the PMH sector (i.e. outside the ORMVAH perimeters and urban areas), some 10,701 wells and boreholes are authorized in the plain in September 2001 according to the ABHT files. 9,900 of them are potentially used for irrigation purposes (801 of the 10,701 are further than 500 m from an irrigated area according to the ETR remote sensing data[12] and potentially not used for irrigation). This figure reaches 14,348 if one adds some 31% of unregistered wells.

Based either on the drilling date recoded during the ABHT inventory or on the authorization data as it appears in the ABHT database of drilling request, the growth rate of boreholes and wells can be estimated to be about 4%/year from 1990 (Figure 3.4.1). Based on the 2001 figure of wells in the PMH sector (14,348), the number of wells and boreholes can be estimated from 10,900 for the 1993/94 agricultural campaign to some 16,140 for the 2003/04 agricultural campaign.

For the GH sector, much smaller than the PMH sector, and where the number of wells is much smaller, the total ratio of unregistered wells cannot be applied efficiently and the total number of wells can hardly be estimated. The approach of the groundwater abstraction will preferably be done based on the water demand.

3.4.2 Groundwater abstraction for irrigation in agriculture

(1) Groundwater exploitation in the PMH sectors

In the PMH sectors, the groundwater abstraction can be estimated from the number of wells and boreholes.

According to the 2001 survey, the abstraction systems are functioning for an average of 2,291 hours/year, with an average instantaneous yield measured at 8.81 m^3/hour. The annual average abstraction per borehole is then 20,184 m^3/year[13]. For the 15,520 wells and boreholes functioning in the PMH sector during the 2002/03 agricultural campaign, the total groundwater abstraction can be evaluated as 313.2 Mm^3.

The total groundwater abstraction can also be estimated from the true evapo-transpiration (ETR) values. This figure is well-known for the 2002/03 agricultural campaign: it has been estimated by the SudMed Project using the remote data, based on the FAO methodology[12]. If the ETR value is more than 3,000 m^3/ha/year, one could consider that the corresponding acreage is a permanently irrigated zone, i.e. irrigated with groundwater. One could also consider that beneath the zones irrigated from

[11] Etude de synthèse hydrogéologique pour l'évaluation des ressources en eau souterraine du bassin hydraulique du Tensift. (2004) ANTEA-ANZAR for ABHT

[12] An estimate of the Evapo-transpiration was conducted within the SudMed Project in partnership with the ABHT: ETR data, 500 m resolution

[13] Consistent with the 21 543 m^3/year calculated beneath the Bahira aquifer using two different methods: estimated annual yield from the instant measured yield and the declared functioning durations, and estimated annual yield from the energetic consumption (from "Inventaire des préleveurs d'eau et établissement des assiettes de redevances" conducted in 2006 by ANZAR for the ABHT).

groundwater, the demand for well or borehole drilling is registered in the ABHT database. At this point, some 84,750 ha will be considered as irrigated with groundwater: they show an ETR larger than 3,000 m^3/ha/year are cultivated outside the GH perimeters and the urban areas and are not further than 500 m from a registered demand for well drilling. The total ETR is there 483.8 Mm^3/year (i.e. an average of 5,708 m^3/ha/year) for the 2002/03 agricultural campaign.

Part of this ETR is covered by the rainfall. In the semi-arid areas, most of the methodologies developed to calculate the part of rainfall effectively consumed by the vegetal cover ("agricultural efficient rain") conclude to a figure between 75 to 92% of the total rainfall[17]. At the present stage, this ratio can be estimated to 82% of the total rainfall for the whole Haouz plain. Table 3.4.2 gives the calculated annual rainfall for each of the irrigated sectors, based on the annual rainfall data.

The average 2002/03 rainfall beneath the PMH zone is 263 mm. The 82% of this figure applied to the total irrigated acreage (84,750 ha) reaches some 182,1 Mm^3. As the part of the surface water in the ETR values is certainly negligible, the abstracted groundwater for the 2002/03 agricultural campaign is then about 301.7 Mm^3, consistent (less than 4% difference) with the 313.2 Mm^3 found using the estimated number of wells and boreholes.

In regard of the consistence of the figures, According to the 2001 survey data, the wells and boreholes are used to irrigate some 5.2 ha[14], based on an average SAU of 13.92 ha/farm for the surveyed farms, with some 42% irrigated land (according to the average value observed beneath the Haouz plain[15]) and an average of 1.12 well or borehole per farm[16]. For the 2002/03 agricultural campaign, the total surface irrigated with groundwater is then estimated to be 80,700 ha (15 520 wells and boreholes each covering some 5.2 ha). This figure is consistent with the 84,750 ha found using the remote sensing data.

The estimated abstracted groundwater for the PMH sector should then be about 310 Mm^3 for the 2002/03 agricultural campaign, corresponding to an irrigated surface of about 82,700 ha, certainly with a growth rate equivalent with the growth rate of boreholes: 4% per year.

(2) Groundwater exploitation in the GH sectors

In the GH sectors, the net groundwater abstraction (total groundwater abstraction minus excess irrigation water re-infiltrated to the aquifer) can be estimate from crop water consumption.

The irrigated acreages calculated from the remote sensing data[17] (43,530 ha for Central Haouz sectors, except N5, R1aval and Z7) are not very different from the ORMVAH figures (48,600 ha for the equivalent sectors)(see Figure 2.2.8 for the location of GH sectors).

The average crop water requirement in this GH sectors was estimated to 6 300 m^3/ha/year (see section 3.5.1). This figure is far from the 5,621 m^3/ha/year measured with the ETR values, indicating that the crops undergo a water stress which is confirmed by the SudMed agronomists[18]. For the present evaluation of the abstraction, the crop water consumption will be taken from the ETR values rather than from the water requirement. It is assumed that the figures given in Table 3.4.3 do not vary much from 1993 to 2004.

Part of this evapo-transpiration is covered by rain. The same 82% ratio as for PMH sectors can be consider to estimate the efficient rainfall from the annual rainfall as detailed in Table 3.4.2.

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[14] Consistent with the 5,24 ha/well ratio (1 671 wells and boreholes for an irrigated surface of 8 750 ha) observed beneath the Bahira aquifer (from "Inventaire des préleveurs d'eau et établissement des assiettes de redevances" conducted in 2006 by ANZAR for the ABHT).

[15] RGA (general agricultural census)1995

[16] 1 342 wells or boreholes for 1 192 surveyed farms in 2001, consistent with the 1,11 well/farm ratio (1 671 wells and boreholes for 1 509 farms) observed beneath the Bahira aquifer (from "Inventaire des préleveurs d'eau et établissement des assiettes de redevances" conducted in 2006 by ANZAR for the ABHT).

[17] Abdelhamid Fadil (2006) Spatialisation de variables hydrologiques pour le bilan hydrique annuel et l'estimation des pompages dans la plaine du Haouz de Marrakech. Mém. de Master, Uni. Marne la Vallée

[18] Vincent Simmoneaux, personal communication

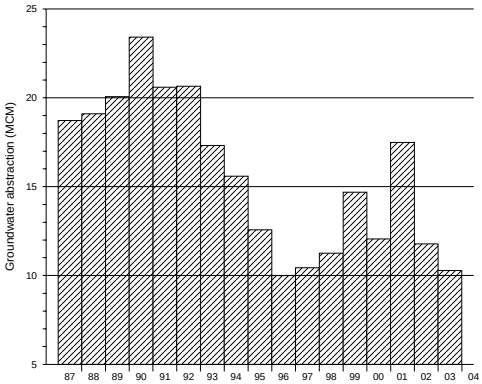
An important part of the water demand in the GH sectors is covered by the surface water. The figures of surface water volumes were extracted from the ORMVAH database. For the Tessaout amont sector, an estimate of the surface water distributed over the Tensfit basin was made based on Fadil investigations[17]. This work shows that 35% of the Tessaout Amont allocation in 2002/03 was distributed in the Bouidda and Tamalet sectors, in the Tensift basin.

Apart from the efficient rainfall and surface water contributions, the remaining part of the ETR is provided by the net groundwater abstraction. Table 3.4.4 gives an estimate of this groundwater abstraction calculated from 1993 to 2004 based on a constant water demand (as calculated for the 2002/03 agricultural campaign). From 1993 to 2004, the estimated groundwater abstraction for irrigation in the GH sectors varies from 26.0 Mm^3 during the 1995/96 agricultural campaign to 129.8 Mm^3 during the 2001/02 agricultural campaign.

3.4.3 Groundwater abstraction for drinking water supply

(1) Water Supply in Marrakech City

The Marrakech drinking water supply partly comes from groundwater, abstracted in 9 different places: one drainage gallery in Aguedal and eight boreholes fields in oued Issil, Menara, Ourika, Isiki, Drain Bouzougouar, N'Fis, Bahja and Saada. In 2003, the total groundwater abstraction was 10.3 Mm^3 (Figure on the right).



Volume of Groundwater Abstraction for Marrakech Water Supply

(2) Water Supply for Town and Villages other than Marrakech

Apart from Marrakech, groundwater is used for drinking water supply of any of the small towns and villages beneath the plain. For the 7 main towns (Sid Zouine, Tahnaout, Ait Ourir, Chichoua, Sid Rahal, Oudaya -also known as Loudaya- and Tamellatet), the total ONEP abstraction reach some 2.7 Mm^3 in 2003 (from ONEP production service figures[19]). The ONEP also distributes water in 5 additional small towns, for an estimated volume of 0.16 Mm^3 in 2003.

Additional groundwater is abstracted for drinking water supply of the rural areas: nearly no surface water is used for this purpose. The total rural population beneath the Haouz plain in 2003 is estimated to 526,210 persons (see section 3.8). With an allowance of 30 l/capita/day, the total abstracted volume for drinking water supply of rural population can be estimated to 5.8 Mm^3/year.

The groundwater abstracted in 2003 for the drinking water supply of Marrakech, the six (6) main towns of the Haouz plain and the rural population may be evaluated as 14.9 Mm^3.

3.4.4 Other Groundwater Uses

(1) Groundwater abstraction for livestock water supply

According to the ORMVAH statistics[20], there are some 116,000 cattle and 599,000 sheep in the Haouz plain. The water demand of this livestock is estimated to 1.5 Mm^3/year[21], probably roughly half provided by the surface water. The groundwater abstraction for livestock supply can then be estimated to about 0.8 Mm^3/year. As a first estimate and at the present scale, this figure can be consider as totally constant.

(2) Additional groundwater abstraction (urban sectors)

The annual amount of groundwater abstracted beneath Marrakech city for the irrigation of green belts can be estimated to about 7.3 Mm^3 in year 2003, based on the following process.

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[19] These figures are different from those collected from the ONEP distribution services. The consolidation is still to be done

[20] *Etude de gestion des principales nappes de la région du Tensift. Mission 1 : connaissance et diagnostic de l'état et de la gestion actuelle des ressources en eaux souterraines*. Rapport définitif. REISING for ABHT

[21] Based on 10 l/day/UGB (cattle) and 5 l/day/UPB (sheep)

- The Marrakech Commune is in charge of some 393.5 ha[22] of green belts, 100% irrigated from groundwater. Based on a total irrigation of 5,600 m^3/ha/year, the gross abstraction is there 2.20 Mm^3/year. The Agadal and Ménara royal domains (respectively 500 and 80 ha) are irrigated from surface water only.
- The Arrondissements deal with some additional 5.5 ha[22] of green belts, also 100% irrigated from groundwater. Based on a total irrigation of 5,600 m^3/ha/year, the gross abstraction is there 0.03 Mm^3/year.
- There are three golf courses in Marrakech (Royal, Amelkis and Palmeraie), for a total water demand of 2.5 Mm^3/year[22]. Part of this water demand is supposed to be covered by surface water (about 1.8 Mm^3 in the 1990's and about 1,0 Mm^3 from year 2000 – see details Table 3.5.5). Some 60% of the golf courses remain irrigated by groundwater, which represents an average of about 1.5 Mm^3/year.
- The INRA domain has a 30 ha garden. Based on total irrigation of 5,600 m^3/ha/year, 100% from groundwater, the gross abstraction is there 0.17 Mm^3/year.
- The garden surface of the main hotels reaches some 511 ha. Based on a total irrigation of 5,600 m^3/ha/year, 100% from groundwater, the gross abstraction is there 2.86 Mm^3/year.
- It is assumed that many individuals get their private well or borehole for irrigation of gardens or for private swimming pool. Groundwater abstraction from these individual boreholes may be about 0.5 Mm^3/year.

This 7.3 Mm^3 is consistent with the 11.5 Mm^3 of total evapo-transpiration beneath the urban area of Marrakech calculated for 2002/03 (SudMed Project[12]), minus 1.0 Mm^3 corresponding of the remaining 40% of water demand for the golf courses and 3.25 Mm^3 corresponding of the ETR beneath the royal domains irrigated from surface water.

3.4.5 Estimated total groundwater abstraction

The total estimated groundwater abstraction is variable from one year to the other (Table 3.4.6), essentially because of the changes in the groundwater demand for irrigation purposes resulting of the rainfall variation and the (related) surface water allocation.

The estimated abstraction as detailed in Table 3.4.6 is much smaller than the previous estimates: a total value of 509 Mm^3 instead of 464 Mm^3 in 2001/02 used for the simulation work[11], and 409 to 495 Mm^3 for irrigation instead of 334 Mm^3 for the 1999/00 agricultural campaign estimated from the analysis of irrigated surfaces[23]. The main difference in these figures comes from the hypothesis previously done of the negligible part of the efficient rainfall in the agricultural water demand in semi-arid climate.

3.5 Present Conditions of Irrigation and Water Saving Irrigation

3.5.1 Irrigation Water Demand

(1) Irrigated Area and Crop Irrigated

In order to identify the total area irrigated in the Study Area, the farming data commune rural were examined (Table 3.5.1 and 3.5.2). The arable land is counted as 368,000 ha and irrigable area to be 203,000 approximately. In the area under the ORMVAH, GH sectors occupies 54,308 ha, which includes a part of the Upper Tessaout Sectors as well as the N'Fis Sector and the Haouz Central Sector in total 48,560 ha. The irrigated area by seguia system along the N'Fis River, which is approximately 10,000 ha and is categorized as a National Irrigation Program (PNI) area, is also included in above GH area.

The cultivation area and cultivated crop were summarized based on the same procedure as with the arable land and other information (Table 3.5.3). The year of data is different for each organization, however, it could be used for estimation of proportion of crops in order to calculate the water demand

[22] *Alimentation en Eau Potable et Industrielle de la Ville de Marrakech*, April 2006, ABHT Internal document

[23] Abourida A., Simmonneaux V., Errouane S. – Apport de la télédétection pour l'estimation des volumes pompés au niveau de la plaine du Haouz (zone semi-aride du Maroc central). Under review

of the areas.

(2) Crop Water Requirement and Water sufficient of Crops

In order to estimate water demand for irrigation, the crop water requirement shown in Table 3.5.4 which is used in ORMVAH was applied. The requirement in the table shows the NET crop water requirement, which dose not consider effective rainfall and application efficiency in the field yet. The water demand for irrigation in the field level was estimated as 1,158 Mm^3/year based on above crop water requirement, as shown in the table 3.5.5.

According to the assessment of the real evapo-transpiration (ETR) in the year 2002/2003 using the remote sensing data by the SudMed Project, the actual water consumption of crops in the field was estimated 959 Mm^3 (Table 3.5.6), which is evaluated that crops suffer approximately 17% of water stress (water deficit) in the field.

Based on the actual record of water use in irrigation as described in the section 3.2.3, 3.4.4 and 3.8.3, the situation of water sufficient of crops are evaluated that approximately 879 Mm^3/year of water is supplied to the field as irrigation water (average of 1993/94 – 2003/04, out of which 757 Mm^3 reached the parcels). In addition, 501 Mm^3 is supplied by effective rainfall (estimated as 90% of the effective rainfall of the basin, 317mm). Thus the total water supplied to the fields sums up to 1,258 Mm^3. This indicates the water consumption per unit area is 7,160 Mm^3 / ha, which is 18% insufficient compared to the crop water demand of 8,790 Mm^3 / ha (Table 3.5.7).

The assessment of actual situation of water sufficient of crops estimated by both methods show close results and it could be said that this represents the currents situation of irrigation in the Haouz Plain.

According to the survey in the GH sectors in the Haouz Central, the average distribution efficiency of the GH irrigation system is 0.88 (Table 3.5.8). Among several assumptions that were proposed for the conveyance loss in the seguia systems in several studies, the assumption that takes account of 10% loss per 1km of canal length, proposed in "*Spatialisation de variables hydrologiques pour le bilan hydrique annuel et l'estimation des pompages dans la plaine du Haouz de Marrakech, Abdelhamid Fadil, 2006* " was applied in the study. ABHT, in its study in 2003, estimates the average length of seguia canal is 6.3 km with the conveyance efficiency of $0.90^{\wedge 6.3}$=0.51.

(3) Present Water Demand for Irrigation

The present water demand for irrigation based on the actual water sufficient level of crops in the field is estimated 1,061 Mm^3/year for 175,704 ha of irrigated area. On the other hand, the potential water demand at the present condition in the study area is estimated with following assumptions:

No irrigation area is newly developed in the GH areas. The fallowing area due to lack of irrigation water, which is approximately 6,300 ha, is taken account of area to be irrigated for estimating water demand. For the PMH area, the area actually irrigated at present is taken into account as irrigation area for estimating water demand.

It is understood that the water demand of crops is not satisfied at present due to lack of irrigation water. Thus, increase of water demand by increasing water application to crops is forecast instead of expanding the irrigation area. Under these conditions, the potential water demand for irrigation is estimated 1,459 Mm^3/year for 182,023 ha of irrigated area.

Estimated Present Water Demand for Irrigation

Area	Present Water Demand		Potential Water Demand	
	Irrigation Area (ha)	Water Demand at Main Canal / Well (Mm^3/year)	Irrigation Area (ha)	Water Demand at Main Canal / Well (Mm^3/year)
ORMVA	137,689	836	144,008	1,158
-GH	40,514	242	46,833	371
-PMH	97,175	593	97,175	787
DPA Marrakech	8,896	52	8,896	69
DPA Chichaoua	29,118	174	29,118	232
Total	175,704	1,061	182,023	1,459

(4) Water Demand Forecasting for Irrigation

The following conditions were applied for forecasting water demand for irrigation:

No irrigation area is newly developed in the GH areas. As for he fallowing area due to lack of irrigation water which is approximately 6,300 ha, two cases are set for forecasting water demand, that is including this area into the irrigated area and not included.

Increasing the trend of borehole installations for irrigation is considered in the water demand forecasting, which is estimated 4% in each year of which 2% is replacement of existing well and others are considered as new development. That is to say, the irrigated area by groundwater in the PMH areas is assumed to increase 2% in each year.

In consideration of the limited available water resources, the water demand for irrigation is estimated in two cases that is the present water stress will continue and another is considering increase of water demand for satisfying water requirement of crop in the field.

Under these conditions, the water demand for irrigation is set as 1,260 Mm^3, of which irrigated area is increasing to 203,377 ha in 2020 from 175,704 ha at present. In addition to above forecasting, the maximum water demand for irrigation, that is whole irrigation developed area of GH areas are under irrigation and whole irrigation area receive full water which satisfy the water sufficient of crop is also set as 1,720 Mm^3, of which irrigated area is increasing to 209,696 ha in 2020 from 182,023 ha of the potential water demand.

Irrigation Area and Water Demand Forecasting for Irrigation

Area	Water Demand in 2020		Maximum Water Demand in 2020	
	Irrigation Area (ha)	Water Demand at Main Canal / Well	Irrigation Area (ha)	Water Demand at Main Canal / Well
ORMVA	156,568	961	162,887	1,324
-GH	40,514	242	46,833	371
-PMH	116,054	719	116,054	953
DPA Marrakech	10,954	69	10,954	92
DPA Chichaoua	35,855	229	35,855	304
Total	203,377	1,260	209,696	1,720

3.5.2 Water Saving Irrigation

(1) Water Saving Irrigation

In order to save water in the field, drip irrigation has an important role especially in the area surfacing water deficit with a small precipitation and large evaporation such as Haouz area. The merit of drip irrigation is very popular among farmers, however, the expansion of the drip irrigation does not proceeded significantly. The present situation of the spread of drip irrigation in ORMVAH area is summarized in Table 3.5.9. The area equipped with drip irrigation is 9,644 ha according to the ORMVAH survey in July 2006 and it is 5.4 % of the total irrigation area, which is higher than the ratio of 3.8% in the whole ORMVAH area. The ratio varies from 1.4 % to 9.3 % by CMVs. 53 % of the drip irrigation is equipped in the GH sectors. Most of drip irrigation system in the area uses groundwater as their water source.

According to the situation of a sample CMV, as shown in Table 3.5.10, drip irrigation is mainly applied to orchard trees and vegetables. The olive and orange occupy 62% of total equipped area and vegetables occupy 22%.

The Ministry of Agriculture and ORMVAH has understood the importance of expanding water saving irrigation technology, and ORMVAH started the Drip Irrigation Development Program in Haouz in 2001. A 24,000 ha of drip irrigation is planned to be developed from 2003 to 2008 in the Program, under the national program of which target is 115,000 ha in whole country. According to the ORMVAH, 6,000 ha of drip irrigation was developed until 2006 and the total area reached 11,000 ha including the area equipped before the program in the Haouz area.

In order to promote the expansion of drip irrigation, the government gives subsidy for introducing drip irrigation system to farmers. The subsidy is applied to construction of wells and installation of pump

as well as equipment such as tubes and filtering system. The ratio of subsidy is 40% for equipment and 30% for well and pump at present, and the ratio is intended to increase to 60% for both equipment and well pump.

Even the ORMVAH has been push forward promoting the system in combination with subsidy for equipment, the progress of expansion is not accelerated due to the difficulty of financing of mid and small farmers and complexity of application to subsidy.

(2) Water Saving Irrigation from the viewpoint of Integrated Water Resources Development

In order to realize the integrated water resources management, it is necessary to promote the water saving irrigation from the view point of; i) reduction of groundwater abstraction, ii) improvement of water balance by reducing net water consumption, and iii) reduction of water cost for irrigation.

1) Contribution to the integrated water resources management through improving conveyance and distribution loss

In the irrigation system using surface water source, the amount of irrigation water is possible to be saved by reducing percolation loss in the canal. The distribution efficiency of the GH sectors in the Haouz Central is approximately 0.88 and the loss in the canal of the PMH sectors is supposed to be much higher than the GH sectors due to insufficient development of canal system. Effective use of surface water source lessens the dependence of irrigation on groundwater and contributes to reduce the groundwater abstraction. However, it is noted that the percolation from canals contributes to the groundwater recharge and that the reduction of percolation loss in canals contributes limitedly to improving water balance in the large area.

2) Contribution to the integrated water resources management through improving application loss

It is expected to reduce the amount of irrigation water through introducing the water saving irrigation such as drip irrigation. The reduction of irrigation water consists of two aspects of effect, i.e., reducing loss by evaporation in the field and reducing water cost.

a. Reduction of amount of irrigation water by drip irrigation

By introducing drip irrigation system, a significant increase of application efficiency of irrigation be expected and it contributes to save water in the field. The application efficiency of the surface irrigation such as basin irrigation or furrow irrigation is around 0.6 ~ 0.7 and the one of drip irrigation is expected 0.90~0.95[24]. It means 25~35% of water is expected to be saved by applying drip irrigation. The reduction of irrigation water contributes to reducing water cost for irrigation (through reducing operation cost of pump), as well as reducing the groundwater abstraction. However, it is noted that the percolation of surplus irrigation water contributes to the groundwater recharge and that the reduction of percolation loss in the filed contributes limitedly to improving water balance in the large area.

b. Reduction of evaporation loss in the filed by drip irrigation

Drip irrigation has effects on reducing the evaporation the topsoil as well as on reducing downward percolation loss of irrigation water. Because the loss of irrigation water by evaporation from the topsoil is a net loss which does not contribute to the groundwater recharge, the control of evaporation makes possible to reduce the net consumption of irrigation water. Thus, it contributes to improving the water balance in the large area as well as reducing groundwater abstraction. As a result of preliminary examination of crop coefficient (K_c) of Olive that is one of major target crop of drip irrigation[25], the K_c was estimated 0.84 for drip irrigation (which varies 0.66~1.01 depending on the growth stage of crop), on the other hand the K_c was estimated 0.94 for basin irrigation (which varies 0.66~1.21). It means that the drip irrigation can save approximately 10% of water consumption through reducing evaporation, in comparison with basin irrigation.

[24] FAO Irrigation and Drainage Paper No.24 “Crop Water Requirement”, 1977

[25] K_c was calculated by the methodology shown in the FAO Irrigation and Drainage Paper No.56 “Crop Evapotranspiration”, 1998.