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KINGDOM OF MOROCCO
MINISTRY OF PUBLIC WORKS
GENERAL DIRECTORATE OF
HYDRAULICS

JAPAN INTERNATIONAL
COOPERATION AGENCY
(JICA)

THE STUDY ON RURAL WATER SUPPLY IN THE PRE-RIF REGION IN MOROCCO

FINAL REPORT

VOLUME I SUMMARY REPORT

AUGUST 1996

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PREFACE

In response to a request from the Government of the Kingdom of Morocco, the Government of Japan decided to conduct a study on Rural Water Supply in the Pre-Rif Region in Morocco and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Morocco a study team headed by Mr. Kiyohiro Inoue, Nippon Koei Co., Ltd. four times between October 1994 and May 1996.

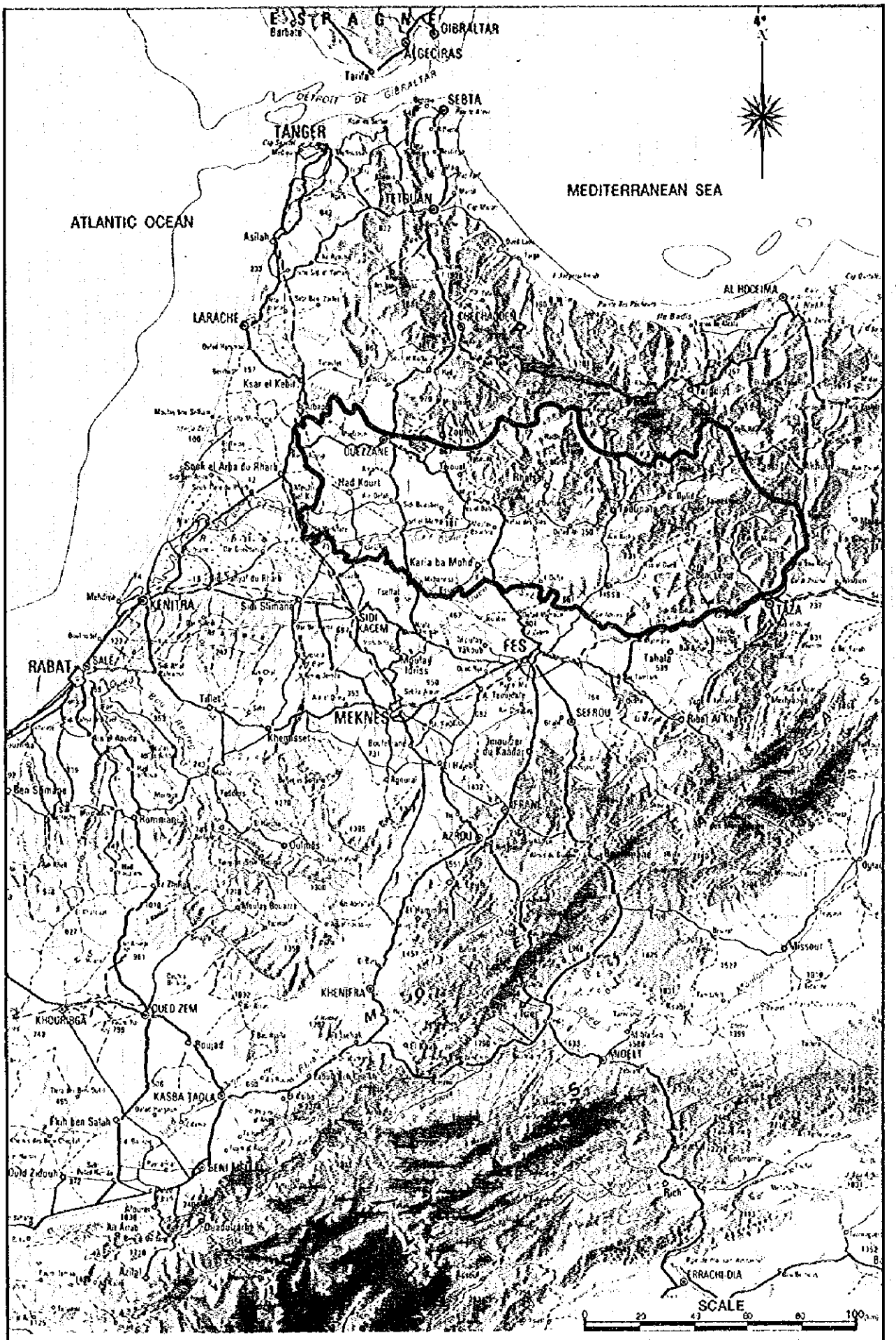
The team held discussions with the officials concerned of the Government of Morocco, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

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

August 1996

Kimio Fujita
President
Japan International Cooperation Agency



LOCATION MAP OF THE STUDY AREA

THE STUDY ON
RURAL WATER SUPPLY IN THE PRE-RIF REGION
IN MOROCCO

Study Period : September, 1994 - June, 1996
Counterpart Agency : Ministry of Public Works
General Directorate of Hydraulics

OUTLINE OF THE STUDY

1. BACKGROUND

The region so called "Pre-Rif" is identified as one of the most important areas in the Study on "Master Plan Study on National Rural Water Supply" made by UNDP through 1990 to 1993. In the report, it is recommended that the rural water supply system should be implemented in view of improvement of the level of living of this region. At present, the water supply for the area is mainly depending on surface water of rivers flowing nearby and shallow groundwater including spring water. It has been recorded that serious water shortage happened from time to time in the dry season. Then the groundwater development is deemed as an urgent requirement together with surface water development for this region, where water supply facilities equipped and distributed are rather small.

2. OBJECTIVE

i) to formulate development strategy for rural water supply in the whole Study Area,

ii) to formulate a water supply plan for the model areas selected from the above strategy, and

iii) to formulate a rural water supply master plan targeting the year of 2010 in the Pre-Rif region.

3. STUDY AREA

The Study Area defined is located in the northern part of Morocco and is defined about 10,000 km^2 extending from east to west by 160 km and from north to south 60 km. The Study Area covers one part of provinces of Sidi Kacem and Taza, and of almost entire part of the province of Taounate.

4. DEVELOPMENT STRATEGY FOR RURAL WATER SUPPLY

4.1 The National Master Plan

The Master Plan for the Development of Rural Potable Water Supply which is the so called "National Master Plan" for the target year of 2010 and finalized with the aid of UNDP on March 1994.

The National Master Plan recommended to raise potable water service ratio from current 14 percent to 80 percent in 2010 as given in Table 1. The following prioritization on the development of water sources is attached to the above strategies:

i) First priority : Spring water development
ii) Second priority : Groundwater development
iii) Third priority : Surface water development
iv) Fourth priority : Water transportation

Table 1 Present And Future Water Supply Pervasion

Type of Service and/or Works	Water Supply Pervasion			
	Present (1990) (%)		Future (2010) (%)	
House connection	2	14	10	80
Public stand pipe with network	6		40	
Rehabilitated source	6		30	
Traditional water sources facilities	16	86	-	20
Private source	23		-	
Rain water	10		-	
Surface water	21		-	
Transport	16		-	
Total:	100	100		100
Projected population (x 10^6)	13.4		14.3	

Source : National Master Plan
Note: Traditional water source facilities are such as tanks or channels for reserving rain water or stream water.

4.2 Formulation of Development Strategy

According to the ongoing programs on surface water supply system established by the ONEP as mentioned above, approximately 50 percent of the people will be able to acquire water by this system by the target year of 2010. The rest of the population may be supplied water either surface water supply system on the basis of probable new water supply system including new water treatment plant, pumping stations and pipelines or the groundwater supply system which will be exploited from now on by the target year.

The unit construction cost of water supply facilities per capita, groundwater exploitation is, in general, more economic, because that groundwater, as far as the Study Area is concerned, does not need treatment. Further, the water source from the supply area can be found much nearer than the case of surface water resulting in saving of pipeline and pumping costs.

In view of operation and maintenance aspect, groundwater supply system is much less complicated compared to the case of surface water due to experiences in the semi-arid area such as the Pre-Rif region.

Taking into aforementioned conditions, the following scenarios as the basic strategy will be proposed.

i) The development of water supply systems in the Study Area for the target year of 2010 shall be established based on groundwater sources in cooperation with surface water sources, and the rate of supply pervasion will be 80 percent in compliance with national policy.

ii) In principle, groundwater will be fully utilized from the above mentioned advantages for establishing potable water supply system in the rural area. Consequently, the thirteen groundwater potential structures, which are identified by this Study, will be developed with the highest priority.

iii) Development of potable water supply system using surface water will be proceeded firstly from the existing program proposed by the ONEP. Other succeeding plan will be

prepared after confirming progress of groundwater development and future plan of water usage by implementing the proposed surface water development plan.

5. WATER SUPPLY PLAN IN MODEL AREAS

5.1 Selection of Model Area

The following thirteen water potential structures containing abundant groundwater were selected as candidates for model areas.

i) Mountainous area

Taineste	Taounate Province
J. Khamise	Taza Province
J. Keil	Taounate Province
J. Berda	Taounate Province
Thar Souk	Taounate Province

ii) Hilly area

Teroual	Sidi Kacem Province
Ourtzagh	Taounate Province
Ain Saddine	Sidi Kacem Province
Taounate	Taounate Province
Tissa	Taounate Province

iii) Flat plain area

Jolf El Melha	Sidi Kacem Province
Ain Defali	Sidi Kacem Province
Had Kourt	Sidi Kacem Province

Taking into account of the priority in the physical conditions among these, current condition of water shortage and socio-economic impacts after provision of water supply facilities were incorporated.

As a conclusion, the mode areas were selected as Ain Defali; the rural center of Ain Defali commune, Teroual; the rural center of Teroual commune and Ain Berda; the rural center of El Bibane commune.

5.2 Features of Proposed Water Supply Plan

(1) Exploratory Wells

In the model areas, the nine exploratory wells were exploited in the course of second field work, and seven out of nine exploratory wells were eventually identified to be groundwater productive wells for potable use for the inhabitants in the areas.

(2) Water Demand

Water demand projection for each model area was carried out as shown in Table 2.

Table 2 Water Demand Projection

Model Area	Year 1995		Year 2010	
	Served Population	Water Demand	Served Population	Water Demand
Ain Defali	20,188	734 m^3/d	22,415	990 m^3/d
Teroual	9,677	345 m^3/d	10,745	468 m^3/d
El Bibane	5,210	180 m^3/d	5,784	248 m^3/d

(3) Facility Plan

The proposed supply system in the model areas shall be divided into first and second prioritized groups; the first is based on gravity system and the second is on pumping system. The system as an urgent improvement program to be adopted this time shall be by gravity system and this system would be completed within three years.

Table 3 Summary of Water Supply Facilities

Water Supply Facilities by Gravity System

Item	Ain Defali	Teroual	Ain Berda
Submersible Pump	Q 0.69 m^3/min Head 48 m Nos. 3 units	Q 0.33 m^3/min Head 46 m Nos. 2 units	Q 0.18 m^3/min Head 65 m Nos. 2 units
Pipeline Installation	D = 75 - 200 mm 44,880 m	D = 89 - 125 mm 12,050 m	D = 25 - 75 mm 11,100 m
Distribution Tank (RC)	V = 600 m^3 x 1 V = 400 m^3 x 1 V = 100 m^3 x 6	V = 280 m^3 x 1 V = 140 m^3 x 2	V = 120 m^3 x 1 V = 30 m^3 x 1 V = 10 m^3 x 1
Stand Pipe	25 Units	9 units	4 units
Appurtenant Facility	LS Electric Works Access Roads	LS Electric Works Access Roads	LS Electric Works Access Roads

Water Supply Facilities by Pumping System (Extension)

Item	Ain Defali	Teroual	Ain Berda
Pipeline Installation	D = 89 - 125 mm 14,900 m	D = 89 mm 8,700 m	(no facility installed)
Pumping Facility	Q 0.11&0.23 m^3/min Head 13&100 m Nos. 6 units	Q 0.16 m^3/min Head 60 - 130 m Nos. 8 units	
Distribution Tank (RC)	V = 100 m^3 x 2	V = 140 m^3 x 2	
Stand Pipe	5 units	6 units	
Appurtenant Facilities	LS Electric Works Access Roads	LS Electric Works Access Roads	

The improvement of the existing water supply facilities is to be made on the basis of the lists provided in the five-years plan prepared by the AH.

5.3 Project Cost

The project cost has been worked out for the following two cases including rehabilitation of existing rural water supply facilities.

i) Project cost of water supply facilities by gravity

ii) Project cost of water supply facilities by gravity and pumps

The estimated project costs are shown in Table 4.

Table 4 Project Cost

Gravity System — US$1.0 = DH8.6 = ¥100.0 (Jan., 1996)

No.	Project Cost Items	Foreign Currency Portion (1,000 US$)	Local Currency Portion (1,000 DH)	Total Equivalent (1,000 DH)
1	Direct construction cost	4,839	15,653	57,272
2	Land acquisition and compensation costs	0	0	0
3	Administration expenses	0	5,727	5,727
4	Engineering services expenses	932	3,436	11,454
	(Total as base cost)	(5,771)	(24,816)	(74,449)
5	Price contingency	411	3,618	7,153
6	Physical contingency	927	4,265	12,240
	Project cost	7,110	32,700	93,842

Gravity + Pumps — US$1.0 = DH8.6 = ¥100.0 (Jan., 1996)

No.	Project Cost Items	Foreign Currency Portion (1,000 US$)	Local Currency Portion (1,000 DH)	Total Equivalent (1,000 DH)
1	Direct construction cost	6,401	19,868	74,917
2	Land acquisition and compensation costs	0	0	0
3	Administration expenses	0	7,492	7,492
4	Engineering services expenses	1,220	4,495	14,983
	(Total as base cost)	(7,621)	(31,855)	(97,392)
5	Price contingency	543	4,638	9,307
6	Physical contingency	1,225	5,474	16,005
	Project cost	9,388	41,966	122,703

Annual operation and maintenance costs were estimated divided into gravity supply system and gravity plus pumping system as summarized below.

Table 5 Operation and Maintenance Cost

		Operation Cost Gravity	Operation Cost Gravity + Pumps
Ain Defali	:	DH 222,000	DH 435,000
Teroual	:	DH 375,000	DH 790,000
Ain Berda	:	DH 78,000	DH 78,000
Total	:	DH 675,000	DH 1,303,000

		Maintenance Cost Gravity	Maintenance Cost Gravity
Ain Defali	:	DH 272,500	DH 362,300
Teroual	:	DH 129,000	DH 220,500
Ain Berda	:	DH 144,200	DH 144,200
Total	:	DH 545,700	DH 727,000

5.4 Project Evaluation

The results of financial evaluation identify that rural water supply project of Ain Defali proves to be relatively viable. Provided that the commune of Ain Defali is only responsible for direct construction costs, the resulting FIRRs (5.1% for Gravity and Pumping, 5.2% for Gravity only) would be financially sustainable for loan scheme consisting of external soft loan and the

prevailing domestic fund from the FEC. This is mainly attributed to a large scale of water demand compared to the other communes.

Though the FIRRs result in negative and marginal value in Teroual and El Bibane, project revenue is large enough to make up for operation and maintenance costs. If both schemes are financed by grant, operation and maintenance of water supply by the relevant communes would be sustainable.

The three model communes are the typical area having been suffering from scarce water resource. The provision of water supply facilities was reported to be the most desirable and actually placed a stop priority as a result of socio-economic survey. Under such circumstance, rural water supply is worth of being implemented because it meets social need of local people. Socio-economic impacts might be considerable particularly in hilly and mountainous areas such as Teroual and El Bibane. The alleviation of physical burden from women and children will definitely improve the working condition of women in household and attend rate of children in elementary school.

6. MASTER PLAN

6.1 Groundwater Supply System

For the establishment of groundwater supply system, the following implementation program is proposed.

i) In compliance with drilling of test wells, pumping tests and subsequent analysis, reliability of groundwater yield for potable water use in the model areas is confirmed. Due to urgent necessity of increasing of production capacity and provision of water distribution facilities, the groundwater development program is recommended as an urgent scheme.

ii) The water supply system recommended in the model areas is classified into two groups; the one is supply by gravity and the other is by pumping. The gravity supply system is to be laid on the first priority and the pumping supply system is on the second in the implementation program.

iii) Establishment of water supply system including both of gravity and pumping system in the model area as well as rehabilitation programs for the existing facilities shall be completed within five years.

iv) Development of ten high potential areas comprising planning, physical inspecting, test drilling, detail designing and construction works is proposed to be completed within ten years in parallel with the development of three model areas.

v) Medium and low potential areas shall be developed thereafter in compliance with the progress and/or results of the development of 10 potential areas. At the same time, development condition of surface water supply system should also be taken into consideration.

6.2 Establishment of Surface Water Supply System

For the establishment of surface water supply system, the following implementation program is proposed:

i) According to urgent needs for exploitation of surface water sources and subsequent development of water supply facilities, the first stage implementation will be dependent upon the ongoing program being carried out by the ONEP. According to enlargement of treatment plant capacities to a double size or more, the supply area could be extended to several communes along the Sebou river.

ii) As for future water resources to meet requirement by the target year, the Al Wahda reservoir which is supposed to be completed within 1996 will be realized, however, there is no plan for water supply to the Pre-Rif region. Substantial planning for utilization of the Al Wahda reservoir shall be commenced around the year, 2000.

iii) By the time of commencement of planning for water supply based on the Al Wahda reservoir, review work of groundwater development programs and their progress as addressed previously shall be carried out in parallel with the programs currently being carried out by the ONEP.

6.3 Implementation Program of Project

The implementation schedule has been scrutinized by the category of 1) urgency of project (short term, medium term, and long term), 2) economic effect , and 3) ease of implementation and establishment of organization, 4) coordination and cooperation with the ongoing and already planned programs, and 5) regional contribution in socio-economic aspects in rural areas.

Out of the schemes proposed to be implemented by the target year of 2010, the following programs have been screened:

(1) Establishment of water supply system in model areas
- i) Development by gravity system
- ii) Development by pumping system

(2) Exploitation of groundwater resources
- i) High potential structures (10 structures)
- ii) Medium potential structures

(3) Rehabilitation of existing facilities of groundwater sources
- i) Model areas
- ii) Others in the Study Area

(4) Development of surface water supply system
- i) Rehabilitation and improvement of ONEP facilities
- ii) New water supply system based on Al Wahda dam

In compliance with the schemes screened, the following programs in three terms have been proposed. The implementation plan for these programs shown in Table 6.

Table 6 Implementation Plan for Water Supply System

No.	Implementation Item	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
(1)	Establishment of Water Supply System in Model Areas															
	1) Development by Gravity System															
	2) Development by Pumping System															
(2)	Exploitation of Groundwater Resources															
	1) High potential structures (10 structures)															
	2) Medium potential structures															
(3)	Rehabilitation of Existing Facilities of Groundwater Sources															
	1) Model Areas															
	2) Others in the Study Area															
(4)	Development of Surface Water Supply System															
	1) Rehabilitation and Improvement of ONEP Facilities															
	2) New Water Supply System based on Al Wahda Reservoir															

THE STUDY
ON
RURAL WATER SUPPLY
IN
THE PRE-RIF REGION
IN
MOROCCO

VOLUME I

SUMMARY REPORT

Table of Contents

Page

Page

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

(Organizations)

JICA	Japan International Cooperation Agency
AH	Administration of Hydraulics
ONEP	The Office of Portable Water
DRPE	Directorate of Research and Planning of Water
DRH	Directorate of Regional Hydraulics
CERED	Research Center of Demographic Studies
FEC	Funds for Commune Equipment
UNDP	United Nation Development Program
WHO	World Health Organization
WB	World Bank
IBRD	International Bank Reconstruction Development

(Terms)

S/W	Scope of Works
IEE	Initial Environmental Examination
EIA	Environmental Impact Assessment
SBO	The Integrated Master Plan on Water Resource Development in Sebou, Bou Regreg and Oum Er Rbia Basins
MSL	Mean Sea Level
VES	Vertical Electric Sounding
VLF	Very Low Frequency
MODFLOW	Modular Three Dimensional Finite Difference Groundwater Flow Model
FDM	Finite Difference Method
O&M	Operation and Maintenance
FC	Foreign Currency
LC	Local Currency
VAT	Value Added Tax
FIRR	Financial Internal Rate of Return
EIRR	Economic Internal Rate of Return
WID	Women in Development
DH	Dirham
US$	United States Dollar
LS	Lump sum
ODA	Official Development Assistance

(Measurements)

mm	milimeter
cm	centimeter
m	meter
km	kilometer
m^2	square meter
Ha	hectare
km^2	square kilometer
m^3	cubic meter
MCM	million cubic meter
m^2/s	square meter per second
m/s	meter per second
m^3/s	cubic meter per second
m^3/d	cubic meter per day
m^3/year	cubic meter per year
l/d/c	liter per day per capita
l/d/head	liter per day per head
l/s	liter per second
°C	Celsius
kW	kilowatt
GWh	gigawatt hour
KHz	kilohertz
ohm-m	ohmmeter

CHAPTER I INTRODUCTION

1.1 Background of the Study

The region so called "Pre-Rif" is identified as one of the most important areas in the Study on "Master Plan Study on National Rural Water Supply" made by UNDP through 1990 to 1993. In the report, it is recommended that the rural water supply system should be implemented in view of improvement of the level of living of this region. At present, the water supply for the area is mainly depending on surface water of rivers flowing nearby and shallow groundwater including spring water. It has been recorded that serious water shortage happened from time to time in the dry season. Then the groundwater development is deemed as an urgent requirement together with surface water development for this region, where water supply facilities equipped an distributed are rather small.

1.2 Objective of the Study

The objective of the Study are summarized in the following three items:

1) to formulate development strategy for rural water supply in the whole Study Area,
2) to formulate a water supply plan for the model areas selected from the above strategy, and
3) to formulate a rural water supply master plan targeting the year of 2010 in the Pre-Rif region.

1.3 Study Area

The Study area defined is about 10,000 km^2 extending from east to west by 160 km and from north to south 60 km. The Study area covers one part of provinces of Sidi Kacem and Taza, and of almost entire part of the province of Taounate.

1.4 Organization of the Study

On the basis of the Scope of work agreed upon the Administration of Hydraulic of the Ministry of Public Works, Vocational Training and Management Training (hereinafter referred to as "AH") and the Japan International Cooperation Agency (hereinafter referred to as "JICA") on January 14, 1994 in Rabat, JICA made a contract with Nippon Koei Co. Ltd., on September 26 1994 to conduct a Master Plan Study on Rural Water Supply in the Pre-Rif Region in Morocco.

The Study was acomplished successfully in a joint effort of the Moroccan and Japanese sides. The Morrocan side organized the conterpart team under the AH, while the Japanese side dispatched the JICA Study Team (hereinafter referred to as "the Study Team"). The Study extended a 21.5-month period including the following three phases according to the Scope of Work.

Table 1.1 Process of the Study

Phase	Description of Study	Study Period
Phase 1	Formulation of Development Strategy	Sept. 1994 - Jan. 1995
Phase 2	Formulation of Water Supply Plan for Selected Model Areas	Feb. 1995 - Dec. 1995
Phase 3	Formulation of Master Plan for Water Supply	Jan. 1996 - June 1996

CHAPTER II GENERAL CONDITION AND DIFFERENTIATION OF THE STUDY AREA

2.1 Natural Conditions

2.1.1 Topography

As for the topography, the Pre-Rif region is surrounded by mountains at its north, east and south, and reaches the Atlantic Ocean at its far end of west. Excepting the right side of the Ouergha river where the peak of the Rif Mountains is located near, the district is dominated by gradual mountain areas with small reliefs and hilly land shape. There is a clear tendency that altitude is higher at east and north parts, and becomes lower towards the south and west. While the altitude is around 400 m at flat lands and about 1,000 to 1,600 m at mountain areas in the east, but only around 600 m even at mountain areas near Ouazzane.

2.1.2 Meteorology

(1) Rainfall

The average annual rainfall varies from 500 to 700 mm in the area along the Sebou river mainstream (Had Kourt - Karia - Tissa), from 700 to 800 mm in the in the upstream of the Inaouen and Lebene river (Tissa - Taza / Tainaste), and 700 to 1,200 mm or more in the north of the Ouergha river (Ouazzane - Rhafsai - Taounate - Thar Souk). The seasonal variation of rainfall clearly shows the dry season from June to September. The rainfall is in general very little during the months of July and August.

(2) Air Temperature

The annual average temperature varies little by locations with a range of 18.4°C to 20.3°C, while the seasonal variation differs extremely from 10°C in January to 30°C in July and August. The average daily maximum and minimum air temperatures are 36.8°C and 4.2°C at Bab Merzouka, 37.3°C and 6.6°C at M'Jaara, and 36.8°C and 6.1°C at Ourtzagh, respectively.

(3) Evaporation

The evaporation records observed by "COROLAD" pan is available at Ourtzagh. The annual evaporation amounts to 1,718 mm. The monthly evaporation becomes highest in July and lowest in December and exceeds the monthly rainfall during April to November.

(4) Relative Humidity

The annual average relative humidity varies from 50 to 70 percent by region. In general, variation of the average monthly shows that the highest takes place in December and the lowest is observed in July.

(5) Solar Radiation

The records of solar radiation are available only at Ouled Yaacoub. The average annual solar radiation is 2,634 hours. The monthly average varies from 159 hours in January to 324 hours in July.

(6) Wind Velocity

The wind velocity by region ranges from 1.1 to 2.1 m/sec on the annual average and from 3.6 to 5.5 m/sec on the average daily maximum. The wind velocity becomes higher in dry season and lower in wet season, but seasonal variation is not conspicuous.

2.1.3 Hydrology

(1) River System

The Sebou river system covers the catchment area of approximately 39,000 km^2 and extends to the Rif mountain range in the north, the Atlas mountain range in the south and hilly watershed in the east of Taza. The Sebou river collects water from the tributaries and runs to the west and eventually flows into the Atlantic ocean near the city of Kenitra.

The Ouergha river is the largest tributary in the system river system basin with a catchment area of 7,300 km^2. The mainstream of the Ouergha river originates in the mountains east of Thar Souk and runs to the west along the foot of the Rif mountains. The tributaries of the Ouergha river flow from the north down to the south forming a gorge at the foot of the Rif mountains. The Ouergha river joins the mainstream of the Sebou river in the vicinity of Khnichet.

(2) Stream Flow Condition

The stream flow condition in the Study Area shows that the most of runoff is likely to be direct runoff and a rate of baseflow is quite low and that the seasonal fluctuation of stream flow is significantly large. On the other hand, the Sebou river shows the quite different flow condition from the other rivers in the Study Area. Baseflow of the rivers are compared based on a rate of 90 percent dependable discharge to average discharge. As shown in Table 2.1, a rate of baseflow of the Sebou river is much higher than those of the other rivers.

Table 2.1 Comparison of Baseflow

River System	Gauging Station	Catchment Area (km^2)	Average Discharge (m^3/sec)	90% Dependable Discharge (m^3/sec)	Rate of Baseflow
Sebou	Dar El Arsa	7620	24.43	7.53	30.8%
Ouergha	M'Jaara	6190	81.99	1.42	1.7%
Lebene	Tissa	792	6.01	0.06	1.0%
Inaouen	Bab Merzouka	1500	6.84	0.21	3.1%
Rdat	Had Kourt	673	2.74	0.00	0.0%

(3) Runoff Rate

The Study Area can be generally classified in the 4 regions in consideration of basin hydrology and rainfall distribution. The rainfall and runoff for the average 37 years and the 10-year drought are summarized by the regions as shown in Table 2.2. In the 10-year drought, the annual rainfall reduces to some 65 percent of the average, while the reduction of annual surface runoff is significant, 25 and 21 percent in the upper Ouergha, the Inaouen and the Lebene basins, and only around 10 percent in the Rdat and the lower Ouergha basin and the middle Sebou sub-basins.

Table 2.2 Rainfall and Surface Runoff by Region

Region	Average 37 Years		10-Year Drought			
	Rainfall (mm)	Runoff (MCM)	Rainfall (mm)	Runoff (MCM)	Ratio to Average	
					Rainfall	Runoff
Ouergha, Upstream M'Jaara	930	2657	583	653	63%	25%
Lebene and Inaouen	651	738	432	154	66%	21%
Rdat and Lower Ouergha	611	218	408	21	67%	10%
Middle Sebou	540	152	365	15	68%	10%

2.1.4 Geology

The Rif chain of northern Morocco represents the southern limb of the western edge of the Alpian chain. It is united to the northern branch of Europe, represented by the betic cordillera, through the Gibraltar arch. Towards the east, it is linked to the Tell chain in Algeria to form the Betico-Rif Telleen arch. The Rif constitutes an average mountain chain that rarely exceeds MSL 2,000 m. The highest summit is Jbel Tidghine which is situated in the Meso-Rif in the Ketama area where the highest point reaches MSL 2,452 m. The existing contrast between the southern and northern domain allows the distinction of two different zones:

i) The Rif chain which is characterized by its deep valleys and its rocky crests thus giving it a mountainous aspect.

ii) The Pre-Rif in the south which is known as lowland or land of hills with marl sedimentation that rarely exceeds MSL 1,400 m.

The geological complexity of the Pre-Rif labels it as one of the most challenging regions with overlapping stratigraphy where old age formations are situated on top of recent ones with confusing stratifications. The structural geology is formed of allochton formations, units, flyschs, of various ages extending from the paroxysmal cycle of the Paleozoic era to the late Tertiary period.

2.1.5 Hydrogeology

(1) Hydrogeological Features of the Study Area

The hydrogeological units of the Study Area are very limited due to the absence of potential aquifers as a result of the geological complexity of the Pre-Rif region whose greater part is characterized with aquiclude formations and only limited structures offering adequate ground water potentials. The geographic distribution of ground water in these structures are determined on the basis of the available water resources of each geological formation.

According to their lithological consistency and the water bearing potentiality, the hydrogeological formations of the Study Area are classified as follows:

1) Formations of Poor Water Potential

   i) Triassic formations composed of red marl with evaporite and halite intercalations.

   ii) Jurassic formations belonging to the upper Lias and upper Jurassic and consisting of schist, silty schist and marl.

   iii) Cretaceous formations comprising silty schists with marl stone with very thin intercalations of marly limestone.

   iv) Eocene and Miocene formations of the Tertiary period consisting of red marl and silty marl and schists respectively.

2) Formations of Fair Water Potential

   i) Oligocene formations composed of sandy marly limestone marked with karsts, fissures and well developed joints.

   ii) Upper Miocene formations comprising conglomerates with marl matrix karstified by fault activities

   iii) Recent Quaternary Villafranchian formations containing conglomerates with loose marl matrix.

3) Formations of Fair to Good Water Potential

   i) Middle Lias formations of the lower Jurassic period composed of limestone and dolomite either outcropping in the form of allochton structures on the crest of monoclines and flexures or deep-seated autochton structures.

(2) Groundwater Potential Structures

The lithological consistency of the outcropping formations and the dispersed geological stratigraphy label the Pre-Rif as a region of poor to fair ground water potential with the absence of shallow favorable aquifers. The examination of satellite image and aero-

photos together with field hydrogeological reconnaissance covering the entire Study Area led to the identification of the following thirteen hydrogeological structures with suitable ground water potential. The locations of these groundwater potential structures are shown in Figure 2.1. Table 2.3 recapitulates their hydrogeological characteristics.

1) Mountainous Water Potential Structures

   i) Taineste Flexure
   ii) Jbel Khmis Monocline
   iii) Jbel Keil Monocline
   iv) Jbel Berda Monocline
   v) Thar Souk Syncline

2) Hilly Water Potential Structures

   i) Teroual Syncline
   ii) Ourtzarh Syncline
   iii) Ain Saddine Syncline
   iv) Taounate Syncline
   v) Tissa Syncline

3) Flat Plain Water Potential Structures

   i) Jorf El Melha Syncline
   ii) Ain Defali Syncline
   iii) Had Kourt Basin

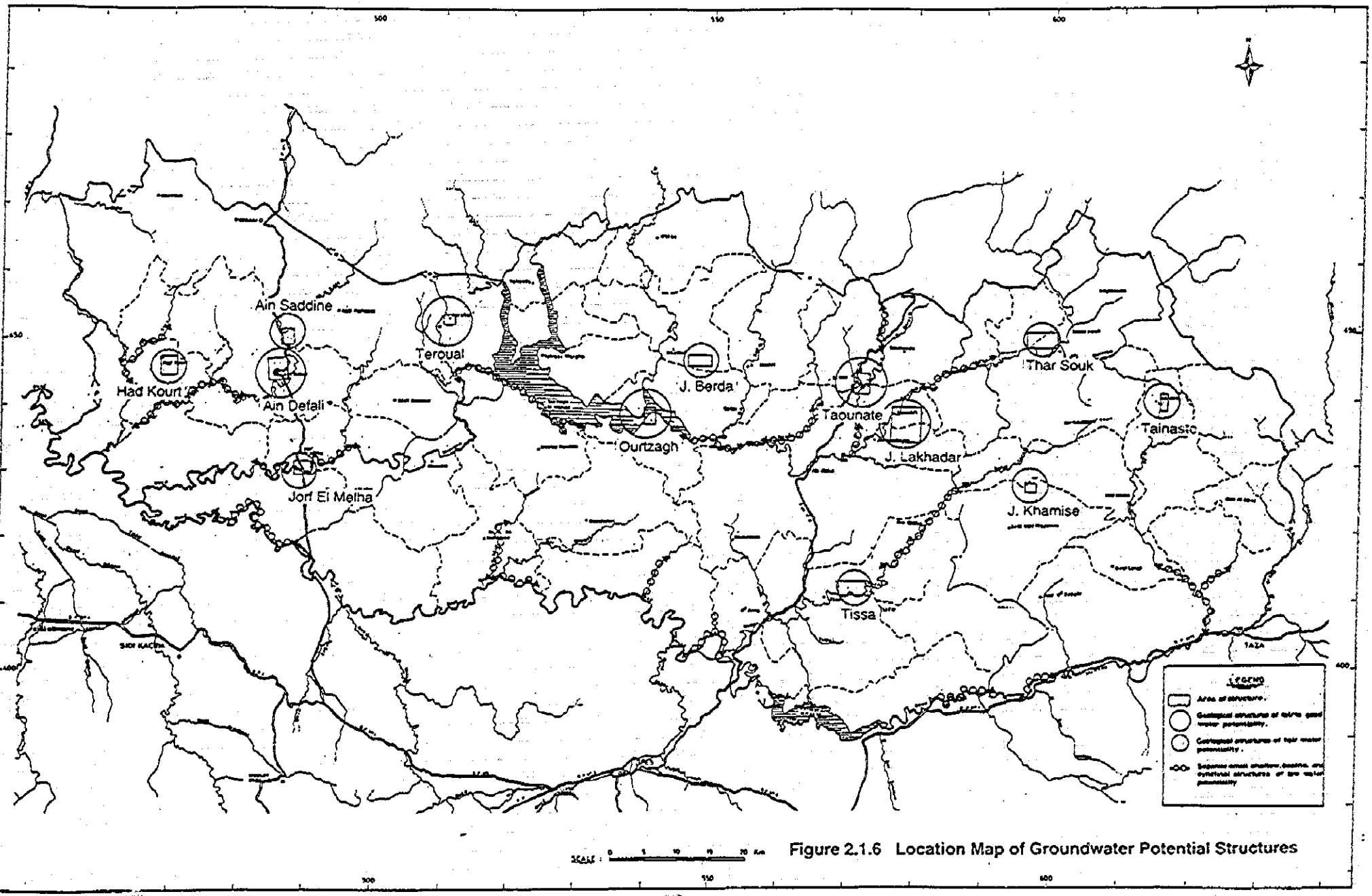


Figure 2.1.6 Location Map of Groundwater Potential Structures

Table 2.3 Hydrogeological Characteristics of Groundwater Potential Structures (1/2)

Geological Structures			Structure Coordinates			Water Bearing Formations		Water Potential (estimated)				
									Ground Water Exploration			
No.	Location	Type	X	Y	Z (m)	Epoch or Stage	Lithology	Spring	No. of Wells Proposed	Depth (m)	Estimated Productivity (l/s)	Water Quality
	Mountainous Water potential Structures											
1	J. Tainaste	Flexure	616000 to 617000	440000 to 442500	1100 to 1300	Quaternary Jurassic Bajocian-upper Lias Middle Lias	Recent Alluvium Limestone & Marly Limestone Limestone & Dolomite	5- Springs Flow Rate Ranges between 15-85 m3/d	1 1 1	125 100 75	Ranges between 2 - 5 5 - 7 2 - 5	Chemically Acceptable
2	J. Khamise	Monocline	599000 to 600500	427500 to 428700	700-800	Jurassic Bajocian-upper Lias	Limestone & Marly Limestone Limestone and Dolomite	5- Springs Flow Rate Ranges between 15 - 50 m3/d	1 1	150 125	Ranges between 5 - 10 3 - 7	Ditto
3	J. Lakhdar (Keil Mountain)	Monocline	577200 to 581500	435500 to 440750	600-700	Jurassic Bajocian-upper Lias Middle Lias	Limestone & Marly Limestone Limestone & Dolomite	8- Springs Flow Rate Ranges between 15-60m3/d One Spring w/ Large Flowrate-Bou Adel 220 l/s	1 1 1	150 150 100	Ranges between 3 - 10 10 - 20 2 - 3	Ditto
4	J. Berda	Monocline	547000 to 550500	447000 to 448500	750-850	Jurassic Bajocian-upper Lias Middle Lias	Limestone & Marly Limestone Limestone & Dolomite	3- Springs Flow Rate Ranges between 20-700 m3/d	1 1 1 1	100 125 125 150	Ranges between 1 - 3 2 - 5 3 - 5 5 - 10	Ditto
5	Thar Souk	Syncline	597500 to 602500	449500 to 452000	480-550	Quaternary Miocene (Sahelian)	Recent alluvium Conglomerates	—	2 3	150(each) 30 (each)	Ranges between 3 - 7 1 - 3	Ditto
	Hilly Water Potential Structures											
6	Teroual	Syncline	511000 to 512500	451500 to 453000	400-430	Upper Miocene Oligocene	Conglomerates + Marl Marly Sandy Limestone	2- Springs Flow Rate Ranges between 20-70 m3/d	3 1 1	30 (each) 125 150	Ranges between 1 - 2 5 - 10 8 - 15	Ditto
7	Ourtzarh	Syncline	540000 to 542000	436200 to 438500	150-190	Quaternary Miocene (Tortonian)	Recent Alluvium Karsts & Fissured Conglomerates	5- Springs Flow Rate Ranges Between 1 - 7 m3/d	2	300 (each)	Ranges between 5 - 12	Ditto

Table 2.3 Hydrogeological Characteristics of Groundater Potential Structures (2/2)

Geological Structures			Structure Coordinates			Water Bearing Formations		Water Potentiality (Estimated)				
								Structure's	Ground Water Exploration			
No.	Location	Type	X	Y	Z	Epoch or Stage	Lithology	Springs	No. of Wells Proposed	Depth (m)	Estimated Productivity (l/s)	Water Quality
8	Ain Saddine (Rdat Valley)	Syncline	486500 to 489000	449000 to 453000	110-200	Quaternary Pliocene Miocene	Recent Alluvium Conglomerates + Marl Conglomerates + Marl	1- Spring Flow Rate 90m3/d	3 1 1	30(each) 100 150	Ranges between 1 - 2 2 - 5 3 - 7	Chemically Acceptable
9	Taounate Sra Valley	Syncline	571000 to 573000	440000 to 443000	300-330	Quaternary Miocene-Tortonian	Recent Alluvium Karsts & fissured conglomerates	—	3 1	30(each) 250	Ranges between 5 - 15 15 - 20	Ditto
10	Tissa Lebene Valley	Syncline	569000 to 547000	410000 to 412000	190-200	Quaternary Oligocene	Conglomerates Marly Sandy Limestone	—	3 1 1	30(each) 75 100	Ranges between 3 - 5 4 - 7 5 - 10	Ditto
Flat Plain water Potenial Structure												
11	Jorf El Malha	Syncline	488500 to 491000	429500 to 431500	40-70	Quaternary Miocene-Tortonian	Recent Alluvium Conglomerates	—	3 1	30(each) 125	Ranges between 5 - 10 7 - 12	Ditto
12	Ain Defali	Syncline	484500 to 487500	443200 to 446500	90-130	Quaternary Miocene	Recent Alluvium Conglomerates	—	3 1	30(each) 125	Ranges between 3 - 5 5-10	Ditto
13	Had Kourt	Depression	468700 to 471300	444000 to 447500	130-150	Quaternary Miocene	Recent Alluvium Conglomerates	—	3 1	30(each) 125	Ranges between 1 - 3 3 - 5	Ditto

Notes : - The numbers and depths of the wells suggested for each structure are based on the hydrogeological field reconnaissance, and are subject to modification in accordance with the geophysical prosoection and logging.
- The estimated productivity of each well is estimated based on the lithological composition of the formations to be penetrated.

2.2 Socio-economic Conditions

2.2.1 Administration and Population

(1) Administration

The country of Morocco is largely divided into seven economic regions. The administration in Morocco consists of hierarchical structures comprising provinces, circles and communes. A commune is the smallest administrative unit where various ethnic and tribes co-exist in the form of douars. Morocco comprises 65 provinces, 159 circles and 1,545 communes. The provinces relating to the Study Area are Sidi Kacem, Taounate and Taza. The province of Sidi Kacem is included in north-west economic region, whereas both provinces of Taounate and Taza in north central economic region. The Study Area consists of 9 circles and 85 communes.

The national census survey was executed in September 1994. The total population in the Study Area was about 1.1 million, which is 4.2 percent of the country's population (26.1 million). Urban population was about 0.1 million while the remaining (1.0 million) was distributed in rural area. The population ratio of urban to total is just 11 percent in the Study Area which is far lower than the same ratio (about 50 percent) nationwide. The population density was about 110 per km^2 in the Study Area while the national average was about 40 per km^2.

2.2.2 Topography and Land Use

Elevation in the Study Area is high at east and north parts and becomes lower towards the south and west. Elevation is around 400 m in the area of flat lands, in the range from 1,000 m to 1,600 m in mountain areas in the east, but only around 600 m near Ouazzane in the west.

The pattern of land use by province is attributed to the difference in topographic conditions. Agricultural land is prominent and distributed extensively in Sidi Kacem characterized by flat and hilly lands, whereas both forest and uncultivated land are outstanding in Taza where mountainous area is dominant. Irrigated land is merely one percent of total area. The typical cash crops cultivated in dry land are cereals such as wheat and barely, legumes such as broad beans, chickpeas and peas. Crop yield is substantially low due to less rainfall. Livestock breeding in pasture is another source of income for rural people. General configuration of land use is given in Table 2.4.

Table 2.4 Land Use in the Study Area

(Unit : Ha)

Province	Agricultural land		Forest	Pasture	Uncultivated	Total
	Dry land	Irrigated				
Sidi Kacem	181,359 (86.7)	695 (0.4)	6,737 (3.2)	9,465 (4.5)	10,945 (5.2)	209,201 (100.0)
Taounate	389,000 (69.3)	4,000 (0.7)	51,700 (9.2)	65,600 (11.7)	51,300 (9.1)	561,600 (100.0)
Taza	310,700 (18.7)	18,300 (1.1)	467,970 (28.1)	329,000 (19.8)	537,130 (32.3)	1,663,100 (100.0)
Total:	881,059 (36.2)	22,995 (1.0)	526,407 (21.6)	404,065 (16.6)	599,375 (24.6)	2,433,901 (100.0)

Source : Provincial Directorate of Agriculture.

2.2.3 Economic Activities

The statistical data on economically active population is only available on the regional bases and for 1986-1987. The data is somewhat old and broad, but indicates the pattern of labor force by economic sector. Table 2.5 shows the proportion of economically active population by sector. The labor force engaged in farming activities is dominant, about 83 percent in north-west region and 87 percent in north-central region.

Table 2.5 Proportion of Labor Force by Sector in Rural Area

(Unit : Ha)

Type of Occupation	North - West	North - Central
1) Professional, Government, Technical	1.5	1.2
2) Commercial services	2.0	2.5
3) Public services	1.0	0.5
4) Agricultural farmers	18.9	22.4
5) Agricultural labors	64.2	64.3
6) Forestation, Fisheries	1.3	0.6
7) Non-agricultural labors	11.0	8.4
8) Others	0.1	0.1
Total:	100.0	100.0

Source : Rural Active Population 1986/87, Statistical Office

It is reported by the Provincial Directorate of Agriculture that an average gross income per farm household and hectare in Sidi Kacem in 1990-1991 was about DH19,940 and

DH3,680. The same source also says that an average net income per farm household and hectare was about DH18,390 and DH3,340, respectively. Net income is assumed to be equivalent to annual household expenditures. According to household consumption and expenditures in 1984-85 published by Statistical Office, an annual average household expenditures were reported to be about DH16,000 in north-west region and DH18,670 in north-central region. The difference between net income (DH18,390) and expenditure (DH18,670) in the north-central region is marginal, indicating almost no income growth since the years of 1984 and 1985.

2.2.4 Population Projection in the Study Area

The population projection carried out in a preliminary level was revised in compliance with the national census survey executed in September 1994. The number of rural commune which was counted at forty nine as of 1986 further increased up to eighty five during the last eight years. The eighty five new communes include seventy seven rural communes and eight urban communes due to the national policy.

On June 1995, the CERED on the basis of the national census survey proposed the annual average population growth rates for urban and rural areas at 3.6 percent and 0.7 percent, respectively. In the report presented by the CERED, it was clearly pointed out that the trend of population growth in urban areas in recent years is substantially high compared to that in rural areas.

Taking into account of these tendencies and rates of increase, future population in respect to each commune in the Study Area was projected up to the year 2010 with five years interval in this Master Plan Study.

2.3 Water Resources

2.3.1 Groundwater

Some of the springs issue from the conglomerate Miocene formations with low yield ranging between 0.5 and 2 l/sec. Others, located at the foot hill of ridges and allochton Jurassic structures, produce between 0.5 and 5 l/sec. Only the springs of Bou Adel, Tazrhadra and Ain Khamisse located in the communes of Ain Mediouna, El Bibane and Rbaa Fouki are considered the three major water sources in the Study Area with flows of 220, 10 and 6 l/sec.

The number of dugholes has been increasing gradually in the Study Area, particularly during the recent drought period, in order to provide the necessary daily water needs. The depth of the dugholes ranges between 5 and 25 m depending on the level of the accumulated groundwater in the Quaternary deposits.

According to available records, the number of dugholes drilled by the AH adds up to 410. Privately owned dugholes amount to 85. The number of wells drilled and registered by the AH adds up to 118 having various depths ranging from 10 to 100 m, with only one extending to 250 m. Ninety one or 77 percent of these wells are dry, mainly due to incorrect location. From these dugholes and wells, the current capacity of groundwater production in the Study Area is calculated to be in the order of 30,000 m^3/d. .

2.3.2 Surface Water

(1) Present Condition

The Sebou river system including the Study Area is the region with the most promising surface water resources in the country. The Sebou river mainstream has a relatively stable baseflow in the dry season so that water of the river has been developed mainly for the irrigation development in the Gharb plain and has also been utilized recently for the potable and industrial water supply. On the other hand, stream flow of the other rivers in the Study Area varies significantly between wet and dry season. Thus, these rivers are not reliable water resources in the present situation even though the annual precipitation is the most abundant in the county.

(2) Ongoing and Proposed Surface Water Development Programs

Under the above-mentioned conditions, the Government of Morocco is proceeding the water resources development of the Sebou river system with the following two principles:

i) Construction of large scale dams for the integrated water resource development of the national level, and

ii) Construction of middle and small scale dams for socio-economic development of rural areas and conservation of watershed.

The outline of the surface water resources development are described below.

1) The Integrated Master Plan on Water Resource Development in the Sebou, Bou Regreg and Oum Er Rbia Basins (SBO Master Plan)

The SBO Master Plan was executed in 1992 for the development of water supply until the target year of 2020 in the Sebou, Bou Regreg and Oum Er Rbia river basins extending the coastal areas of Atlantic Ocean such as Kenitra, Rabat, Casablanca and El Jadia.

The Sebou River basin is considered as the most important water source in the country. The average surface water flow of the entire Sebou river basin is estimated at 5,600 million m^3/year. In order to develop the water resource, the surface water development plan of the Sebou basin is going to be implemented comprising 18 dams.

On the other hand, Rharb, Maamoura and Fes-Meknes plain are identified as the major groundwater potential regions. Potential of the groundwater resource of these regions is estimated at 707 million m^3/year in total.

The SBO Master Plan concluded that the available water resource in the Sebou basin is estimated at 4,889 million m^3/year in 2020 by achieving the proposed development program. Out of this amount of resource, 4,061 million m^3/year will be utilized to meet with the water demand within the Sebou basin, 60 million m^3/year will be preserved for environmental flow at the downstream end of the river, and 768 million m^3/year will be transferred to the coastal region mainly for future water supply to Casablanca.

2) Agricultural Development Project of the Ouergha River Basin

Development of medium and small scale dams is the one of the important policy of the country in terms of water resources and socio-economical development for rural areas. The purposes of this project are 1) water supply for domestic and livestock use, 2) irrigation and 3) conservation of watershed.

The dam inventory was prepared for 358 sites. Subsequent to the these dam sites, the master plan concluded proposing implementation of the construction of 215 dams including 8 medium scale dams, 36 small scale dams and 171 hill dams. As of 1995, one medium scale dam (Sahela), two small scale dams and 14 'hill' dams (Lacs Collinaires) have been completed as of 1995.

Regarding the development programs, the following dams are existing or under construction in and around the Study Area as listed on Table 2.6.

Table 2.6 Dams Concerned with the Study Area

Name	River	Reservoir Storage (million m^3)	Remarks
Idriss No. 1	Inaouen	1,186	Existing
Allal Fassi	Sebou	34	Existing
El Kansera	Beht	266	Existing
Sahela	Sahela	62	Existing
Al Wahda	Ouergha	3,800	Under Construction
Sidi Eduahed	Mikkes	170	Under Construction
Bouhouda	Sra	50	Under Construction

Source: AII

2.4 Analyses of Satellite Photos and Aero-photos

2.4.1 Analyses of Satellite Photos

Land shapes were identified as linear fault valleys, fault cliffs, cairncol and cairn bat, and then the photo-lineaments and fracture traces were extracted.

In the east half of the Study Area, there are relatively long lineaments running from north-east to south-west. Next long lineaments are found at east-west direction, and relatively short lineaments are extracted at the direction from north-east to south-west as well as from south-west to north-east. The photo-lineaments of north-east to south-west direction coincide with the direction of thrust fault which determines the geological structure of the Study Area. Since the main geological borders are running towards this direction, these features are considered to have been topographically reflected on the lineaments. The photo-lineaments of east-west direction are relatively short and are considered to be the borderline of geology.

In the west half of the Study Area, the photo-lineaments are scarce and most of them are short. As for the direction, north-west to south-east, and east-west are predominant in contrast to the east half of the Study Area, which is consistent with the direction of thrust faults. Also, since the main geological borders are running towards this direction, these features are considered to have been topographically reflected on the lineaments.

2.4.2 Analyses of Aero-photos

The classification of the flat plains, hills and mountainous areas are carried out. Of them, the flat plains belong to the distribution of the recent Quaternary deposition. The depressed basins and the deposition of the valleys represent the behavior of the synclinal structures. The hilly areas with their inclined edges and flanks represent the existence of the calcareous formations of the Cretaceous period. The gentle ridges and low hilly areas represent the deposition of the mioceneous marl and schists.

The north eastern area for the Pre-Rif region are identified by the massive rocky formations. The triangular shaped area situated among Taounate, Taza and Thar Souk is characterized by deep valleys and rocky mountains. The mountains are related to the limestone and dolomitic limestone of the Jurassic period. They are located in the form of rocky ridges or anticlinal and monoclinal structures of the Jurassic sedimentation.

2.5 Existing Conditions of Water Supply

2.5.1 General Aspect of Rural Water Supply in Morocco

More than 12 millions of population which correspond approximately to 52 percent of the total population presently reside in the rural area of Morocco. The rural population which occupies more than a half of the entire population engages in the agricultural sector playing a significant role of the national economy.

The AH executed the "Master Plan for the Development of Rural Potable Water Supply" which is the so called "National Master Plan" for the target year of 2010 and finalized second edition with the aid of UNDP on March 1994 following the previous edition issued in 1992. This National Master Plan has already been accepted by the Government of Morocco as the national policy and plan for rural water supply development in Morocco for coming 20 years.

It is also reported that an approximately 14 percent of the rural population is satisfactorily provided with public water supply facilities and the rest is supplied inadequately in quantity and quality. The latter case is by such as extracting water from unequipped private wells or springs, utilizing rain and river water and transportation from other areas beyond communal or provincial boundaries.

In the National Master Plan above said, the fundamental strategies for establishing the potable water supply system in the rural areas are flagged as follows:

i) to improve accessibility to the water sources which are satisfactorily equipped with facilities,
ii) to provide efficient facilities to the water sources, and
iii) to raise the rate of supply pervasion.

The National Master Plan also recommended to raise potable water service ratio from current 14 percent to 80 percent in 2010 as given in Table 2.7. The following prioritization on the development of water sources is attached to the above strategies:

1) First priority	: Spring water development
2) Second priority	: Groundwater development
3) Third priority	: Surface water development
4) Fourth priority	: Water transportation

Table 2.7 Present And Future Water Supply Pervasion

Type of Service and/or Works	Water Supply Pervasion			
	Present (1990) (%)		Future (2010) (%)	
House connection	2	14	10	80
Public stand pipe with network	6		40	
Rehabilitated source	6		30	
Traditional water sources facilities	16	86	-	20
Private source	23		-	
Rain water	10		-	
Surface water	21		-	
Transport	16		-	
Total:	100	100		100
Projected population (x 10^6)	13.4		14.3	

Source : National Master Plan

Note: Traditional water source facilities are such as tanks or channels for reserving rain water or stream water.

2.5.2 Existing Water Supply System in the Study Area

(1) Surface Water Supply System

The surface water supply system which constitutes largest water supply system in the Taounate province as well as in the entire Study Area currently controlled by the ONEP are established at the three locations in the southern boundary along the Sebou river. The location of these systems are shown in Figure 2.2.

1) Ain Gdah Water Supply System

The intake facilities are located on the right bank of the Inaouen river 43 km to the east from the city of Fes. The treatment plant is situated in the neighboring site of the intake facilities. The design capacity of the treatment plant is 5,500 m^3/d and current average daily water production rate is reported to be approximately 800 m^3/d in winter and 2,000 m^3/d in summer, respectively.

2) Mekansa Water Supply System

The design capacity of the treatment plant is 4,800 m^3/d and current daily average water production rate is reported to be approximately 2,200 m^3/d in winter. Because of less consumption of supplied water and subsequent need of less production, the treatment plant is currently operated, as of December 1994, only 6 hours a day. The treated water at the Mekansa water treatment plant is distributed after transmission to 90 douars scattered in the Mekansa commune.

3) Karia Ba Mohamed Water Supply System

Karia Ba Mohamed water supply system was established in 1985 by the ONEP in order to supply water to the Karia Ba Mohamed town including 9 douars located along the transmission main. Domestic water for the town of Karia Ba Mohamed was previously supplied by two springs located in the midst of the town, however, one of them was abandoned due to high saline content. The remaining spring with the estimated yield of 14 l/s is still in use for public water supply purpose by mixing with the treated water from the aforementioned treatment plant.

The intake facilities with a capacity of 50 l/s are located on the right bank of the Sebou river in the commune of Karia Ba Mohamed. The design capacity of the treatment plant set for the target year of 2000 is 2,600 m^3/d and the current average daily production rate, as of December 1994, is reported to be 1,300 m^3/d.

(2) Groundwater Supply System and Facilities

The public water supply systems which are dependent upon groundwater have been established in many communes in the Study Area, such as Taounate, Tissa, Karia Ba Mohamed, Ain Aicha, Rhafsai, Ourtzagh and Moulay Bouchta as the major systems in the Taounate province under the control of the ONEP. In addition, Ouazzane, Had Kourt, and Jolf El Merha are pointed out as the major systems in the Sidi Kacem province. The location of these groundwater supply systems is given in Figure 2.2.

The water supply facilities controlled and managed by communal authorities may be divided into two categories. The one is the case established by the communes by themselves, and the other is the case that wells and dug holes were initially constructed by the AH and thereafter transferred to the communal authorities in order to enforce their self-supporting capability.

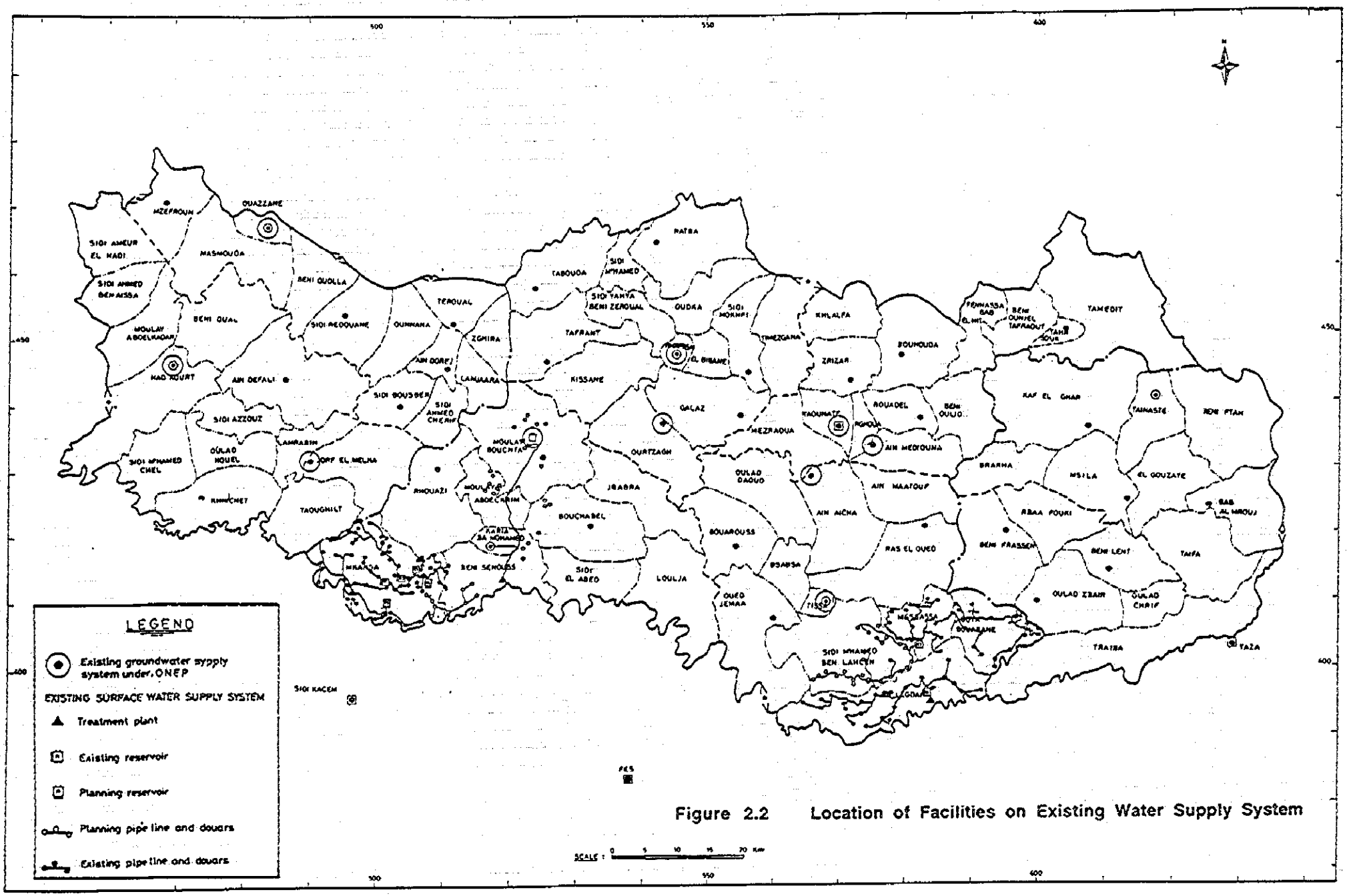


Figure 2.2 Location of Facilities on Existing Water Supply System

2.5.3 Existing Conditions of Water Use and Consumption

(1) Estimated Water Consumption in the Previous Study

The National Master Plan issued in 1994 represented the existing and projected future unit water consumption as of 1990 and 2010 as given in Table 2.8 in compliance with the type of facilities being or to be provided in the rural areas in Morocco.

Table 2.8 Existing and Future Unit Water Consumption for Domestic Use

(Unit: l/c/d)

Type of Service	1990	2010
Equipped well and springs	15	15
Public stand pipes	20	30
House connection	40	50

Source: National Master Plan, 1992

In the National Master Plan, projection is given as shown in Table 2.7 for the future services categorized in four types, 1) stand pipe: 40 percent, 2) house connection: 10 percent, 3) rehabilitated source: 30 percent, and 4) non-equipped or private source: 20 percent. In line with this category, the report concluded that the domestic water demand in rural areas in 2010 would be 188 million m^3/year or 36 l/c/d in average of four types, whereas water consumption for livestock feeding would be 20 /head/d.

Whereas, the National Master Plan introduced the projected water consumption by the DRPE for the target year in 1990. At the stage of projection, the total available water in the three provinces consisting of surface and groundwater are 28 l/c/d, 27 l/c/d and 27 l/c/d, respectively.

(2) Present Water Use in the Study Area

1) Taounate Province

The Ain Gdah system which includes the largest service area has less house connections as small as 9.3 percent in the rate of saved population and similarly the Mekansa system including the third largest service area has 9.8 percent. The percentage calculated is based on the rate of 8 persons per house connection as estimated in the National Master Plan. These two systems mainly supply water by stand pipes.

The available flow rate of the Taounate, Karia Ba Mohamed, Ain Gdah and Mekansa systems which are ranked on top four in the magnitude amount to 215 l/s which equivalent to 87 percent of the total.

The highest relative unit water consumption is seen at Karia Ba Mohamed with the amount of 63.4 l/c/d followed by 59.8 l/c/d and 43.7 l/c/d at Taounate and Tissa, respectively. It is assessed that these supply areas are rather small but provided with comparatively sufficient house connection facilities compared to others.

2) Sidi Kacem Province

The municipality of Ouazzane is presently being supplied with water from the four boreholes located in the plain of Bouagba, 34 km to the west from the town of Ouazzane. The yield of these bore holes are estimated to be about 120 l/s. Due to topographic configuration and the difference in altitude of about 275 m between the source and the town, transmission facilities are equipped with a number of reservoirs and booster pumps.

The average and peak flow rates of 60 l/s and 80 l/s respectively are reported by the ONEP to supply water for the municipal population of 52,200. The water from the same source is also supplied to the commune of Masmouda with an average flow of 0.5 l/s or approximately 43 m^3/d.

The water supply system in the rural center of Jolf El Melha consists of wells equipped with pump facilities, distribution network and house connections. The supply capacity in June 1995 was about 4.6 l/s, whereas water demand was estimated in the order of 10 l/s, thus water deficit of Jolf El Melha is reported by the ONEP to be around 55 percent.

The rural center of Had Kourt is supplied with water from a well and a spring equipped with pumps feeding the network of the rural center of Had Kourt. The present water demand estimated by the ONEP is around 7 l/s, whereas average and peak flow rate in the existing facilities are 2.4 and 2.5 l/s, respectively. Due to less potential of water source, current water deficit is reported to be around 65 percent.

3) Taza Province

On the provincial level, the ONEP Taza is regularly receiving requests from various communes in the Province, whereby the communal authorities request the ONEP to take place management of the existing water supply facilities in order to enhance. Amongst these communes, Tainaste, Oulad Zbair and Beni Lent are the ones situated within the Study Area.

(3) Existing Constraints on Water Source and Demand

1) Quantitative Constraints

The rate of surface water production in the Taounate province is 17 percent, 25 percent and 7 percent in the Ain Gdah, Karia Ba Mohamed and Mekansa systems, respectively and these corresponds approximately to 50 percent in total. This implicates that the role of the surface water supply system in the Taounate province is indeed very large at present.

The surface water potential at the intake site is large enough, especially, at the site of Karia Ba Mohamed and Mekansa water treatment plants in the down reaches of the Sebou river. However, the low flow rate at Ain Gdah will be critical when considered about heavy drought periods as encountered in 1995. For instance, during the Study period in

July 1995, the operation of the Ain Gdah water treatment plant was stopped for six days due to water shortage in the Inaouen river.

As for the case of groundwater sources controlled by the ONEP, it is envisaged that there would not likely to be much influence by dry periods, since the wells and dug holes are located in relatively good geophysical formations in the vicinity of rivers.

In case of the Sidi Kacem province, the great majority of the flat plains are suffering from water shortage due to less potential of groundwater source under difficult geophysical formations which may be unable to constitute a good aquifer.

2) Qualitative Constraints

The contamination of the Sebou river is predominantly caused by domestic and industrial waste water discharge from the city of Fes and its suburban areas. The RADEEF has been implementing a new project for industrial wastewater disposal. The project includes the construction of lagoons for retention of olive oil and a treatment plant with mechanical treatment methods. In compliance with the completion of this disposal system, water pollution of the Sebou river due to olive oil is expected to be largely diminished in the near future.

Meanwhile, water pollution due to domestic wastewater discharge will remain for the time being until wastewater disposal system has been established in and around the city of Fes.

The problem of salinity of the groundwater is not an easy task to solve, since the problem is totally depends upon the geophysical conditions.

3) Constraints on Operation and Maintenance Works of ONEP

In the existing water supply systems by the ONEP, there is not much serious constraints on the operation and maintenance aspects as a whole. However, it should be pointed out that water leakage from the transmission pipelines are sometimes observed. Further, it is hardly accessible to the leakage site to repair during especially the rainy season, due to collapse or slippery ground conditions.

2.5.4 Proposed and Ongoing Project by ONEP

Table 2.9 gives the proposed and ongoing projects being and to be carried out under the ONEP in the province of Taounate . Of them, six projects including Ain Aicha, Ain Mediouna, Rhafsai, Taounate, Laghouazi and Ourtzagh were already concluded in the contracts and other three projects are in preparation of construction. The remaining projects also have already been promised in their financial aid from foreign countries. With due completion of these projects, the existing water supply systems in the Province of Taounate will be extensively improved.

Table 2.9 Proposed and Ongoing Projects by ONEP in Taounate Province

Rural Center	Project Description	Cost(DH) (x1,000)	Design Work	Constru. Period	Remarks
*M'kansa	Rehabilitation of water supply facilities and reinforcement of treatment capacity	10,000	completed	12 months	Invitation for tender expected on July 17, 95
*Karia Ba Mohamed	Double the capacity of water supply facilities up to 30 l/s	30,000	completed	12 months	Invitation for tender expected on July 17, 95
*My Bouchta	Construction of transmission line, extension of network to accommodate a flow rate of 10 l/s with reservoir	18,500	to be completed by August 95	12 months	Invitation for tender expected on August 17, 95
*My Bouchta	Provision of facilities to the douars	10,000	to be completed by August 95	12 months	Invitation for tender expected on August 17, 95
*Ain Aicha	Equipping a well for a flow rate of 10 l/s and extension of network including a reservoir	14,000	to be completed by July 95	8 months	Invitation for tender expected on July 17, 95
*Ain Mediouna	Exploitation of a well for a flow rate of 10 l/s and extension of the network, including the construction of a reservoir	14,000	to be completed by July 95	8 months	Invitation for tender expected on July 17, 95
*Rhafsai	Transmission line, extension of network, construction of a reservoir for a flow rate of 5 l/s	10,500	to be completed by July 95	8 months	Invitation for tender expected on July 17, 95
*Taounate	Provision of water production and distribution facilities	77,000 10,000	completed completed	12 months 12 months	Work on production facilities started on July 7, 95 Work on production facilities started on July 24, 95
Laghouazi	Equipping a well for a flow rate of 2 l/s, distribution network and reservoir	6,000	to be completed by August 95	8 months	Selection of water source is under way
*Ourtzagh	Rehabilitation of the force main and the distribution network	2,700	to be completed by August 95	8 months	Invitation for tender for the rehabilitation of the distribution facilities July 17,95
Tafrant	Provision of water production and distribution facilities	12,000	to be completed by August 95	8 months	Selection of the water source is under way and invitation for tender for the distribution facilities on July 17, 95
Bouchabel	Supply of Bouchabel rural center and 18 douars from the proposed transmission line of Mly Bouchta	6,000	to be completed by July 95	12 months	Design work under preparation by the Regional Direction of ONEP
Tahar-souk	Equipping a spring, extension of network and rehabilitation of the reservoir	3,000	to be completed by July 95	12 months	design work under preparation by ONEP
Sidi M'hamed Bel Laheen	Supply of the rural center and 15 douars from the Ain Gdah system	5,700	to be completed by July 95	12 months	Construction started in June 95
Bni Souss	Supply of the rural center and 15 douars from the M'kansa system	2,000	to be completed by July 95	12 months	Construction started in June 95

Source: ONEP Taounate Provincial Office

* : Existing ONEP system

2.6 Initial Environmental Examination

2.6.1 Existing Conditions of Environmental Aspects

(1) Water Quality

1) Norms or Standards

Table 2.10 summarizes the drinking water quality standards used in Morocco and compares them with the WHO recommended standards. Allowable water quality for livestock in Morocco is also given.

2) Groundwater Quality

Available water quality of most springs in the Study Area have been classified into five classes, namely, good, passable, average, low and saline. Of them, 8 springs are defined as low quality and not suitable for drinking purpose. The west part of the Taounate commune is well known as spring water yielding area, although saline water is found occasionally due to complicated geophysical configurations.

The water quality data for selected number of dugholes in the Study Area gives that 14 out of 49 locations (29 percent) have saline water and low class water under the conductivity testing, and the dugholes defined as saline water has been mostly abandoned.

3) Surface Water Quality

The Sebou river basin is subject to regular monitoring (BOD, COD, dissolved oxygen, total nitrogen, fecal coliform) at various points along the river and its tributaries.

Extensive discharge of domestic untreated sewage into the Sebou river by numerous urban centers worsens water quality. Concentrations of bacteriological parameters of pollution caused by sewage (total coliform, fecal coliform) are very high in areas immediately downstream of urban centers along the Sebou river and its tributaries.

(2) Sanitation and Wastewater Disposal

Some features of prevailing conditions are as follows:

i) Less than 20 percent of the population in villages of the Study Area have individual latrines. In the most of rural villages scattered in mountains and hilly areas, latrines are primitive type, made of traditional locally available material (wood and mud).

ii) In general, nothing is planned for wastewater disposal. Potential pollution of water sources (springs or dugholes) is high in some locations. Local ground permeability conditions would be a cause of pollution of such drinking water sources.

iii) Rural schools and markets have sanitary problems. In many cases, schools are built without latrine due to a lack of water supply. Markets are major sources of pollution because waste disposal is scarecely managed.

iv) Pollution of the Sebou river and its tributaries by domestic sewage is a major sanitary problem.

(3) Health and Water Borne Diseases

A classification of the provinces were given on the basis of incidence of cholera, typhoid and diarrhea in 1990 (cholera also 1993). The Taza and Sidi Kacem provinces can be classified in group 1 of the maximum incidence along with four other provinces outside the Study Area. Taounate can be classified in group 2 of incidence following group 1.

In particular, communes of the Taza province within the Study Area and falling in homogenous zone 7 as defined in the National Master Plan reported high incidence of water related diseases. The Taounate commune reported several cholera cases in 1993. The Sidi Kacem province reported 38 cases of cholera in 1993. The number of cases were much higher in each of these provinces in 1990.

(4) Institution and Management

Many institutions are involved in provision of rural water supply. These include the Ministry of Interior, the Ministry of Public Works, the Ministry of Agriculture and Agrarian Reform, the Ministry of Public Health and the National Office of Potable Water.

The Department of Epidemiology and Sanitary Programmes under the Ministry of Public Health has a decentralized structure. There are over 220 rural sanitary departmental units for the entire country. In general, 1 to 3 communes are covered by each unit. These sanitary department units are in turn divided into sections that are led by itinerant nurses. These itinerant nurses are responsible for effecting disinfection action of water sources as well as for providing sanitary education. The program of disinfection concerns principally the collective wells. Private wells are only covered in general in the case of an epidemic outbreak.

Almost half of equipped water sources in the Study Area are under private management. The rest of the water sources are under management of villages or communes. However, the villages or communes are hardly ever involved in the disinfection. This is a major institutional problem obstructing adequate or proper disinfection of water sources.

(5) Sociological Aspects

The factors of water supply difficulty and the dominating position of women and children in the execution of this task have serious effects on the health condition as well as on living conditions and welfare. These include:

i) Areas with high prevalence of water borne diseases have high female illiteracy rates (about 90 percent).

ii) Women's activities outside home i.e. bringing water results in high prevalence of water borne diseases, especially infant diarrhea with high mortality rates.

iii) Difficult water supply conditions have resulted in high migration rates.

iv) Low incomes added to difficult service conditions and poor hygiene practices are recognized as factors leading to existence of water borne diseases.

v) Effects of the disinfection are not understood or neglected. For example, many coffee shops in rural towns use non-disinfected water since people does not like disinfected water.

vi) Indigenous ownership claims water sources to forbid development and/or sharing with neighboring areas. This problem is reported in some mountain localities of the Study Area.

2.6.2 Environmental Impacts and Intervention Measures

Areas with high incidence of water related diseases are characterized by the following:

i) There are less disinfecting operations.

ii) Less than 8 percent of water sources are properly equipped.

iii) More than 80 percent of water intake points are in a bad condition (hygiene, cleanliness, operation and maintenance).

iv) There is a large number of non-equipped water resources (mostly private shallow wells).

v) Mother and children, particularly girls, have the role of bringing water from the source to their house. The average time required ranges from 1.5 to 2 hours (round trip) in many hilly and mountainous areas. This in turn results in low education level of mothers and children as well as neglect or inadequate care of infants.

vi) Less than 5 percent of localities possess latrines or less than 20 percent of the population utilizes latrines.

Provision of potable water supply to rural communities in the Study Area entails consideration of various environmental aspects. Intervention measures are required not only providing good and safe water supply but simultaneously implementing actions related to excreta disposal, wastewater disposal, improved health care (disinfection of water supply and preparedness to tackle epidemics) and education related to personal and domestic hygiene. These actions need to be focused to varying degrees on the user, the living environment and the health care system.

The following important actions need to be considered in formulating interventions:

i) Increased disinfection of water sources.

ii) Increased community and local participation in management, operation and maintenance of water sources.

iii) Necessity to impart education related to sanitation and personal hygiene.

iv) Improvement of the institutional set up for managing various aspects related to water supply and improved coordination among various organizations for water management.

v) Need for provision of sanitary latrines and waste water drainage and disposal in addition to providing water supply. This is very important since in the absence of such measures the potential for pollution of existing water sources could be high.

vi) Focus on women to impart sanitary education because of their dominant role and promote compulsory education of children.

Table 2.10 Potable Water Quality Standard

AGENCY/COUNTRY	WHO* Recomm. Standards Maximum	MOROCCO Allowable value		MOROCCO SUITABLE QUALITY FOR LIVESTOCK			
		Recomm.	Acceptable	Good	Passable	Average	Low
PARAMETERS							
1. Total hardness(meg/l) 1 meg/l = 50 mg/l as CaCO3	<10						
2. Turbidity (NTU)	5	1	5				
3. Color (platinum-cobalt scale)	15	5	20				
4. Iron, as Fe (mg/l)	0.3	0.3					
5. Manganese, as Mn (mg/l)	0.1						
6. pH	6.5 ~ 8.5	6.5 ~ 8.5	9.2 (min.6.0)				
7. Nitrate, as N03 (mg/l)	45		50				
8. Sulfate, as SO4 (mg/l)	400	200		0 ~ 150	150 ~ 290	290 ~580	580 ~1150
9. Flouoride, as F (mg/l)	1.5	0.7	1.5				
10. Arsenic, as As (mg/l)		0.05					
11. Magnesium, as Mg (mg/l)	150	100		0 ~ 30	30 ~60	60 ~120	> 120
12. Salinity							
a. Dry residual (mg/l) at 180 C		1000	2000	0 ~ 500	500 ~1000	1000 ~2000	2000 ~4000
b. Electrical Conductivity (µS/cm at 20°C)		1300	2700	0 ~ 800	800 ~1600	1600 ~3200	3200 ~6400
c. Chloride (mg/l)	250	300	750	0 ~ 180	180 ~ 360	360 ~710	710 ~1420
13. Total Coliforms (no./100 ml)							
a. Piped water supply	0	0	0				
b. Disinfected water at entrance of distribution system	0	0	3 (no two consecutive samples at same point)				

Source: National Master Plan
Note: * World Health Organization

2.7 Geophysical Prospecting

2.7.1 General

Goephysical prospecting by electrical sounding was conducted on the seven geologic structures of Jorf El Melha, Ain Defali, Teroual, Ourtzagh, Ain Berda, Taounate, and J. Keil, in order to identify the detailed configuration of their hydrogeological features. In addition electromagnetic sounding was performed on the structure of Ain Berda to detect the cracked and fissured consolidated formations therein.

Vertical electrical sounding (VES) consisting of the Schlumberger electrode array was used to specify the stratigraphical column of the aforementioned geological structures and to determine the exact thickness of the various water bearing formations.

Electromagnetic sounding was carried out by VLF (very low frequency, 3 to 30 Khz) MT (Magnetotelluric) resistivity measuring system in order to confirm the locations of faults and fractures within the geological structures.

2.7.2 Survey Results

(1) Jorf El Melha Structure

Resistivity readings at the structure of Jorf El Melha range between 160 and 430 ohm-m for the upper layer composed of fine alluvium and conglomerate and extending between 10 and 30 m deep. The lower layer has very low resistivity readings of 0.8 to 7 ohm-m which correspond to impervious marl deposits.

(2) Ain Defali Structure

Electric soundings carried out in the N-S and E-W directions confirm the presence of a water bearing formation consisting of conglomerate and marl matrix with resistivity readings ranging from 15 to 100 ohm-m in the E-W direction and 60 to 300 in the N-S direction and extending about 150 m deep. Beyond this depth, the resistivity drops to less than 10 ohm-m indicating the presence of an impervious marl layer of more than 100 deep.

(3) Teroual Structure

The results indicated the presence of a water bearing silt stone formation with resistivity in the order of 100 ohm-m along the the western edge of the syncline structure. According to VES line A, the productive layer extends from 30 to 150 m below ground level. At VES points 6 and 7 of line B, the survey revealed the presence of another water bearing formation, with resistivity ranging between 40 to 100 ohm-m, outcropping along the eastern flank of the syncline and dipping towards the west to a depth exceeding 250 m from ground level. The two layers are separated with impervious deposits of about 125 m thick having a resistivity of 10 to 20 ohm-m.

(4) Ourtzagh Structure

The survey indicated that the flanks of the syncline are dipping towards its axis at VES point 10 where the top of the conglomerate formation is about 300 m below ground level. Resistivity readings of 50 ohm-m characterize this formation as a water bearing stratum. The overlaying layers consist of impervious marl deposits having a resistivity range of 2 to 4 ohm-m. The shallow surface of the syncline is covered, up to about 25 m deep, with conglomerate formation having resistivity readings of 20 to 187 ohm-m indicating the presence of water accumulation.

(5) Ain Berda Structure

The survey was carried out along the fault line of the structure as inaccessibility prevented from investigating the top of the monocline. The resistivity profile along the survey lines indicated the presence of water bearing formation with readings ranging from 30 to 360 ohm-m and extending between 70 and 150 m from ground level and about 35 m below the level of the existing spring of Tazghadra. The underlying formation is marked with low resistivity of 10 to 20 ohm-m revealing the presence of impervious deposits. The electromagnetic sounding carried out on the top of the structure registered a constant resistivity of 50 ohm-m indicating the presence of water bearing formations.

(6) Taounate Structure

The survey confirmed the presence of two syncline structures located along the Sra river. The first structure stretches north south in the direction of VES line B and includes two water bearing formations. A shallow one with resistivity readings of 30 to 56 ohm-m and a thickness ranging from 20 to 70 m at VES points 16 and 12 respectively, and a deep formation located some 250 m below ground level having a thickness of 125 m and resistivity ranging from 20 to 50 ohm-m. The second syncline lies in the east west direction along VES line C and is composed of an upper water bearing formation extending between 175 and 250 m below ground level with resistivity readings ranging from 10 to 89 ohm-m. The lower formation consists of impervious stratum having a resistivity of 1 ohm-m.

(7) Jbel Keil Structure

The survey confirmed the presence of large limestone boulders and conglomerate formation extending about 25 m below the level of the existing spring of Bouadel and identified as the water bearing stratum of the monocline. The resistivity readings of the section above the spring range from 50 to 1500 ohm-m, whereas those of the area around the spring vary between 850 and 1200 ohm-m. The base formation below the structure consists of impervious marl with resistivity of 61 ohm-m indicating the presence of schist and consolidated marl stone.

2.8 Recommendation of Model Area

2.8.1 Conditions of Selecting Model Area

In the course of executing the study in the first stage, selection of model areas in a preliminary level was made in compliance with the results of 1) topographic analysis, 2) geological and hydrogeological analysis, 3) satellite and aero-photos analysis, 4) site inspecting and reconnaissance survey, 5) inventories of existing rural water supply facilities, 6) prevalence of infrastructure and 7) socio-economic survey and analysis.

The primary conditions considered in selecting model areas are given as follows. They are:

i) The model areas shall be rich in hydrogeological and structural potential for reserving groundwater.

ii) The model areas shall be in each condition as frequently and severely, especially during dry season, suffered from water shortage in recent years, and subsequently people have to travel several kilometers spending a couple of hours to acquire water.

iii) The model areas shall be such as the rural center of the commune having large population, and the results of water supply development would assert much influence and impacts on socio-economic aspects.

iv) The model areas can be representatives among others in the Study Area in topographic, socio-economic and water sources conditions. In this regard, the areas shall be representatives of mountainous, hilly and flat zones which constitute general topographic configuration of the Study Area.

2.8.2 Selection of Model Area

In line with above conditions, especially in physical aspects, the following thirteen water potential structures containing abundant groundwater were selected as candidates for model areas. The location of these potential structures are given in Figure 2.1.

1) Mountainous area

i)	Taineste	Taounate Province
ii)	J. Khamise	Taza Province
iii)	J. Keil	Taounate Province
iv)	J. Berda	Taounate Province
v)	Thar Souk	Taounate Province

2) Hilly area

i)	Teroual	Sidi Kacem Province
ii)	Ourtzagh	Taounate Province
iii)	Ain Saddine	Sidi Kacem Province
iv)	Taounate	Taounate Province
v)	Tissa	Taounate Province

3) Flat plain area

i)	Jolf El Melha	Sidi Kacem Province
ii)	Ain Defali	Sidi Kacem Province
iii)	Had Kourt	Sidi Kacem Province

Out of these candidates, seven were selected as high prioritized areas for implementing geophysical prospecting. They are:

i) Jorf El Melha
ii) Ain Defali
iii) Teroual
iv) Ourtzagh
v) Ain Berda
vi) Taounate
vii) J. Keil

The results of geophysical prospecting are given in the previous section in detail. Taking into account of the priority in the physical conditions among these, current condition of water shortage and socio-economic impacts after provision of water supply facilities were incorporated.

As a conclusion, the mode areas were selected as Ain Defali; the rural center of Ain Defali commune, Teroual; the rural center of Teroual commune and Ain Berda; the rural center of El Bibane commune.

2.9 Formulation of Development Strategy

2.9.1 Basic Conditions

On the basis of the study results on general conditions for the Study Area, the development strategy of rural water supply was formulated in compliance with the following conditions:

i) Because of the scarce potentiality of source waters in the Study Area, both of surface water and groundwater are indispensable for the future water supply development. As for the groundwater sources, thirteen high potential areas for groundwater yield have been identified, and in addition medium and low potential areas. Those groundwater potential areas are and will be applicable with high probability for rural water supply purpose, although the magnitude of them are not so large compared with surface water, immediately after exploitation of wells and dugholes.

ii) The National Master Plan which was accepted as one of the national policies for the development of rural water supply shall be the primary strategy in the course of water supply development of the Pre-Rif region. As is proposed in this National Master Plan, the surface water supply scheme is allocated on the third priority in the rural water supply development programs.

iii) According to the National Master Plan, existing public water supply pervasion of 14 percent is planned to raise 80 percent by the target year of 2010. However, this figure of 80 percent is not approachable unless surface water supply system including existing ongoing programs being carried out by the ONEP is further promoted.

iv) While, as for the surface water resources, several plans and programs for utilization for water supply system have been established by the AH on a hydraulically quantitative view point, however, facilities planning has not been completed yet or still in a level of premature against the target year of 2010.

v) The ONEP has planned and been carrying out improvement and expansion programs of the existing three surface water supply systems including treatment plants, pipelines, pumping stations and other appurtenant facilities. These ongoing schemes can be applicable for the system required in 2010.

vi) Establishment of the system of water supply based on either surface water or groundwater shall be completed within fifteen years by the target year of 2010. In view of the supply area, one third of the Study Area, which correspond to approximately 50 percent of the people, will be supplied by the surface water according to the ongoing programs by the ONEP.

2.9.2 Impact on Establishment of Rural Water Supply

The existing rural water supply system in the Pre-Rif region is largely divided into three types. The first is the supply system to the large towns such as Ourzzane in the Sidi Kacem province with the population of more than 50,000 and Taounate in the Taounate province with the population of more than 20,000. This type of system has comparatively sufficient supply amount with large number of wells and abundant source water.

The second is the type which is supplied with surface water such as Ain Gdah, Karia Ba Mohamed and Mekansa. This type of the system has also comparatively sufficient supply amount depending on the source water from the Sebou river.

The third is the type which is supplied with water from dug holes and springs which are very rarely equipped with facilities. This type of the system has very poor amount of source water and brings constraints to the rural people of traveling a long distance for carrying water. The great majority of the people in the Study Area belongs to this group.

The impacts on establishment of rural water supply system may differ in magnitude depending on current condition of each type of water supply and subsequent constraints. However, common impacts will be envisaged to be brought on the view point of socio-economy, uprating of rural economy and individual living standard, opportunity for job acquisition, and development of women and children.

2.9.3 Set up of Development Scenario

According to the ongoing programs on surface water supply system established by the ONEP as mentioned above, approximately 50 percent of the people will be able to acquire water by this system by the target year of 2010. The rest of the population may be supplied water either surface water supply system on the basis of probable new water supply system including new water treatment plant, pumping stations and pipelines or the groundwater supply system which will be exploited from now on by the target year.

The unit construction cost of water supply facilities per capita, groundwater exploitation is, in general, more economic, because that groundwater, as far as the Study Area is concerned, does not need treatment. Further, the water source from the supply area can be found much nearer than the case of surface water resulting in saving of pipeline and pumping costs.

In view of operation and maintenance aspect, groundwater supply system is much less complicated compared to the case of surface water due to experiences in the arid area such as the Pre-Rif region.

Taking into aforementioned conditions, the following scenarios as the basic strategy will be proposed.

i) The development of water supply systems in the Study Area for the target year of 2010 shall be established based on groundwater sources in cooperation with surface water sources, and the rate of supply pervasion will be 80 percent in compliance with national policy.

ii) In principle, groundwater will be fully utilized from the above mentioned advantages for establishing potable water supply system in the rural area. Consequently, the thirteen groundwater potential structures, which are identified by this Study, will be developed with the highest priority.

iii) Development of potable water supply system using surface water will be proceeded firstly from the existing program proposed by the ONEP. Other succeeding plan will be prepared after confirming progress of groundwater development and future plan of water usage by implementing the proposed surface water development program.

CHAPTER III STUDY ON WATER SUPPLY IN MODEL AREAS

3.1 Natural Conditions

3.1.1 Topography

The three model areas for the detail investigations were selected, Ain Defali, Teroual and El Bibane communes. Location of each commune is shown in Figure 3.1.

(1) Ain Defali

The Ain Defali commune is located in the west of the Study Area, covering an area of 250 km^2 belonging to the Sidi Kacem province. Topography of Ain Defali is generally flat with the low hills showing a gentle slope which is a particular topography in this region. The ground elevation varies from 80 m along the Rdat river to 250 m in the north-western part.

(2) Teroual

The Teroual commune belongs to the Sidi Kacem province and covers an area of 90 km^2 with the town of Teroual which is located around 10 km north-west from the Al Wahda dam site. Topography is obviously changing around the commune between the flat area in the south-west and the mountainous area in the north-east. The elevation of the Teroual town is 250 m with the topography showing an outlet of the basin. The steep mountains ranging on the north to east is the watershed boundary with an elevation of 500 to 600 m.

(3) El Bibane

The El Bibane commune belonging to the Taounate province is located near the town of Rhafsai which is situated 10 km north from Ourtzagh along the Ouergha river. The area of El Bibane is 50 km^2. The mountainous area is called Jbel Berda having the two steep mountains with the elevations of 900 m and 1,000 m at their summits. The relatively flat area is limited around the south-east to west along the foot of the mountains with an elevation of 500 to 600 m.

3.1.2 Hydrology

(1) Ain Defali

The average annual rainfall is 600 mm. The Rdat river running though the commune has a relatively wide catchment area. However, the mountainous area, which is the water source of the Rdat river, is so small that the river almost dries up in the dry season and the runoff rate is smaller than the other major rivers in the Study Area. The small streams running through the low hills shows runoff with in a short period only after rainfall.

(2) Teroual

The average annual rainfall is 800 mm around the Teroual town and 1,000 to 1,200 mm from the north of the watershed. Around the Teroual commune, only a small tributary of the Ouergha river runs from north to south on the west of the commune.

(3) El Bibane

The average annual rainfall is 1,000 mm. Since the commune is located on the watershed with the steep mountains, the most of runoff is supposed to flow into the Aoulai and the Amzáz rivers through small gorges in a short period.

3.1.3 Geology

(1) Ain Defali

The geological features of the syncline structure of Ain Defali enclose the deposits of two main epochs the Pleistocene of the Quaternary period and the middle Miocene of the Tertiary period. The former consists of a surface layer of recent alluvium composed of silty marl and gravels having an average depth of 15 m below ground level. The underlying layer is the Quaternary ancient (Villafranchian) composed of conglomerate and marl matrix deposits with an average thickness of 125 m. The terminal layer of the syncline belongs to the Turtonian age of the middle Miocene epoch consisting of marl and silty marl deposits having a thickness of several hundred meters.

(2) Teroual

The study of the stratigraphical column reveals the presence of various geological epochs belonging to the Tertiary period The upper most layer consists of the Turtonian marl and silty marl of the upper Miocene and extending around 30 m below ground level. The subsequent layer, comprising siltstone, sandstone and conglomerate with marl matrix of the Oligocene epoch, has an average thickness of about 150 m. The lower formation encloses limestone, marly limestone and marl deposits of the Eocene epoch and extends around 200 m.

(3) El Bibane

The geological configuration of the model area indicates that the depositions located on the summit of the monocline of Jbel Berda consist of limestone, marly limestone dolomite and schist formations of the middle Jurassic epoch dipping in the east west direction and flattens out in the south west direction. The monocline overlays an impervious marlstone and schist formation of the upper Cretaceous.

3.1.4 Hydrogeology

(1) Ain Defali

The syncline structure of Ain Defali resembles a closed basin stretching 4 km from east to west and 3 km from north to south with an area of 12 km^2, and is filled with water bearing conglomerate with marl matrix of the Quaternary deposits up to a depth of 150 m below ground level.

The two existing springs at the southern side issue water from the shallow conglomerate formations of higher recharge sources and are independent from the actual water bearing formation of the syncline structure. The existing dugholes spread around the structure are of shallow depth averaging around 15 m. As such these water facilities exploit only the superficial groundwater of the conglomerate surface layer.

(2) Teroual

The syncline structure of Teroual is roughly a closed basin oriented in the SE - NW direction and stretching 3 km along its major axis and 2.2 km along the minor axis, thus covering an area of 6 km^2 . The upper water bearing formation of the syncline belongs to the Oligocene epoch and consist of siltstone with marl matrix having a thickness of about 100 m. The second water bearing formation is separated from the upper one by an impervious marl layer of the Oligocene epoch. It consists of sandy marly limestone having a thickness of around 100 m. The two faults striking the syncline in the NE - SW and N - S directions induced fractures into the formations of the basin and gave rise to the existing springs.

(3) El Bibane

The structure is oriented in the SE - NW direction and covers an area of 6.3 km^2. It is stricken with two major faults oriented SE - NW that formed a syncline having a water bearing conglomerate formation.

The existing four springs issue water from the structure at the contact line between the Jurassic schisty formation and the underlying Cretaceous impervious marl base.

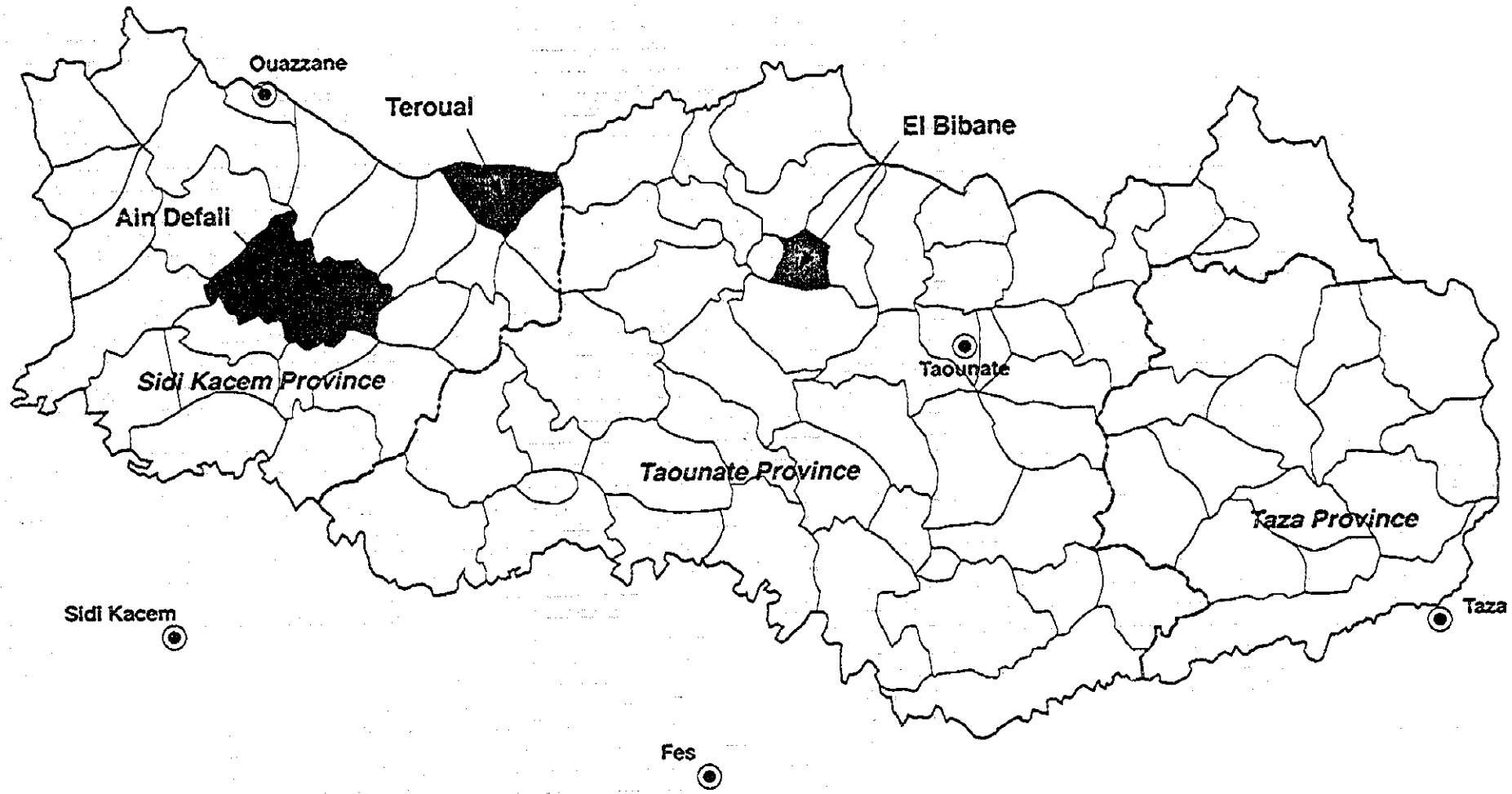


Figure 3.1 Location of Model Areas

3.2 Socio-economic Conditions

3.2.1 Administration and Population

The administration and population in each of the model areas are shown in Table 3.1.

Table 3.1 Administration and Population in Model Area

Province	Circle	Commune	Nos. of douars	Population	Pop./douar
Sidi Kacem	Had Kourt	Ain Defali	60	25,116	420
	Ouazzane	Teroual	29	12,096	420
Taounate	Rhafsai	El Bibane	10	6,511	650
Total/Average			99	43,723	440

Source: CERED

3.2.2 Land Use

Farming activities are the essential way of making a livelihood for local people in the Study Area. This circumstance is also true of the three communes. Table 3.2 shows the types of crops and cultivated areas in the three communes.

Table 3.2 Land Use by Agricultural Crops in Model Area

(Unit : Ha)

Crops	Ain Defali	Teroual	El Bibane
Crops			
Hard wheat	4,500	1,100	470
Soft wheat	7,000	1,650	570
Barley	2,000	550	200
Vegetable	10	60	50
Legume	1,850	1,000	26
Beet	20	---	---
Sunflower	300	50	---
Tobacco	350	150	---
Fodder	---	240	10
Plantation			
Forest	462	---	---
Fig	---	---	450
Olive	1,030	660	520
Citrus fruits	99	30	---
Pomegranate	9	---	---
Grape	---	90	---
Pasture	120	900	---
Uncultivated	---	---	600
Total:	17,750	6,480	2,296

Source: Provincial Directorate of Agriculture

3.2.3 Household Sector

According to the Provincial Directorate of Agriculture, annual net income generated from agricultural activities such as vegetation, livestock breeding and forestation was reported to be DH3,000 per person in Taounate in 1993-94, and DH19,944 per farm or DH3,680 per ha in Sidi Kacem in 1990-91. Household expenditures are another method of evaluating purchasing power of rural households. Table 3.3 shows per capita expenditures per month by income class.

Table 3.3 Expenditure per Capita and Month by Income Class

(Unit: DH)

Commune	Rich	Middle	Poor	Average
Ain Defali	316	295	171	260
Teroual	288	256	147	230
El Bibane	490	276	156	308

The above figures are the results obtained from the extensive sample survey. The average expenditures are simply multiplied by twelve months to estimate annual average expenditure per person, resulting in DH3,120 in Ain Defali, DH2,760 in Teroual and DH3,700 in El Bibane.

3.2.4 Social Infrastructure

Ain Defali is relatively well equipped with social facilities and services. El Bibane is envisaged to be the least developed rural commune. The development of Teroual is in the middle between Ain Defali and El Bibane in terms of social infrastructure. Infrastructural facilities and social services are mostly observed at rural centers of communes.

The classes of roads consist of principal, secondary, provincial and commune roads. The access to the rural center of Ain Defali is relatively easy as both principal and secondary roads are linked to Ain Defali. Public services such as electricity and telephone concentrate the rural center in three communes.

3.2.5 Life and Works of Women

(1) Water Transportation

The task of water transportation is normally conducted by women and children. This task requires much of physical energy and sacrifices the valuable time because of long distance between water sources and homes.

(2) Wood Collection

The types of fuel used in the three communes are either butane gas or wood depending on the purposes of fuel usage. The consumption of butane gas depends on household

income. Most of families utilize wood for bread baking. Traditional cooking by use of wood is highlighted at the time of harvesting and olive collection.

(3) Agricultural Works

In general, the male tasks of farming practices are plowing, harvesting and cereal threshing only. However, women in rural areas are heavily involved in various kinds of farming practices including livestock breeding. Plowing is practiced during winter season. Women are involved in farming activities through the year.

(4) Crafting Activities

Among many douars surveyed, women in 14 douars engage themselves in various activities or participate in crafting works with their husbands. The majority of these cases were envisaged in Teroual and El Bibane.

3.2.6 Existing Conditions of Water Use

(1) Involvement of Women and Children in Water Management

Table 3.4 shows the participation rate of men, women and children by commune.

Table 3.4 Participation Rates of Men, Wemen and Children in Water Management

(Unit : percent)

Commune	Men	Women	Children	Total
Ain Defali	35	17	48	100
Teroual	28	36	36	100
El Bibane	17	22	61	100

(2) Water Consumption

An average daily water consumption per person in the three communes is in the range from 15 to 17 litters in summer and 13 to 14 litters in winter. The surveyed data on water consumption is considerably lower than the statistical data (i.e. 35 to 40 l/c/d) projected by the DRPE.

(3) Water Collection and Storage

The use of mules and donkeys for water transportation is prominent, followed by manpower by local people. Local people sometimes use vehicles like tractors for water transportation in Ain Defali. Containers used for transportation are made of plastic and rubber. Water for livestock breeding is normally stored in small ponds outside.

(4) Sanitary Conditions

None of the douars in the model areas has a public wastewater collection system. Out of 4,364 dwellings surveyed, only 1,414 or 32 percent have latrines. Table 3.5 shows the existing sanitary conditions of dwellings with respect to construction material and latrine having septic tank.

Table 3.5 Sanitary Conditions

Items	Ain Defal	Teroual	El Bibane	Total
(1) Nos of dwellings	1,980	1,134	1,250	4,364
(2) Nos of dwellings of concrete structure	313	46	104	463
(3) Nos of dwelling with septic tank	303	372	659	1,414
(4) Ratio of (2) / (1)	16 %	4 %	8 %	11 %
(5) Ratio of (3) / (1)	19 %	33 %	53 %	32 %

Source: National Master Plan

(5) Existing Water Supply Conditions

The model areas are endowed with a number of water sources such as springs, dugholes and wells, as shown in Table 3.6. Some of water sources were dried up due to limited precipitation. The number of dried water sources were counted in the survey. The duration of water scarcity was reported to be 5 to 6 months during a drought year and 2 to 3 months in a normal year.

Table 3.6 Number of Existing Water Sources

Commune	Nos of Douars	Spring water		Dug holes	
		Available	Dried	Available	Dried
Ain Defali	60	25	23	73	195
Teroual	28	52	58	17	97
El Bibane	10	11	18	28	17
Total:	97	88	99	118	309

Source: AH

Table 3.7 summarizes the ratios of population distribution by the range of distance from housing to water sources. Ain Defali is marked with a large number of scattered water sources. Water sources in the areas of Teroual and El Bibane are located relatively close to the douars where more than half of the population collect water at a distance less than 1 km.

Table 3.7 Ratios of Population Distribution by Distance

(Unit : percent)

Commune	0 km	0.1 - 1.0 km	1.0 - 4 km	< 4 km	Total
Ain Defali	3.1	38.9	33.5	24.5	100.0
Teroual	16.9	52.0	31.0	0	100.0
El Bibane	0	52.5	47.5	0	100.0

Source: AH

Table 3.8 shows the ratios of population distribution by transportation time for water collection. In general, rural people spend more time for water collection during summer in dry season than winter in wet season.

Table 3.8 Ratios of Population Distribution By Transportation Time

(Unit : percent)

Commune	Season	0 - 0.5 hrs	0.5 - 1.0 hrs	1.0 - 2.0 hrs	< 2.0 hrs	Total
Ain Defali	Summer	10.3	15.2	8.5	66.0	100.0
	Winter	35.0	48.5	9.3	7.2	100.0
Teroual	Summer	27.1	34.8	38.1	---	100.0
	Winter	63.2	36.8	---	---	100.0
El Bibane	Summer	23.8	13.1	63.1	---	100.0
	Winter	68.5	31.5	---	---	100.0

Source: AH

(6) Cost of Water Collection and Willingness-to-pay

In relation to cost of water collection, a number of cases were encountered during the socio-economic survey with the following items :

i) Breeding cost of animals is the range from DH240 to DH720 per month.

ii) Use of a tractor costs DH400 per month excluding rental charge.

iii) Guarding fees rang from DH10 to DH20 per month and household if water source is located within the douar.

Table 3.9 shows the rough estimate of the expenditures which a household is willing to pay for water every three months.

Table 3.9 Willingness-to-pay of Household per Three Months

(Unit : DH)

Commune	Poor	Average	Rich
Ain Defali	60	183	340
Teroual	45	81	150
El Bibane	65	85	143

3.3 Hydrogeology and Groundwater Development

3.3.1 Exploratory Well Drilling

The drilling wells were originally planned to be executed at 8 locations. However, due to encountering the Triassic formation at well No. TRA1 in Teroual, it was decided to abandon the said well and substitute it with an additional well labelled TRA3.

In addition one of the exploratory wells, namely No. JBD1, at Jbel Berda had to be also abandoned as a result of encountering hydrocarbon gas that exploded while drilling.

The remaining seven wells were completed successfully up to the planned depth with sufficient groundwater yields of adequate quality good for potable water use. The total length of drilling added up to 1,298 m.

3.3.2 Inventory of Existing Groundwater Sources

The surveyed existing water sources in the syncline of Ain Defali comprised 18 dugholes, and 2 springs. All dugholes are privately owned and vary between 3 and 30 m in depth. The 2 springs owned by the commune are located in the douar of Beni Sennana. Their observed flow rates are 0.25 l/sec and 0.33 l/sec.

The syncline structure of Teroual encloses 3 dugholes, 1 springs and 1 borehole. The survey of these facilities indicated that the depth of dugholes varies between 6 and 14 m. The existing borehole was drilled by the AH to a depth of 82 m. At the time of the inventory, the yield of the existing spring started to deplete from the observed 60 m^3/d to a complete dry up in October 1995.

The existing water sources in the monocline of Jbel Berda inlcudes 10 dugholes and 4 springs. The average depth of dugholes varies between 10 and 18 m. The existing springs, that usually have surplus flows supplying the commune of Rhafsai, were not in a better condition, their yield dropped as a result of the exceptional drought and the measured flows ranged from 0.08 l/sec to 5.58 l/sec.

The inventory survey also covered the monitoring of groundwater levels at the above mentioned existing water facilities, either by manual level reading or automatic measurement by water level recorders installed on six existing dugholes and seven exploratory wells.

3.3.3 Analysis of Hydrogeological Structures

(1) Ain Defali Structure

The three exploratory wells ADF1, ADF2 and ADF3, located along EW axis of the structure, penetrate the syncline to a depth of 76m, 55m and 150m respectively thus allowing to detail the hydrogeological characteristics of the underlying formations with respect to water accumulation. The yields of these wells, at the time of the constant rate pumping test, were measured as 15 l/sec, 5 l/sec and 12 l/sec respectively with corresponding drawdowns of 14.35m, 31.82m and 23.41m.

The water reserve of the syncline is approximated at 1.2 x 10^6 m^3 which is calculated in function of the area of the structure (12 km^2), the thickets of the productive water bearing formation (120 m) and an estimated storage coefficient of 0.8 x 10^{-3}.

(2) Teroual Structure

The execution of the first well TRA1 disclosed the presence of a 130 m thick Triassic salt patch. It could not be detected by geophysical prospecting due to the high resistivity of the consolidated salt formation. The second well TRA2 revealed the presence of two aquifers in the syncline. The first one, with good quality water, is located between 40 and 170 m below ground level and the second encountered between 215 and 300 m with high salt content and had to be isolated from the upper aquifer by cement plug. The third well TRA3 was deemed necessary in order to perform the hydrogeological analysis of the structure and led to successful results.

The two wells TRA2 and TRA3 produced a yield of 10 l/sec each after a 72 hours constant rate pumping test with drawdowns of 21.6 m and 0.68 m respectively and corresponding transmissivities of 9.8x10^{-4} m^2/sec and 8.73x10^{-4} m^2/sec. The water reserve of the Oligocene water bearing formation of the syncline is approximated at 0.7x10^6 m^3 which correspond to an area of structure of 6.1 km^2 having a thickness of 40 m and a storage coefficient of 2.61x10^{-3}.

(3) Jbel Berda Structure

The execution of the three wells confirmed the presence of water accumulation in the base formation of the structure and in the upper marlstone and schist close to the fault line.

Constant rate pumping tests at wells JBD2 and JBD3 produced yields of 2.5 l/sec and 11 l/sec and drawdowns of 48.19 m and 31.42 m respectively with corresponding transmissivity values of 9.8 x 10^{-5} m^2/sec and 4.88 x 10^{-4} m^2/sec. Whereas well JBD1 gave a yield of 1.5 l/sec at a depth of 63 m which was expected to increase as drilling progressed. Unfortunately, exploding hydrocarbon gas encountered at 67 m contaminated the groundwater and necessitated to backfill and abandon the well.

The water reserve in the base formation of the monocline is approximated at about 0.75 x 10^6 m^3 which correspond to an area of structure of 6.3 km^2 and a water bearing layer of 60 m with an estimated storage coefficient of 2.5 x 10^{-3}.

3.3.4 Water Balance Analysis

A tank model method which is a serial storage type model was applied for the water balance analysis. The tank model is composed of a number of containers which indicate the catchment basin (hereinafter the container is called a 'tank').

When a model with serial three tanks is provided, each tank represents the runoff mechanism on the ground surface or layer, and is a component of the runoff hydrograph, which are generally considered as follows:

Top tank	Surface Runoff
2nd tank	Sub-surface / Groundwater Runoff
3rd tank	Groundwater Runoff (Baseflow)

The tank model was established for the gauged river basin which is closely located to the objective area. The objective river basins are the Rdat river basin for Ain Defali and the Amzaz river basin for J. Berda, respectively. For Teroual, since no runoff record is available on the neighboring tributary, the tank model established for the Rdat river basin was applied.

The tank model constructed for the river basin was used for estimating the groundwater recharge of the objective area. From the results of the tank model simulation, the groundwater recharge for each objective area was obtained by the following equation:

$$Gr = P - Ro - E$$

Precipitation (P), surface outflow (Ro) and evapotranspiration (E) are components of surface runoff system expressed by the top tank. Value of (P – Ro – E) gives runoff from bottom hole of the top tank. The estimated groundwater recharge (Gr) is shown in Table 3.10

Table 3.10 Water Balance of Objective Area (1)

Unit: mm/year

Objective Area	Precipitation (P)	Surface Runoff (Ro)	Evapo-transpiration (E)	Recharge (Gr)
Ain Defali	587	65	468	54
Teroual	775	154	544	77
J. Berda	953	336	533	84

3.3.5 Groundwater Simulation

In this Study, the software MODFLOW, "A Modular Three-Dimensional Finite-Difference Groundwater Flow Model", was introduced to preparation of simulation model. The MODFLOW is developed by the US Geological Survey and is being used over the world with its wide applications covering two-dimensional, quasi-three dimensional and three-dimensional modeling of groundwater flow. Based on the data obtained during the field investigation, the groundwater flow system in each objective area was estimated by modeling. For numerical model, the objective area was divided into mesh blocks. The data including topography, thickness and hydraulic constant of aquifer, etc. were given by mesh block.

Inflow to the objective area was initially set at the groundwater recharge estimated by the tank model. The sum of outflow from the objective area and spring yield was equivalent to the inflow. In the process of modeling, the groundwater recharge estimated by the tank

model was evaluated as acceptable for Ain Defali and Teroual. On the other hand, the recharge of J. Berda was evaluated much larger than that estimated by the tank model because of the yield of Tazrhadra spring which gives a relatively stable yield during dry season. As a result, water balance of each objective area was obtained as shown in Table 3.11.

Table 3.11 Water Balance of Objective Area (2)

Objective Area	Area (km^2)	Precipitation (10^6m^3/year)	Evapo-transpiration (10^6m^3/year)	Surface Runoff (10^6m^3/year)	Groundwater Runoff (10^6m^3/year)
Ain Defali	12.0	7.044	5.616	0.780	0.648
Teroual	6.1	4.728	3.424	0.943	0.381
J. Berda	6.3	6.016	3.198	2.121	0.697

The simulation study was carried out using the model for each objective area with the additional input of groundwater yield to be extracted. The initial condition of simulation was assumed as the steady state condition reproduced by modeling.

The allowable yield of groundwater extraction from the exploratory well was evaluated with the criteria of the lowering of groundwater level after 20 years pumping. The study was carried out for the alternative allowable limit of 10 m, 15 m and 20 m. In addition, the groundwater recharge was provided for two cases as follows:

i) Average recharge, and

ii) Estimated recharge year by year for the recent 20 years (1975/76 - 1994/95).

The results of simulation are listed on Table 3.12.

Table 3.12 Results of Groundwater Simulation

Ain Defali

Recharge	Allowable Limit GWL Lowering	Yield of Exploratory Well (m^3/day)			
		ADF1	ADF2	ADF3	Total
Average	10 m	241	60	155	456
	15 m	354	86	233	673
	20 m	475	120	311	906
Recent 20 Years	10 m	224	43	120	387
	15 m	336	77	120	533
	20 m	457	120	285	862

Teroual

Recharge	Allowable Limit GWL Lowering	Yield of Exploratory Well (m^3/day)		
		TRA2	TRA3	Total
Average	10 m	111	106	217
	15 m	166	157	323
	20 m	224	207	431
Recent 20 Years	10 m	108	103	211
	15 m	164	155	319
	20 m	220	207	427

J. Berda

Recharge	Allowable Limit GWL Lowering	Yield of Exploratory Well (m^3/day)		
		JBD2	JBD3	Total
Average	10 m	43	64	107
	15 m	64	99	163
	20 m	90	133	223
Recent 20 Years	10 m	34	47	81
	15 m	56	82	138
	20 m	82	116	198

3.4 Water Demand Projection of Model Areas

3.4.1 Population Projection and Distribution

The socio-economic survey revealed the current population at the three model areas, namely, three communes as 25,234 at Ain Defali, 12,096 at Teroual, and 6,511 at El Bibane, respectively. On the basis of these, future population up to the target year was estimated applying the rate of annual increase of 0.7 percent as was established. The projected future population in each commune as the model areas is 28,000 in Ain Defali, 13,000 in Teroual, and 7,200 in El Bibane commune in the year 2010.

3.4.2 Existing Water Supply Conditions in the Model Area

(1) Ain Defali

Water is mainly obtained by means of mules from dugholes and springs in the vicinity. The average distance to the water source is approximately 4.8 km and two to three hours are spent to get water.

The domestic unit water consumption is estimated at 17.3 l/c/d and 14.5 l/c/d in summer and winter, respectively. The water for livestock is occasionally fed in houses during summer time and its rate is estimated to be about 15 percent. Whereas, water is fed in the nearest rivers and streams in winter, since comparatively abundant surface water is readily obtainable during winter.

The existing water supply system in the rural center of Ain Defali is currently managed by the communal organization itself. The water sources consist of a spring located at Bni Sennana and two dugholes located at Laamirat and Ain Defali, respectively.

It is recently reported by the ONEP Sidi Kacem office that the ratio of water consumption in the rural center to the estimated water demand resulted approximately in 40 percent or inversely 60 percent of water deficit to the demand.

(2) Teroual

The means of transportation of water and persons in charge to carry water resemble to that in Ain Defali. Due to hilly topographic configuration no vehicle is used to carry water as far as observed. The domestic unit water consumption in these areas are estimated at 15.2 l/c/d and 13.7 l/c/d in summer and in winter, respectively.

In the rural center of Teroual, the water supply system is provided with a distribution tank, distribution pipes and house connection facilities relying upon the spring water located on the slope of a mountain in the village.

The spring water at the same time is also diverted to a reservoir located on top of a hill by pumping and distributed to the center of Teroual by gravity. The residents thereafter receive water by house connection facilities. The number of current house connection provided in the center as of July 1995 is counted as 360, which corresponds approximately to 50 percent of the requested number. The 50 percent of the population still await for the provision of house

connection facilities. However, current total groundwater issue cannot meet the demand even for the residents already provided with house connection facilities.

(3) El Bibane

Due to mountainous topographic conditions and concentration of residential areas in the vicinity of the rural center, the distance to carry water is rather short compared with other model areas varying from zero to 3 km. The domestic unit water consumption in this commune is estimated at 16.9 l/c/d and 13.3 l/c/d in summer and in winter, respectively.

In the rural center of this commune, two dugholes located in the midst of the housing area were exploited by the AH in 1983. They are currently dry and not in use any more. Whereas, two springs in the neighborhood currently yield water at only 0.02 to 0.09 l/s, or approximately 1.7 m^3/d to 7.8 m^3/d. As is obviously seen by this figure, the residents are severely suffered from water shortage.

While, the spring at Tazrhadra, a couple of hundred meters down from Ain Berda currently yields water about 10 l/s which corresponds to 864 m^3/d. This water is partially transported to the neighboring town of Rhafsai at the foot of Jbel Berda mountain and 3.6 km apart from Tazrhadra with the amount of 1 l/s in summer time and 5.5 l/s in winter time.

3.4.3 Parameters for Water Demand Projection

(1) Service Ratio of Water Supply

The National Master Plan presented in the first edition in 1992, proposed the future water supply system in the rural areas in Morocco applying the ratio of 10 percent for house connection, 30 percent for refurbished water sources, and 40 percent for public stand pipes. The existing condition of water supply in the Pre-Rif region is, compared to other typical rural regions in Morocco, considered to be approachable to this target by the year of 2010.

(2) Unit Water Demand

As was given in Chapter II, the DRPE proposed future water demand at around 30 l/c/d.

The National Master Plan on the other hand concluded that the unit water demand for 2010 in compliance with water supply facilities would reach the following values as given in Table 3.13.

Table 3.13 Unit Water Demand in compliance with Water Supply Facilities for 2010

Item	RWS	PSP	HC
Supplied Person per Unit	250	200	8
Domestic Unit Demand (l/c/d)	15	30	50
Livestock Unit Demand (l/large unit/d)	20	20	20

Note:
RWS: Refurbished Water Source
PSP: Public Stand Pipe
HC: House Connection
Source: National Master Plan

The existing net water demand is established at 20 l/c/d. The unit water demand for domestic use was established to increase by 3 percent annually from 20 l/c/d for the year 1995 to 31 l/c/d for the year 2010.

Whereas, the unit water demand for livestock was set up at 20 l/head/d and to be constant up to the target year of 2010. However, the practical water demand of livestock was computed on the basis of the results of socio-economic survey applying 15 percent of 20 l/head/d on average through the year, since the water for livestock, in general, is fed by natural surface waters such as rivers and streams in the rural areas.

(3) Unaccounted for Water

Unaccounted for water shall be basically applied on urban areas and rural areas where water supply system is provided by the ONEP, since the system constitutes with pipe reticulation. The model areas, in the light of this, will be provided with adequate water supply facilities equivalent to the existing ONEP system, and consequently the parameter of unaccounted for water should be taken into consideration.

For establishment of practical figures, non of the data in relation with model areas exists. Therefore, existing data of water production and water charging record compiled in the system of Ain Gdah and Mekansa water supply system shall be referred and applied with 3 percent of annual decrease from 40 percent in 1995 to 26 percent in 2010.

3.4.4 Water Demand Projection

On the basis of the parameters of service ratio, unit water demand, and unaccounted for water, the water demand are computed as 990 m^3/d (11.5 l/s) at Ain Defali, 468 m^3/d (5.4 l/s) at Teroual, and 248 m^3/d (2.9 l/s) at El Bibane, respectively, in the year 2010.