No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF AGRICULTURE, RURAL DEVELOPMENT AND SEA FISHERIES
REGIONAL AGENCY FOR RURAL DEVELOPMENT OF THE TAFILALET

THE DEVELOPMENT STUDY
ON
RURAL COMMUNITY DEVELOPMENT PROJECT
IN
SEMI-ARID EAST ATLAS REGIONS
WITH KHETTARA REHABILITATION

MAIN REPORT

DECEMBER 2005

NIPPON GIKEN Inc.

NIPPON KOEI Co.,Ltd.

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Reports and Products

Reports and Products	Languages
Main report	Japanese, French, English
Annexe	French, English
Data book	French
Khettara rehabilitation and maintenance works	French, English
Khettara water use	French, English
Agriculture and extension service	French, English
Organization strengthening on khettara village	French, English
Khettara inventory	French, English
Seminar text	French, English
Brochure (PR materials)	French, English, Arabic

Exchange Rates

US$1.00=DH8.70
US$1.00=￥110

PREFACE

In response to the request from the Government of the Kingdom of Morocco, the Government of Japan decided to conduct the Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation and entrusted the study to the Japan International Cooperation Agency (JICA).

The JICA sent the study team headed by Mr. Michimasa Menjo, Nippon Giken Inc. to the Kingdom of Morocco for the period from February, 2003 to October 2005.

The team held discussions with the government officials concerned of the Goverment of the Kingdom of Morocco and conducted field surveys, verification study, and also held workshops and seminars. The team prepared the final report after the home work study in Japan.

I hope that the report including various manuals and inventory study results will contribute to successful agriculture and rural community development in the arid regions in Morocco, especially preservation of the groundwater intake systems (khettaras) that have history for several hundreds of years and sustains the life of local people, and furthermore to the enhancement of the friendly relationship between our two countries.

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

December 2005

Etsuo Kitahara
Vice President
Japan International Cooperation Agency

December 2005

Ms. Sadako Ogata
President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Madam:

We are pleased to submit the final report of "the development study on rural community development project in semi-arid east Atlas regions with khettara rehabilitation" in the Kingdom of Morocco. The report presents the master plan consisting of various project components, i.e. khettara rehabilitation, water-saving irrigation, farming and extension services as well as organization strengthening of farmers in the east Atlas regions, those are mostly suffering from poverty in the country.

In Morocco, 47% of the total population live in the rural areas and work in the agriculture sector, thus, the primary sector including agriculture and animal husbandry still plays an important role in the Moroccan economy. However, the GDP of primary sector showed a growth rate of minus 0.8 %, and this negative growth might be due to lower growth of rural economy and continuous droughts in recent years. Reflecting on these problems, the Moroccan Government has created a 5-year plan, putting particular emphasis on poverty reduction in rural areas. Specific measures include accelerating the programs of the rural infrastructures and comprehensive development of rural communities with farmers' participation.

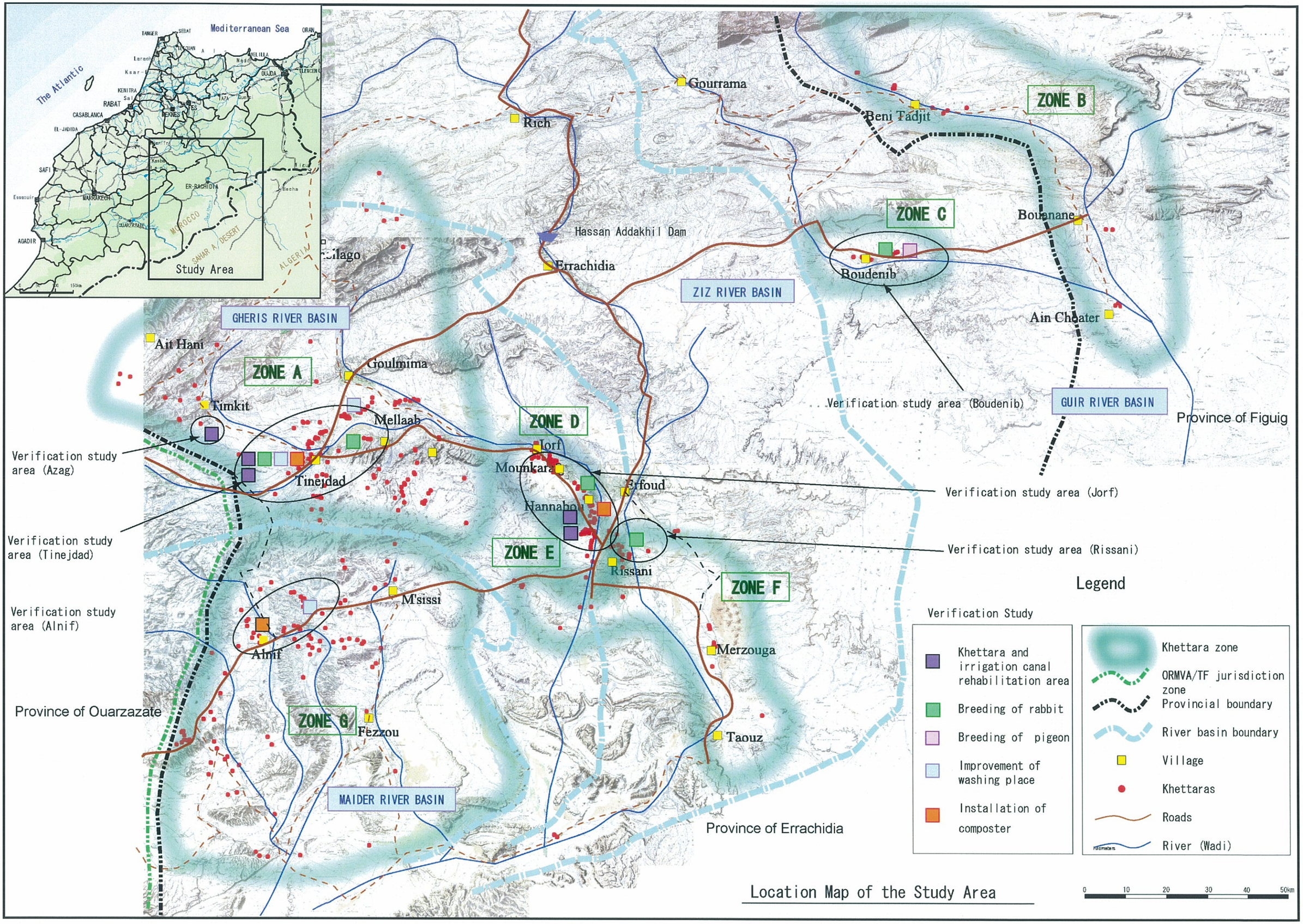
During the verification study, 1) khettara rehabilitation works, 2) introduction of water-saving irrigation to confirm its adaptability, 3) cultivation of high value crops such as vegetables, 4) technology transfer on food processing (dates) and small animal husbandry, 5) study tours and seminars were conducted to accelerate participation by officials, farmers and associations, those are responsible for playing an important role in the framework of the project. The verification study indicates that farmers have a higher intention to participate in the project, and also the officials have adamant sense of responsibility for the khettara rehabilitation.

We hope that the report will be useful for the agricultural development in arid regions in Morocco and also accelerating further khettara rehabilitation works.

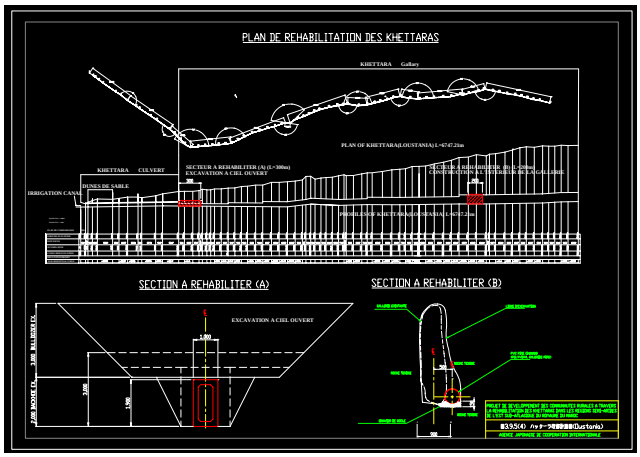
We wish to express our deep appreciation and sincere gratitude to the officials concerned of your Agency, the advisory committee members, the Ministry of Foreign Affairs, the Ministry of Agriculture, Forestry and Fisheries of the Government of Japan for the courtesies and cooperation kindly extended to the team. We also express our gratitude to the officials concerned of the Ministry of Agriculture, Rural Development and Fisheries, the Regional Office of Rural Development of the Tafilalet of Morocco, the JICA Morocco office and experts for the close cooperation and various assistances extended to the team during field survey in Morocco.

Very truly yours,

Michimasa Menjo
Team leader of the development study on rural community development project in semi-arid east Atlas regions with khettara rehabilitation


Mediterranean Sea
The Atlantic
Study Area
MOROCCO
SAHARA DESERT
ALGERIA
Gourrama
Rich
Beni Tadjit
ZONE B
ZONE C
Hassan Addakhil Dam
Errachidia
Boudenib
Bouanane
Ain Chaater
ZIZ RIVER BASIN
GHERIS RIVER BASIN
Ait Hani
ZONE A
Goulmima
Timkit
Mellaab
ZONE D
Jorf
Mounkara
Erfoud
Hannabo
Tinejdad
Verification study area (Azag)
Verification study area (Tinejdad)
Verification study area (Alnif)
Verification study area (Boudenib)
Verification study area (Jorf)
Verification study area (Rissani)
GUIR RIVER BASIN
Province of Figuig
ZONE E
Rissani
ZONE F
M'sissi
Alnif
Merzouga
Province of Ouarzazate
ZONE G
Fezzou
Taouz
MAIDER RIVER BASIN
Province of Errachidia
Legend
Verification Study
Khettara and irrigation canal rehabilitation area
Breeding of rabbit
Breeding of pigeon
Improvement of washing place
Installation of composter
Khettara zone
ORMVA/TF jurisdiction zone
Provincial boundary
River basin boundary
Village
Khettaras
Roads
River (Wadi)
Location Map of the Study Area
0 10 20 30 40 50km

Ground view of khettara. (Geological condition varies in location of each khettara. The right photo shows damaged khettara by sand dunes.)



Plan and longitudinal section of khettara

Typical section of gallery
(Height: 1.5 - 2.0m, width: 0.6m)

Before rehabilitation works of khettara

Open excavation works by excavator and rock beaker

Gallery before rehabilitation works

Concrete culvert construction with open excavation work

Section of gallery
(Height: 1.5m, width 0.6m)

PVC pipe is available to reduce leakage loss from gallery

Pipe laying at 16 m deep from the ground

PVC pipe laying
(Excavation and smoothing bottom surface before pipe laying)

Gallery before pipe laying

Gallery before pipe laying

Galley before rehabilitation
(Gallery wall is susceptible to collapse)

Concrete culvert for rehabilitation
(Wall concrete is under construction.)

Concrete works in the tunnel
(Water sop is installed, yellow color in the photo.)

Inside gallery

Open excavation work

Vertical shaft work using pre-fabricated concrete

Canal rehabilitation work by concrete lining canal

Basin irrigation is applied to irrigation method. Water supply is regulated baed on water rights. Two week interval of water supply may exerts influence on growth of crops.

Before rehabilitation work

Canal rehabilitation work by concrete lining canal

About 10% increase of irrigation efficiency

After rehabilitation work

Basin irrigation	Furrow irrigation
Water requirement and harvest are verified among various irrigation methods	Drip irrigation

Pump station

On-farm reservoir (under ground)

On-farm reservoir is advantageous to shorten water supply interval from present 10 to 15 days to 3 to 4 days for water-saving irrigation method.
(Demonstration farm)

Carrot harvested in the demonstration farm is high quality, thus selling price was

Turnip cultivation in the demonstration farm

Water tapping at outlet of gallery
(Study includes improvement of public health care.)

Study tours with participation of farmers were conducted to enhance organization strengthening of farmers' groups.

Khettara water is used for washing. Study emphasis on importance of water quality preservation for irrigation purpose, etc.

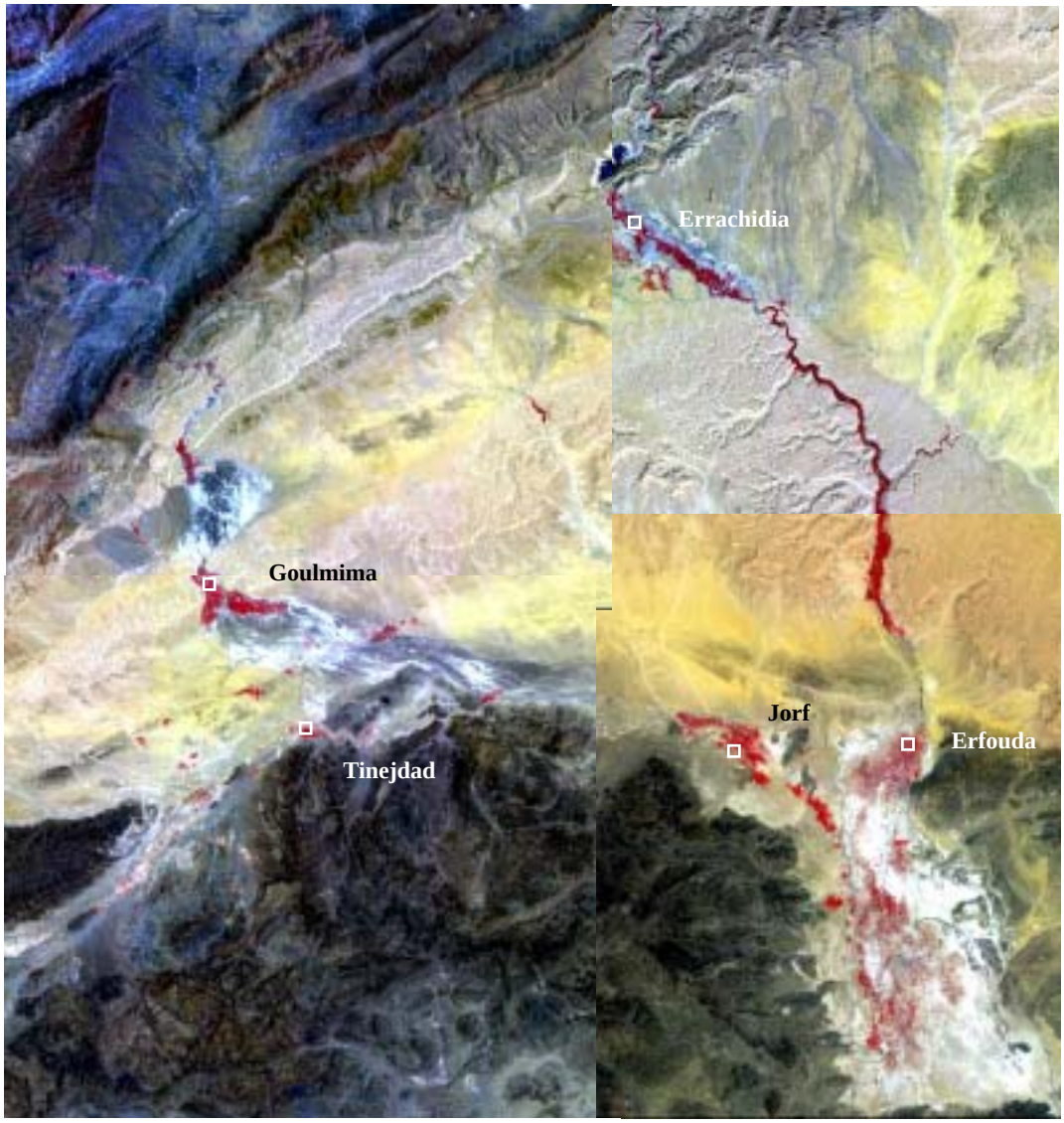
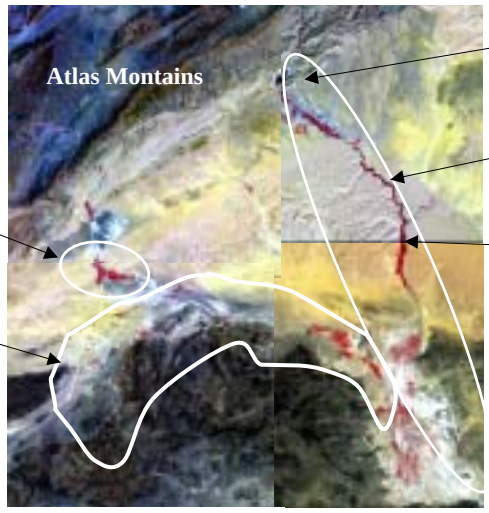


Image Satellite (SPOT-5)



Location of Hassan Addakhil dam

Command area of Hassan Addakhil dam

A special product of "dates" is cultivated along the Ziz river.

Irrigation area with communal pump systems

Many khettaras are densely located in this area.

(Red colored potion in satellite image shows irrigation area)

Satellite image of Hassan Addakhil Hasan Addakhil dam and commanded Areas of khettaras

Summary

1. Significance of Khettara Rehabilitation

In Morocco, the farming style is remarkably different from each other between east and west regions of the Atlas Mountains. Surface water such as rainwater and perennial river flow is utilized for the irrigation in the west region, while flood flow and subsurface water are utilized for the irrigation in the east semi-arid region. Subsurface water is utilized by pumpage or the subsurface tunnel structure, which is called the khettara. The inhabitants maintains water right from old times and established firm operation and maintenance system of the khettara such as rehabilitation cost and labor work sharing. However it has become difficult to maintain the said system and rural community itself due to desertification and depopulation of the rural regions. There were about 410 khettaras in the Tafilalet region, however recent inventory study indicates that the majority of the khettara has not been available due to shortage of flow.

There were 570 khettaras of 2,900 km long in the Tafilalet area according to the census in 1967, however the inventory survey in the study indicates that 410 khettaras are recognized as a productive khettara, and remaining 160 khettaras are not in use and already abandoned due to drying up since 1970s. Among these 410 khettaras, 191 khettaras are recognized as a "productive khettaras" that have a flow at present, and the remaining 219 khettaras are in dry condition or its flow has been extremely reduced due to continuous drought since 1997. The production amount of wheat, which is principal agriculture products in the region has deduced by half in a recent decade. Since decline of groundwater table by continuous drought has originated these problems, therefore it is fundamental issue to rapidly secure the water source of the khettaras.

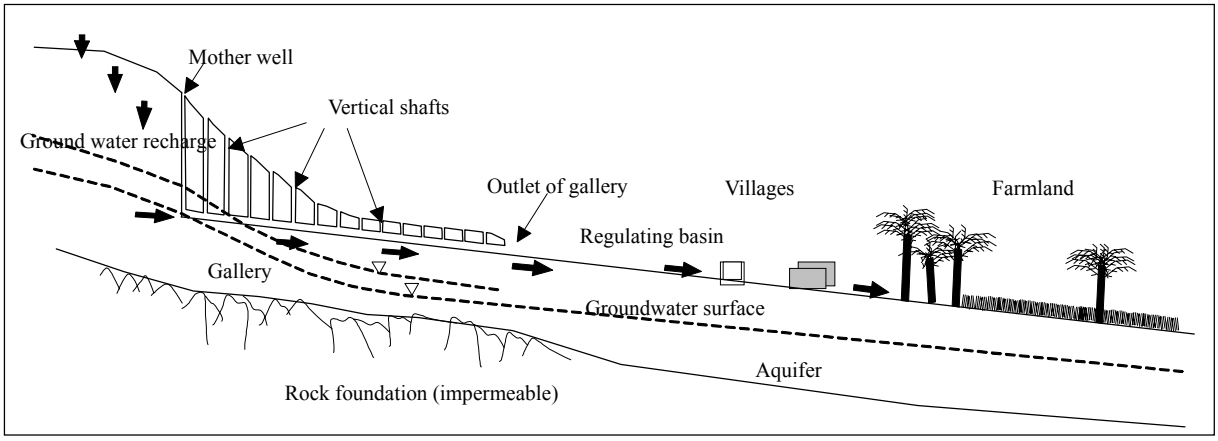
Several projects such as construction of dams, flood diversion weirs, irrigation canal networks and pump irrigation systems have been launched so as to effectively utilize water source, and these projects have rapidly improved water use efficiency and satisfied increased water requirement. However large fluctuation of rainfall furthermore continuous drought disables to stably supply irrigation water through these facilities. Since flood irrigation systems also excessively depend on flood occurrence, unstable climate causes large fluctuation of irrigation period, irrigable area by year. Though individual khettara discharge is very small, however total annual flow amount of 35 Mm^3 from 191 khettaras exceeds storage amount of the Hassan Addakhill dam of 26 Mm^3 observed in 2002.

Khettara has advantageous points of 1) influence by drought is small, 2) stable flow is secured through the year, 3) gravity flow minimizes operation cost, and well maintained by traditional water users' groups, and 4) subsurface water does not have an evaporation loss like surface water, so it contributes to water preservation. Making use of these advantageous characteristics, preservation of the khettara system is essential to maintain agricultural productivity and rural living condition through an effectively use of the khettara flow.

On the other hand, increase and stable supply of khettara flow associated with the khettara rehabilitation works contribute to poverty alleviation together with improvement of agricultural productivity, and also

useful from environmental and social points of views, such as farmland conservation from present devastated conditions by water shortage and mitigation of population move from rural area to urban area, etc.

Furthermore, it is significant to preserve khettara systems in the Tafilalet region as a historical and cultural inheritance considering the facts that water systems similar to the khettara system in middle and other arid countries including other regions in Morocco have disappeared or devastated due to decline of groundwater table or shifting to modern irrigation methods.



Schematic Diagram of Khettara System

2. Objectives of the Study

The study was conducted to formulate the khettara rehabilitation and rural community development project in line with the Scope of Works (S/W) mutually agreed between the Japan International Cooperation Agency (JICA) and the Regional Agency for Rural Development of Tafilalet (ORMVA/TF) in October 14, 2002. The Study aims at conducting following objectives for the khettaras and khettara communities:

1) Preparation of the Master plan on the khettara rehabilitation and rural community development
2) Preparation of the khettara rehabilitation plan
3) Technical transfer on project planning, implementation and management to the ORMVA/TF staff and farmers through master plan preparation and the verification study.

The report summarizes the study results on the khettara rehabilitation and rural community development (Master plan), khettara rehabilitation plan in Phase 1 study and the Verification study for finalizing the Master plan in Phase 2 study.

3. Strategy on Agricultural Development

The growth rate of the total GDP in Morocco from 1991 to 1999 was 1.9%. However, the growth rate of the primary sector was negative, namely –0.8%. The main reasons behind this negative growth were the increase of the number of poor in the rural areas and the consecutive droughts in recent years. Following to the liberalization of external trade and the restructuring of state enterprises aiming at the integration with the world economy, the Moroccan economy was showing stable growth until the beginning of 1990s.

However, this policy has brought about the inequalities between the rich and the poor, and the share of the poor population in the rural areas increased from 18% in 1990/1991 to 27% in 1998/1999. In order to face this problem, the Moroccan government has elaborated the 5-year plan for rural economic development (2000-2004), which was approved by the Parliament in July 2000. This 5-year plan put particular stress on the poverty reduction in the rural areas, to list some specific measures: 1) to accelerate the programs of the agriculture infrastructure facilities so that the number of the beneficiaries can achieve 60 – 70% of total rural population until 2004, 2) to generally develop rural communities, in the participatory way and prioritizing the poorest population.

The Ministry of Agriculture, Rural Development and Fisheries presented the "Rural Development Strategy 2020" in December 1999 aiming at poverty alleviation in the rural areas until 2020. The Strategy fixed specific objectives as follows:

- Increase of the agriculture production to respond the future internal and external demand for food products,
- Increase of the employment and revenues in the agriculture,
- Creation and diversification of the employment in the para-agriculture activities and outside of the agriculture sector,
- Prevention from the process of human-made environmental degradation,
- Upgrading and improvement of the education and professional training of rural men and women,
- Improvement of services related to the quality of life and well-being, and
- Correcting of regional and sub-regional imbalances in the field of development and infrastructure.

The Ministry of Agriculture, Rural Development and Fishery has the complete authority of the Moroccan Government for elaborating and executing of the agriculture development policy. At the regional level, there are 40 provincial agriculture directorates (DPA) and 9 regional offices of agriculture development. They are in charge of the agriculture development at the regional level. The ORMVAs are responsible for management of the large-scale irrigation systems and the supporting services for farmers. The ORMVA/TF (Tafilalet), which is the counterpart agency of the present Project, has its zone of operations located almost completely in the Tafilalet region.

4. General Information of the Study Area

Morocco consists of 16 regions and they are composed of provinces or prefectures. Tafilalet region, covered by ORMVA/TF includes the whole Errachidia Province and adjacent Beni-Tadjit Cercle in Figuig Province.

The responsibility area of ORMVA/TF is located between longitude 5°17' and 2°17'west, and latitude 30°17' and 33°4' north. Grand Atlas runs in the north of the Study area and a wide plain of 1,000 to 1,200 m high spreads toward Errachidia and Boudenib in the south. In the south of the plain, a carse

formed by the Todrha-Ferkla rivers and Gheris river lie, and there is sedimented area by the Ziz river, which flows from north to south. Those constitute vast Tafilalet Plain, where Jorf-Erfoud to Rissani area is located at the elevation of 600 to 800 m. The main aquifer is Pliocene to Quaternary aquifer and the aquifer in rock foundation is important in some areas.

Annual rainfall fluctuates from 50 to 200 mm, and temperature changes 7°C to 35°C. Annual rainfall fluctuates drastically year by year. Interannual variability of past 20 years rainfall shows rich rainfall in around 1989 and 1993 to 95, and drought in 1982 to 83 and around 1997 to present.

River systems in the Study area are classified as the Guir river, Gheris/Ziz rivers and Maider river systems with their drainage area of Guir: 13,400 km^2, Gheris/Ziz: 20,200 km^2 and Maider: 12,000 km^2. Yearly fluctuation is large as same as the rainfall data, and the run-off volume between 1980 and 85, and after 2000 is quite small due to drought. Groundwater level has gradually declined due to continuous drought since 1997.

The soil in the Study area is relatively fertile. Regarding the pedological features of the soil, those are generally sandy areas, coming from loamy sand of silt clay. There is a problem of saline soils and limy soils in the Study area. Concerning the salinity, it seems that the salt was brought by the extensive utilization of the irrigation water with strong saline content. Concerning the limy soils, the hardening of the superficial soil is observed due to the accumulation of the calcium carbonate in the shallower layers.

5. Agriculture and Social Infrastructures in the Tafilalet Region

Within the land area of 7.7 million ha in the Tafilalet region covered by the ORMVA/TF, over 52 % of the lands are not appropriate for the agriculture use, and the irrigated lands represent mere 0.8 %. The average area of one agricultural holding is of about 5.78ha, however in the Errachidia province, it is only 1.41ha. Limited about 10 % owns 5 ha farmland.

The principal agriculture products cultivated in the Tafilalet region are: fruits (dates, olives, apples, etc.), cereals (wheat, barley, maize), fodder (alfalfa), legumes, vegetables and others (henna and cumin). The production above has extremely decreased by recent drought except apple production. Concerning animal husbandry, two types of animal husbandry are normally applied in the Tafilalet region. Those are the extensive rearing of mixed hoards of sheep, goats and camels in the nomad or semi-nomad system in the vast grazing lands, or intensive sedentary rearing of cattle and sheep on a small scale localized in the irrigated zones. Latter is favorable in the Tafilalet region. The annual meat production is 7,100 tons. Otherwise, the rearing of sheep of D'man race, apiculture, and poultry farming are practiced on a small scale. Those activities represent the new source of revenue in the region.

Water supply facilities in the study area have been provided by the ONEP (Office National de l'Eau Potable). Availability of potable water supply exceeds 80% and 50 % of total population in urban areas and rural areas, respectively. The ONEP has 5 year project proposal to extend service area to 97 % of total area by 2007. Electricity is basically provided by ONE (Office National de l'Electricite) both in urban and rural areas. Availability of in the Errachidia province is 86 % in the urban area and 50 % in the

rural area. The ONE has been propelling expansion of electricity supply area together with facility installation for potable water by the ONEP. Therefore, availability of electricity in rural areas is also presumed to be improved in recent years. Roads in the Errachidia province are composed of national, regional and rural roads with their length and paving rate by asphalt of 593.9 km (90 %), 491.3 km (62 %), and 802.0 km (10 %), respectively. Rural roads aside from these main roads are mostly not paved.

General hospital as well as regional hospitals is only located in urban areas and not in the rural communes. Even though health post is generally located in each rural commune, that location is still far from hettara villages. Hence, people in khettara villages have very limited access to these health and medical care facilities. For public education, 566 primary schools (98,158 students), 49 secondary schools (32,407 students) and 19 colleges (13,556 students) are located in the Errachidia province. Almost all khettara villages, *ksar/doua,r* has at least one primary school even in rural areas. On the other hand, number of secondary school is less than 1/10 of that of primary school. It becomes more serious for girl students, since many parents in rural area hesitate to send their daughter(s) to the school outside of their home *ksar/douar* from cultural and religious reasons.

Percentage of people under poverty line on national level was increased from 13.1% (3.3 million) in 1991 to 19.0% (5.3 million) in 1999. Rate of poverty in rural area was particularly increased from 18.0 % in 1991 to 27.1% in 1999. Rate of poverty in the Tafilalet region, in particular, appeared 29%, which was the worst in the country. In general, one or two family members are working away from home for supporting family expense. For destinations, 68% are in big cities inside Morocco, while 20% are outside of the country. Small and medium cities in Tafilalet region consist of only 10 %.

6. Present Condition of Khettara and Khettara Communities

The following show physical information of the khettara itself.

Information of Khettaras

Zone	No. of khettaras	Productive khettaras[1]	Total discharge[2] (lit/sec)	Average discharge (lit/sec)	Total length of khettaras (m)	Average length of khettaras (m)
A	137	74	359	4.5	221,351	1,616
B	24	20	179	8.9	32,178	1,341
C	8	8	93	11.6	46,650	5,831
D	69	24	270	12.8	384,403	5,571
E	25	14	96	6.9	159,722	6,389
F	44	10	25	2.3	215,550	4,899
G	103	41	73	2.0	252,580	2,452
Total	410	191	1,094	5.7	1,312,434	3,201

Notes: [1] Number of productive khettaras is estimated based on the inventory survey conducted in 1999 by the ORMVA/TF and during the study by the JICA Study team.
[2] Discharge data are based on observation in February to July in 2005.

Khettara flow is used for potable, domestic water for washing, animal feeding and finally used for irrigation purpose. The basin irrigation method has spread in the whole irrigated areas by the rotation irrigation of the khettara flow. Rotation method is firmly regulated in line with water rights.

Discharge of khettaras in the area varies from 0 to 50 lit/sec. Khettara discharge of less than 5 lit/sec occupies 60 % of the whole khettaras, and its average discharge is 5.7 lit/sec according to the discharge measurement in February to July 2005. With respect to khettara discharge per unit irrigated area as an indicator for irrigable water supply, 36 % of the khettaras have less than 0.2 lit/sec/ha and 58 % have less than 0.4 lit/sec/ha, while the average is 0.25 lit/sec/ha.

The following are remarkable points in terms of khettara rehabilitation as well as water use:

1) Khettaras are well maintained by the traditional water users' groups. However, khettara discharge has decreased due to poor maintenance in several khettaras due to heavy financial loads for khettara rehabilitation works.

2) Rehabilitation work may affect discharge of other khettaras when plural khettaras are located adjoining each other. In relating to this fact, traditional water right system restricts any rehabilitation works without mutual agreement between these khettaras. In addition, excessive pumpage in the recharge area or aquifers of particular khettaras reduces khettara discharge in several areas.

3) The most of the irrigation canals are earthen canals. Much water amount filtrates into the ground from the earthen canals, and that leads to decrease of irrigation water.

4) Basin irrigation causes large evaporation loss from its wider farm plot and rough farmland surface accelerates decline of water use efficiency.

There are many voluntary groups called “Association” in rural area. Association is founded in accordance with the Association law enacted in 1958, and partially modified in 1973 and 2003. In the Tafilalet region, many associations have been established and operated with their own objectives, i.e. rural development, social development, cultural exchange and so on. However, most of these associations have been established after 2002 and do not have actual activity except sending requests to outside organizations for support on the khettara rehabilitation work. There exists only Khettara Association El Amal which unified 26 khettaras and supported by the ORMVA/TF.

7. Support Service for Agriculture and Rural Communities

The ORMVA/TF is responsible for the improvement of the irrigation facilities and extension services for the agriculture and animal husbandry techniques in the irrigated areas in the Study area. The ORMVA/TF is also responsible for the coordination with the organizations in charge of the agriculture development and water resources exploitation. Otherwise, this administration provides the technical and financial support for the rehabilitation of khettaras constructed by the local population, as well as the support within the framework of extension and promotion of the techniques for the management and distribution of irrigation

water.

In addition to the above, the ORMVA/TF encourages the activities for the women development scheme. Those activities include 1) promotion of women income generating activities, 2) education and assistance for the rural women, 3) organization and strengthening of women cooperatives of sheep (D'man) rearing, 4) organization of women community centers (CAF), and 5) working on literacy. There exist 207 cooperatives in administrative area of the ORMVA/TF in the Tafilalet region. Many agriculture cooperatives were established under the direction of the government for, among the others, provision of the material for the livestock. The agriculture cooperatives (sheep, dates, apiculture, etc.) do not profit from the cooperative activities because each farmer is working individually.

8. Environmental Condition

Climate is in severely dry condition in the Tafilalet region. Annual rainfall is about 100 to 250 mm in the north and 50 mm in the south area. Consecutive droughts since 1980s have seriously extended farmland devastation. In general, desertification are originated from a natural and an artificial factors. It is assumed that the problem of desertification in the Tafilalet region is caused by both factors. Several environmental conservation project have launched such as revitalization of forest ecology, restoration of water use facilities, instruction and extension services to farmers, countermeasures to erosion and sedimentation, measures for salt injury, etc. An on-going program for desertification prevention is "National Action Program for Desertification Prevention" (Programme d'action National de Lutte Contre la Desertification) formulated in June 2001.

9. Master Plan on the Khettara Rehabilitation and Rural Community Development

The following are basic concepts to formulate the Master plan in due consideration of constraints and development potential mentioned above:

(a) 410 khettaras and related khettara communities are subject for the development plan. Khettara rehabilitation and rural community development plan is formulated from both points of improvement of water use and farming practice focusing on minimal unit of khettara community (ksar).

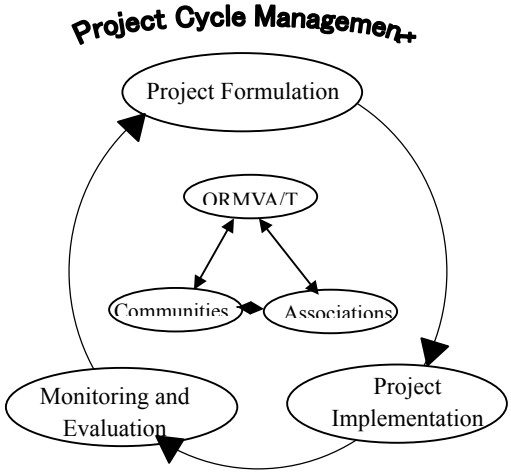
(b) Khettara discharge is absolutely in short for irrigation in the Study area, therefore water resources development is inevitable to formulate the rural development plan. For this purpose, shifting to pump irrigation system, recharge facility planning and further surface water development are included in the development plan.

(c) The Master plan consists of various project components, i.e. water resources development, water use, farming and extension service, strengthening of farmers' organizations, environmental conservation, etc. With respect to this, the Master plan shall be formulated in due consideration of present long-term development plan of the related governmental agencies.

(d) Development plan is divided into several phases in terms of implementation schedule, outcome of project benefit, and annual budgetary allocation. Efficiency, urgency as well as remedy on poverty alleviation are considered in project phasing during the preparation of the implementation program.

In the short-term program, preservation of water sources, mainly khettara rehabilitation work is the principal target so as to improve agricultural productivity and rural living condition. In intermediate and long term programs, recharge facility planning for groundwater conservation are proposed to improve agricultural productivity and to sustain further farming simultaneously with the rehabilitation works for the khettara.

(e) For project formulation and review of the khettara rehabilitation and rural community development scheme, the ORMVA/TF, khettara communities and associations (local NGOs) play an important role in the frame work of the project cycle management in accordance with the principle proposed in "the 2020 Rural Development Strategy". In this basic concept of the Master plan, appropriate institutional framework is proposed with proper clarification of each player's role, corresponding to each project phase.



Institutional Set up during Project Formulation and Implementation

Aiming at accelerating participation of the beneficiaries to the project, improvement of rural living condition by means of rehabilitation of the khettaras and rural infrastructures is necessary in short term, and secondly introduction and diversification of income generation activities are encouraged in long-term so as to stimulate their self-reliance to the project.

10. Verification Study

The Verification study aims at completing the Master Plan based on the Verification study results on the proposed components in the Master plan.

Project components	Activities
Responsible agency: ORMVA/TF	・ Update of inventory ・ Seminar opening
• Khettara rehabilitation	・ Increase of flow ・ Construction planning
• Irrigation canal rehabilitation	・ Increase of flow ・ Construction planning
• Water use	・ Demonstration of furrow and drip irrigation systems
• Farming	・ Cultivation of cash crops ・ Processing of agricultural products
• Farmers' organizations	・ Register of farmers' groups and accelerating activities ・ Study tours
• Income generation and rural life improvement activities	・ Breeding of small animals ・ Improvement of water quality ・ Public health and hygiene
• Afforestation	・ Introduction of "double sack method"
• Recharge facility planning	・ Data collection and analysis ・ Technical transfer of groundwater analysis

1) Revising Master plan
2) Capacity building of ORMVA/TF
3) Strengthening of farmers' organizations
4) Establishing monitoring and evaluation system

→ Review and revise of Master plan and khettara rehabilitation plan

Rehabilitation of khettara (Shafts and gallery)

Rehabilitation of khettara (Tunnel works)

Rehabilitation of irrigation canal (Concrete canal)

Farming and water use (Drip irrigation)

Farming and water use (Demonstration farm)

Farming and water use (Cultivation of tomato)

Farming and water use
(Cultivation of turnip)

Farming and water use
(Cultivation of water melon)

Food processing
(Remover of dates seed)

Strengthening of farmers' organizations (Study tour)

Strengthening of farmers' organizations
(equipment lending scheme)

Strengthening of farmers' organizations
(Breaker lending)

Improvement of life condition
(Diffusion of compost)

Income generation activities
(Breeding of pigeon)

Improvement of life condition
(Installation of washing place)

Income generation activities
(Breeding of rabbit)

Activation of women groups
(Seminar for rabbit breeding)

Afforestation
(Planting seedling)

Afforestation (Tamarix)

Afforestation (Atriplex)

Recharge facility planning
(Observation of groundwater level)

11. Objectives of the Project and Basic Concept of the Master Plan

The fundamental objective of the present Project is to "stabilize and increase the revenues of the rural communities", and following phasing schedule is proposed:

1) Short term scenario (First 5 years): includes the rehabilitation of khettaras and irrigation canals, improvement of the irrigation systems and farming practices, formulation of the farmers organizations to realize rapid outcome of the project effects. Along with these activities, the studies for the conservation and development of underground waters, which will serve sustainable development of water resources. Concerning the irrigation and agriculture farming practices, the water saving irrigation system is introduced in the khettara areas after having confirmed the economic potential of the sites. From the point of view of the organizations, it is planned to strengthen the capacity of the water users' groups in such a manner to empower them to be able to apply by themselves for the external aid. Furthermore, diversification of the income generating activities and development of the women's associations are commenced within the framework of the rural community development.

2) Intermediate-term scenario(6 to 10 years): continuously provides rehabilitation works aiming at increase the khettara discharge, and commences the construction of the recharge and small-scale storage facilities in the same time. The exploitation of the groundwater by the communal pumpage might be envisaged on condition that the groundwater table would be recovered with the recharge works. In the organizational plan, it is planned to establish a collaboration system between the khettaras water users' groups to reinforce their organizational capability for participating in the recharge facility planning. In addition, the income generating activities, such as implemented in the short-term program, are extended to all the rural communities in order to realize the equal development in the whole Study area.

3) Long-term scenario (11 to 20 years): focuses on the rehabilitation of the khettaras which have dried up or its discharge has extremely reduced at present. In principle, the rehabilitation work is commenced from the khettaras that a flow is recovered by recharge effect, etc. In respect to irrigation, farming and the organization strengthening schemes, it is implemented to diffuse the project effects verified in the medium-term period in terms of the water saving irrigation and strengthening the organizations for the whole Study area.

Details of the project components are tabulated below in conformity with development scenarios for short, intermediate and long term periods above,

Project Components in respective Phase related to the Khettaras Rehabilitation

Term		Short-term (5 years)	Med-term (6 to 10 years)	Long-term (11 to 20 years)
Khettaras		130 khettaras (2 lit/sec≦Q)		219 khettaras (0 lit/sec =Q)
		600 m (maximum)	Remaining portion of short-term rehabilitation	
		Khettaras requiring urgent rehabilitation	61 khettaras (0<Q<2 lit/sec)	
Khettaras Rehabilitation	Contents	Rehabilitation of the vertical shafts and gallery and installing small diameter pipes	Rehabilitation of the vertical shafts and gallery and installing small diameter pipes	Rehabilitation of the vertical shafts and gallery Communal pump irrigation system
	Rate of rehabilitation	30%	30%	---
Irrigation Systems	Contents and objective of works	Canal lining with concrete Improvement of outlets	---	---
		Rehabilitation length: 116 km	---	---
		Improvement of outlets of concrete canal	---	---
		Rehabilitation length: 127 km	---	---
Agriculture and water use	Extension method	● Experiments of the cultivations of vegetables and high value agricultural products ● Installation of demonstration farm for water saving irrigation ● Proceed with the subsidy system for the water saving irrigation		
	Extension target	Rate of extension of water saving irrigation methods : 10 %(Drip irrigation: 5 %, Furrow irrigation : 5 %) About 2 model farms per Ksar are installed annually.		Installation rate is reviewed with 10-years monitoring and analyze constraints to extension services
Organizational Strengthening	Khettara rehabilitation	● Establishment of association (1 association for 1 Ksar) (Add organizational capacity on traditional water users' groups to sens application for assistance from outside organizations). ● Acquiring basic knowledge and skills on association management. ● Strengthening implementation capability on khettara rehabilitation works in cooperation with traditional khettara water users' groups and associations.		● Establishment of equipment lending cooperative for khettara rehabilitation works. (1 cooperative in 1 ORMVA/TF subdivision area) ● Establishment of communal pump cooperative aiming at supplementing water source for khettara. (Target figure is set taking pumping plan into account.)
	Water saving irrigation	● Establishment of drip irrigation cooperative and its extension （Target figure is set taking above target on extension of drip irrigation into account.）		
Recharge Facilities	Contents	Investigation and design Implementation of promotion plan.	Implementation of construction and new project	Implementation of new project
	Objective	2 - 3 projects	6 projects	(continued)

Concerning the 1) rural infrastructures (water supply, electrification, roads, education and sanitary facilities), 2) income generating activities, 3) improvement of farms' agriculture practices (excluding water saving irrigation), and 4) prevention form farmland devastation (afforestation), it is proposed to implement from the beginning of the implementation stage so as to achieve equity to access to the development opportunity to whole khettara communities. The following table indicates the details of project components in respective phase other than the rehabilitation of khettaras.

Project Components in respective Phase not-related to the Khettaras Rehabilitation

Term		Short-term (5 years)	Med-term (6 to 10 years)	Long-term (11 to 20 years)
Rural Infrastructures	Potable water supply（ONEP）	Rate of service of 97% by 2007 in line with the program of potable water supply	---	
	Electrification (ONE）	Electrification by 2005 in 111 ksars/duars not covered at present.	---	
	Road (Provincial Gov.)	on-going		
	Sanitary (Provincial Gov.)	on-going		
	Sanitary installations (Provincial health delegation)	Starting of the construction or rehabilitation of 21 collective sanitary before 2004. Extending of mobile medical services	---	
Income Generation Activities	Projects	● Agriculture: Cultivation of vegetables and high value agricultural products ● Animal husbandry: sheep, goats, and small poultry-yard animals ● Small industries: Weaving or processing of agriculture products		
	Objectives	● Formulating of projects which contribute to development ● Increasing of literacy rate for women in the framework of participation in the economic activities	● Development of income generation activities, improvement of the economic conditions by organization ● Establishing market areas ● Technical assistance for extension and knowledge on the financial management of the projects for the women's participation	● Promotion of the production of specialty of each Ksar
Prevention from Farmland Devastation (Afforestation)	Contents	● Extension of planting techniques to environmental NGOs ● Extension of the demonstration farms to the irrigated areas		Extension of planting to recharge area of khettaras
	Project	About 150ha (Planting is started from present influenced by desertification and where khettara discharge is observed)		All khettara areas including those the discharge is recovered by recharge facilities and in areas for implementation of collective pumps.
Agriculture, Extension Services (except water saving irrigation)	Farming technique	Development of basic techniques in experimental farms of the ORMVA/TF		
	Dates palms	● Extension of farming techniques in the demonstration farms and introduction of processing machines ● Strengthening of sales of products through cooperatives		
	Improvement of life conditions	● Extension activities for maintenance of khettara water quality and garbage disposal in the khettara community		
	Market	Extension of materials for processing agriculture products	Construction of post harvest facilities (Collection farm products, etc)	

Note) Improvement of rural infrastructures is maintained by other governmental organizations except the ORMVA/TF.

The ORMVA/TF is responsible for not only the implementation of the project for the khettara rehabilitation and rural community development, but for overall project management. In the scope of the project management, the ORMVA/TF plays important roles of 1) revision of the plan, 2) update data base of khettaras, 3) the monitoring and valuation of the project, 4) preparation of budget, 5) strengthening of

project network and 6) knowledge management, etc. The following table presents the roles of the ORMVA/TF in each phase of the development.

Roles of the ORMVA/TF in the Project

Term		**Short-term（5 years）**	**Med-term（6 to 10 years）**	**Long-term（11 to 20 years）**
Roles of ORMVA/TF	Revision of Master Plan	Revision of mid- and long-term plans	Revision of long-term plan	Revision as required
	Update of khettaras database	● Update of khettaras data base ● Revision of annual plan based on khettaras data base ● Data collection on groundwater survey		
	Monitoring and evaluation	● Feed-back of the monitoring and evaluation results into the annual program ● Revision of annual program		
	Preparation of budget	● Preparation of budget based on the Master plan and annual program ● Promotion of each project for the donors and international organizations according to the needs		
	Network strengthening	● Educating the associations through the project implementation ● Strengthening of collaboration with the associations		---
	Knowledge management	Collecting foreign experiences in the field of khettaras and agriculture, etc.	Information transfer to other local areas and abroad concerning khettaras rehabilitation and agriculture.	

Farmers represented by traditional khettara water users' groups register their groups to governmental associations so as to receive assistance for the khettara rehabilitation works from outside organizations more smoothly. Associations supports traditional khettara water users' groups on their rehabilitation works through sending application to outside organizations for assistance, management and coordination of rehabilitation works, and joint monitoring activity with the ORMVA/TF.

Roles of Farmers' Organizations in Development Phases

Period		Short-term (5 years)	Mid-term (6 to 10 years)	Long-term (11 to 20 years)
Khettara farmers (Traditional Khettara water user's organization)	Khettara rehabilitation works	Provide of workforce on rehabilitation works and share a part of construction cost.		
	Khettara maintenance works	Continue maintenance work in accordance with their traditional custom on water uses.		
	Water saving irrigation	● Consider applicability of drip irrigation technique. ● Establish drip irrigation cooperatives. ● Construct and manage drip irrigation facility through cooperative.		
Khettara/rural development association*	Khettara rehabilitation works	● Prepare application to outside organization. ● Manage rehabilitation works.		Cooperate and implement joint works with other associations (i.e. establish equipment lending cooperative, pump cooperative, etc.)
	Monitoring and evaluation	Participate and facilitate joint monitoring activity with ORMVA/TF and traditional Khettara organization.		
	Water saving irrigation	● Spread knowledge on water saving irrigation techniques. ● Support farmers to establish drip irrigation cooperatives.		
	Other rural development works	● Facilitate projects and activities contributing to improvement of rural life and income generation activity.		

12. Project Implementation Plan

Work Volume of the project is as follows:

(Work Volume)

Construction Volume of the Khettaras and Irrigation Canals

	Rehabilitation Length（m）			Irrigation Canal（m） (including diversion outlets)
	Short-Term	Intermediate-Term	Total	Short-Term
Zone A	18,457	16,687	35,144	55,412
Zone B	4,685	2,924	7,609	10,153
Zone C	4,245	5,835	10,080	6,740
Zone D	12,150	19,396	31,546	19,706
Zone E	6,600	18,945	25,545	4,760
Zone F	3,410	6,704	10,114	3,580
Zone G	7,548	11,184	18,732	15,822
Total	57,095	81,675	138,770 （30%）	116,172 （100%）
	Total length of khettaras		462,567 （100%）	Total length 242,868 （100%）

Project for Recharge Facilities

Short-Term	Intermediate-Term
1) Small scale recharge pond (Hannabou area)	1) Flood conveyance canal: Tributaries of the Gheris river (Ferkla Soufla area)
2) Flood diversion weir (Boudenib area)	2) Flood diversion weir (Sifa area)
6) Flood dispersion dike (Tributaries of the Gheris river, Ferkla Soufla area)	3) Recharge dam (Fezzou area, Alnif)
	4) Recharge dam (Ahassia area, Alnif)
	5) Recharge dam (Tanguerfa area, Goulmima, Ferkla Soufla)
	6) Flood dispersion dike (Tributaries of the Gheris river, Ferkla Soufla area)

Activities on Farming, Water Use and Organizational Strengthening

	Short-Term	Intermediate-Term
Farming, Water Use	1) Water saving irrigation 10% (Drip irrigation: 5%, 150ha, furrow irrigation: 5%, 150ha）	
	2) Training activities: Water use Demonstration farm Income generation program	
Organizational Strengthening	3) Seminar and training	

Afforstation

	Short-Term	Intermediate-Term
Afforstation	1) Afforestation for sandstorm (Afforestation area: 150 ha)	

(Fund Requirement)

Fund Requirement

(unit : DH'000)

	Short-Trem	Intermediate Term	Total
I. Construction cost			
Rehabilitation of khettaras	77,850	112,250	190,100
Rehabilitation of irrigation canals	39,150	-	39,150
Construction of recharge facilities	33,600	165,840	199,440
Afforestation	850	850	1,700
Total	151,450	278,940	430,390
II. Administration cost	4,560	8,370	12,930
III. Engineering cost	9,210	22,190	31,400
IV. Contingency (Physical)	16,530	30,960	47,490
V. Contingency (Price)	7,660	38,350	46,010
Total	189,410	378,810	568,200
Drip irrigation (Subsidy)	30,000	30,000	60,000

Note: *:Cost for recharge facilities is composed of whole facility construction, accordingly cost allocation between surface water use and groundwater use is not considered in the estimates.

(Implementation Schedule)

Implementation Schedule (Short and Intermediate Terms)

No	Rehabilitation works / Year	Short Term (5 years) 1	2	3	4	5	Intermediate Term (5 years) 6	7	8	9	10
1.	Khettara rehabilitation works										
	130 khettaras (Discharge ≧2 lit/sec)	■	■	■	■	■	■	■	■	■	■
	61 khettaras (Discharge < 2 lit/sec)						■	■	■	■	■
2.	Irrigation canals rehabilitation works	■	■	■	■	■					
3.	Construction of recharge facilities	■	■	■	■	■	■	■	■	■	■
4.	Afforestation	■	■	■	■	■	■	■	■	■	■
		Total 150 ha planting in 10 years									
5.	Water saving irrigation (Drip irigation system)	■	■	■	■	■	■	■	■	■	■
		ORMVA/TF is responsible for technical assistance, including administrative support for registration to khettara associations									

13. Project Evaluation

The benefits of the project is quantified in the analysis result of the increase in the agriculture production associated with increase of the khettara discharge. The following table presents the summary of economic benefits and economic costs, in net present values applying the discount rate of 10 %.

The economic internal rate of return (EIRR) and Net Incremental Benefits for the short and intermediate terms is estimated at about 12.2% and DH22.6 million, respectively.

Summary of Economic Benefits and Costs (Net Present Value, Discount rate = 10%)

('000DH)

Economic benefits	NPV	Economic costs	NPV
Incremental agriculture production:		Incremental investment costs:	
from khettaras rehabilitation :	39,100	khettaras rehabilitation :	101,300
from canals rehabilitation :	32,000	canals rehabilitation :	26,900
from rehabilitation :	37,600	Incremental recurrent costs :	
Increased yield (on existing area)	30,000	khettaras maintenance	- 10,300
		canals maintenance	- 800
Total Benefits	139,700	Total Costs	117,100
Net Incremental Benefits :**22 ,600**			
B/C 1.2			
EIRR: 12.2 %			

(Farm economy analysis)

By the implementation of the project, irrigable area increases by 0.16 ha, bringing the total irrigable area of 0.96 ha. Those values is considered for the comparison in the financial situation with and without project conditions. The table below indicates that the implementation of the Project brings the additional revenue of DH15,400 for one farm irrigated by khettara, which will bring the household average income to DH10,000.

Moreover, the farmers profits from the considerable reduction in the maintenance costs for khettaras and irrigation canals. That can be utilized by the farmers for other activities, which consequently can further increase the incomes.

Analysis of Farm Economy (financial values)

	Wheat	Vegetables	Beans	Alfalfa	Dates and olives	Total
Present situation						
Irrigated area (ha)	0.50	0.05	0.02	0.14	0.12	
Net income (DH)	1 380	1 100	90	630	2 160	5 400
With Project						
Irrigated area (ha)	0.49	0.13	0.07	0.13	0.20	
Net income (DH)	2 030	4 730	480	890	7 280	15 400
Balance						
Net income	650	3 620	390	260	5 120	10 000

(Fiscal Impact)

Fund requirement for the project is estimated at DH292 million in total for the rehabilitation of the khettara and irrigation canals. Annual fund requirement is about DH28.9 million per year during the first 5 years and DH29.6 million per year during the following 5 years. Since the ORMVA/TF has dedicated the annual budget of DH5 million for the development of khettaras, so this amount will be secured even after

the year 2006. The local budget of the ORMVA/TF covers 20% of the total costs of the project, accordingly it is necessary to consider the financial assistance from the donors or international organizations in order to obtain credit or grant for the remaining 80 %.

Evaluation of the Master Plan

Evaluation	Descriptions
Efficiency	● The economic cost and benefit are estimated at DH117 million and DH140 million, respectively. While the benefit/ cost ratio is estimated at 1.2, and sufficient economic benefits of EIRR 12.2 % is given by the project. **B/C=1.2** **EIRR (Economic Internal Rate of Return) =12.2 %**
Effectiveness	● The objective of the khettaras rehabilitation and rural community development is to stabilize and increase the agriculture revenues. The increase of the volumes of khettaras water, improvement of water use efficiency as well as farm skills bring about the real increase in the agriculture revenue and contribute to poverty alleviation in the rural areas. ● According to the economic analysis, the revenue of the farm changes on average from present DH5 400 to DH15 400, which is the increase of DH10 000 par household.
Impact	● The realization of the Master plan contributes to poverty alleviation and improvement of the living condition of the rural communities, which coincides with the development policies in 5-year plan and the Rural Development Strategy 2020. ● In the long term, the project has a social impact from the economic vitalization in the sector, from increase of the school attendance rate, settlement of the population and conservation of the environment.
Relevance	● Aiming at poverty alleviation, the 5-year plan and the Rural Development Strategy 2020 put their development concept on strengthening of the agriculture production, improvement of the opportunities for employment and income generation, creation of diversified employments for creation of the additional incomes and non-agriculture incomes, eliminating the inter- and intra-regional inequalities through the opportunities of the infrastructure development. Since the percentage of poor is very significant in the Tafilalet region, the objectives of the Master plan perfectly coincides with those of the national programs. ● The farmers in the Project area must immigrate to other cities or countries in order to compensate the insufficient incomes resulting from the decrease in agriculture production due to a shortage of khettaras water. They also rely on pump irrigation to maintain their incomes. In these circumstances, the farmers have high expectations towards the remedy such as increase of khettara water that leads to the increase of their revenues.
Sustainability	● The ORMVA/ TF, the project implementing agency, has sufficient capacity for the implementation of the project in the Master Plan. ● The khettaras are very old traditional irrigation structures constructed and operated by the population in the autonomous manner. Their utilization and maintenance are managed by the customary laws rooted in the region. The Master plan suggests the project components in full consideration of the customary laws and regional customs, in the way , the project has high sustainability. ● Considering the local situation and the capacities of the stakeholders, the development objectives are defined by phase. That should also contribute to maintain the project sustainability. ● The Master plan includes the income generating activities in the form visible for the farmers, so that the enthusiasm of the farmers should be lasting. ● The EIRR of 12.2% should translate into the higher economic viability of the project.

14. Khettara Rehabilitation Plan

The purpose of the khettaras rehabilitation plan is to study effectiveness and validity on the scale and components of rehabilitation in detail, for the whole khettara community covered by the Master plan through the study of the modeling sites.

The following are pointed out in relation to an effectiveness and relevance of the project components in the Master plan.

(1) Rehabilitation works for khettaras and irrigation canals

The benefit associated with khettara rehabilitation consists of discharge increase and decrease of O&M work load. However the rehabilitation cost sometimes surpasses the benefit because rehabilitation works underground requires larger cost. From the economical point of view, it is necessary to rehabilitate especially the sections, where leakage prevention is efficiently possible.

The canal rehabilitation has usually higher const-benefit performance than khettara rehabilitation since canal rehabilitation is not costly and leakage prevention effect by rehabilitation works surely appears. Therefore, as it is proposed in the Master plan, completion of the primary canals rehabilitation within 5 years is quite valid.

(2) Farming and water saving irrigation

As for the water saving irrigation (drip irrigation), it is necessary to intensively use 2 to 3 ha of farmland so as to minimize facility cost per unit area. However farmland use is divided into pieces in these days, so integration of farmland and adjustment of water right should be accelerated by drip irrigation cooperatives (newly established).

As for vegetables as high value crops, it is necessary to shorten irrigation interval days for production increase and quality improvement, and agricultural technology extension by the ORMVA/TF is strongly require. It is also necessary to maintain cultivation plans based on the local farmers' experiences and knowledge, like area increase of alfalfa (fodder crop for animals), and henna and cumin mainly cultivated in the Alnif area.

(3) Organizations for operation and maintenance

Necessity of following organization strengthening components proposed in the Master plan was confirmed in order that each farmer's organization becomes able to fulfill expected roles.

1) Strengthening of traditional khettara water users' groups on its institutional aspect (registration as an association)

2) Acquiring basic knowledge and skills on association management

3) Enhancing project implementation capability through joint implementation of the khettara rehabilitation works in cooperation with the traditional organizations and associations.

15. Conclusions and Recommendations

(Conclusions)

1) Rehabilitation schedule is divided into three phases, short term (first 5 years), intermediate term (6 to 10 tears) and long term (10 to 20 years) in the Master plan. Besides, rehabilitation schedule is broadly divided into two groups, i.e., 191 productive khettaras that have a flow at present and remaining 219 re-productive khettaras that have recently dried up. Productive khettaras are rehabilitated for 10 years during short and intermediate term periods. Rehabilitation of re-productive khettaras is carried out on condition that the khettara flow recovers by effect of recharge phenomenon, as well.

2) Rehabilitation works for irrigation canals (primary canals) and diversion outlets aim at improving water use efficiency. Since economic analysis proves that the benefit originated from the rehabilitation of the irrigation canals is more advantageous compared with that by the khettaras, the works are scheduled in the short term period (first 5 years).

3) With respect to farming and water use, 1) a research for the vegetables and other high value agricultural products, 2) introduction of water saving irrigation, 3) implementation of water management programs, 4) introduction of cultivation techniques for quality improvement, and 5) assistance for the distribution and marketing are activated during the project implementation. For income generation activities, support programs for agriculture, animal husbandry and small industry are encouraged. In the field of strengthening of the farmers' organizations, technical and institutional support is provided aiming at improvement of maintenance conditions of the khettara and living conditions in the rural community.

4) Groundwater recharge is the reliable method to increase khettara flow. Meanwhile recharge facility site suitable for supplying groundwater to many khettaras is limited due to unfavorable geography and climates in the Tafilalet region. It is therefore necessary to verify project effect originated from the recharge facility construction considering location of the khettaras and hydro-geological conditions.

(Recommendations)

Water source available for the khettaras is different in the Project area due to seasonal and annual changes of climate, fluctuation of meteoro-hydrological conditions, geographical condition, and groundwater itself has been drying up in several areas by excessive pumpage or other causes.

The following are recommendations for smooth project implementation taking various natural and artificial conditions into account:

1) The ORMVA/TF is responsible for reviewing the Master plan referring results of the monitoring and evaluation at least once in three year in conformity with project progress. The Master plan

shall be revised through supplementary verification study when proposed plan lacks positive proof or has uncertain factors.

2) Control of excessive pumpage, shifting to communal pump irrigation system and diffusion of water saving irrigation system (e.g. drip irrigation and furrow irrigation systems) are strongly encouraged aiming at groundwater conservation.

3) Water saving system (drip irrigation system) is introduced by self-effort of the farmers, so that availability of their initial investment and application to governmental subsidy directly affects its progress. The ORMVA/TF and other related governmental agencies should positively support farmers to utilize subsidy system.

4) Flood diversion and recharge facilities shall be constructed to improve water use. Since it is impracticable to accurately estimate recharge effect due to intricate subsurface structure, it is proposed that facility plan is established mainly for surface water use and secondary groundwater recharge use during the project economic evaluation.

5) Khettara inventory shall be periodically updated because inventory data provide necessary information for the planning of the khettara and irrigation canal rehabilitation. Daily basis discharge measurement has been conducting for 30 khettaras. It is suggested to continuously conduct discharge measurement for a long period so as to effectively utilize its results during a review of the Master plan.

6) Various manuals for khettara rehabilitation and maintenance works, khettara water use, agriculture and extension service and organization strengthening on khettara community have been prepared in the course of the study. The ORMVA/TF is requested to revise and distribute these manuals to the beneficiaries for information sharing on khettara rehabilitation and agricultural development scheme.

7) Apart from increasing agriculture production by the efficient use of limited water resource, there exist very few way to improve agriculture revenues in the Study area. It is therefore essential to find a new type job using the limited resources with the simple techniques and practicable investment in addition to the proposed income generation activities such as animal breeding, food processing as well as cultivation of vegetables and other high value farm products.

8) Traditional khettara water users' groups and khettara associations are responsible for request to outside organizations for financial assistance, participation through the project implementation, and joint monitoring with the ORMVA/TF. In addition requested to introduce water saving irrigation skills to the farmers in the khettara villages. The ORMVA/TF has an important role for overall project management as a leading government agency from technical and financial aspect to these farmers' organizations.

9) Since the khettara system has been well maintained by farmers for several hundreds of years, rehabilitation work shall be carried out in careful consideration of concerns of farmers and

traditional water users' organizations. To achieve this issue, farmers shall continuously participate in the project from the planning to implementation stages. The ORMVA/TF implements proper rehabilitation works through mutual understanding with farmers.

Water-saving irrigation shall also be introduced to the farmers in due consideration of the locality of each khettara and community. It is difficult to secure all funding locally, therefore, the ORMVA/TF will fully exert its influence on international and foreign organizations to cope with this situation.

10) This project is carried out within a participative approach framework. Furthermore, it responds to the overall strategy of the National Initiative for Human Development (INDH: National initiative launched by His Majesty the King Mohammed VI in 2005. This initiative covers major policies to achieve human development and poverty reduction, with the main purpose of redressing regional disparities.) aiming at the development and improvement of living conditions of rural communities in the Tafilalet region.

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in Semi-Arid East Atlas Regions with Khettara Rehabilitation

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Abreviation

Abreviation	French/English	English
ADS	Agence de Développement Social	Social Development Agency
AUEA	Users' Association of Agriculture Water	Agriculture Water Users' Association
C/P	Counterpart	Counterpart
CAF	Centres d'Animation Feminines	Women Development Center
CE	Centre d'Elevage	Animal Husbandry Center
CLCA	Caisse Locale de Credit Agricole	Local Agricultural Credit Bank
CMV	Centre de mise en Valeur	Developmen t Center
CNCA	Caisse Nationale de Credit Agricole	National Agricultural Credit Bank
CRCA	Caisse Regionale de Credit Agricole	Regional Agricultural Credit Bank
DE	Direction de l'Elevage	Direction of Animal Husbandry
DEPAP	Direction des entreprises Publiques Agricoles et des Associations Professionnelles	Direction of Public Agricultural Enterprise and Professional Associations
DERD	Direction de l'Enseignement de la recherche et du developpement	Direction of Education, Research and Development
DGH	Direction Generale de L'Hydrolique	General Direction of Hydralic
DH	Dirham	Dirham (Currency of Morocco)
DIGRAP	Diagnostic Rapide	Rapid Survey (one kind of RRA)
DPA	Directions Provinciales de l'Agriculture	Direction of Provincial Agriculture
DPAE	Direction de la Planification et des Affaires Economiques	Direction of Planning and Economy
DPV	Direction de la Production Végetale	irection of Vegetable Production
DPVCTRE	Direction de la Protection des Végetaux, des contrôles Techniques et de la Repression des Fraudes	Direction of Vegetable Protection, Technical Control and Smuggling
DRH	Direction de la Region Hydraulique	Regional Direction of Hydralic
EIA	Environmental Impact Assessment	Environmental Impact Assessment
F/S	Feasibility Study	Feasibility Study
FIDA	Fond International pour le Developpement Agricole	International Fund for Agricultural Development
GDP	Gross Domestic Procuct	Gross Domestic Procuct
GIS	Geographical Information System	Geographical Information System
IEE	Initial Environmental Examination	Initial Environmental Examination
IMF	International Monetary Fund	International Monetary Fund
JICA	Japan International Cooperation Agency	Japan International Cooperation Agency
M/P	Master Plan Study	Master Plan Study
MADRM	Ministere de l'Agriculture, du Développement Rural et des Pêches Maritimes	Ministry of Agriculture, Rural Development and Fishries
NEA (ENA)	Ecole Nationale d'Agriculture	National Agricultural University
NGO	Non Governmental Organization	Non Governmental Organization
OJT	On the Job Training	On the Job Training
ONE	Office National de l'Electricite	National Electric Office
ONEP	Office National de l'Eau Potable	National Potable Water Supply Office
ORMVA	Office Regional de le Mise en Valeur Agricole	Regional Agricultural Development Office
ORMVA/TF	Office Regional de le Mise en Valeur Agricole/ Tafilalet	Regional Agricultural Development Office in Tafilalet
PAGER	Programme d'Approvisionnement Groupe eu Eau portable de populations Rurales	Rural Potable Water Supply Program
PCM	Project Cycle Management	Project Cycle Management

Abreviation	French/English	English
PDM	Project Design Matrix	Project Design Matrix
RRA	Rapid Rural Appraisal	Rapid Rural Appraisal
S/W	Scope of Work	Scope of Work
SD	Sub Division	Sub Division
SEMVA	Station Experimentale et de Mise en Valeur Agricole	Agricultural Development Experimental Station
SMN	Service de la Meteorologie Nationale	National Meteorological Service
V/S	Verification Study	Verification Study
WHO	World Health Organization	World Health Organization

Chapter 1 Introduction

1.1 General

The main report summarizes the study results on the Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation in line with the Scope of Works (S/W) mutually agreed between the Japan International Cooperation Agency (JICA) and the Regional Agency for Rural Development of Tafilalet (ORMVA/TF) in October 14, 2002. The Scope of Work and the Minutes of Meeting are shown on Attachment 1.1 and 1.2.

The report consists of Phase 1 and Phase 2 study results in line with Clause 4 in the Scope of Work. The former is composed of data collection, field investigation, the draft Master plan and the initial environmental examination, and the latter is composed of "the Khettara rehabilitation plan", environmental examination, the verification study and final Master plan conducted from February 2003 to July 2005.

1.2 Background of the Study

The chief industries of Morocco are agriculture and phosphate ore mining. The farming style is remarkably different from each other between east and west regions of the Atlas Mountains. Surface water such as rainwater and perennial river flow is utilized for the irrigation in the west region, while flood flow and subsurface water are utilized for the irrigation in the east (semi-arid) region. Subsurface water is utilized by pumpage or the subsurface tunnel structure, which is called the khettara. The khettara system has its origin in the quanat in Iran, and it seems having been introduced by the Muslim expanded to the Morocco in the twelfth century. The khettara water is used for potable water, livestock and domestic use at first, and used for irrigation for date palm, olive, wheat, barley, tomato, carrot, turnip, herb, etc.

The inhabitants maintains water right from old times and established firm operation and maintenance system of the khettara such as rehabilitation cost and labor work sharing. However it has become difficult to maintain the said system due to desertification advance and depopulation of the rural regions. There were about 410 khettaras in the Tafilalet region, however recent inventory study indicates that the majority of the khettara has not been available due to shortage of flow.

Since the khettaras have a very long history, thus various efforts are being well performed to maintain the khettara system for a long period in each village. On the whole, cause of damages or obstructions varies with each khettara, and an extent of a maintenance work also differs in each village due to his monetary problem and availability of labor force. In addition, a variety of new ideas and new devices are being incorporated in their farming to effectively and efficiently use a khettara flow. The study aims at establishing an ideal farming skill by means of data collection and processing from scientific and technical points of views.

1.3 Significance of Khettara Rehabilitation

The Tafilalet region extremely lacks a rainfall, 50 to 200 mm per annum and rainfall varies year by year, in addition torrential floods are localized and shortly continues in one to two days long. On the other hand,

continuous drought in recent years has decreased water source and caused reduction of irrigable area as well as devastation of the farmlands by desertification advance.

In the Tafilalet region, surface water conveyed to the farmlands through small scale diversion weirs, and khettara flow are fully utilized for potable water and irrigation. A part of whole water is drawn by these traditional khettara systems, and remaining water is further recharged as groundwater and drawn at downstream area. Thus sustainable water circulation is maintained for a long period.

In recent years, water utilization systems have been modernized to accelerate water resources development and to improve water use efficiency, such as large scale reservoirs, flood diversion weirs and their irrigation canal networks as well as pump stations. These facilities have enabled to supply required water in correspondence with increase of water demand. It however causes several problems in water use such as groundwater level degradation due to excessive groundwater pumpage and whole run-off storage in the reservoirs which hinders groundwater recharge.

The Hassan Addakhill dam was located at the Ziz Valley and completed in 1971 with its total storage volume of 350 Mm^3 to constantly supply irrigation water, control floods and accelerate groundwater recharge. Several weirs and canal networks located at downstream of the dam have their diversion capacity of 140 Mm^3 per annum for total command area of about 28,000 ha. However the storage amount decreased to 5 to 20 % of the storage capacity in the drought year (1980 to 1991 and 1995 to present). Inflow amount to the dam recorded in 2001 and 2003 was only 28 to 32 Mm^3 which was equivalent to 8 to 9 % of storage capacity because of continuous drought year since 1997. Consequently, released water from the dam was limited in minimal and total released amount from the dam was only 26 Mm^3 in 2002 which was 7 % of designed amount. These facts indicated that the large fluctuation of annual rainfall affected storage amount, and continuous drought caused unstable water supply, especially by a continuation of the drought years. A huge amount of the evaporation from the reservoir surface reduced storage water about 20 Mm^3 per annum, furthermore deteriorated farming practice due to reduction of fertility of the soil and groundwater recharge effect.

Several project such as construction of flood diversion weirs and irrigation canal networks have been launched so as to effectively utilize water source, and these projects have rapidly improved water use efficiency and thus extended command areas compared with existing small scale irrigation systems. However, since flood diversion systems excessively depend on flood occurrence, irrigation period, irrigable area are unstable by year. Floods have occurred at most 5 times per annum according to the inventory survey. It is assumed that flood occurrence is one to three times a year in accordance with the flood record at Tadighoust during the normal year in 1995 to 1996 and 1989 to 1990. (refer to Figure 1.3.1)

To cope with water shortage, pumpage is successful to obtain irrigation water as long as farmers can stand its installation and operation costs. While recent drawing down of the groundwater level by excessively large pumping and shortage of recharge amount by continuous drought has caused decrease or drying up of the khettara flow. A similar phenomenon has encountered in Tinejdad. Groundwater balance between

supply and demand is in unbalance and caught in a vicious circle, e.g. groundwater decline induces deeper well construction.

On contrary to these modern water use systems, khettara system is visualized from its constancy of flow. Khettara flow has become smaller amount, however its perennial flow (5.7 lit/sec per khettara in average) secures water supply for potable water, domestic water and irrigation water. There exist 191 productive khettaras with their total flow discharge of 1,100 lit/sec in the Study area. Though individual khettara discharge is very small, annual flow amount of 35 Mm^3 exceeds storage amount of the Hassan Addakhill dam of 26 Mm^3 observed in 2002.

(1) Importance of khettara rehabilitation from the aspect of water source

Khettaras have the following advantages comparing with other water sources. Based on such advantages, khettaras have the function to supply water that is necessary for agricultural production and life of rural communities. Preservation of these functions is indispensable to maintain and accelerate rural activities and lives in the study area.

1) Continuous drought decreases khettara flow. However discharge fluctuation is smaller than surface water since khettara flow source is subsurface water.
2) Khettara discharge is small, however perennial flow secures rural life.
3) Water quality of khettara flow is good for potable use.
4) Gravity flow minimizes operation cost.
5) Subsurface water does not have an evaporation loss like surface water, so it contributes to water preservation.
6) Water fee is not collected according to traditional operation and maintenance system.
7) Irrigation water is regularly distributed in line with traditional water use system, and khettara system is well maintained by traditional water users' organizations.

(2) Importance of khettara rehabilitation from the aspect of poverty alleviation

The rate of the poor in Tafilalet is 29 % and it is higher than the Moroccan average of 19 %, so people survive with migrant income other than with agriculture. The basic approach to alleviate poverty in khettara communities is to increase of agricultural income, which is the major economical source in the area. Increase of usable water and its stable supply expand irrigable area, and contribute to the growth of agricultural production and income.

(3) Importance of khettara rehabilitation from the aspect of natural environment

Farmlands (oasis) have gone in half of khettara villages among 410 khettaras in the Study area, or irrigated farmlands have decreased in khettaras, whose discharge have been decreasing. Such a situation leads to expansion of desertification and devastation of farmlands. So it can be said that khettara farmlands (oasis) are located at the frontline against desertification, conservation and revitalization of irrigated farmlands by

khettara rehabilitation is the major countermeasure for desertification.

(4) Importance of khettara rehabilitation from the aspect of rural development

Khettaras communities have formulated based on traditional water right system to operate and maintain khettaras. Such a communal management system has been succeeded until now and the system maintains water management of khettaras. Dried up khettaras have brought disappearance of rural communities due to population outflow. Therefore, preservation of khettara communities through rehabilitation works contributes to long term settlement of local people in the area. That also prevents population move to urban areas, which are one of the serious social problems in these days.

(5) Importance of khettara rehabilitation from the aspect of history and culture

Traditional groundwater collecting facilities are widely distributed all over the world, especially in the Middle East. But they have not been used or have been abandoned due to degradation of groundwater and development of modern irrigation facilities in many countries. Even in Morocco, 606 khettaras irrigated about 20,000 ha of farmland at the Haouz plain near Marrakech, with total discharge of 3,200 lit/sec in 1970's, but most of them have been dried up now. Therefore, a large number of khettaras are maintained only in and around Tafilalet region in Morocco, it is therefore important to preserve the khettaras as historical and cultural heritage.

1.4 Objectives and Study Area

The Study area is situated at the Tafilalet region in the east area of the Atlas mountain range. The Study aims at conducting following objectives for the khettaras and khettara communities:

1) Preparation of the Master plan on the khettara rehabilitation and rural community development
2) Preparation of the khettara rehabilitation plan
3) Technical transfer on project planning, implementation and management to the ORMVA/TF staff through master plan preparation and the verification study.
4) Technical transfer on farming skills to the farmers through the Verification study.

The Study area is divided into seven (7) zones according to topographical and geo-hydrological delineation by the ORMVA/TF. The table below shows location of the zones and related offices of the ORMVA/TF.

Zoning and Related Offices of the ORMVA/TF

Zone	Location (Commune)	ORMVA/TF Sub-Division and CMVs	River basin
A	Goulmima、Tinejdad	Goulmima (SD)	Gheris river
B	Beni-Tadjit、Gourrama	Beni-Tadjit (SD), Gourrama (CMV)、Rich(SD)	Guir river
C	Boudenib	Boudenib (CMV)、Errachidia (SD)Errachidia (SD)	Guir river
D	Fezna、Jorf、Arab-Sabbah-Gheris	Erfoud (SD)	Gheris river
E	Sifa	Erfoud (SD)	Gheris river
F	Rissani、Taouz	Erfoud (SD)	Ziz river
G	Alnif	Erfoud (SD)	Maider river

Note: Location of zoning is show on "Location Map of the Study Area" in the opening page.

1.5 Scope of the Study

The study is composed of two (2) phases:

(1) First Phase: Preparation of the Master plan

The Master plan study was conducted for ten (10) months from February to November 2003.

Present condition in the Tafilalet region in terms of meteoro-hydrology, groundwater, geo-hydrology, irrigation, farming practice, rural community, and environment was collected and sorted as a fundamental study. The work aimd at studying khettaras, and their communities from various points such as structure, function and maintenance system of the khettaras, characteristics of community, organizational structure of house holds and community activities through the inventory survey of the khettaras and rapid rural appraisal (RRA) on agriculture and rural communities. The study results were utilized to prepare the Master plan on the khettara rehabilitation and rural community development project. The projects aim at realizing increase of the agricultural productivity and farm income of the inhabitants through preservation and effective use of the water source by means of the rehabilitation works for the khettaras and irrigation canals. It was necessary to give full consideration concerning to technical, economical and environmental aspects to the project planning on the basis of the existing entire development plan of the Tafilalet region by the ORMVA/TF.

Base on the Master plan, proposed plan for the Verification study scheduled in Phase 2 was established. The proposed plan included objectives of the study, location of selected khettaras, scope of the study, etc. The first seminar on khettara rehabilitation and rural community development was held at the end of the Phase 1 study by the Study team and specialists related to the study.

(2) Second Phase: The Verification study and preparation of the final Master plan

The Verification study and preparation of the final Master plan were conducted for twenty two (22) months from January 2004 to October 2005.

The khettara rehabilitation plan was prepared for the areas selected during the Phase 1 study at the beginning of the Phase 2 study. In addition, the Environmental impact assessment (EIA) was conducted for the selected areas by the ORMVA/TF with technical support by the Study team. The khettara rehabilitation plan aims at verifying of relevance of the proposed khettara rehabilitation and rural community development plan for whole 410 khettaras and communities through a detailed study on the selected khettaras and their communities as a model.

The sites for the Verification study were selected from the model sites above. The study activities were monitored and evaluated in the course of the study to review the objectives and target of the Verification study. Method on project planning, monitoring and evaluation were transferred to the ORMVA/TF for his further activities after the study completed.

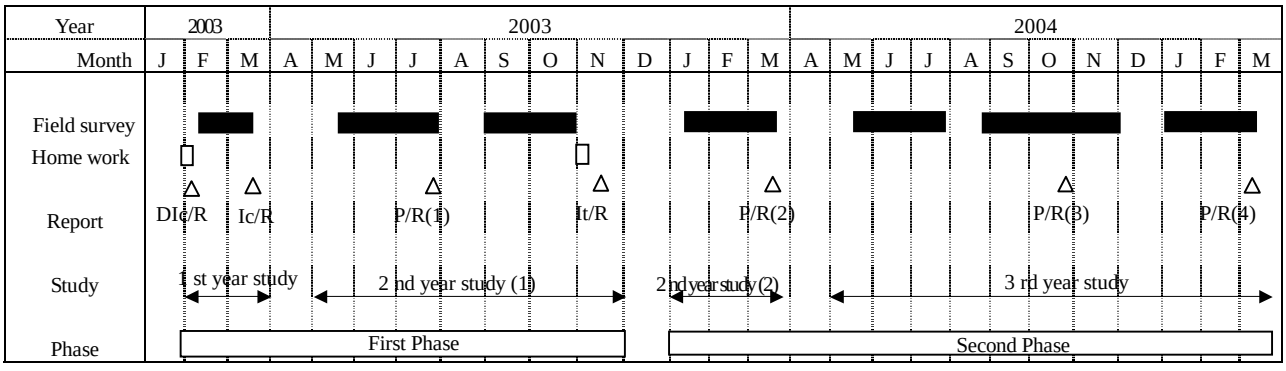
The second seminar on the khettara rehabilitation and rural community development as well as effective water use and rural development harmonized with environment was held at the end of the Phase 2 study by the Study team, the ORMVA/TF and specialists related to the study.

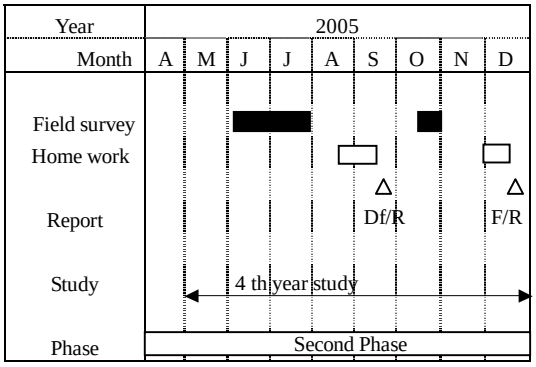
(3) Technical transfer

Technical issues related to the study were transferred to the counterparts, staff of the ORMVA/TF and other related agencies during the Phase 1 and 2 study periods by means of seminars and on-the-job training style.

1.6 Schedule of the Study

Overall schedule of the study was as follows:





DIc/R: Draft Inception Report
Ic/R: Inception Report
P/R: Progress Report
It/R: Interim Report
Df/R: Draft Final Report
F/R: Final Report

【First Phase】Preparation of the Master plan, khettara rehabilitation plan	
1 st year study	
The preparatory home work February, 2003	Prior to the field survey, collection and sorting of related data were carried out. In addition draft inception report was prepared on the basis of the methodology and schedule of the entire study.
The first field survey February to March, 2003	Discussion meeting on the draft inception report was held with related governmental agencies, and the report was agreed with both parties. Through the field survey and discussions about the contents and method for the technical transfer, the Inception report was finalized.
2 nd year study (1)	
The second field survey May to October, 2003	Study results of the field survey detailed in the inception report were compiled into the progress report (1) in August 2003, and the Study team and counterparts visited Oman so as to collect information on farming practice in arid area, governmental policy and system for the water resources development, etc. in July 2003. The Interim report compiling the khettara rehabilitation and rural community development plan (M/P) and the Verification study plan was prepared. The Verification study plan included proposed sites and activities during the study. The first seminar was held in the end of the second field survey.
The first home work October to November, 2003	The Interim report was completed in this work with an approval of the JICA advisory committee. The report gave details on the khettara rehabilitation and rural community development plan (M/P), khettara rehabilitation plan concept and proposed contents for the Verification study.
【Second Phase】 Supplementary investigation of selected sites, commencement of the Verification study and compilation of the final study report	
2 nd year study (2)	
The third field survey January to March, 2004	Both the Study team and related counterpart agencies (the ORMVA/TF) mutually agreed with the Interim report and selection of the proposed sites for the Verification study through several discussions. The Progress report (2) was prepared and agreed with both parties. The report was composed of the khettara rehabilitation plan and supplementary investigation results.
Third year study	
The forth field survey May, 2004 to March, 2005	The Verification study was continuously carried out since the third field survey period. The monitoring and intermediate evaluation were performed to review the study activities, targets and present evaluation indicators in accordance with the pre-determined evaluation indicators and institutional setup so as to effectively implement the Verification study. The Progress reports (3) and (4) gave detailed information about the Verification study in the middle and end periods of the study.
4 th year study	
The fifth field survey June to July, 2005	The Verification study was performed in succession from the previous forth field survey. The khettara rehabilitation and rural community development plan (M/P) and the khettara rehabilitation plan were prepared based on the study results during the 1 st to 5 th field surveys. In addition, tools for diffusion, seminar texts and various manuals were prepared in the period.
The second home work August to September, 2005	The draft final report was prepared with an approval of the JICA advisory committee.
The 6 th field survey October, 2005	Both the Study team and related counterpart agencies mutually agreed with the draft final report through several discussions. The contents and results of the technical transfer activities were compiled in the report, and the second seminar was held in the end of the 6 th field survey.
The third home work December, 2005	After necessary revision of the draft final report in consideration of the comments from the counterpart agencies, the whole study reports were finalized, as well as other study products, i.e. tools for diffusion, seminar texts and various manuals.

Chapter 2 General View of Agriculture Sector

2.1 Agriculture Sector

In 2001, the GDP of Morocco was DH 383 billion, or GDP per capita of US$ 1,259. The share of the primary sector (agriculture, animal husbandry and fishery) in GDP is 15.8% and the share of secondary sector is 30.9%. The remaining GDP of 38.1% is the tertiary sector. The following table shows the evolution of GDP in Morocco between 1998 and 2001.

Evolution of GDP in Morocco (Unit: DH million)

	1998	1999	2000	2001
Primary sector	59 211 (17.2%)	52 905 (15.3%)	49 570 (14.0%)	60 546 (15.8%)
Secondary sector	108 669 (31.6%)	110 552 (32.0%)	112 867 (31.9%)	118 238 (30.9%)
Tertiary sector	128 891 (37.5%)	132 713 (38.4%)	141 142 (39.9%)	145 974 (38.1%)
Public sector	47 234 (13.7%)	49 424 (14.3%)	50 489 (14.3%)	58 138 (15.2%)
Total	344 005 (100%)	345 594 (100%)	354 068 (100%)	382 897 (100%)

Source: IMF
Note: The numbers in brackets indicate the percentage shares by sector.

The growth rate of the total GDP in Morocco from 1991 to 1999 was 1.9%. However, the growth rate of the primary sector was negative, namely -0.8%. The main reasons behind this negative growth were the increase of the number of poor in the rural areas and the consecutive droughts in recent years.[1] It must be noted that 47% of the total population of Morocco live in the rural areas and work in the agriculture sector. However, the share of the agriculture sector in total GDP is only 15.8%. Nevertheless, the production, transportation and services are to the considerable extent related to the delivery of the agriculture entrants, as well as processing and distribution of the agriculture products. Consequently, the primary sector still plays an important role in the Moroccan economy.

Public investment for the agriculture sector is of DH 2.3 billion, equivalent of 10.4% of the total public investment. The following table presents the evolution of public investment between 1998 and 2001.

Evolution of Public Investment in Morocco (Unit: DH million)

	1998	1999	2000	2001
Agriculture	1 878	2 234	1 160	2 284
(Percentage)	(10.8 %)	(12.8 %)	(8.5 %)	(10.4 %)
Total	17 428	17 485	13 648	21 866

As can be seen above, the agriculture sector benefits from the considerable public investments, after the transport and communication sector. However, more than 70% of public investment in the agriculture sector is dedicated for the installation of large scale irrigation facilities, and the investments for the poor communities are insufficient.[2]

[1] World Bank, Project Appraisal Documents for Rainfed Agriculture Development Project, May 2003.
[2] World Bank, Country Assistance Strategy of World Bank, May 2001

2.2 Agriculture Development Policy and Rural Communities

Following to the liberalization of external trade and the restructuring of state enterprises aiming at the integration with the world economy, the Moroccan economy was showing stable growth until the beginning of 1990s. However, this policy has brought about the inequalities between the rich and the poor, and the share of the poor population in the rural areas increased from 18% in 1990/1991 to 27% in 1998/1999[3]. In order to face this problem, the Moroccan government has elaborated the 5-year plan for rural economic development (2000-2004), which was approved by the Parliament in July 2000. This 5-year plan put particular stress on the poverty reduction in the rural areas, to list some specific measures: 1) to accelerate the programs of the agriculture infrastructure facilities so that the number of the beneficiaries can achieve 60 - 70% of total rural population until 2004, 2) to generally develop rural communities, in the participatory way and prioritizing the poorest population.

The Ministry of Agriculture and Rural Development presented in December 1999 the "Rural Development Strategy 2020" aiming at reducing poverty in the rural areas until 2020. In order to achieve this aim, the Strategy fixed specific objectives, not limited to the improvement of the agriculture livelihoods, but also including:

- Increase of the agriculture production to respond the future internal and external demand for food products;
- Increase of the employment and revenues in the agriculture;
- Creation and diversification of the employment in the para-agriculture activities and outside of the agriculture sector in order to respond to the demand for employment of the active rural population which cannot be absorbed by the agriculture production;
- Prevention from the process of human-made environmental degradation;
- Upgrading and improvement of the education and professional training of rural men and women;
- Improvement of services related to the quality of life and well-being;
- Correcting of regional and sub-regional imbalances in the field of infrastructure, commerce and land management.

In order to achieve the above objectives, "the Strategy 2020" proposes to implement the action programs designed around the three driving ideas:

1) "Decentralization" to adapt the better action plans to the local actual conditions, 2) "integration" aiming at the coherence of the sectoral programs in order to maximize their synergies for the local actors, and 3) "participation" for mobilizing most effective actors in the development process.

The principle of "decentralization" consists of transferring the authorities of the Ministry of Agriculture, Rural Development and Fishery to provinces and local offices. The principle of "integration" consists of

[3] Statistical Office of Morocco, Statistical Year Book, 1999

reinforcing the cooperation between the governmental organizations, private enterprises, NGOs, farmers, etc. to jointly respond to problems. The principle of "participation" aims at: 1) stimulating the initiative of farmers in the development programs' activities, 2) improving the accessibility to the agriculture credit system, and 3) training farmers to enable them to evaluate and monitor their activities.

The principle of "participation" puts stress on the activities of the villagers' associations and the NGOs, underlying their lack of implementing capacity and technical capacity, with the exception of certain NGOs and/or villagers' associations who are active at the national level. Consequently, the particular stress is put on reinforcement of their capacity in order to set a real partnership between the villagers' associations and the governmental organizations/ private enterprises.

2.3 Farmers Organizations and Associations

The Ministry of Agriculture, Rural Development and Sea Fisheries has the complete authority of the Moroccan Government for elaborating and implementing of the agriculture development policy. Table 2.3.1 presents organization chart of the Ministry. The Ministry includes a number of directorates. Those which are mainly in charge of the agriculture techniques development and extension as well as the farmers' organizations are the Directorate of Planification of Economic Affairs (DPAE), the Directorate of Education, Research and Development (DERD), the Directorate of Crop Production, Control Techniques, and Repression of Fraud (DPVCTRE), the Directorate of Crop Protection (DPV), the Directorate of Animal Husbandry (DE), and the Directorate of Public Agriculture Enterprises and Professional Associations (DEPAP).

At the regional level, there are 40 provincial agriculture directorates (DPAs) and 9 regional Authorities of agriculture development (ORMVAs). They are in charge of the agriculture development at the regional level. The DPAs are mainly in charge of the small and medium irrigation systems and of sectors of rain-fed agriculture (Bour). The ORMVAs are in charge of the large-scale irrigation (and small and medium irrigation). Consequently, the areas of activities of DPA and ORMVA do not overlap.

There are nine (9) ORMVAs, namely Doukkala, Gharb, Haouz, Loukkos, Ouarzazate, Souss-Massa, Tadla, Mouloya and Tafilalet. The mandate of the ORMVA is to promote or to execute the development works for the improvement of agriculture productivity and for the development of the supporting services for farmers. The ORMVA is a public establishment with legal personality and financial autonomy, placed under the guardianship of the Ministry of Agriculture and Rural Development and Sea Fisheries. The ORMVA/TF (Tafilalet), which is the counterpart agency of the present study, has its zone of operations located almost completely in the area of Tafilalet.

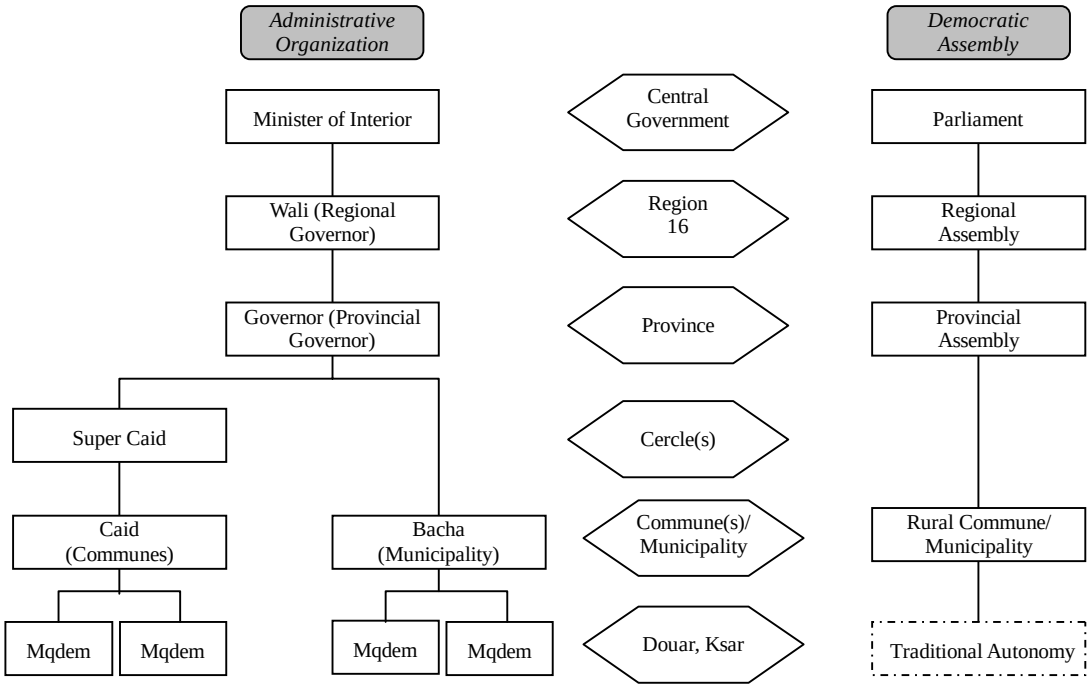
Chapter 3 General Information of the Study Area

3.1 Socio-economic Condition

3.1.1 Location, Administrative Organization

In Morocco, administration consists of 16 regions and they are composed of provinces or prefectures. A province includes urban and rural area, respectively called municipality or urban commune, and rural commune. They are the smallest administrative organizations.

The smallest communal group for rural people within a rural commune is called douar or ksar. The relationship among those administrative organizations, communal groups, responsible government offices, responsible officers, and democratic assemblies is shown in the figure below.



Administrative Organizations and Democratic Assemblies in Morocco

Tafilalet region, covered by the ORMVA/TF that is the counterpart agency of the Study, includes the whole Errachidia Province and adjacent Beni-Tadjit Cercle in Figuig Province (refer to Figure 3.1.1 Administrative Map in the Study area).

Administrative organizations related with existing khettaras (410) are clarified in the table below.

Administrative Organizations in the Study Area

Zone	Province	Cercle	Municipality	Rural Commune
A	Errachidia	Goulmima	—	Melaab, Ferkla Soufla, Ferkla El Oulia, Tadighoust, Gheris Essoufli, Aghbalou N'Kerdous
		Assoul	—	Assoul, Ait Hani, Amellagou
B	Figuig	Beni-Tadjit	—	Beni-Tadjit, Bouanane, Ain Chouater
C	Errachidia	—	Boudenib	—
D	Errachidia	—	Jorf	—
		Erfoud	—	Fezna, Arab Sebbah Gheris
E	Errachidia	Erfoud	—	Sifa, Arab Sebbah Ziz
F	Errachidia	Rissani	—	Rissani, Essfalat, Beni M'Hamed Sijilmassa, Taouz
G	Errachidia	Erfoud	—	Alnif, M'cissi, Hssia

3.1.2 Major Socio-economic Indicators

Major socio-economic indicators of municipalities and rural communes, where khettaras are used in the Study area, are clarified as the table below.

Comparison of Socio-Economic Indicators between National Average and Study Area

Item		National		Study Area
		Urban	Rural	
Population		13,407,835	12,665,882	262,797
Economically active population (%)	Whole	32.2	30.1	24.3
	(Male)	51.7	51.2	42.3
	(Female)	17.3	9.3	6.8
Illiteracy rate (%)	Whole	37.0	75.0	60.0
	(Male)	25.0	61.0	39.3
	(Female)	49.0	89.0	79.5
Enrollment ratio (8 – 13 years) (%)	Whole	83.9	43.4	66.2
	(Male)	87.5	59.6	81.5
	(Female)	80.4	26.6	50.2
Marriage (% of population more than 15 years old)	Unmarried	N.A.	N.A.	31.2
	Married	N.A.	N.A.	59.2
	Divorce/ Widow, etc.	N.A.	N.A.	9.6
Average marriage age (years)	Whole	29.0	26.2	23.9
	(Male)	31.2	28.3	26.5
	(Female)	26.9	24.2	21.3

Source : "Recensement General de la Population 1994", Direction de la Statistique
Number of rural communes using khettaras is based on the ADI survey result in 2003.

According to the table above, enrollment ratio in the Study area is higher than the national rural average for both male and female, and illiteracy rate is lower. However, the economically active population is lower than the national average. This is most probably because there are very limited economical activities and employment opportunity in the Study area.

3.2 Natural Condition

3.2.1 Topography and Geology

(1) Topography

The Study area is the whole responsibility area of the ORMVA/TF, covering the whole Errachidia Province and western half of the Figuig Province.

The responsibility area of the ORMVA/TF is located between longitude 5 degrees 17 minutes and 2 degrees 17 minutes west, and latitude 30 degrees 17 minutes and 33 degrees 4 minutes north. The Grand Atlas runs from west south west to east north east in the north of the Study area. The highest peaks in the watershed area are J.Anderdonz (3,057m) and J.Iouigharacene (3,058m), and the range goes down to 2,000m high at the southern end.

The southern tip of Grand Atlas ends as cliff and a wide plain of 1,000 to 1,200m high spreads toward Errachidia and Boudenib in the south.

In the south of the plain, a carse formed by the Todrha-Ferkla river and the Gheris river lies, and there is sedimented area by the Ziz river, which flows from north to south. Those constitute vast Tafilalet Plain, where Jorf-Erfoud to Rissani area is located. The elevation is 600 to 800m.

J.Ougnate (1,719m), J.Gaiz (1,425m) and Bou Gafer in Anti Atlas are facing the Grand Atlas in the west of the Tafilalet plain. In the east, the vast Guir Hammada spreads at the downstream of the Guir river, which runs from the Grand Atlas toward south. The elevation is about 1,000m. Further south is a part of Sahara desert.

The famous tourist spot, Chebbi dune complex is located in the south east of the Tafilalet plain. The dunes are constituted with the sand, transported by the wind from the western tip of Guir Hammada. The sand is produced as a result of erosion by rivers (the Beida river and its tributaries).

River systems in the Study area are clarified into the Guir river, the Gheris-Ziz rivers and the Maider river systems.

(2) Geology and geo-hydrology

Geography in the Study area is classified as the Grand Atlas, Errachidia-Boudenib basin, Todrha/Felkra-Gheris to the Tafilalet plain, Anti Atlas, Sahara desert and Guir Hammada. The classification is based on the geographical distribution of bedrock. In other words;

- Grand Atlas : The area is fold-fault mountains formed by the mountain building before Cretaceous period (called Helsinia mountain building) with Jurassic-Triassic layer and Paleozoic strata basically. The southern boundary of the area is the tectonic line called the South Atlas Fault, appearing as a cliff and separating with southern plain.
- Errachidia-Boudenib Basin : It is constituted with the horizontal layer of Cretaceous limestone, as it is generally called Cretaceous basin.

- Todrha/Felkra-Gheris - Tafilalet Plain : It is a subsiding basin and alluvial sediment is deposited on the rock foundation.

- Anti Atlas : It is constituted with Paleozoic and Precambrian strata, including rich eruptive rocks.

- Sahara Desert and Guir Hammada : The area is constituted with stabilized block and horizontal layers of Paleozoic, Mesozoic and Triassic on the Precambrian foundation.

Table 3.2.1 and 3.2.2 show the order of geological layers, geo-hydrology distribution and aquifer distribution of each river basin.

In every river basin, the main aquifer is the Pliocene to Quaternary aquifer and the aquifer in rock foundation is important in some areas. Especially in Boudenib area, Senonien-Turonien limestone and Quaternary aquifer complement each other. Tinejdad area lacks for limestone, so Infracenomanien limestone in lower layer forms small-scale rock foundation aquifer. In the Maider river basin, fissure waters are sometimes found in Paleozoic fracture zone.

The geological map in the Study area is shown on the Figure 3.2.1.

3.2.2 Climate and Hydrology

(1) Climate

Monthly- Annual Rainfall in the Study Area (mm)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Amouguer	9	16	15	16	18	12	5	12	20	27	16	11	176
Tadighoust	12	19	11	16	12	5	1	7	13	21	23	15	142
Errachidia	12	20	9	11	10	9	5	4	7	21	18	19	107
Erfoud	5	8	4	4	4	3	1	2	6	7	6	6	51
Taouz	4	5	4	7	3	1	0	1	3	7	6	6	45

Monthly- Annual Temperature in the Study Area (Celsius degree)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Amouguer	7	9	12	15	18	23	27	25	22	17	12	8	16
Tadighoust	8	11	15	18	23	28	32	30	26	20	14	10	20
Errachidia	7	10	13	17	21	26	29	29	24	18	12	8	18
Erfoud	10	13	17	20	24	29	33	29	28	22	15	11	21
Taouz	10	13	18	22	27	31	35	35	30	22	16	11	22

Monthly and annual rainfall and temperature in the Study area are shown in the table above. The station Amougour is located at Grand Atlas mountain, while Tadighoust and Errachidia are located at the exit from Grand Atlas. Erfoud is located in Tafilalet plain and Taouz is located further south near the border with Algeria. Each data of rainfall and temperature shows typical value in the area.

Figure 3.2.2 shows average annual rainfall distribution in the Study area. Annual rainfall fluctuates drastically year by year. Interannual variability of past 20 years rainfall is shown on Figure 3.2.3. It shows rich rainfall in around 1989 and 1993 to 95, and drought in 1982 to 83 and around 2000 until present.

Monthly and Annual Evaporation by Evaporation Pan in the Study Area (mm)

Station	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Amouguer	121	131	188	213	283	329	382	345	244	180	134	117	2668
Tadighoust	124	137	192	256	318	395	466	381	320	177	126	85	2977
SEMVA	59	89	149	196	246	303	339	301	228	158	83	53	2189
Taouz	201	266	393	485	594	646	666	667	509	384	263	196	5268

The table above shows monthly and annual evaporation by evaporation pan in the Study area. Generally, annual evaporation varies widely between 2,000 and 3,000 mm and especially it exceeds 5,000 mm in the south at Taouz. Though Tadighoust and Errachidia (SEMVA) are located at the exit from the Grand Atlas, the value of Errachidia (SEMVA) is relatively low, because the station in Errachidia (SEMVA) is in experimental plot of the ORMVA/TF affected by trees and vegetation in the plot.

Humidity is relatively low, as Errachidia has 41 % average humidity. Humidity between June and August is lower than 30 %, while between November and February slightly exceeds 50 %.

(2) Hydrology and groundwater

River systems in the Study area are classified as the Guir river, the Gheris/Ziz rivers and the Maider river systems. Catchment areas of each system are; Guir- 13,400 km^2, Gheris/Ziz- 20,200 km^2 (21,300 km^2 with Chebbi Dunes), and Maider- 12,000 km^2. These systems are further classified into tributary basins as indicated in the table below. Observation stations in each basin are shown in Table 3.2.3. The minor observatories observe only water level of river flow.

The table below shows the data of annual average discharge obtained in the major observation stations. Yearly fluctuation is large same as the rainfall data, and the volume between 1980 and 85, and after 2000 is quite small due to a drought.

Average Discharge

Discharge	Tazouguert	TitN'Aissa	BniYatti	AitBouijane	Meroutcha	Tadighoust
(m^3/sec)	1.17	0.46	2.45	0.87	0.82	1.30
(Mm^3/year)	37	14	77	27	26	41

Discharge	F.Tillichit	M'Zizel	FoumZabeli	BHAddakhil	R.Erfoud	L'Hmida
(m^3/sec)	2.20	1.96	4.43	8.84	2.72	0.90
(Mm^3/year)	69	62	140	279	86	28

The DRH has installed observation wells in each region and kept record of groundwater level monthly (refer to Table 3.2.4). Several sets of data were obtained for each area. The results are shown on Figure 3.2.4 to 3.2.6.

As it is clearly observed from those graphs, drastic degradation of groundwater level started from 1982 to

83, corresponding to the prolonged drought. After some years with low level, it started recovering from 1988 to 89 and it went up to the former level in around 1990. However being different from these fluctuations, the groundwater level at Tinejdad tended to go down gradually.

Like these periodical fluctuations and gradual lowering tendency of groundwater level are clearly observed especially in low lands around major rivers. Comparing with them, groundwater level at the foot of mountains and along medium and small tributaries is relatively steady.

Since the DRH paused monthly observation after 1997 in observation wells, there was no available data for changes of groundwater level afterward. Therefore it was not possible to measure the affect of recent droughts.

On the other hand, the ORMVA/TF has kept monthly records of groundwater level since 1995 in some pumping stations at Jorf, Erfoud and Rissani areas. Figure 3.2.7 shows the observation data. According to the figure, it is clear that groundwater especially in Jorf area has been severely affected by recent droughts.

3.2.3 Soils

The soil in the Study area is relatively fertile, with the sedimentation materials originating from each basin. The surface layer is rather thick (over 30cm). Regarding the pedological features of the soil, those are generally sandy areas, coming from loamy sand of silt clay.

The following table presents the pedological distribution of the areas included in the Study area. The information was prepared by the CMV.

Pedological Distributions of Study Areas

(unit: ha)

No.	CMVs	Loamy sand	Silt clayey	Lime soil (sandy or clayey)	Total
2	703 Erfoud	77 935	29 975	11 990	119 900
7	704 Goulmima	Data not available			-
3	705 Rissani	417 627	198 870	46 403	662 900
1	706 Boudnib	353 625	70 725	47 150	471 500
13	707 Beni-Tadjit	39 450	144 650	78 900	263 000
14	709 Bouanane	Data not available			-
9	712 Tinejdat	29 219	38 958	29 219	97 395
8	713 Tadighoust	Data not available			-
10	714 Assoul	Data not available			-
5	716 Mezzouga	Data not available			-
4	717 Jorf	16 500	0	93 500	110 000
6	718 Alnif	Data not available			-
11	720 Kerdous	64 980	43 320	108 300	216 600
12	722 Mellaab	75 600	50 400	0	126 000
	Total	1 074 936	576 898	415 462	2 067 295
	(%)	(52.0 %)	(27.9 %)	(20.1 %)	(100.0 %)

In the Study area, there is a problem of saline soils and limy soils. Concerning the salinity, it seems that the original soil does not contain the salt, but that the salt was brought by the extensive utilization of the irrigation water with strong saline content. Concerning the limy soils, the hardening of the superficial soil was observed due to the accumulation of the calcium carbonate in the shallower layers.

3.3 Water Resources

(1) Possible developing water volume in each river basin

Figure 3.3.1 and 3.3.2 show the results of the survey in 1994 (ETUDE DU PLAN DIRECTEUR DE L'AMENAGEMENT DES EAUX DES BASSINS DU GUIR, ZIZ, RHERISS ET DRAA: VOLUME I, UNITES FIGUIG, GUIR-BOUANANE, ZIZ-RHERIS ET MAIDER) by the DGH of the Ministry of Territory Development, Water and Environment.

Table 3.3.1 shows volume of water use in each basin. But the Maider river basin has insufficient data, so it is not possible to grasp concrete volume of water use in the basin from the data. Therefore the volume of water use in the basin was calculated by the estimated volume supplied at upstream and the measured volume at downstream afterward.

Possible developing water volumes in each basin are explained in the table below.

Possible Developing Water Volumes in Each Basin

River Basin	Possible developing water volumes in each basin
Gheris・Ziz River	92.5 % of 349 Mm^3/year of river discharge is utilized. Discharge of the Ziz river is used almost 100 %, so 26 Mm^3/year of the Gheris river is possible water resource to develop. Zones A, D, and E, where groundwater level is going down rapidly, are located along the Rheris river. It is possible to facilitate flood irrigation and groundwater recharge.
Guir River	Only 20 % of 188 Mm^3/year of river discharge is used, so 153 Mm^3/year is released downstream. Zone B and C are located at the basin, and the potential to develop groundwater recharge and surface flow is high.
Maider River	There is no data of river discharge. When the total discharge in the basin is assumed as 49 Mm^3/year, 45 Mm^3/year is used for irrigation, but 11 Mm^3/year is groundwater. Therefore 70 % (34 Mm^3/year) of surface water is used, so the possible developing surface water is estimated at 15 Mm^3/year.

Discharge of khettaras tends to decrease due to degradation of groundwater level caused by recent droughts and spread of pumps. It became also difficult to secure necessary labor force to maintain khettaras in these days. Certain amount of discharge was found in only 191 khettaras among 410 khettaras, according to the inventory survey conducted during the study.

(2) Present water source

Water sources and actual intake discharge in 2003-2004 in the Tafilalet region are explained below. The actual intake discharge in 2003-2004 is evaluated as a typical water use under average rainfall condition in the Tafilalet region, because inflow volume to the Hassan Addakhil dam in 2003-2004 is almost same as the average inflow of last 34 years record.

(a) Dam

The Hassan Addakhil dam is the first dam constructed in the eastern Atlas area as a large-scale structure for water use. The dam is located at Foum-Ghiour ("Mouth of Ghiour" in Arabic) in the outskirt of Errachidia city along the Ziz river. The unprecedented flood in 1965 served as the catalyst of dam construction and the flood discharge reaches 5,000 m^3/sec. The service area of the dam is 27,900 ha. Though its storage volume reaches 350 Mm^3, average stored volume from 1971, start of storage, to present is 71 Mm^3, equivalent to only 20 % of possible storage volume. Actual stored volume in 2003-2004 reached 80 Mm^3, however conveyed water volume to benefited area was only 57 % as indicated in the table below.

Hassan Addakhil Dam Water Supply (2003-2004)

Benefited area	Conveyed Water (Mm^3)	Planned Water (Mm^3)	Supply Rate (%)
Migrated farmland	8.3	10	83
Ziz River Right bank	3.2	5	64
Ziz River Left bank	19.7	35	56
Tafilalet Plain	48.4	90	54
Total	79.6	140	57

Source : Rapport de Gestion, ORMVA/TF

(b) Diversion weir

Many weirs were constructed in the Tafilalet region for flood irrigation or diversion to the other basin. Large- scale weirs are Mouley Brahim, Lahmida, and Elbrouj. Mouley Brahim weirs and Lahmida are located at downstream of the Gheris river, in the west of Erfoud, and they divert flood water of the Gheris river to farmlands along the Ziz river basin. Elbrouj weir was constructed along the Ziz river in the north of Erfoud and it delivers water to the farmlands at downstream of Ziz River. The table below shows actual intake discharge in 2003-04 and it is just 23 % of planned intake discharge. Locations of weirs along the Gheris, Ziz and Guir river systems are shown on Figures 3.3.3 and 3.3.4.

Total of Actual Intake Discharges of 3 Major Weirs (2003-2004)

Benefited Area	Farm Area (ha)	Planned Intake Discharge (Mm^3)	Intake Rate (%)
Ziz River farmland and transferred farmland	5,500	31	38
Tafilalet Plain	22,400	76	15
Total	27,900	107	23

Source: Rapport de Gestion, ORMVA/TF

Actual Intake Discharges of 3 Major Weirs (2003-2004)

Weir	Intake Discharge (Mm^3)	Intake Rate (%)
Mouley Brahim	8.1	29
Lahmida	2.1	8
Elbrouj	17.8	63
Total	28.0	100

Source: Rapport de Gestion, ORMVA/TF

(c) Groundwater

The wells under the ORMVA/TF in Tafilalet area are 114 of communal and 6,700 of private, and they supply irrigation water for fruit trees and vegetables mostly. Annual pumped volume from private wells is calculated about 22 Mm^3 from the assumptions below.

- 60 % of 6,700 wells are used (6,700 x 0.6 = 4,000).
- Pumped discharge is 5 lit/sec and operating hour is 3 hrs/day.
- Operating day is 100 days/year.

Pumped volume = 4,000×（0.005×3×3,600）×100÷1000,000=22 Mm^3

As intake from private wells requires approval from the government, the number of approved wells is just 109 (1.6 % of total number of private wells). Communal wells constructed by the ORMVA/TF are shown on Figure 3.3.5.

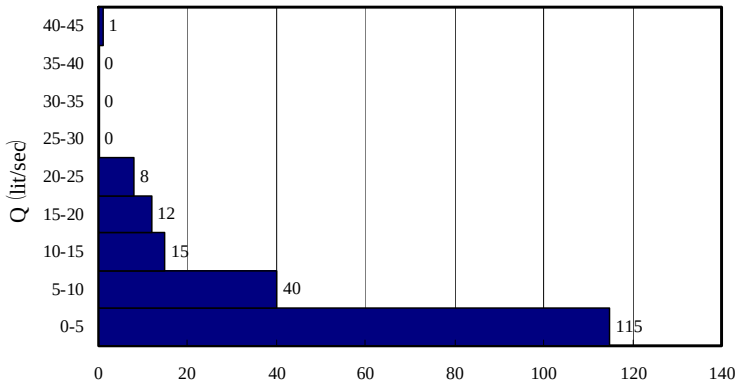
(d) Khettara

The number of khettaras is decreasing gradually after 1970's due to convenience of pumps and difficulties of operation and maintenance of the khettaras. At present, discharge is recognized only in about 190 khettaras.

Sixty percent (60 %) of khettaras among the 190 have little discharge less than 5.0 lit/sec according to the inventory survey (Figure 3.3.6). The average discharge is only 5.9 lit/sec. Even the biggest khettara, Fougania, has only 44.2 lit/sec of discharge.

Those little discharges are still decreasing year by year due to the drought continuing after 1997, as the total discharge is decreasing from 1.2 m^3/sec in 2001 to 1.1 m^3/sec in 2005. The discharge decrease is more conspicuous in the southern part of the Tafilalet region, where there is less rainfall and smaller recharging area. Discharge in the area decreases about 70 % during the study period.

Total water use in khettaras surveyed from 2004 to 2005 is estimated about 31 Mm^3/year.



Khettara discharge distribution

(e) Potable water (Groundwater)

Groundwater is used as a source for potable water. Supplied volume is as follows:

Potable Water Supply

Area	2000		2020	
	lit/sec	Mm^3/year	lit/sec	Mm^3/year
Rural	126	3.97	158	4.98
Urban	234	7.38	359	11.32
Total	360	11.35	517	16.30

Source: Elaboration du Schéma Directeur pour L'Améloiration de L'Approvisionnement en Eau Potable des Populations Rurals de la Province D'Errachidia (Ministere de L'Equipement, Janvier 2003)

Analyses above are summarized as below:

Outline of the Water Use in the Study Area

Classification	Facility	Consumption	Note
Surface Water (2003-2004)	Stored in dam and flood irrigation	108 Mm^3	Potential of surface water use Ziz River : 243 Mm^3 Gheris River : 106 Mm^3 Guir River : 188 Mm^3 Total : 537 Mm^3
Groundwater	Pump	22 Mm^3	
	Khettara	31 Mm^3	
	Pump wells for potables*[1]	11 Mm^3	
	Total	64 Mm^3	

Note*[1]: Pumping volume of potable water is the planned value in 2000.

3.4 Traditional Irrigation Facility (Khettara)

3.4.1 General

There were 570 khettaras of 2,900 km long in the Tafilalet area. According to the inventory survey in the study, 410 khettaras are recognized as a productive khettara, and remaining 160 khettaras are not in use and already abandoned due to drying up since 1970s. Among these 410 khettaras, 191 khettaras are recognized as a "productive khettaras" that have a flow at present, and the remaining 219 khettaras are recognized as a "re-productive" khettaras that have no flow at present, however have a high potential to yield the khettara flow with increase of rainfall or recharge effect. General information of khettaras based on the inventory survey of the Study is shown in the table below.

General Information of Khettaras

Zone	Number of khettaras	Khettaras with water [1]
A	137	80
B	24	20
C	8	8
D	69	21
E	25	14
F	44	11
G	103	37
Total	410	191

Note: [1] "Khettaras with water" means khettaras, in which discharge was observed through inventory surveys of ORMVA/TF in 1999 and JICA in 2003.

The table shows that only 47 % (=191 khettaras) have water among total of 410 khettaras targeted by inventory surveys, so a half do not have water. Table 3.4.1 "Features of khettaras in Each Zone" shows khettaras in each zone and assessment of their discharge potentials.

3.4.2 Facility of Khettara

(1) Structure

As explained on Figure 3.4.1 "Section of Khettara", a khettara and downstream canal is classified into 5 sections according to their functions and structures.

Sections of Khettara

No.	Section	Function
1	Groundwater recharge/ yield zone	Water yield area of khettaras
2	Water conveyance zone (Gallery)	It is a conveyance area at downstream of yield area. Depth is 2 to 18 meters. When the depth is small as 4 to 5 meters, a culvert is constructed by concrete or masonry with open excavation.
3	Water conveyance zone (Open channel)	A delivery canal connecting the outlet of the gallery and a village.
4	Intake zone of domestic water	Domestic water for potable water of residents and local animals, and washing etc. is taken in the area.
5	Intake zone of irrigation water	Irrigation water is conveyed and used in the area.

A typical cross-section is shown on Figure 3.4.2 “Khettara Typical Cross-section”.

(2) Function degradation/ damage

Present condition of function degradations and damages of khettaras are summarized in the table below, according to the sections shown on Figure 3.4.1.

Function Degradation/ Damage of Khettaras

No.	Section	Function Degradation/ Damage of Khettaras
1	Groundwater recharge/ yield zone	- Sediment enters into khettaras due to erosion of vertical shafts and inflow of flood. - Sand flows in through vertical shafts at where desertification is aggravating. - In case the yield zone of a khettara is located in a river course, flood water collapses walls of vertical shafts and gallery.
2	Water conveyance zone (Gallery)	- Same as above
3	Water conveyance zone (Open channel)	- In case canal is extremely lower than ground level, earth wall is eroded and accumulated in the canal.
4	Intake zone of domestic water	- Some khettaras have hygiene problems, because potable water intake is located adjacent to washing area.
5	Intake zone of irrigation water	- Although most main canals are constructed by concrete or masonry, leakage is observed from canal bottom.

3.4.3 Operation and Maintenance

(1) Operation and maintenance

Operation and maintenance (O&M) of khettaras are carried out by traditional water users’ organizations. Principal O&M activities are removal of sediment and protection of vertical shafts. Necessary expenses for removal of sediment are shouldered by water users’ organizations. Aside from O&M, expenses for extension of a mother well to increase yield are also shared by water users’ organizations.

(2) Influence of desertification

Influence of desertification stands out at the downstream areas of the Gheris river in Zones D and E (Jorf, Fezna, Monkara, Hannabou, Sifa), at the downstream area of the Ziz river in Zone F (Rissani, Taouz), and at Bouanane in Zone B. Residents take countermeasures to minimize sand intrusion, such as raising of vertical shafts about 1 meter above ground, and closing of vertical shafts those are unnecessary for O&M, which are normally provided in 15 to 30 meters interval.

(3) Influence of flood

Many portions in the routes of khettaras exist near and parallel with rivers. In case of flood, flood water enters into the khettara with excessive sediment through vertical shafts, and collapses inside. Present countermeasures are to raise surrounding ground of vertical shafts to prevent flood water from entering, and to protect the gallery and vertical shafts with concrete and masonry to minimize flood damage. In some areas, after cleaning inside the khettara, vertical shafts are covered or clagged on top with sand and gravel so as to protect khettaras from flood.

3.4.4 Present Condition of Khettara Rehabilitation

(1) Rehabilitation method

Rehabilitation methods of khettaras are explained below (refer to Figure 3.4.1).

Rehabilitation Method of Khettara

No.	Section	Rehabilitation Method
1	Groundwater recharge/ yield zone	Extension of yield zone Protection of yield zone with concrete (weep holes are provided together)
2	Water conveyance zone (Gallery)	Conversion to culvert with concrete and masonry, and vertical shaft construction
3	Water conveyance zone (Open channel)	Construction of open canal with concrete lining and masonry (H=40 to 120 cm), widening of open canal (W=60 cm), installation of cover (H= 120 cm)
4	Intake zone of domestic water	Protection of areas for potable water and washing with concrete and masonry, separation of potable water intake and washing area (1 site)
5	Intake zone of irrigation water	Main canal lining with concrete and masonry

(2) Scale of rehabilitation

Major rehabilitation work for khettaras are shown in the table below:

Rehabilitated Khettaras by ORMVA/TF

Year	Area	Components	Volume	Cost (DH)	Financial Source
1995 to 2003	Jorf, Alnif, Taouz, Beni-Tadjid, Goulmima	- Desiltation, canal shaping	62 khettaras	12,200,000	IFAD
2002 to 2004*	12 areas	- Rehabilitation of vertical shafts and galleries - Irrigation canal construction - Regulating basin construction	12 khettaras	6,113,452	Small-scale Grant Aid Program of Japan

IFAD: International Fund for Agricultural Development

* Projects implemented with Japan's Small-scale Grant Aid Program are shown in Table 3.4.2.

3.4.5 Problems on Khettara Rehabilitation

Purposes and components on khettara rehabilitation are classified on the table below.

Purposes and Components on Khettara Rehabilitation

	Purposes	Components
1	To extend yield zone and protect galley wall	Extension of yield zone Gallery protection
2	To minimize leak from gallery	Gallery lining
3	To prevent collapse of inner wall of vertical shafts and gallery	Protection of vertical shafts and gallery
4	To prevent sand intrusion to khettara, due to desertification	Raising of vertical shafts
5	To minimize leak from open canal	Canal lining
6	To prevent sand intrusion to open canal	Conversion to culvert
7	To minimize flood flow into khettara	Raising of vertical shafts, dike construction of the river
8	To keep public health in potable water intake and washing area	Protection with concrete and masonry, isolation of washing drainage

Summary of Problems on Khettara Rehabilitation

Aspect	Explanation
Technical	- It is difficult to validate increase of water by extension of gallery due to difficulties of analyses in geo-hydrological point of view.
Economical	- Length of gallery lining and/or culvert construction is limited due to financial constraints. - Related to the above, it is difficult to assess the effect of rehabilitation (increase of water, easiness of O&M).
Social	- The influence of rehabilitation to neighboring khettaras and customs of rural society like water rights, is not clear. Some areas are affected by pump irrigation at upstream of yield zone of khettara.

3.5 Water Use of Khettara

3.5.1 General

Water collected by khettaras flows open canal nearby a village and it is used as domestic water for potables and washing, and animal feeding. After that, the water is used for irrigation in beneficial area (oasis). The order of water use is basically potable (for both people and animals) first, then washing and irrigation use. Some khettaras have washing places in the middle of irrigation canals, depending on the relative position of canal route and village location.

Most khettaras have not been able to irrigate the whole beneficial area in these years due to decrease of water. Although there is discharge from khettaras through the year, discharge in the summer period is generally smaller than that in the winter period. On the contrary, evapo-transpiration that controls crop water consumption is rather higher in the summer period. Therefore, irrigable area decreases in the summer period and increases in the winter period.

On the other hand, in order to make up for the lack of khettara water, pumps are installed along canals to use groundwater for irrigation in some places.

3.5.2 Domestic Water

Water sources in the Study area are classified into khettara, the ONEP and rural water supply program (PAGER), wells installed by local people, etc. Installation of water supply facility by the ONEP is carried out actively in recent years. Water supply rate increased from 12 % in 1982 to 82 % in 2003, and a 5 year plan was developed targeting the increase of water supply rate to 97 % by 2007.

Communal faucets are constructed in many khettara villages. Water fee is volumetric and the rate is DH0.05 DH/ 5 liters (equivalent to a plastic container). Although the water quality of khettara flow is being degraded, free khettara water is consumed in some villages.

As khettara water is used for washing water at the same time, degradation of water quality for irrigation is observed at downstream.

3.5.3 Irrigation System

(1) Irrigation facilities

Khettara water is distributed up to the tail end of irrigated area through small-scale open canal with gentle slope. Irrigation canals (width and height: 0.3 to 0.5 meter) are classified as follows:

Main canal: It is a major canal delivering water from the start point of irrigation canal to the secondary canal. Both concrete lined and earth portions are observed.

Secondary canal: It is a tributary open canal connecting from the main canal. Most of them are not lined with concrete.

On-farm canal: It delivers water to every field plot. All of them are unlined.

As most canals are just earth canal, a lot of water infiltrates into the ground on the way of delivery and that hampers effective water use.

There is no gate but just openings on the open canal at diversion points from irrigation canals to farm blocks. Each water user controls water distribution and closure by piling soil with a hoe. The water loss from those diversion points should not be neglected because of their large amount.

Some khettaras have also a regulating reservoir at the beginning of open canal. According to the inventory survey, its average size is 12 to 19 meters rectangular and 0.5 to 1.2 meter deep. Its purposes are as follows:

(i) After the temporary storage, water retained in the reservoir is released rapidly. The method enables to increase delivery volume per unit time increases and minimizes a delivery loss. Accordingly it makes water distribution to further field possible.

(ii) As irrigation period is sometimes shortened (e.g. from 24 hours to daytime 12 hours), khettara water is stored in the reservoir through the night to prevent waste loss (control volume for the gap between delivery period and irrigation period).

(2) Irrigation method

The basin irrigation method by khettara water is applied in all the irrigated areas (oasis). However its irrigation efficiency is low, because of higher evaporation rate from widely wetted farm plot, and large infiltration loss below root depth due to uneven irrigation interval and also irregular water depth on the farm plot.

Some improvements are observed to use limited water in efficient manner, such as downsizing of a basin plot to minimize water loss and partial irrigation to the roots of date palm. They are however not countermeasures to improve irrigation efficiency drastically.

(3) Water distribution schedule

The rotation irrigation in corresponding to the traditional water rights is applied to distribution management of khettara water. The time zone for water use is designated by water rights as irrigation period in a certain days of interval. Interval days are different in each khettara, as it varies from 4 to 26 days according to the inventory survey. Irrigation hour is basically 24 hours and one khettara has one rotation block. Complete rotation irrigation is performed for the whole day and night.

As for actual irrigation for each crop, practical interval is allowed through the management of distribution schedule, such as partial use of irrigation period and exchange of the periods with other users.

Negative effects appear in these days, like disperse of farmlands due to land inheritance, and lower irrigation efficiency due to segmentalization of irrigation period caused by fragmenting water rights.

3.5.4 Water Requirement and Quantity of Irrigation Water in the Field Level

(1) Water requirement

According to the inventory survey and discharge measurement, discharge of khettaras in the area varies from 0 to 50 lit/sec. Discharge data of khettaras are shown on Figure 3.4.3. Sixty percent (60 %) khettaras have discharge less than 5 lit/sec and 95 % have less than 20 lit/sec, while the average is 5.7 lit/sec only. Concerning khettara discharge per unit irrigated area as an indicator for irrigable water supply, 34 % of khettaras have less than 0.2 lit/sec/ha and 56 % have less than 0.4 lit/sec/ha.

(2) Quantity of irrigation water in the field level

Each water right holder regulary controls irrigation water to give a proper water depth of 50 to 100 mm in all his plots according to the interval days and period of time designated by the water right.

However, actual water consumption of crops varies corresponding to evapo-transpiration (e.g. 5 to 6 mm/day in summer, 1 to 2 mm in winter), variety of crops and their growth stages.

Since water management in the on-farm level is practiced with experiences and feelings of farmers, it is difficult to control water supply and interval days carefully, corresponding to the soil moisture in each growth stage for each crop, as long as the basin irrigation method and the traditional water right are applied. That results in over or under irrigation condition.

Therefore, from the viewpoint of efficient water use, a certain countermeasure to control unbalance between demand and supply of irrigation water is necessary.

3.5.5 Operation and Maintenance (O&M)

Sediment in irrigation canal is desilted by water users once to several times a year in the same manner as khettara, and labor works are provided according to the length of irrigation period entitled in the water right.

Firm O&M system will not be assured in the future, as the present earth canal needs a large amount of labor work for O&M. It is essential to reduce labor requirement for O&M by means of canal lining, etc.

3.5.6 Water Right

Water right of a khettara is a designated right by the tradition according to the contribution to its construction at the time. Total irrigation hour in one interval (e.g. 8 days times 24 hours = 192 hours, in case 8 interval days) is divided into each irrigation period for each water right holder. The period varies from several ten minutes to several hours in general.

The irrigation period of each user is not always same. The time sometimes comes at night after the previous turn at day time, to keep equity in terms of labor force and distribution quantity. Each khettara has each rule to stipulate the order.

As irrigation water is conveyed by open canal, reaching time of water is different in the farm nearby the outlet of the khettara and in the farm located far from the outlet. Khettara’s another feature is that the

irrigation time table is stipulated considering reaching time of water to each farm block, to distribute water appropriately based on the water right and to prevent from waste release owing to a poor operation.

Water right is owned by individuals and inherited generation to generation. One right is sometimes divided into many holders. It is allowed to sell or buy a water right, and irrigation time based on the water right is also borrowed and lent, when necessary.

In some cases, the interval days (rotation cycle) is increased one day (e.g. from 8 to 9 days), and the khettara water in a day are allocated to applicants as a lending day, to make up for O&M cost of khettara itself.

3.6 Agriculture

3.6.1 Agriculture Land Use

The agriculture land use in the Tafilalet region covered by the ORMVA/TF is indicated in the following table.

Agriculture Land Use in Tafilalet Region

Agriculture Land Use	Area (ha)
Irrigated area	60 000 (0.8 %)
Forests	115 000 (1.5 %)
Pastures	3 500 000 (45.3 %)
Waste land	4 050 000 (52.4 %)
Total	7 725 000 (100.0 %)

Source : ORMVA/TF

As shown in the table above, over 52% of the lands is not appropriate for the agriculture use and the irrigated lands represent mere 0.8%. According to the ORMVA/TF, the effective mobilization of the water resources would allow enlarging the irrigated lands to 75,000 ha.

The agriculture zones are divided into three categories: the mountain zone, the intermediary zone, and the lowland zone. The Ziz river basin, the Guir river basin and upstream of Gheris river basin are included in the mountain zone, producing cereals, pastures and fruit trees such as apple trees. The animal husbandry also plays an important role. The oasis zone of Tafilalet, downstream of the the Tougha, Guir and Gheris river basins are located in the lowland zone with the cultivation of dates (dates are one of the major products), the alfalfa, and vegetables. The majority of the cultivations irritated by khettaras is located in the lowland zone. The intermediary zone is located in the mountain foot of the Atlas chain and includes Beni-Tadjit and Errachidia. In this area the dates, olives, cereals, legumes, fodder crops and vegetables are cultivated.

3.6.2 Land Status

The Moroccan Government classifies the properties and agriculture lands into five categories : private property (Melk), collective property (Collectif), agriculture lands owned by administrative Ministry related to mosque (Habous), agriculture lands assigned to military (Guish), and the state domains. The private properties occupy only 75% of the agriculture lands as the country average, but they occupy 95% in the Errachidia province. The following table presents the definition of each status and the distribution in the Errachidia province.

Distribution of Properties in Errachidia Province

Property	Definition	Area (%)
Private property (Melk)	Agriculture lands belonging to individuals.	53 517 ha (95.2 %)
Collective property (Collectif)	Rain-fed agriculture lands cultivated collectively; the products are distributed among the farmers. Since they are irrigated, each farmer must cultivate by individual efforts the lands assigned to him.	637 ha (1.1 %)
Property of mosque (Habous)	Agriculture lands belonging to Ministry related to mosque.	1 653 ha (2.9 %)
Agriculture lands assigned to military (Guish)	Agriculture lands assigned to military which are for the service of the ancient King. This regime does not exist any more but land status persist.	0 ha (0.0 %)
State domain	The domain of the state which is managed by the regional government.	415 ha (0.7 %)
Total		56 222 ha (100.0 %)

Source : Agriculture Census of Errachidia, January 2000.

In Morocco, the average area of one agricultural holding is of about 5.78ha. However, in the Errachidia province, it is only 1.41ha. The distribution of agriculture lands by area in the Tafilalet region under the jurisdiction of the ORMVA/TF is indicated in the table below. It is noticeable that the region encounters many micro-properties.

Distribution of Agriculture Lands by Area in Tafilalet Region

Area of agriculture lands by farm	Distribution
Less than 5 ha	90.8
5 to 10 ha	7.1
10 to 15 ha	1.9
15 to 20 ha	0.1
Over 20 ha	0.1
Total	100.0

Source : ORMVA/TF

3.6.3 Agriculture Production

The principal agriculture products cultivated in the Tafilalet region are: fruits (dates, olives, apples, etc.), cereals (wheat, barley, maize), fodder (alfalfa), legumes, vegetables and others (henna and cumin). The cultivated areas, the production and yield by product in 2001/02 are indicated in the following table.

Cultivated Area, Agricultural Production in the Tafilalet Region

Product	Average of 1989～1994		Average of 2001/02	
	Cultivated area (ha) or number of trees	Production (Tons)	Cultivated area or number of trees	Production (Tons)
Fruits (fruit trees)				
Dates	1,250,000	26,200 tons	1,385,000	9,200 tons
Olives	975,000	13,000 tons	1,128,440	3,270 tons
Apples	400,000	6,000 tons	512,000	10,900 tons
Cereals				
Hard wheat	13,650 ha	38,000 tons	7,110 ha	14,500 tons
Other wheat	13,950 ha	35,000 tons	9,715 ha	19,650 tons
Barley	8,600 ha	19,200 tons	4,660 ha	5,790 tons
Maize	3,000 ha	5,500 tons	2,635 ha	2,880 tons
Legumes	1,560 ha	2,400 tons	876 ha	1,080 tons
Vegetables	1,900 ha	36,300 tons	1,610 ha	33,200 tons
Fodders				
Alfalfa	9,250 ha	585,000 tons	8,000 ha	320,000 tons
Others				
Henna	640 ha	1,700 tons	100 ha	117 tons
Cumin	n.d.	n.d.	40 ha	30 tons

Source: ORMVA/TF
Note: n.d. signifies not determined
The number of fruit trees includes the young trees which do not yet yield the fruits.

Dates

Dates are the main product of the Tafilalet region which is accounting for 25% of the total date trees in Morocco. However, the percentage of the high quality types, such as the Mejhoul, Boufeggous, or Bouslikhene is not very high, only 5%, 8%, and 14% respectively. The other types are ordinary. The cultivation of dates is threatened by the droughts (decrease of precipitation) and by the Bayoud disease, against which there is no effective remedy, the only way being to cut the contaminated date trees, or re-plant a resistance variety.

Olives

45% of olive trees are old (more than 50 years) and producing weak yield. The only type cultivated is the “Picholine Marocaine”. Other than oil manufacturers of Rich, Errachidia and Goulmina, the production of

oil of olives is mostly done by small business or applying traditional methods.

Wheat

The areas cultivated by wheat decreased from 27,500 ha (average of 1989 to 1994) to 13,800 ha, which brought about considerable decrease in the wheat production, from 73,000 tons (average of 1989 to 1994) to 34,150 tons. Otherwise, the average yield in the region was 2.6 ton/ha between 1989 to 1994, which was below the national average of 3 to 4 ton/ha. The yield of the region has further dropped to the level of 2.0 ton/ha. The harvested wheat is mostly for the household self-consumption.

Other agriculture products

The vegetables cultivated in the Tafilalet region are : onions, gombo, tomatoes, melons, turnips, etc. Some farmers engage in garden cultivations using pump-irrigated parcels, and sell the products in the neighboring markets or through the intermediaries. The alfalfa is cultivated for the livestock and for the farmers, or for sales in the neighboring markets as the fodder. The henna and cumin of the Alnif area are sold in the Tafilalet and the other regions as local specialty.

3.6.4 Animal Husbandry

Two types of animal husbandry are normally applied in the Tafilalet region. Those are the extensive rearing of mixed hoards of sheep, goats and camels in the nomad or semi-nomad system in the vast grazing lands, or intensive sedentary rearing on a small scale localized in the irrigated zones (including khettaras irrigated areas).

The total number of livestock in the Tafilalet region is presented in the following table.

Number of Livestock in Tafilalet Region

Livestock	Number	Comment
Cattle	36,000	9 % of pure race, 27% of mixed race and 64% of hybrid race
Sheep	400,000	Including 100,000 of D'man race
Goats	350,000	
Camels	7,500	

Source: ORMVA/TF

In the Tafilalet region, the annual milk production is about 11 million liters, of which 42% (4.6 million liters) are provided by two livestock cooperatives. The annual meat production is 7,100 tons. Otherwise, the rearing of sheep of D'man race, bee-keeping, and poultry-keeping are practiced on a small scale by the livestock associations. Those activities represent the new source of revenue for the region.

3.7 Rural Infrastructure

3.7.1 Water Supply

Water supply facilities in the Study area have been provided by the ONEP (Office National de l'Eau Potable). Availability of potable water supply exceeds 80% of total population in urban areas, including Errachidia, Erfoud, Aoufous, Rissani, Goulmima and Tinjdad. Even in the rural areas, the figure has been reached around 50%. Besides the ONEP, local governments such as Rural Commune and Municipality have also constructed water supply facilities although the number is quite limited.

Potable water supply has been identified as one of the most important development fields in the Errachidia Province. From 1985 to 2001, totally DH 430 million of investment has been poured into this sector aiming at achieving provision of potable water for all people in the province.

Individual house connections in urban areas and public faucets in rural areas are found as typical potable water supply facilities in the Study area. Following table presents availability of potable water facilities. Substantial improvement has been made during the years between 1994 and 2002. Figure 3.7.1 indicates pump stations and service network operated by the ONEP.

Availability of potable water facility in Errachidia Province

Area	1994	2002
Urban Areas	75%	100%
Rural Areas	31%	53%

Source: "Recensement General de la Population 1994", Direction de la Statistique and Information from ONEP Errachidia Office (2003)

3.7.2 Electricity

Electricity is basically provided by the ONE (Office National de l'Electricite) both in urban and rural areas. However, some of the facilities in rural areas have also been installed and managed by local governments. ONE usually supplies electricity to individual houses through substations and transmission lines. Individual system using diesel generator is commonly used for electric supply managed by local government.

Following table presents availability of electricity in the Errachidia Province. The ONE has been propelling expansion of electricity supply area together with facility installation for potable water by the ONEP. Therefore, availability of electricity in rural areas is also presumed to be improved in recent years.

Availability of Electricity in the Errachidia Province

Urban Area	86%
Rural Area	50%

Source: "Recensement General de la Population 1994" (Direction de la Statistique)

3.7.3 Roads

Roads in the Errachidia Province are composed of national, regional and rural roads. Length and condition of each road are presented on the following table.

Length and Condition of Roads in the Errachidia Province

Type of Road	Total length (km)	Paved (km) (%)	Unpaved (km) (%)
National Road	593.9 km	534.9 km (90%)	59.0 km (10%)
Regional Road	491.3 km	306.8 km (62%)	184.5 km (38%)
Rural Road	802.0 km	78.2 km (10%)	723.8 km (90%)

Source: Delegation de l'equipement, Errachidia

Most of the main roads, such as national and regional roads connecting Errachidia city and other municipalities, are paved. However, rural roads aside from these main roads are mostly not paved. Road map of Errachidia Province is presented on Figure 3.7.2.

3.7.4 Health and Medical Care Facility

Health and medical facilities in the Errachidia Province are presented on the following table. General hospital as well as regional hospitals is only located in urban areas such as Municipalities and not in Rural Communes. Even though health post is generally located in each Rural Commune, that location is still far from khettara communities. Hence, people in khettara communities have very limited access to these health and medical care facilities. Lack of maternity facility and qualified birth attendant are serious concerns in khettara communities.

Health and Medical Facility in the Errachidia Province

Type	No. of location	Type	No. of location
General Hospital	1	Municipality Health Post (Without maternity facility)	8
Regional Hospital	5	Municipality Health Post (With maternity facility)	2
Polyclinic	3	Rural Commune Health Post (Without maternity facility)	52
		Rural Commune Health Post (With maternity facility)	12

Source: Information de la Sante, Errachidia

3.7.5 Education

For public education, 566 primary schools (98,158 students), 49 secondary schools (32,407 students) and 19 colleges (13,556 students) are located in the Errachidia Province. Almost all Ksar/douar has at least one primary school even in rural areas. On the other hand, number of secondary school is less than 1/10

of that of primary school. Only one or two secondary school(s) is located in one Rural Commune in average.

Long distance to secondary schools is one of the biggest obstacles for higher education. Based on the situation mentioned above, many students in rural Ksar/douar have to commute more than 10km to secondary schools located in centre of Rural Commune. This becomes more serious for girl students, since many parents in rural area hesitate to send their daughter(s) to the school outside of their home Ksar/douar from cultural and religious reasons.

3.8 Rural Society in Khettara Communities

3.8.1 Lifestyle

Socio-economic survey carried out in this study revealed people's life in khettara communities as follows:

(1) Family structure and literacy

One family in the khettara community, typically has about 7 members. Among them, 1 or 2 members, usually young male(s), live and work outside of their home village for supporting family expense.

Illiteracy rate for male and female are 29% and 59% respectively in the Study area as a whole. Looking at difference in age and gender, it is found that illiteracy rate for male in the age bracket from 30 to 50 years old, who is usually a head of the household, is more than 50%. Illiteracy rate for female in the same age bracket is also found over 80%.

However, more students, both boys and girls, have become able to go to primary school in their own communities since number of primary school has been increased in recent years. As a result, almost all of children in school age are currently receiving education on Arabic reading and writing even in khettara communities. Therefore, illiteracy rate in khettara communities is expected to be lowered gradually.

(2) Potable water

Many people in the khettara community have gained access to potable water owing to the extended service provided by the ONEP. However, availability of potable water through house connection or public faucet is about 58% of total population. Still 23% of the people in khettara community use khettara water as a source for potable water.

People need to carry water from public faucet, well or khettaras in the area where house connection has not been made. Normally female or children are engaged in this activity. Average frequency of water fetching is 3 to 4 times per day, and one household consumes 140 to 200 liters per day. Distance to the water point varies from one house to another, depends on location of the house and water point. However, the average distance is calculated from 0.2 to 1 km, and it takes 20 minutes to 1 hour.

(3) Energy for house

Availability of electricity in the khettara communities varies on each location. Zones C, D and E have attained 100%, while Zone F attained 80%, Zones A and B 50%, Zone G only 20%. In Zone G, where availability of electricity is very low, 54% of the people use power generator for house lightening while 14% use oil lamps.

LP (Liquified petroleum) gas and fire woods are used for cooking depending on the cuisine. For instance, tagine, cous-cous and breads are cooked by fire woods, and tea is prepared by LP gas.

(4) Toilet facility

Dry pit latrine (50%) and non-flushing toilet[1] (30%) are commonly used in the khettara community. Also, houses without any toilet facility consists more than 10% .

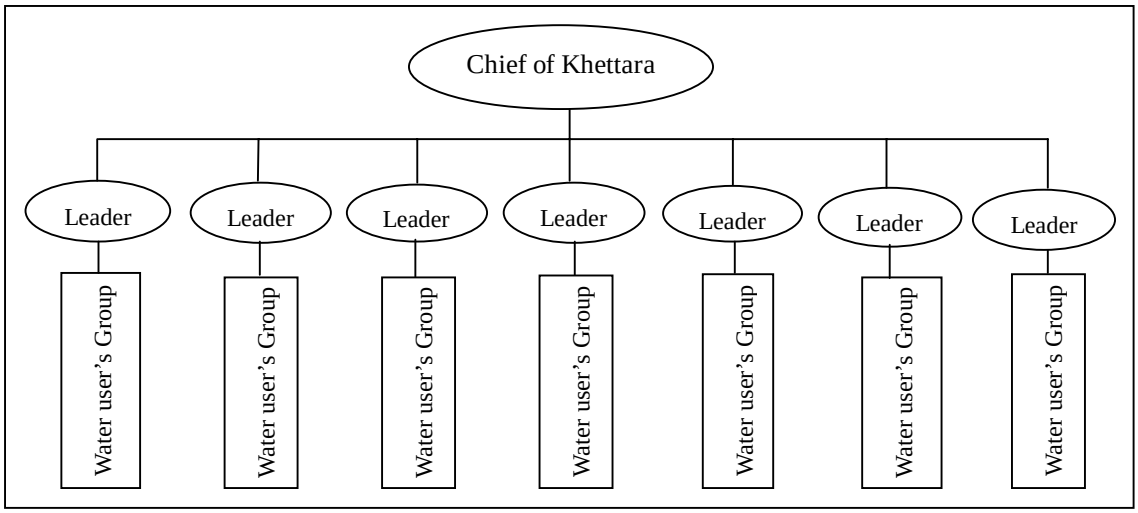
(5) Work away from home

In general, one or two family members are working away from home for supporting family expense. Men in the age of 30's are most commonly immigrated to cities to work. Among them, 43% work less than 1 year, 25% work more than 1 year, and 20% work permanently outside of their home village. Seasonal emigrants only consist of 11%. For destinations, 68% are in big cities inside Morocco, while 20% are outside of the country such as France, Spain, Italy, Saudi Arabia, Iraq, and so on. Small and medium cities in the Tafilalet region consist of only 10%.

3.8.2 Water Rights on Traditional Khettara Water User's Organization

Traditional khettara water user's organization is composed of small water user's organizations on each day of water cycle. Usually 10 to 20 people, consisting of same blood relatives in many cases, divide their one day water right to each individual. Water cycle varies from 8 to 15 days. Each water user's organization selects their leaders, and these group leaders elect a chief of the khettara. Hence, typical traditional khettara water user's organization has a chief representing a few hundreds water users. Organization structure of traditional khettara water user's organization is presented on the figure below:

[1] Non-flushing toilet means that toilet facility using bucket for flushing.



Traditional Khettara Water User's Organization

Within the traditional organization, work loads and financial burdens for maintenance and rehabilitation works of khettara are divided to each individual in accordance with their amount of water right. The traditional organization like this was formulated and has been managed by local people for long time, but does not have any legal status or registration.

3.8.3 Other Farmer's Organizations

(1) Association for rural development

There are many voluntary groups called "Association" in the rural area including khettara communities. Association is founded in accordance with the Association law enacted in 1958, and partially modified in 1973 and 2003. Local people establish an association with calling people sharing same interests and register it to the government with taking prescribed procedure. In Tafilalet region, many associations have been established and operated with their own objectives, i.e. rural development, social development, cultural exchange and so on, in order to improve people's life in the area.

Number of Association in the Field of Rural Development in the Tafilalet Region (as of 2003)

Cercle	Number
Goulmima, Tinejdad, Assoul, Amellago	50
Errachidia, Boudenib	41
Rich, Imilchil	25
Erfoud, Rissani, Taouz, Alnif	41
Beni-Tadjit, Bouanane, Ain Chouater	34
Total	191

Source: ORMVA/TF

(2) Khettara association

The ORMVA/TF has been supporting traditional khettara water use's organizations to transform to associations since 1999. This is because that traditional organization, which does not have legal status,

has difficulty to obtain governmental supports for their activity. The ORMVA/TF has been trying to facilitate more governmental supports to khettara rehabilitation works by transforming its traditional organization to contemporary association with legal registration. For the sake of convenience, the ORMVA/TF calls association established to support khettara rehabilitation works as a "khettara association", even though there is no difference on legal status between khettara association and other associations.

In the Study area, there are 9 khettara Associations in Zone D centered by Jorf. These khettara associations have been established and managed by one or more traditional organizations as members. There is also a Union unifying these 9 khettara associations. However, most of these associations have been established after 2002 and do not have actual activity except sending requests to outside organizations for support on khettara rehabilitation work.

There is also one khettara Association in Commune Rural Ferkla Soufla, where the ORMVA/TF CMV Tinejdad is mandated. This association is composed of representatives from 26 khettaras in the area and registered as AUEA (User's association of agriculture water), in addition to normal association. However, it was established in 2002 and not much activity has been done except having meetings among members.

Organization structure of khettara Associations in Jorf and Tinejdad areas are shown on Figure 3.8.1.

3.8.4 Gender

RRA (Rapid Rural Appraisal) was carried out in Ksar Tizougaghine in Tinejdad area. It founds the following gender differences in that area:

- Men are mainly engaged in agriculture and livestock breeding activities. Women, on the other hand, have large variety of activities including meal preparation, house cleaning, laundry, water fetching, firewood collection, adult education and so on. Consequently, workload of women on agriculture activity appeared less compared to that of men.
- Women prepared "Seasonal Calendar" showing agriculture activities together with other events and festivals including wedding ceremony. On the other hand, men prepared the calendar with identifying seasonal work away from home, khettara maintenance works and school events as important events in a year, in addition to agriculture activities.
- Although opportunity for girls to go school was limited in the past, the situation has been improved even in a khettara communities like Tizougaghine. Illiteracy rate of women has been dramatically decreased recently.
- Men drew "Mobility Map" including a secondary school located in Tinejdad town, which is about 16 km away from the village, while women did not include this on the map. This shows that women in this village normally do not go to secondary school. Distance to the school appeared an obstacle for girls to take higher education. The biggest difference on "Mobility Map" between men and women is the work away from home.

- Even though both men and women appeared to go to *souk* (market), post office, hospital and other public places in the nearest town, women still needs to take permissions from their husband to visit these places. Moreover, men control house economy or money.
- There are many associations in the khettara communities supporting women's activity including adult education on literacy, handicraft and other cultural activities.

3.8.5 Poverty

The World Bank carried out poverty survey in Morocco in 1991 and 1998. The following table shows the summary.

Summary of Poverty Surveys in Morocco

Items	unit	1990/91			1998/99		
		Urban	Rural	National	Urban	Rural	National
Poverty line	DH/person/ year	2,674	2,384	2,495	3,922	3,037	3,337
Population	Thousand people	12,005	13,603	25,608	15,051	12,920	27,971
Population under poverty line	Thousand people	912 (7.6%)	2,448 (18.0%)	3,360 (13.1%)	1,811 (12.0%)	3,496 (27.1%)	5,307 (19.0%)

Source: The World Bank, Poverty Updated, March 2001

According to the survey, percentage of people under poverty line on national level was increased from 13.1% (3.4 million) in 1991 to 19.0% (5.3 million) in 1998. The survey pointed out following reasons, i) economy was stagnated in 1990s compared to 80s, ii) especially the growth in agriculture sector became minus1.8%, iii) distribution of wealth was one-sided and rural area was left out from the growth. As the result, rate of poverty in rural area was increased dramatically from 18.0% in 1991 to 27.1% in 1998. The figure for the Tafilalet region, in particular, appeared 29%, which was the worst in the country.

Based on the World Bank survey and more detailed socio-economic survey carried out in this study, poverty situation in the Study area can be described as follows:

- Average farm land in the Errachidia Province is 1.41 ha, while that of the national average is 5.78 ha. This shows that farm land in Errachidia is quite small compared to the national average. Furthermore, farms with smaller land tend to be poorer even in the same village.
- Agriculture production has been decreased dramatically owing to the recent decrease in rainfall. This situation forces farmers to sustain agriculture activity only for their own self-consumption, but not for marketing, and resulted in lowering their income.
- Potential on economic development is quite low in that area because of severe natural condition and limited water resources.
- Villages away from main national or regional roads tend to be economically poorer owing to lower accessibility to markets.

The following table shows a typical household income of a farmer in khettara communities, calculated from the result of socio-economic survey carried out in this study.

Average Household Income in Khettara Communities

Source of income	Household income (DH/year)	%
Agriculture production	7,200	17
Wage earned from agriculture activity	5,050	12
Livestock	4,600	11
Income from agriculture activities	***16,850***	***40***
Wage earned from non-agriculture activities	9,700	23
Handicraft	1,500	4
Casual work	8,000	19
Money sent from family member(s)	6,400	15
Income from non-agriculture activities	***25,600***	***60***
TOTAL	**42,450**	**100**

Source: Socio-economic survey in khettara communities, JICA Study, June 2003

Considering that the average number of family member is around 7 in the Study area, average annual income per capita is calculated as DH 6,064 (= DH 42,450 / 7), which exceeds the poverty line of DH 3,037 determined by the World Bank. However, it is also found that the income from agriculture activities only consists of 40% of total income. In case that only income from agriculture activities being taken account, the income appeared DH 2,400/year, which is below the World Bank poverty line.

Thus, it is found that the life of farmers in khettara communities is sustained by income from non-agriculture activities and money sent from family members outside of the communities.

3.9 Support Service for Agriculture and Rural Communities

3.9.1 System of Support Service for Agriculture and Rural Communities

The support service for agriculture and rural communities in the Study area is ensured by the ORMVA/TF (see Figure 3.9.1). The ORMVA/TF is in charge of the improvement of the irrigation facilities and extension services for the agriculture and animal husbandry techniques in the irrigated areas of the Study area. The ORMVA/TF is also responsible for the coordination with the organizations in charge of the agriculture development and water resources exploitation. Otherwise, this administration provides with the technical and financial support for the rehabilitation of khettaras constructed by the local population, as well as the support within the framework of extension and promotion of the techniques for the management and distribution of irrigation water. The ORMVA/TF consists of numerous services with the tasks described in the following table.

Services of ORMVA/TF and Their Main Activities

Service	Main Activities	Remarks
Planning and Programming Service	Planning and programming, monitoring, evaluation and management of markets, etc.	
Equipment Service	Plan, concept and management of works on irrigation facilities, etc.	Also in charge of khettara rehabilitation works
Management of Irrigation and Drainage Network Service	Maintenance and rehabilitation of irrigation net work systems, etc.	
Agriculture Production Service	Agriculture activities and agro-economic studies, etc.	
Extension and Professional Organizations Service	Extension, education and professional organizations, etc.	
Animal Husbandry Service	Animal production and animal health, etc.	
Administrative and Financial Service	Personal and financial management, continuous education, etc.	
Material Service	Procurement and inventory of equipment, maintenance of buildings, etc.	

Source : ORMVA/TF

The ORMVA/TF has 5 Sub-Division offices (Errachidia, Rich, Erfoud, Goulmima and Beni-Tadjit). In each Sub-Division office, there is one agent in charge of coordination of the equipment works, maintenance of the network, agriculture, animal husbandry and material. Under the guardianship of the Sub-Division office, there are 22 centers: the development centers (CMVs) in charge of the extension and support services, and the animal husbandry centers (CEs) in charge of the animal health (vaccination, etc.) as explained in Figure 3.9.2.

The services of the agriculture support of the ORMVA/TF are ensured in the sense of “Extension service and Animal husbandry service → Sub-Division offices → CMVs and CEs → farmers ”.

3.9.2 Agriculture Extension

The activities of the agriculture extension of the ORMVA/TF are based on three pillars, namely “extension and agriculture techniques for target groups”, “extension for bigger number of beneficiaries”, and “personalized extension”. The first pillar consists of 1) meeting and discussion with farmers, 2) presentations by the extension workers, 3) group visits of farmers to other sectors, and 4) monitoring and evaluation of the group of farmers. The second pillar consists of 1) generalization of the agriculture techniques, 2) sensitization of farmers by agriculture exploitation, 3) collaboration with the NGOs for the sensitization and providing information for farmers. Finally, the third pillar consists of 1) visiting individual farmers, 2) putting advanced techniques into practice, 3) encouraging farmers incentives, 4) spreading positive effects by farmers visiting other farmers, etc.

Those activities are reviewed in the monthly meetings in the level of CMVs, the quarterly meetings in Errachidia and annual meeting held in July in Errachidia. For the annual meetings, they summarize and evaluate the annual results. In the course of annual meetings, the program of extension for the next year is elaborated.

3.9.3 Agriculture Research and Experimental Study

In Errachidia, there is one experimental and agriculture development station (SEMVA), placed under the direction of the Agriculture Production Service of the ORMVA/TF. The staff includes five researchers or technicians, supported by some part time staffs in case it is needed. The subjects of the research dwell on the 1) drip irrigation for dates, 2) improvement of the farming techniques of dates seeding and of distribution of improved seeds to farmers, 3) meteorological observations, 4) testing on the prevention against diseases and insects dangerous for dates, 5) improvement of dates' harvesting techniques, including demonstration. The land in the experimental station also includes the demonstration cultivations of olive trees, vegetables and alfalfa.

3.9.4 Support for Rural Women

Other than the extension services above, the ORMVA/TF is putting stress on the activities of the support for the rural women. Those activities include 1) promotion of women income generating activities, 2) education and assistance for the rural women, 3) organization and strengthening of women cooperatives of sheep (D'man) rearing, 4) organization of women community centers (CAF), and 5) working on literacy. The promotion of women income generating activities includes 1) creation of women cooperatives, 2) installing herb gardens, 3) poultry distribution. The education and assistance for rural women consists of 1) organization of study tours for the benefit of rural women having few opportunities to spend time outside of the household, 2) other education courses. The organization of women community centers is mostly for the support of the basic traditional activities such as seaming or cooking, with the collaboration of NGOs.

3.9.5 Agriculture Cooperatives

In the Tafilalet region, there exist 207 cooperatives for the total of 13 542 members. They can be grouped in 17 sectors.

Cooperatives by Sector and Number of Members

Activities	Number of Cooperatives	Number of Members
1. Pumping cooperatives	79	4,870
2. Sheep (D'man) rearing cooperatives (men)	15	529
3. Sheep (D'man) rearing women cooperatives	31	1,117
4. Union of cooperatives of sheep (D'man) rearing	1	-
5. Pasturing management cooperatives	17	4,509
6. Milk products cooperatives	3	615
7. Oil of olives manufacturers cooperatives	6	503
8. Agriculture materials supply cooperatives (UCMA/ Common Utilization of Agriculture Materials)	7	51
9. Dates producers cooperatives	11	155
10. Apples producers cooperatives	1	29
11. Collective property management cooperatives	9	87
12. Beef cattle producers cooperatives	3	66
13. Bee-keepers cooperatives	8	223
14. Poultry-keepers cooperatives	2	-
15. Cow breeding cooperative	7	735
16. Fruit tree planting cooperative	1	30
17. Rabbit breeding cooperative	1	8
Total	207	13,542

Source: ORMVA/TF

Many agriculture cooperatives were established under the direction of the government for, among the others, provision of the material for the livestock. There is a large number of pumping cooperatives, but in fact 15 of those (26% of the pumping cooperatives) are not functioning. Otherwise, the balance of income and expenditure is negative in 12 cooperatives (21%). The field survey reveals that the milk production cooperatives are very active and utilize well the advantages of shared shipment given by the cooperative system; the revenues obtained from the sales of milk are increasing. On the contrary, the agriculture cooperatives (sheep, dates, bee-keeping, etc.) are almost not functioning and do not profit from the cooperative activities, with each farmer working individually.

3.9.6 System of Agriculture Credit

The National Agricultural Credit Bank (CNCA) opened the regional office (CRCA) in Errachidia and 4 branches (CLCA) in Errachidia, Rich, Erfoud and in Beni-Tadjit. There are two forms of credit, namely short-term credit and long-term credit. Those who fulfilled the process of the short-term credit can apply for the long-term credit. The interest rate of the short-term credit is of 8 to 10% annually for the maximum

period of one year. The interest rate of the long-term credit is of 10 to 12.5% annually with the duration of one year to 15 years. The total amount of the short-term loans is of DH1,621 million, equivalent of 3% of the total loans amount of DH48 million. The following table shows the results of loans in 2000 - 2004.

Loan Record of Agricultural Bank (2000 - 2004)

	ERRACHIDIA				RICH		ERFOUD		BENI TADJIT		Total	
	CRCA		CLCA		CLCA		CLCA		CLCA			
	No.	Amount (DH)	No.	Amount (DH)	No.	Amount (DH)	No.	Amount (DH)	No.	Amount (DH)	No.	Amount (DH)
Short-term	65	861,318	80	294,280	178	128,375	83	306,768	24	28,780	430	1,619,521
Long-term	15	4,235,908	43	62,133	6	49,893	110	290,188	-	-	174	46,381,122
Total	80	5,097,226	123	356,413	184	178,268	193	596,974	24	28,780	604	48,000,463

Source: ORMVA/TF (Moyenne de 5 dernières années des crédits octroyés aux agriculteurs de la zone)

In addition to the system of national credit mentioned above, there is a system of micro-credit recently established for the benefit of the poor population. In fact, the Foundation of Agriculture Credit for Micro-credit started its activities in Errachidia in January 2002, with the intention of creating the regional platform. 111 persons have already benefited from micro-credit (half of whom are women). They obtained the total amount of DH158 000 to finance the activities such as animal husbandry, purchase of fodders, or purchase of sewing machines.

3.10 Natural Environment

3.10.1 General Condition of Natural Environment

(1) Environmental problems in the Tafilalet region

Climate in the Tafilalet region area is very dry. As annual rainfall is about 100 to 250 mm in the north and 50 mm in the south, the climate is quite severe. Droughts have continued since 1980's, so desertification is escalating.

(2) Condition of desertification

(i) Causes of desertification

In general, causes of desertification are classified into a natural factor of climate aridification and an artificial factor brought by human activities over the natural capacity of the fragile ecological system in arid and semi-arid areas. It is assumed that the problem of desertification in the Tafilalet region is caused by both factors as shown on the table below:

Factors of Desertification

(a) Natural Factor	- Little rainfall (continuous occurrence of drought) - Soil erosion by flood and transport of sediment - Sand sedimentation by strong wind
(b) Artificial Factor	- Over-cutting of trees for fire wood - Overgrazing beyond reproductive capacity of glass land - Land reclamation seeking for better condition of land

(ii) Influence of desertification

Influences of desertification vary in a wide range from erosion and sedimentation by water and wind, to decrease of vegetation, etc. Those have deteriorated biological diversity and have damage livelihood of farmers and nomads.

Influence of Desertification

(a) Influence in oasis	- Land (especially farmland) erosion along a river by a flood - Damages to farmlands and infrastructures caused by sedimentation (threatening 60 % of farmland, 30 km of irrigation canal (incl. khettaras), 10 km of road) - Damage to palm yards by Bayoud disease - Salt accumulation in the soil
(b) Influence in range area	- Decrease of vegetation - Increase of exploiting pressure to range area with little vegetation - As a result, discontinuous vegetation, weakening resistivity to erosion are further accelerated.

(iii) General information of environmental projects including desertification countermeasure

Environmental programs in Tafilalet are shown in the table below (including programs of agencies other than the ORMVA/TF).

Anti-Environmental Programs under Implementation

Items	Descriptions
(a) Revitalization of forest ecology	- Instruction to residents in the mountain (providing area without animal feeding and tree cutting) and tree planting (about 1,000 ha) - Establishing wild animal sanctuary
(b) Restoration of water use facilities	- Construction of large-scale facilities (dam, weir) for water use - Surface flow diversion to other river system (from Gheris to Ziz rivers) by intake weirs (barrages de derivation) - Rehabilitation of medium to small scale water use structures (khettara, well, canal)

Items	Descriptions
(c) Instruction and extension services to farmers	- Revitalization of date palms (distribution of 130,000 seedlings of date palm) - Extension of water saving technologies through pilot farms, etc. - Recommendation of fruit tree planting to improve livelihood (in the mountain area) - Projects for rural woman to obtain income (animal breeding etc.) - Improvement of range area use: providing fallow area, fodder crop planting, rational (reasonable) management of natural resources by communal organization of animal owners
(d) Countermeasures to erosion and sedimentation	- Dam construction for sediment control - River dike protection with masonry (10 % of necessary length (20 km) completed) - Installation of cross shape sand protection fence (made of palm leaves and grass called alfalfa) in 400 ha (DH 65,000 / ha) Most of them are made of only palm leaves, because alfalfa is expensive. Concrete fences were used before, but they are not made any more because they are expensive and they include asbestos. - Tree planting of 130 ha in the desert : Tamarix aphylla
(e) Measures for salt injury	- Improvement of physical and chemical features of damaged soil - Study on resistive species against salt injury

3.10.2 On-going Programs for Desertification Prevention

An on-going program for desertification prevention is “National Action Program for Desertification Prevention” (Programme d’action National de Lutte Contre la Desertification) formulated in June 2001.

3.10.3 Environmental Assessment

Implementation system for Environmental Assessment has been established in May 2003 in Morocco. General information on Environmental Assessment system is shown on Table 3.10.1 “General Information of Environmental Assessment System”.

Chapter 4 Constraints and Potentials for Development

4.1 Direction of the Rural Community Development in the Semi-Arid East Atlas

In the Tafilalet region, annual rainfall is limited to 50 to 200 mm and fluctuates widely from year to year, and drought is persistent for several years. It is indispensable to secure a stability of the agricultural productivity so as to maintain the rural community. However this severe climatic condition make it difficult to diversify its water source from groundwater use to surface water use even supplemental supply by the dams and flood intake construction because of extremely small and large fluctuation of annual rainfall amount. In addition, irrigable area benefited from a dam and diversion weir is restricted within narrow limits because suitable site for these facilities scarcely exists, therefore it is impracticable to establish comprehensive water source development plan including khettaras which are scattered in the wider area in the Tafilalet region.

Meanwhile, water use system of the khettaras has been firmly maintained by the substantial rural communities based on the traditional water right. It is no exaggeration to say that sustainable farming system has been preserved through solely a perennial flow of the khettaras. Poor market system, i.e. large consumable city is not in surrounding area and cheap agricultural products are transported from Agadir and Marrakech, may obstruct agri-business development in the region. On the other hand, dates cultivation and self-consumptive farming style consisting of vegetable cultivation suitable to a arid region have prevented prompt shift to groundwater use by pump, and furthermore have sustained small but stable farm income and also have conserved groundwater source continuously, consequently has formed Environmentally-Friendly Farming.

Concerning an extension of market system, a great deal of import of wheat, vegetables, poultry and mutton from other regions proves high market potential of the Tafilalet region. Focusing on the agri-business development, improvement of agricultural productivity by the effective use of khettara water and exporting products to outside regions are the targets of the Tafilalet region.

Besides the said development potential, the Tafilalet region carries unfavorable conditions in the rural communities such as deterioration of agricultural productivity accompanied with decrease of khettara water caused by decline of the groundwater level and settlement of village people to the urban areas to earn livelihood. There is no doubt that theses problems have been arisen from the decrease of the khettara water due to continuous drought, accordingly maintenance of khettara water is the most important and urgent subject in the region. Preserving firm rural community system is fundamental issue in the Tafilalet region with improvement of the efficiency of the khettara water use by means of reduction of water loss through the rehabilitation of the khettaras and irrigation canals, and introduction and diffusion of the water saving irrigation system.

The following table indicates availability of the water source in the Tafilalet region. The amount of the surface water use in 2003/2004 is almost same as the average of past 34 years records, and its amount occupies about two third of the total amount of water source. However surface water amount has

fluctuated year by year, and the years that surface water amount were less than 50 % of average water requirement counted to 16 years during past 34 years, judging from the dam storage records. Furthermore such drought condition tends to continue for 5 to 10 years. As described above, it is fundamental requirement to secure a stability of the agricultural productivity so as to realize sustainable agricultural development. A stability of the agricultural productivity is realized in fertile farmland with continuous cultivation and fertilization. Irrigation system composed of dams and flood diversion facilities may have a limitation to secure stable agricultural productivity.

Water Use in the Tafilalet Region

Water source	Facilities	Water volume	Remarks
Surface water use (2003/2004)	Dam and diversion weir	108 Mm^3 (63%)	Potential of surface water Ziz river basin : 243 Mm^3 Gheris river basin : 106 Mm^3 Guir river basin : 188 Mm^3 Total : 537 Mm^3
Subsurface water use	Pump station (irrigation) Khettara Pump station for potable water supply*[1]	22 Mm^3 31 Mm^3 11 Mm^3	
	Total	64 Mm^3 (37%)	
Total		172 Mm^3 (100%)	

Note*[1]: Designed pumping volume in 2000.

As to the groundwater use, the total flow from khettaras occupies about 50 % of total groundwater use, and pumpage volume for irrigation use secondly occupies about 30 %. Irrigation areas by the pump irrigation system have unevenly distributed and scattered in the Study area. Some pump irrigation systems, which were shifted from khettara to pump irrigation system have caused drying up of the several khettaras around the pump stations. For example in the Tinejdad area, pump stations were installed in short distance of 100 to 300 m, and finally, 400 pump stations were constructed for the last 10 years. But the number have decreased to 90 stations at present, due to interference of the groundwater adjoining each other, and furthermore, groundwater level has declined about 50 m in some areas. In general, pump irrigation system is recommended instead of khettara irrigation because of its less water transmission loss and convenience to adjust an irrigation schedule, etc. Therefore, it seems difficult to return the pump irrigation system to the previous khettara system, although the khettara system is more sustainable to cope with decline of groundwater level caused by excessive pumpage from the hydro- geological point of view. In this regard, it is proposed that the pump irrigation system shall be introduced as a supplementary system of the khettara system from a groundwater conservation standpoint.

The number of khettaras, that flow was reduced extremely or dried up, has run to a considerable number of about 220 sites, which is more than half of the total 410 khettaras, since the continuous drought has arisen in 1997. To cope with the present condition, construction of recharge facilities and diversion weir is also necessary to secure even minimal irrigation water to obtain farm income, and consequently to maintain

khettara communities. This direction with regard to the water resources development in the Tafilalet region agrees with governmental water policy of the ORMVA/TF as shown below.

Further Projects of Hydraulic Structures of ORMVA/TF (2006-2008)

	Category	Facilities
1.	Small-medium hydraulic project (PMH)	Diversion weir, canal, rehabilitation of khettara, pump installation
2.	Rehabilitation of flood protection facilities	Infrastructure, river protection works
3.	Rehabilitation of diversion facilities	Diversion weir, canal

Source: Rapport de Gestion 2006-2008, ORMVA/TF (draft)
Note: PMH: Petite et Moyenne Hydraulique

4.2 Constraints for Development

4.2.1 Analysis Methods

The followings are reference to analyze constraints to the rural community development:

1) Review of existing data and literatures
2) Field investigation for khettaras and khettara communities
3) Hearing survey from the ORMVA/TF and inhabitants
4) Information from the ORMVA/TF and various associations through workshops
5) Inventory survey of khettaras
6) Analysis of questionnaire during Rapid Rural Appraisal (RRA)
7) Information on rural infrastructural service from related governmental agencies

Field investigations were carried out by both the Study team and the ORMVA/TF. The Study team was responsible for collecting and sorting of data, which are necessary to analyze constraints for the rural community development, such as present condition of the khettaras, agriculture, irrigation activities as well as activities of the farmers' organizations. Since the khettaras were widely distributed in the Tafilalet region, the constraints analysis for rural community development scheme was conducted taking account of characteristics of each zone, in terms of water source potential, khettara discharge, and actual activities of the existing farmers' organizations, as well.

4.2.2 Principal Constraints for Development

(1) Water resources

(a) Decrease of rainfall amount

The annual rainfall amount has continuously decreased since 1980s in the Tafilalet region, and no

remarkable tendency of increasing is found. Recently surface water and recharge have rapidly decreased due to a continuous drought since 1997. Less frequency of floods occurrence in recent years has caused reduction of the agricultural productivity though several irrigation systems were completed to supply floods to the downstream farmlands.

(b) Shifting to pump irrigation system

Pump irrigation systems have introduced to the areas along the rivers of Todrha and Gheris because of their convenience. However some farmers have abandoned pump systems due to degradation of groundwater level since 1980's and escalation of operation cost. The khettara flow used to be maintained through daily maintenance works. However when pump irrigation system has been introduced even partially, the khettara maintenance system has rapidly broken. Several khettara communities have controlled introduction of a pump irrigation by themselves, meanwhile it is necessary to consider that changes of social structure may cause destruction of entire khettara system.

(2) Khettaras

(a) Decrease of khettara flow by drought

It is anticipated that the reduction of the recharge amount associated with drought causes decrease of the khettara flow. This fact is remarkably noticed in the areas of Sifa (Zone E), Rissani and Taouz (Zone F) and Alnif (Zone G) because watershed areas of the khettaras are as small as 10 km^2 in these areas, thus susceptible to drought. The khettara discharge has decreased to about 70 % at present since 2001. On contrary to this, the khettaras located at inundated area of the rivers Guir and Gheris have relatively stable flow because watershed area is wider, consequently not susceptible to drought.

(b) Decrease of khettara flow by leakage loss and poor maintenance works

In most cases, yield section is located at most upstream of the khettara gallery where groundwater level is higher than the gallery base. Leakage loss is observed in the conveyance section of the gallery downstream of the yield section. Its leakage loss mainly causes decrease of the khettara flow, especially when the section is composed of permeable materials, e.g., sand gravel layers. Otherwise sand accumulation in the gallery causes decrease of khettara flow. Collapse of the gallery wall and inflow of sand material through vertical shafts cause sand accumulation in the gallery.

The traditional water user groups of khettaras are responsible for the maintenance of the khettara. But it is observed that a longer khettara or gallery passing sand and gravel layers requires a heavy burden on expenses and labor works for maintenance. Especially, when the khettara is constructed along the river (wadi), flood water flowing into the gallery through vertical shafts heavily damages or erodes the khettara, and the damage brings huge expenses and labor works for removal of sand deposits in the gallery.

(c) Uncertain factors on hydro-geological information

Extension of the gallery is proposed to increase khettara discharge. Extension work needs considerably higher cost of about DH20,000 for 30 meter extension. Extension work is made by contract basis and a contract includes minimum 30 m extension service. When discharge is smaller than expected, the work constrains farmers to bear only expenses without return. Geo-hydrological survey is effective to solve the constraints when the farmers' groups can stand expense for the survey.

(d) Traditional water right system

When several khettaras are located adjoining each other, agreements between water users of those khettaras are required for extension of a gallery, re-profiling of a gallery base, which aim at increase of a khettara flow. Financial ability is different from each khettara community, however majority of khettara communities are not able to provide money for the rehabilitation works.

(e) Decline of groundwater level by excessive pumpage

Several khettaras have dried up together with decline of the groundwater level by excessive pumpage in and around the Tinejdad area. Khettara maintenance work induces heavy labor force, consequently it is impracticable to return the pump irrigation system to the previous khettara system.

(f) Limit of re-profiling of the gallery

Khettara investigation indicates followings:

- Gallery base slope is almost horizontal, e.g. 1/3,000 to 5,000 in several khettaras because the farmers' groups have re-profiled gallery base as lower as possible so as to maximize khettara flow. Re-profiling of the gallery base is no longer possible in case outcrop of rock foundation appears along the present gallery base.
- Section of khettara is kept in small area to prevent galley wall collapse at the most downstream section because of thin earth coverage from the ground surface. Smaller khettara gallery section of around 1.0 m high hinders periodical maintenance works.
- Gallery alignment is not linear but largely winding in whole line. This alignment was decided when excavators looked for soft section during the khettara construction.

Rehabilitation and maintenance of khettaras are difficult because of the present conditions as mentioned above. Such severe conditions increase cost of rehabilitation works and consequently hinder discharge improvement.

(g) Discharge fluctuation

Khettara discharge increases from November to March, and gradually decreases after these months corresponding to the annual rainfall distribution in the Tafilalet region. Decrease of the

khettara flow in the early spring makes cultivation only once a year during the winter in several areas.

(3) Water use

(a) Decrease in the value of potable water due to water quality deterioration

Deterioration of water quality caused by the underground infiltration of livestock excrement and domestic waste water was observed in some khettaras. In this study, water quality analysis was made with the samples taken from 28 khettaras, however no water samples satisfy the potable water criteria in Morocco. From this result, it is difficult to justify potability of khettara water.

With rapid extension of service area of the ONEP, it is preferable to shift potable water source from khettara to service by the ONEP.

(b) Decrease in the amount of available water due to the infiltration loss from earthen canals

Most of the irrigation canals are earthen canals. Much water amount filtrates into the ground from the earthen canals, and infiltration loss leads to decrease of available irrigation water amount.

Water users divert water flow by blocking off the inlet points with soil. This traditional operation method also causes the infiltration loss from the diversion points. It is regarded as one of the causes of decreasing the amount of available irrigation water because number of the inlet points is numerous.

(c) Decrease in the amount of available water due to the basin irrigation method

Basin irrigation method is applied to all khettara irrigation areas without any exception. This prevailing irrigation method obstructs the effective water use due to the following disadvantages:

- Large evaporation from soil surface spreading the whole farm plots.
- Large infiltration loss due to uneven water depth and longer impound hours in the farm plot.

(d) Lack of irrigation flexibility due to rigid water use interval and time schedule regulated by traditional water right

Water management on khettara water is defined as the rotation system based on traditional water right. This water right regulates water use interval and time allocated to each user.

As long as farmers keep on basin irrigation method on the premise of this traditional water right, it would be hard to maintain optimum soil moisture corresponding to the crop growth stage. In this sense, basin irrigation method is one of the constraint against the effective water use.

(4) Agriculture and agriculture extension

(a) Drastic reduction of the agriculture production and corresponding revenues caused by the weak rainfall

In the course of the last 10 years, the production of the principal agriculture products in the Study area decreased by half. Other than the wheat, only the products resistant to drought are cultivated (dates, olives, alfalfa), and the profitable cultivations, such as the vegetables, are limited to the areas where pump irrigation is possible.

(b) Lack of financing for the research and development of the cultivations adapted in the region

The agriculture production service of the ORMVA/TF has a experimental land of 10ha in Errachidia and employs 5 people. The subjects of the research are concentrated on the dates cultivation, and most recently also on the experiments for the water saving irrigation. No practical research is undertaken for the use of water and the cultivation systems which would match the specific characteristics of khettaras and which might be adaptable in the region.

(c) Activities favorable to the practical extension of the water saving irrigation are less frequent than other activities

In the region, the extension services are essentially concentrated on the cultivation methods of important products, such as dates, olives, and cereals. The extension services of the techniques of the vegetables or fodders cultivation, and the water saving irrigation in particular, is still limited.

(d) The fleet of automobiles of the CMV offices is not sufficient

The area under the responsibility of the ORMVA/TF is divided into 5 Sub-Divisions (Errachidia, Rich, Erfoud, Goulmima and Beni-Tadjit). Each Sub-Division is granted the resources from the development centers (CMVs), which are in charge of the extension services and education. There are 22 CMVs in total. Each CMV can use no more than 2 vehicles, which is making it difficult to ensure functioning of the extension services in the deeper sense.

(5) Rural society / organization and institution

(a) Insufficient institutional arrangement

Khettara is an irrigation system voluntary constructed and managed by local people. Because of this, institutional arrangement for governmental support on its operation, maintenance and rehabilitation works has been delayed and not sufficient compared to irrigation systems constructed by the government.

(b) Insufficient publicity of institutional support

There are several institutional supports for the khettara rehabilitation work besides technical and financial support by the ORMVA/TF. ADS (Agency for Social Development) provides materials for the rehabilitation work. Also international development agency such as IFAD (International

Fund for Agricultural Development)and foreign donors including Japanese government have their own supporting schemes. However, information on these institutional supports has not been widely publicized to the local people. As a result, people do not know how they can request support for the khettara rehabilitation works from these outside organizations. Different supporting scheme as well as different application procedures by each organization brings more difficulty to the local people on their application procedure.

(c) No legal status on traditional khettara organization

Traditional khettara water user's organization has been formed and managed by local people in accordance with their customary laws for a long time. This kind of traditional management system was consistent with their historical and social background and worked well for carrying out khettara maintenance and rehabilitation works among water users by fairly distributing their work loads and financial burdens.

However, traditional organization has not obtained legal status or registration, and their operation is not following the procedure in contemporary laws. Because of this, outside organizations, including international development agencies and NGOs, are reluctant to extend their support to the traditional organizations.

4.3 Development Potential

With respect to the constraints described in Sub-Chapter 4.2, the following development potential is proposed in accordance with the survey results during the field investigation survey:

(1) Water resources development

The Study area is broadly composed of three (3) river basins of Guir, Ziz - Gheris and Maider. The development potential of these river basins are detailed in Sub-Chapter 3.3 (1). The DRH has a plan to construct dams in these river basins. The following are the water resource potential including subsurface water, without dam construction plan.

Guir river basin: About 153 Mm^3 or 80 % of total run-off is available for water use. Zone B and C are located in the basin. Potential on water source development for groundwater recharge and surface water use is high.

Ziz river basin: Most of river run-off is utilized, thus potential on water source development is low. Floods diverted from the Gheris river to the Ziz river is utilized in Zone F (Rissani, Taouz areas)

Gheris river basin: About 26 Mm^3 or 25 % of the river run-off is available for water use. Surface water use (floods) and groundwater recharge are accelerated to preserve groundwater source in the basin where Zones D and E are located.

It is effective to divert flood water to the watershed area or recharge area aiming at accelerating groundwater recharge, even though frequency of flood occurrence remarkably affects recharge phenomenon. Recharge pond, dam, extension and widening of riverbed surface, re-profiling of existing riverbed into gentle slope, and seepage from farmland surface are proposed as a recharge facility or methods. However, sedimentation is pointed out as a common fault of these facilities, because sedimentation gradually reduces seepage volume.

Tens of diversion weirs and canal networks were constructed by the ORMVA/TF in the Study area. These systems aim to not only irrigate farmlands but also accelerate groundwater recharge from the farmland surface with surplus water beyond a irrigation water requirement.

(2) Khettaras

Groundwater level determines a yield of the khettara because the khettaras are situated in the shallow aquifers. Groundwater recharge directly contributes to maintain and increase groundwater level, in other respects, removal of sediments in the gallery, protection of gallery wall, as well as canal lining increase khettara flow and furthermore lessen maintenance works.

Table below explains potential and hindrance for the water resources development on khettara rehabilitation in each zone.

Increase of Water Sources

Zone	Present situations	Development potential
A	The Gheris river is the source for groundwater recharge. Extension of the gallery is effective to increase khettara discharge. Pump irrigation in the upstream of the Tinejdad caused decline of the groundwater level. Some countermeasures are required for groundwater conservation, such as control of pumping up.	Acceleration of the groundwater recharge has high potential for increase of the khettara flow in the Gheris river basin. Excessive diversion of the run-off at upstream of the Todrha river and pumping up may provide small potential on the groundwater recharge scheme.
B	Potential on water source development is high in the Ait-Aissa river basin (largest tributary of the Guir river). As most khettaras are located along the river (wadi), extension of the gallery is effective to increase yield of the khettaras.	Extension of the gallery is effective to increase khettara discharge.
C	Potential on water source development is high in the Guir river. As most khettaras are located at inundate area of the river, extension of the gallery is effective to increase yield of the khettaras.	Potential on water source development is high. Extension of the gallery is effective to increase khettara discharge.

Zone	Present situations	Development potential
D	Groundwater recharge from the Gheris river directly increase the khettara flow in this zone. Excessively large pumpage along the Todrha river may reduce recharge amount at the downstream area of the Gheris river.	Run-off from the Todrha river is minimal because of excessive large diversion at the most upstream of the river. Run-off from the Oukhit river (wadi) is proposed for the groundwater recharge for the khettaras in Zone D.
E	The khettaras are definitely divided into two groups, khettaras with adequate discharge and those with minimal discharge. It is assumed that difference of their own maintenance work causes a various discharge, especially in the sand dune area.	Run-off from the Hanich and Gounat rivers (wadi) is effective for the recharge use.
F	Run-off from the Ziz river increase recharge amount in the Rissani area, however decrease of recharge amount during the drought years directly affects khettara flow. Water development potential in the Taouz area is scarcely expected because of few run-off from the Ziz river.	Saline groundwater from deeper aquifers is also unsuitable for irrigation in the Rissani area. Few run-off from the rivers of Ziz, Gheris and Todrha less contributes to groundwater recharge in the Taouz area.
G	Watershed area is small in most of the khettara sites. Some khettara irrigation area obtains necessary water by pumping up of the riverbed water. Water in the fissure in the rock foundation is available for the irrigation use in the case thickness of the river deposit is thin. Collecting conduit is available to effectively collect the riverbed water during the drought period.	Khettara discharge largely fluctuates by season because of smaller watershed. Extension of riverbed gallery and yield from the fissures may increase khettara discharge.

(3) Water Use

Farmers created and formulated the organization for cooperative water management and also developed water saving farming techniques to cope with severe conditions in khettara irrigation area mentioned below.

- This area is located in an arid region characterized by rainfall scarcity of 50 to 200 mm coupled with high evaporation of 2,000 to 3,000 mm.
- Available khettara water is limited, and water discharge is 5.7 lit/sec on average.

Following measures have been taken from the viewpoint of water saving, however, these are not accepted as drastic countermeasures to fully utilize the potential for khettara water.

- Rigid water distribution on 24 hours basis during day and night contributes to minimizing the amount of waste water.
- Planting of tree crops such as date and olive intercepts direct sunray. This contributes to minimizing evaporation from soil surface of farmlands.
- Concrete lining leads to reduction of water conveyance loss in irrigation canal.

- Dividing the farmlands into small plots is effective to keep water depth uniform, and that contributes to save irrigation water amount.
- Partial irrigation concentrating on root zone of tree crops leads to saving irrigation water amount.

Effective utilization of the water collected by khettara is an essential approach for developing the potential of water use. Basic strategy of the approach is summarized in three points, 1) restrain of evaporation loss, 2) restrain of infiltration loss, and 3) restrain of operation loss. The table attached below gives the concrete countermeasures to accelerate water saving at actual sites.

Water saving approach is classified into irrigation canal level and on farm level. Taking account of present situation in khettara irrigation area, the following measures are recommended as water saving approaches with high potential.

(a) Irrigation canal level

- Most part of irrigation canals is earthen canal with large infiltration loss. In general, conveyance efficiency is estimated at 70 to 80 %[1] for earthen canal and *80 to 90 % for lining canal. Lining the earthen canals with concrete reliably contributes to increase the amount of available water by reducing 10 % of filtration loss.
- It is common that water users divert water flow by blocking off the outlet points with soil; therefore infiltration loss and operation loss cannot be avoided. Inlet improvement leads to restraining the infiltration loss and reducing operation loss through improvement of water proof and handling. The amount of available water amount is expected to increase with the inlets improvement because the number of the inlets is numerous.

(b) On farm level

- Furrow irrigation is recognized to be more effective method for water saving rather than traditional basin irrigation because evaporation from partially wet zone among furrow is minimized comparing to that spread in whole irrigation plot of basin irrigation. Drip irrigation is the most preferable water saving techniques since water is supplied directly to the root zone through emitters placed on the soil surface. These two water saving techniques have high potential for expanding water saving and enlarging irrigable area.
- It is so hard to drastically change traditional water right system which regulates water use interval and water use time schedule. Installation of on farm reservoir makes it possible to shorten irrigation interval and provide the flexibility of irrigation scheduling even under the condition of traditional water right. Accordingly, vegetable cultivation is applicable to khettara irrigation area all the year around.

[1] Source: "Applications of Climatic Data for Effective Irrigation Planning and Management" (FAO)

Water saving measures

Category	Water Saving measure		Contents	Effect		
	Item	Measure		Restrain of evaporation loss	Restrain of seepage loss	Restrain of operation loss
Irrigation canal level	Canal rehabilitation	Lining	Decreasing seepage loss		○	○
		Culvert	Depressing evaporation from water surface	○		
	Inlet improvement	Installation of simple gate etc,	Decreasing seepage and operation loss		○	○
On farm level	Decrease of evaporation	Shelter belt	Blocking wind	○		
		Multi cropping	Blocking sunshine	○		
		Mulching	Depressing evaporation from soil surface	○		
	Irrigation method	Sprinkler	Equalizing watering amount		○	○
		Furrow	Partial irrigation	○	○	
		Drip	Partial irrigation	○	○	○
	Cultivation technique	Selection of crops	Crops with small amount of consumptive water	○		
		Double sack method	Improvement of root zone	○	○	
	Soil improvement	Retaining admixture	Retaining soil moisture		○	
	Water management	On farm reservoir	Flexible water use			○

(4) Agriculture and agriculture extension

The following development potentials are identified in terms of agriculture and extension service.

- It is possible to expand agricultural area from a viewpoint of land potential,
- Basic extension system in terms of institutional and extension techniques has been already developed.
- The ORMVA/TF has already implemented the assistance for rural women and poor.

For formulation of agricultural development plan, strength and weakness analysis on existing agriculture activities was made.

Strength and Weakness Analysis on Existing Agriculture Activities

Crop	**Strengths**	Weakness
Date Palm	- There is marketing advantage, since local production is very popular.	- Good variety is not enough. - Disease damage has been expanded. - Annual water requirement is large.
Olive	- Demand including self consumption is stabilized.	- Old trees are majority. - Method on oil processing is traditional one. - Annual water requirement is large.
Tree crops（apple etc.）	- There is marketing advantage in a part of the Study area	- Most of individual cultivation area is small. - Market channel is limited. - Annual water requirement is large.
Wheat	- Water consumption is relatively small. - Marketing price is stabilized.	- Productivity is low.
Vegetable	- There is marketing potential, since most of vegetable is imported.	- Irrigation is based on the pump. - Price is not stable.
Fodder Crop	- Demand including self consumption (for livestock) is stabilized. - Water consumption is relatively small.	- Price is low.
Henna and cumin	- Local production has advantage in the market	
Livestock	- There is advantaged variety. - There is marketing potential, since most of vegetable is imported.	- Most of individual cultivation area is small. - Market channel is limited. - Production techniques are not matured.
Bee farming	- Local production has advantage in the market.	- Area of flower cultivation is limited. - Scale on business is small.
Others（handicraft）		- There is no marketing channel. - Production techniques are not matured due to the initial stage of the introduction.

(5) Rural society / organization and institution

Although capacity of farmer's organization is different on each place and organization itself, it can be analyzed and summarized as follows:

Capacity of Farmer's Organizations in Khettara Communities

Type of organization	Institutional aspect	Activity and farmer's participation	Management capacity	
			Ability on fund raising	Ability on project implementation
Traditional Khettara Water User's Organization	×	○	○	△
	- No legal registration - Management by customary law	Carry out khettara maintenance and rehabilitation works by water users	Chief of khettara collects money from water users	Having accumulated experience and know-how, but reluctant to adopt new methods and techniques.
Khettara Association	○	×	×	△
	- Legal registration is made - Management by contemporary law (Charter, general assembly, etc.)	Main activity is preparation of applications for outside organizations.	Membership fee is normally not collected	New leader is positively adopting new methods and techniques, but has not acquired trust from the traditional organizations because of little experience in the past.
Rural Development Association	○	△	×	△
	- Legal registration is made - Management by contemporary law (Charter, general assembly, etc.)	Varies on each organization.	Membership fee is normally not collected	New leader is positively adopting new methods and techniques, but has not acquired trust from the traditional organizations because of little experience in the past.

Based on the analysis presented above, development potential for strengthening farmer's organization can be considered as follows:

- Although the traditional organization has not obtained legal status, it has carried out khettara maintenance and rehabilitation works for a long time by unifying people with their customary law. Experience, knowledge and unity of water users accumulated through these activities will be a strong base for the future maintenance and rehabilitation works.
- By strengthening traditional organization in institutional aspect, i.e. registering and operating as an association, it becomes an organization equipped with accumulated know-how and leadership on implementation of khettara rehabilitation works together with a function to apply for assistance from outside organizations.
- Khettara association is established to support khettara maintenance and rehabilitation works. However, it also has a potential to be developed to an organization supporting other rural development activities, including extension of water saving irrigation and new farming techniques, construction of education and health care facilities, adult education, etc., based on acquired trust with the local people.
- For khettara communities currently having only traditional organization, the organization can be institutionally strengthened to Khettara Association. The association will be able to expand its activity from support on Khettara maintenance and rehabilitation works to other rural development activities based on its organizational base.

Chapter 5 Basic Concepts on the Khettara Rehabilitation and Rural Community Development Plan

5.1 Basic Concepts

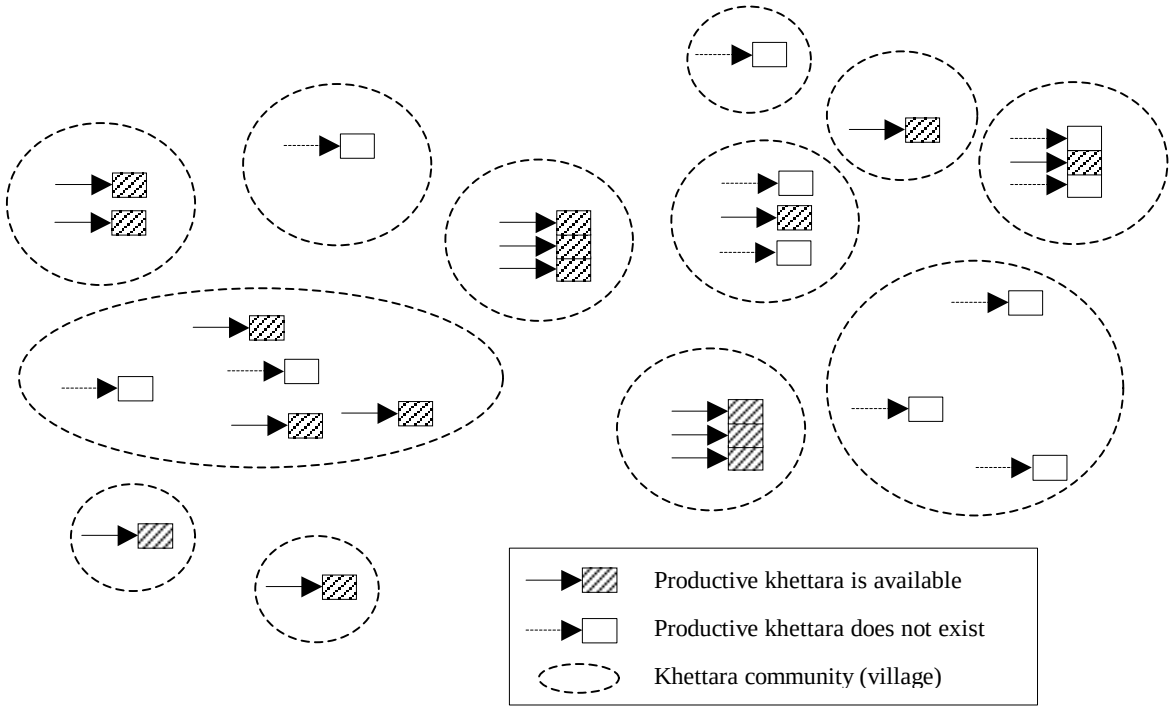
The Master plan formulates the development plan for agriculture and rural communities with effective utilization of the khettaras. There are 191 productive khettaras among total 410 khettaras. In most cases, khettara communities (villages) own both a productive khettara that has a flow and a re-productive khettara that has no flow at present, while some khettara communities have no productive khettara.

The water source potentials vary from the areas where khettaras are located. Some areas have shifted their water sources from khettara use to full-scale pump irrigation system. In this fact, it is necessary to formulate the development plan taking the natural and social characteristics of each khettara community into account.

The following are basic concepts to formulate the development plan for agriculture and rural communities:

(a) Development plan includes 410 khettara and related khettara communities.

In the khettara village that is a minimum administrative unit and forms khettara community, there exist both productive and re-productive khettaras. Khettara water right is distributed under contract basis even in the khettara village that have no productive khettara. Considering these circumstances, it is proposed in the Master plan that 191 productive khettaras are urgently rehabilitated and communal pump system is consecutively introduced to the khettara villages that have no productive khettara at present to secure their living conditions.



(b) Khettara discharge is absolutely in short for irrigation in the Study area, therefore water resources development is inevitable to formulate the rural development plan. Pump irrigation system is recognized as indispensable to continue agricultural production from the facts that khettara water is absolutely insufficient in whole Study area and pump irrigation system has already spread to cope with recent severe drought.

Diversion weirs and canal network system shall be included in the development plan to effectively utilize surface water.

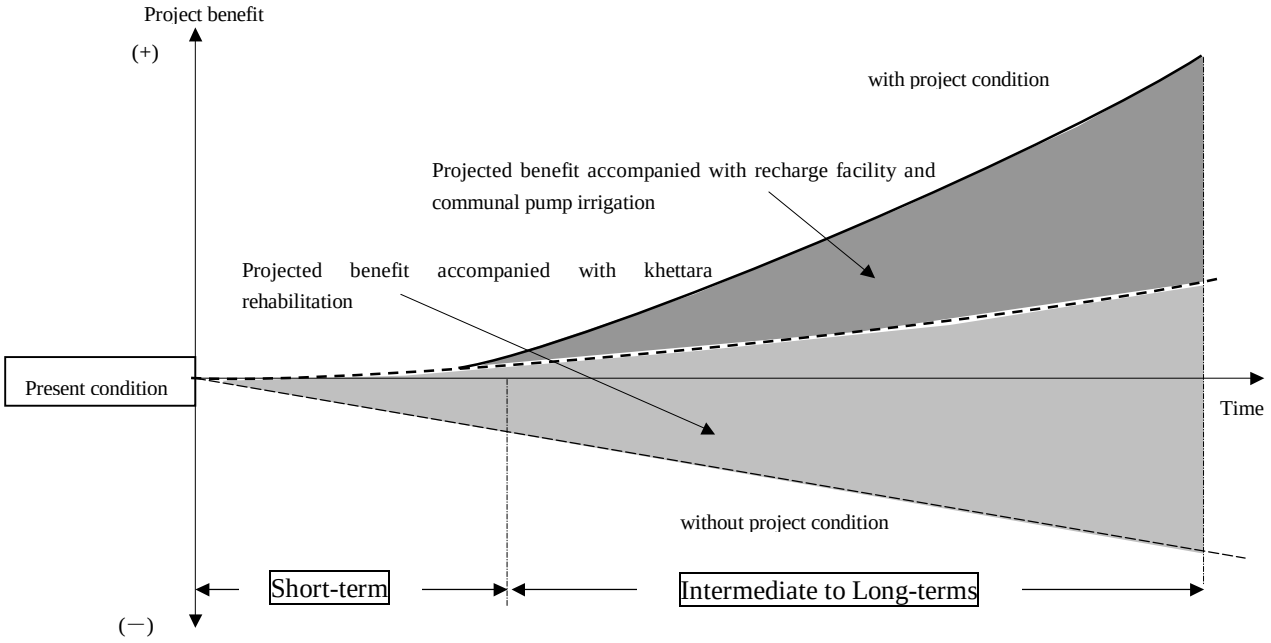
(c) The Master plan consists of various project components, i.e. water resources development, water use, farming and extension service, strengthening of farmers' organizations, environmental conservation, etc. aiming at rural community development. With respect to this, the Master plan shall be formulated in due consideration of present long-term development plan of the related governmental agencies.

(d) Taking (b) and (c) above into consideration, development plan is divided into several phases in terms of implementation schedule, timing of outcome of project benefit, and annual budgetary allocation. Efficiency, urgency as well as remedy on poverty alleviation are considered in project phasing during the preparation of the implementation program.

(e) Project target shall be determined in implementing phasing program mentioned in (d) above. Insufficient flow of the khettaras has caused lower farming activity and accelerated depopulation of rural communities. When this problem is left as it is, social system of khettara community itself may collapse. Although development effect of the project is mainly accompanied with khettara discharge (or pump irrigation), the water source development has a limit in incremental scale when sustainability of the water use is considered. In this regard, project target is principally emphasized on preservation of present khettara discharge or improvement in the limits of the possible.

In the short-term program, preservation of water sources is the main target so as to improve agricultural productivity and rural living condition. For khettara rehabilitation planning, proper rehabilitation method shall be proposed in due consideration of water use potential in various river basins.

In intermediate and long term programs, recharge facility planning for groundwater conservation and diffusion of pump irrigation system are proposed to improve agricultural productivity and to sustain further farming practice in addition to the rehabilitation works for the khettara.

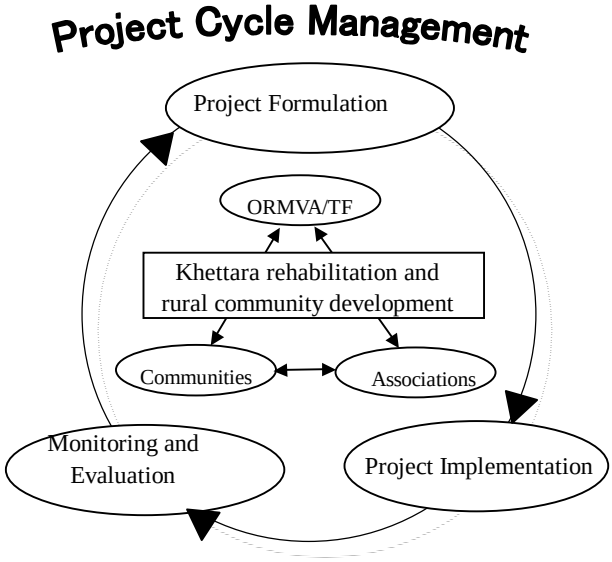


(f) Khettara rehabilitation is the main components in this development plan. To cope with decrease of the khettara discharge, recharge facility construction is one of the effective remedy for groundwater conservation. Storage dam or recharge dam is proposed as a large scale facility for the groundwater recharge. Storage dam fulfills the function to recharge groundwater through riverbed in addition to its main purpose of direct supply of irrigation water to the command area. The DRH has proposed three (3) dams, such as Tadighoust, Ouaklim and Timkit dams in the Study area in the 5 year water resources development plan.

The Master plan includes recharge dam construction in the intermediate and long-term programs. However dam plan mentioned above is excluded from the Master plan because of following reasons:

- Proposed dam is constructed to principally supply surface water for the irrigation purpose, accordingly groundwater recharge that directly contributes to increase of khettara flow, is supplementary or indirect effect.
- Location of the beneficial area and scale of groundwater recharge is not specified without detailed hydro-geological investigation. The mechanism of recharge phenomenon such as recharge route, existence of aquifers shall be exploited to ensure improvement of khettara discharge when large dam construction become principal remedy. (When dam project including downstream irrigation network plan is realized, flexibility on facility planning between the dam project and khettara rehabilitation project is required.)

(g) For project formulation and review of the khettara rehabilitation and rural community development scheme, the ORMVA/TF, khettara communities and associations (local NGOs) play an important role in the frame work of the project cycle management in terms of planning, implementation monitoring and evaluation activities over a long period in accordance with the principle proposed in "the 2020 Rural Development Strategy" as well as inspection results during a tour in Oman. (see illustration below)



Institutional Set up during Project Formulation and Implementation

The ORMVA/TF is responsible for over all project management in the frame work of the said project cycle management. Meanwhile beneficiaries (farmers) is responsible for participation to the entire project process during not only the project implementation but project planning as well as monitoring and evaluation activities. Associations are expected to be a coordinator between the ORMVA/TF and beneficiaries and furthermore have a role as a consultant through an entire project cycle.

In this basic concept of the Master plan, appropriate institutional framework is proposed with proper clarification of each player's role, corresponding to each project phase.

(h) Aiming at accelerating participation of the beneficiaries to the project, improvement of rural living condition by means of rehabilitation of the khettaras and rural infrastructures is necessary in short term, and secondly introduction and diversification of income generation activities are encouraged in long-term so as to stimulate their self-reliance to the project. Activation of the activities of the ORMVA/TF and additional investment to accelerate income generation activities are proposed for this purpose. Concerning income generation activities, cultivation of cash crops such as vegetables and high value vegetables, livestock breeding, food processing of agricultural products are proposed considering carefully the various situations, for example farmers' views, limited sources in the khettara communities, etc.

5.2 Project Strategy and Long Term Development Plan

The following development concepts and strategy are described in the National Development Plan (Plan de Dévéloppement National 1999-2004), the Rural Development Strategy 2002 (Stratègie 2020 de Développement Rurale, 1999):

1) Increase of agricultural products to meet domestic food demand
2) Creation of employment opportunity and poverty alleviation
3) Control of excessive development for natural resources conservation, such as over cultivation, and water resources conservation
4) Rehabilitation of present agricultural production system
5) Improvement of educational level in rural areas
6) Improvement of rural living standard and social welfare from the view points of public health, potable water supply, electrification and transportation, etc.
7) Strengthening of regional economy by improvement of rural infrastructures and increase of development opportunity

Shortage of groundwater and excessively large pumpage have induced rapid and disordered water resources development in the Study area. Consequently agricultural productivity has become low due to decrease of the water resource, and it has accelerated devastation of the rural circumstances. Inhabitants who have lost their employment have moved to the urban area, consequently mass unemployment and security in the urban areas has become social problem.

It is essential to support rural communities to achieve the above development strategy by means of stable water supply that is a fundamental constraint in the rural area, improvement of agricultural productivity, encouragement of initial investment and extension of marketing opportunity. Accordingly the project strategy is summarized as:1) proper water management aiming at sustainable water resources development, 2) improvement of rural living conditions and 3) increase of agricultural productivity. These are thus in consistency with the development strategy in the National Development Plan and the Rural Development Strategy.

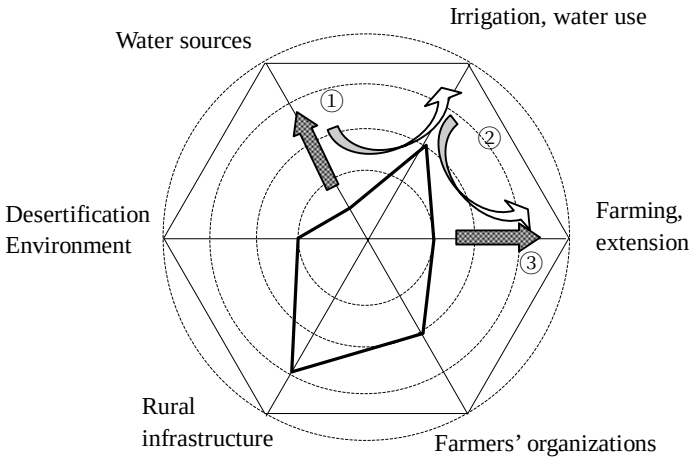
5.3 Proposed Components in the Master Plan

In discussing the project components, it is important to recognize both utilization of external resource input into the project and internal development of the recipient side that effectively utilize the external resource.

Effective use of increased water by khettara and irrigation canal rehabilitation works and improvement of irrigation and farm skills are recognized as an external resource. Capacity building of the farmers' organizations, improvement of awareness on public health and environmental preservation are recognized as an internal development.

As shown in the figure below, an external source, especially water source is extremely scarce in the Study area, and it causes lower farm skills, irrigation technique and poor activities of the farmers' organizations. Meanwhile rural infrastructures such as facilities for electricity and potable water supply have been well developed for the completion in 2005 to 2007.

In the development plan, increase of available water supply is firstly accomplished by the khettara and irrigation canal rehabilitation that is recognized as an external resource. Consecutively rural community development is achieved by incremental benefit, mainly originated from increase of available water, improvement of water use efficiency and diffusion of farming skills, etc.



Development of Rural Area

The following table shows proposed project components and details.

Proposed Project Components

Components	Project Components	
	External resources	Internal development (Participatory approach)
Rehabilitation of khettaras	Water resources development Khettara rehabilitation works Construction of recharge facilities	Increase of awareness for water resource preservation
Farming and extension	Technical transfer of modern farming skills Diffusion of income generation activities Construction of post harvest facilities	Cooperation with association for diffusion activity Extension of marketing area
Water use	Corrective maintenance of irrigation system Rehabilitation of irrigation networks Diffusion of water saving irrigation methods	Strengthening of water users associations (monitoring and evaluation on water use)
Institutional strengthening of farmers' organizations	Education, procurement of training materials and tools	Establishing and strengthening of khettara associations
Groundwater use Environmental preservation	Groundwater conservation Afforestation (prevention from farmland devastation)	Propagation for anti-devastation of farmland
Public health and hygiene	Improvement of water quality by facility planning	Increase of awareness on public health and hygiene