Chapter 6 Verification Study

6.1 Outline of the 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 (Khettara Rehabilitation and Rural Community Development Project) and khettara rehabilitation plan.

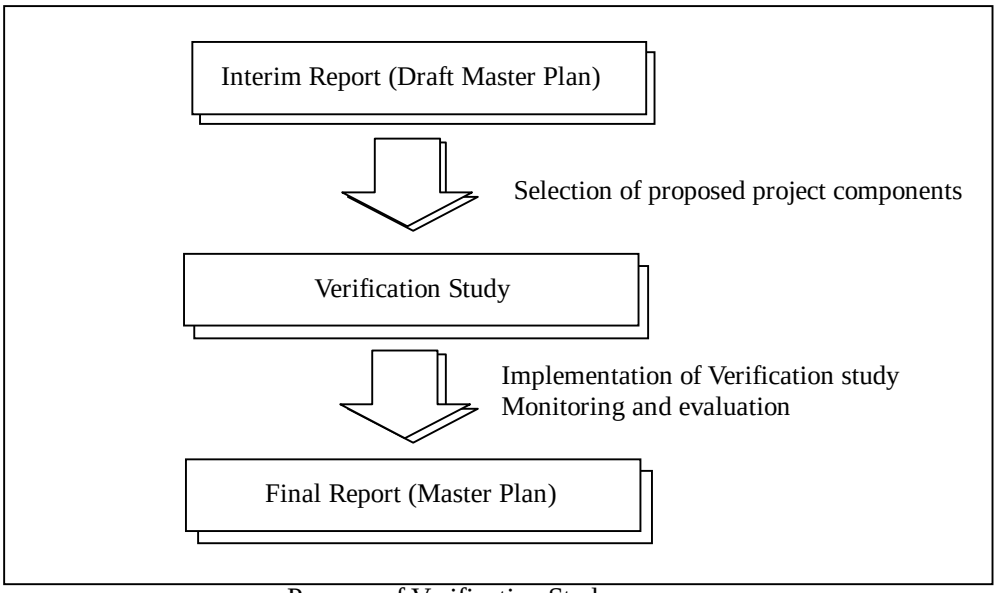
The following are objectives of the Verification study:

1) The study aims at completing the Master Plan based on the Verification study results on the proposed components in the Master Plan (Khettara rehabilitation and Rural Community Development Project) and the khettara rehabilitation plan from the technical, social and economical points of views.

2) The ORMVA/TF is responsible for project implementation and management of the Khettara Rehabilitation and Rural Community Development Project. The study includes a capacity building of the ORMVA/TF through project monitoring and evaluation activities, technical transfer during seminars and workshops.

3) The study aims at activating farmers' group activities, e.g. traditional water users' organizations, khettara associations, beneficial farmers on such as enrollment of their organizations to associations to acquire technical and financial supports for a khettara rehabilitation works from the outside organizations.

4) The study supports establishing monitoring system comprising of the ORMVA/TF, on traditional water users' organizations and khettara associations. Evaluation based on the monitoring activities is effectively utilized for revise and review of the Master plan.



Purpose of Verification Study

As for the project components in the Master plan shown in Chapter 8, projected benefits and relevance of each project component were verified during the study.

Project components		Verification study	Activities
Responsible agency: ORMVA/TF	1) Capacity building of ORMVA/TF 2) Establishing monitoring and evaluation system	1) Seminars for the ORMVA/TF	・ Update of inventory ・ Seminar opening
• Khettara rehabilitation		2) Rehabilitation works for khettaras	・ Increase of flow ・ Construction planning
• Irrigation canal rehabilitation		3) Rehabilitation works for irrigation canals	・ Increase of flow ・ Construction planning
• Water use		Diffusion of water saving irrigation	・ Demonstration of furrow and drip irrigation systems
• Farming	1) Revising Master plan 2) Capacity building of ORMVA/TF 3) Strengthening of farmers' organizations 4) Establishing monitoring and evaluation system	4) Farming	・ Cultivation of cash crops ・ Processing of agricultural products
• Farmers' organizations		5) Strengthening of Farmers' organizations	・ Register of farmers' organizations and accelerating activities ・ Study tours
• Income generation and rural life improvement activities		6) Income generation and rural life improvement activities	・ Breeding of small animals ・ Improvement of water quality ・ Public health and hygiene
• Afforestation		7) Mitigation of farmland devastation	・ Introduction of "double sack method"
• Recharge facility planning	1) Capacity building of ORMVA/TF 2) Establishing monitoring and evaluation system	8) Data collection for recharge facility planning	・ Data collection and analysis ・ Technical transfer of groundwater analysis

Activities of the Verification Study

6.2 Site Selection for the Verification Study

The sites for the Verification study were selected from model sites for the khettara rehabilitation plan among 410 khettaras.

(1) Guideline for site selection

The following table shows guideline for the site selection composed of various factors such as readiness of monitoring activities, effect of demonstration, diffusion to the farmers' groups as well as agreement of farmers' groups on conducting the Verification study.

Guideline for Site Selection

Guideline for Site Selection	
(1)	It is preferable to select khettara that discharge is 5.0 lit/sec or more.
(2)	Khettara discharge remarkably increases by the rehabilitation works.
(3)	Labor requirement for maintenance remarkably reduces by the rehabilitation works.
(4)	Leakage loss from the irrigation canal remarkably reduces by the rehabilitation works.
(5)	Farm houses who have a large experience of vegetable cultivation participate in the study for marketing research.
(6)	Aiming at farm skill diffusion, a farm area has high potential of productivity by rehabilitation works and introduction of modern farming skills including topographic condition. (Incremental benefit is estimated by increase of cultivation area and amount of products accompanied with increase of irrigation water by the rehabilitation works. It is important to select farm area at where pump irrigation is not introduced to monitor the benefit originated by increase of khettara flow.)
(7)	It is preferable to select the area where khettara associations or rural development associations have established, and their intentions to improve association's ability are high. In the case association is not yet established, active khettara water users organization is selected to register them to a khettara association as a part of the study.
(8)	Traditional water users' organizations or khettara associations have strong intention to participate the study.
(9)	Traditional water users' organizations or khettara associations can provide necessary labor or shoulder a part of expense during the study.

(2) Sites of the Verification study

The sites of the Verification study are indicated below: (see Figure 6.2.1)

Sites for the Verification Study

Khettara communities / Components	1)Ait Ben Omar	2)Diba	3)Azag	4) Lambarkia	5) Oustania	6)Timarzite	7)Jdida Taoumart
1) Capacity building of ORMVA/TF	Khettara communities above are subject to the Verification study.						
Sub-Divisions	Goulmima			Erfoud			
CMVs	Tinejdad			Jorf		Alnif	
2) Monitoring on khettara rehabilitation	●	●	●	●	●	○	○
3) Water use	●			●			●
4) Farming and extension services	●			●			●
5) Organization strengthening	●	●	●	●	●	●	●
	Khettara associations and rural development associations under the administration of the CMV Tinejidad, and CMV Jorf					Traditional water users' groups under the administration of the CMV Alnif	
6) Improvement of rural living condition	△Tizougaghine (Bakkassia), △Mellaab (Oukhite), △Jorf, △Rissani △□Boudenib						
Breeding of small animals Pigeon: 1△ Rabbit: 5□							
Washing place（3○）	○Tinejdad (Ait Ben Omar) ○Tizougaghine（Ait Moulay Hamoun)）					○Alnif (Taoumart)	
Compost (3)	○Tinejdad (Ait Ben Omar)			○Jolf (Bouya)		○Alnif (Alnif)	
7) Afforestation				●Lambarkia			
8) Recharge facility planning	(ORMVA/TF, Sub-Divisions and CMVs)						

● Khettara communities selected for the Verification study

○ Khettara communities (khettara rehabilitation was conducted by the small scale grant program)

▭ Farmers' organizations subject to the Verification study

Rehabilitation by associations: Concrete breakers were provided to the associations of Erfoud and Goulmima areas aiming at encouragement of their ability on management, etc.

6.3 Components of the Verification Study

Proposed eight (8) components and details for the Verification study are as follows:

1. Capacity building of the ORMVA/TF
    1) Establishing network between the ORMVA/TF and farmers' organizations
    2) Update of inventory data and GIS data distribution
    3) Data collection and information sharing on agricultural development scheme
    4) Strengthening of project evaluation and monitoring capability
    5) Technical seminar related to the Verification study
2. Rehabilitation of the khettaras
    1) Evaluation and feedback on khettara rehabilitation (Master Plan)
    2) Verification of benefits by khettara rehabilitation (Water loss)
    3) Verification of benefits by khettara rehabilitation (Labor for maintenance)
    4) Capacity building on khettara rehabilitation planning of the ORMVA/TF
3. Water use
    1) Minimization of water conveyance loss on irrigation canal
    2) Preparation of design manual for irrigation canal rehabilitation
    3) Demonstration and comparison of proposed water saving irrigation system
4. Farming and extension
    1) Adaptability test and demonstration for water saving irrigation
    2) Demonstration on agro-processing (Date palm, henna and okra (gumbo))
5. Organization strengthening
    1) Facilitating establishment of associations
    2) Training for associations
    3) Strengthening capacity of associations for applying support from outside organizations
    4) Implementation of khettara rehabilitation work by associations in cooperation with traditional khettara water user's organizations
    5) Formulating monitoring system in cooperation with the ORMVA/TF, associations and traditional khettara water user's organizations
    6) Spreading knowledge on water saving irrigation technique by associations

7) Exchange of information, sharing knowledge and experience between associations

6. Rural life improvement

1) Income generation activities (Breeding of rabbit and pigeon)

2) Hygiene control of khettara (Construction of washing place)

3) Environmental improvement of khettara community (Construction of compost)

7. Prevention of farmland devastation

1) Afforestation (Adaptation of double sack method)

8. Data collection for further recharge facility planning

1) Data collection of meteoro-hydrological and groundwater level records

2) Study for groundwater analysis

6.4 Implementation Plan

The Verification study has been conducted for 16 months from May 2004 to July 2005 in conformity with the selected components. On the process of the Verification study, monitoring and evaluation were periodically performed to check the progress and to review the indicator for output and target in line with the PDM (Project Design Matrix) of respective component.

The Master plan shall be continuously reviewed and revised by the ORMVA/TF and beneficiaries in the process of Plan -> Do -> Check -> Action. For these purposes, the following were especially considered during monitoring and evaluation period:

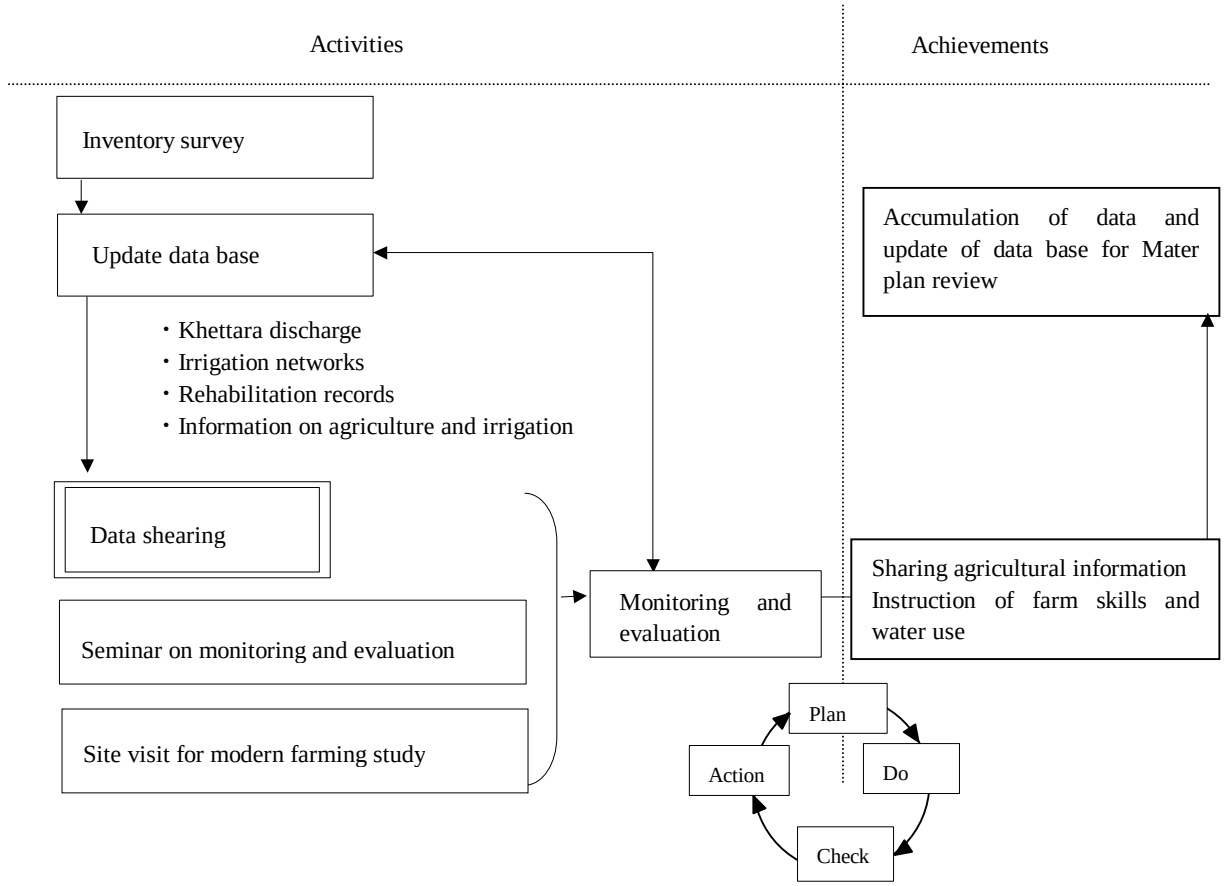
1) It is essential that beneficiaries, i.e., farmers, traditional water users' organizations and khettara associations understand project components, implementation progress and expected benefits to continuously implement the khettara rehabilitation and rural community development project (Master plan). In this regard, participation of the beneficiaries to the study, for example “monitoring plan with participation of the beneficiaries” was positively accelerated during the Verification study.

2) The ORMVA/TF plays important role for project implementation, management and revise of the project. In addition the ORMVA/TF is responsible for providing necessary information to the farmers related to the project including data collection, sorting and analysis. The study included a capacity building of the ORMVA/TF through project monitoring and evaluation activities to secure proper monitoring and evaluation activities of the project.

6.5 Outcome and Review of the Master Plan

6.5.1 Capacity Building of ORMVA/TF

	Verification components
1)	Establishing network
2)	Update of inventory data
3)	Data collection and information on agricultural development scheme
4)	Strengthening of project evaluation and monitoring capability
5)	Technical seminar related to the Verification study



1) Outcome of the study

Collection and update of fundamental information (khettara inventory) for the Master plan review and revise, accumulation of farming skills, capacity building of monitoring and evaluation, and site visit for collecting modern farming skills were conducted during the Verification study.

The inventory for 410 khettaras and GIS image have been distributed to the ORMVA/TF Sub-Divisions and CMVs and updating work of the khettara inventory, sharing of farming information between the ORMVA/TF and farmers have been achieved during the study. GIS information includes 1) khettara route (location of mother well, gallery route, location of outlet), 2) command area, 3) irrigation canal networks, 4) water use in each khettara communities, natural condition, 5) pump stations for potable water

supply (location of pump station, well depth, water quality). In addition, GIS image provides topographic information, river information (location, alignment) for further groundwater recharge planning. It is expected that the ORMVA/TF effectively utilizes GIS application for his further study.

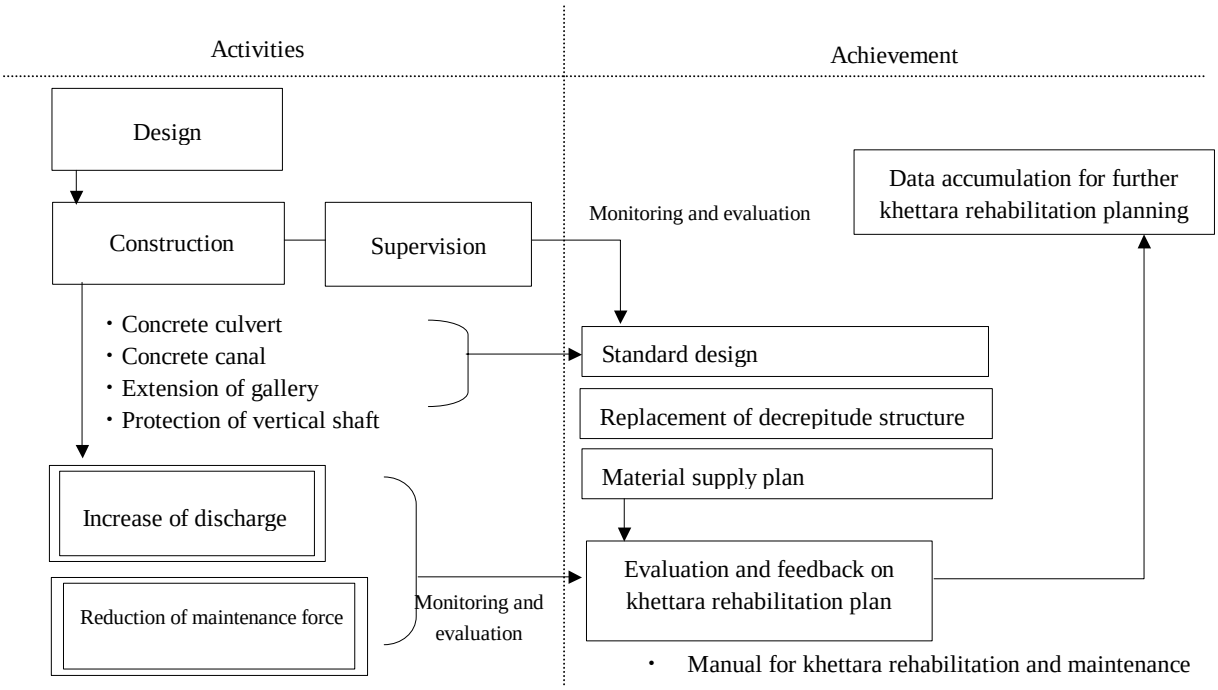
Insufficient information regarding water sources and farming skills is the constraint for agricultural development in the Study area. With respect to this situation, workshops on groundwater use, water saving irrigation method, farming and extension service were held to transfer information to the ORMVA/TF and farmers.

2) Feedback to the Master plan

The ORMVA/TF has responsibility for project management of the khettara rehabilitation and rural community development project. Since the khettaras are scattered in the Study area, and each khettara has various geo-hydrological characteristics as well as water resources potential, especially groundwater use. In this fact, it is necessary to periodically review and revise the Master plan to effectively use the limited budget. Update of the khettara inventory and improvement of irrigation and farming skill have achieved during the study.

6.5.2 Rehabilitation of Khettaras

	Verification components
1)	Evaluation and feedback on khettara rehabilitation plan
2)	Verification of benefits by khettara rehabilitation (Water loss)
3)	Verification of benefits by khettara rehabilitation (Labor for maintenance)
4)	Capacity building on khettara rehabilitation planning of the ORMVA/TF



(1) Evaluation and feedback on khettara rehabilitation (Master Plan)

1) Feedback to the Master plan

(a) Scope of rehabilitation works

Rehabilitation work for discharge increase and reduction of the maintenance force is broadly composed of 1) rehabilitation of the gallery and vertical shaft, 2) extension of the gallery and enlargement, 3) re-profiling of gallery base including removal of outcrop of rock foundation, 4) flood protection work such as river dike protection, protection of gallery and vertical shafts. It is effective work to extend and re-profiling the gallery to increase the khettara flow taking into consideration of present condition that khettara flow has been gradually decreasing. Meanwhile, it is prohibited by tradition to extend gallery without mutual understanding where many khettaras are conjugated because a gallery extension may cause water decrease of adjoining khettaras. On the other hand, extension and re-profiling of khettara gallery have been strongly requested where each khettara separately exists and there was no traditional restriction on rehabilitation works, like Alnif area.

It was observed that the ORMVA/TF has not positively included such khettaras in his rehabilitation plan not to sow discord due to the said traditional restriction. In addition, the ORMVA/TF has not carried out extension of the galleries to prevent unexpected water decrease which might be caused by the rehabilitation works.

In consideration of the matters above, rehabilitation plan is established taking account of the limit of the rehabilitation as follow:

1) Rehabilitation works of galleries and shafts aiming at increase of khettara discharge as well as reduction of maintenance load of the khettaras

2) Dike construction and reinforcement of galleries and shafts to mitigate flood damages

(b) Rehabilitation cost

Following rehabilitation cost collected during the Verification study is applicable to estimate entire project cost.

Rehabilitation Cost for Khettara Gallery Construction

Khettara	Construction	Earth work (DH / m)	Concrete work (DH / m)	Total (DH / m)
Ait Ben Omar	Tunnel work	140	1,220 (1,090)	1,360 (1,230)
Diba	Rock excavation＋bed degradation Concrete canal	500	300	800
Lambarkia	Open excavation Concrete culvert	270	1,630 (1,390)	1,900 (1,660)
Oustania	Open excavation Concrete culvert	250	1,630 (1,390)	1,880 (1,640)
	Pipe installation（φ400）	90	520	610
Azag	Pipe installation（φ200）	---	240	240
	Dike protection (Masonry)	190	960	1,150

（ ）shows price for reinforcing bar applying Moroccan standard (allowable stress is 2/3 of yield load)

(Open excavation + Concrete culvert) = DH1,640 - 1,660/m, (Concrete culvert in tunnel) = DH1,360/m, (Concrete canal in tunnel) = DH800/m, (PVC pipe installation φ400mm (15-20 lit/sec)) = DH610/m, (PVC pipe installation φ200mm (5-8 lit/sec)) = DH240/m.

(Open excavation + Concrete culvert) is selected emphasizing on easiness of construction work, however this method is limited to 5 to 6 m deep from the ground surface because of machinery specification. Tunnel work is available within the cost above when the existing tunnel has wider opening and straight line alignment. However higher cost is necessary when existing tunnel is narrower and complicatedly distorted.

As the construction cost for the khettara Diba indicates, concrete canal construction is applicable to the tunnel work and needs less cost rather than the concrete culvert construction. A few disadvantages are however pointed, e.g., higher cost for diversion work when khettara discharge is relatively large, and risk of wall collapse of gallery.

Rehabilitation cost of DH1,200 /m has been applied to the cost estimates in the Master plan.

(2) Verification of benefits by khettara rehabilitation (Water loss)

1) Outcome of the study

Discharge data observed during the rehabilitation work are sorted in the table below:

Reduction of Water Loss by Discharge Classification

Present discharge of khettara（lit/sec）	10≦Q	5≦Q<10	Q<5
Reduction of water loss（lit/sec/km）	2.5	2.0	1.5
Ait Ben Omar	—	2.3→0.3=2.0	—
Diba	—	—	1.0→0.0=1.0
Lambarkia	0.9→0.0=0.9	—	—
Oustania (Culvert section)	2.3→0.0=2.3	—	—
Oustania (Pipe section)	6.0→0.5=5.5	—	—
Azag	—	—	1.7→0.0=1.7

2) Feedback to the Master plan

The table below shows the rehabilitation effect (reduction of water leakage) with classification into 3 discharge groups. The results of discharge measurement in table below satisfied reduction rate below with disregarding of few dispersion of observed data.

Reduction Rate of Water Leakage by Rehabilitation Works (Master pln)

Present discharge: Q（lit/sec）	10≦Q	5≦Q<10	Q<5
Reduction of water leakage（lit/sec/km）	2.5	2.0	1.5

(3) Verification of benefits by khettara rehabilitation (Labor for maintenance)

1) Outcome of the study

Baseline Data on Khettara Maintenance Works

Items	Unit	Ait Ben Omar	Diba	Lambarkia	Oustania
Removal of deposit in gallery	capita/year	294 capita/year	245 capita/year	1,800 capita/year	1,248 capita/year
Removal of deposit per km	capita/year/km	196 capita/year/km (Total length 1.5km)	144 capita/year/km (Total length 1.7km)	295 capita/year/km (Total length 6.1km)	162 capita/year/km (Total length 7.7km)

Source: Socio economic survey (JICA Study team)

Dredging of sediment in the gallery occupies majority of the maintenance works. Since collapse of the gallery and vertical shaft walls and sand inflow from the vertical shafts cause sediment deposits, rehabilitation of the gallery and vertical shaft directly minimizes labor and cost for the maintenance works. The vertical shafts located in the sand dune area are closed for several hundred meters to several km through the year to prevent inflow of sand, accordingly rehabilitation of the galley and vertical shafts is advantageous for the khettaras located in the sand dune area.

2) Feedback to the Master plan

It was uncertain to estimate the benefits of labor force reduction for the maintenance work by the hearing from the farmers. It is however assumed that reduction rate of 80 % is applicable to the project evaluation in the Master plan study.

(4) Capacity building on khettara rehabilitation planning of the ORMVA/TF

1) Outcome of the study

(a) Preparation of standard design

Standard deign of gallery and vertical shaft was prepared taking account of local conditions of each khettaras such as geological features and structural requirement as well as temporary work planning. Standard design includes study of inner dimension of the gallery and vertical shaft, thickness of members, etc. (refer to Manual for khettara rehabilitation and maintenance work)

(b) Preparation of material supply plan

Dispersion of grain size distribution affects compression strength of a concrete. As course and fine aggregates are collected from natural river deposits, proper screening is required to produce well qualified concrete. Fundamental data on aggregates and concrete mixing are provided in Manual for khettara rehabilitation and maintenance work.

(c) Reconstruction plan for decrepit structures of khettaras

Rehabilitation plan is prepared for the khettaras which have decrepit section and extremely narrow sections. During this study, problems and rehabilitation requirement was discussed for these structures. (refer to Manual for khettara rehabilitation and maintenance work)

(d) Improvement of supervision activities of rehabilitation works

In the course of the study, concrete quality control, economical comparison study between concrete culvert and PVC pipe was conducted.

2) Feedback to the Master plan

The Verification study through the khettara rehabilitation works aims at employing following issues based on the construction experiences using a concrete culvert undertaken by the ORMVA/TF.

(a) Khettara gallery

Rehabilitation work precedes with construction of a small section portion downstream of the gallery. Since downstream gallery is located at shallow depth from the ground surface, open excavation method is applied to replace the gallery with concrete culvert type in consideration of the safety of workers. In tunnel site, culvert type is preferable to prevent from sediment deposits in the gallery section, however open channel type is also applicable when gallery is composed of rock layers.

(b) Construction in tunnel

It is concluded that the earth work deeper than 5 m from the ground surface requires comparatively high cost because of limited arm length of around 5 m. Accordingly, earth work by manual in a tunnel may be economically advantageous when gallery lies lower than 5 m in depth. While wider gallery section must be secured in the tunnel work for the installation and removal of about 1.85 m height concrete form. With respect to this fact, proper section planning and construction planning are established from the economical point of view.

(c) Route planning (Dewatering)

On selection of the khettara route during the rehabilitation works, by-pass route along the existing gallery is most appropriate because of facility of diversion work. Whereas by-pass route is not found due to land acquisition problem including renting from land owner(s) or adjoining khettaras are located closely, rehabilitation route shall be selected on the existing route. In this occasion, diversion method, e.g. pumpage to the ground surface or pipeline in the gallery shall be deliberated during construction planning.

(d) Machinery and equipment plan

Availability of machinery and equipment (excavator and rock breaker) is most critical factor to determine the construction schedule. Both equipments are in short in the Tafilalet region, and difficulty of their mobilization causes delay of the construction completion. Proper construction plan shall be established considering the availability of machinery and equipment.

(e) Pre-fabricated concrete product

It is advantageous to utilize pre-fabricated concrete products for the khettara rehabilitation works (vertical shafts) because of its readiness of quality control, rapid installation as far as its production is simultaneously carried out with gallery concrete casting. Use of pre-fabricated concrete shall be encouraged for khettara rehabilitation works considering standardization of gallery and vertical shaft section.

(f) Materials

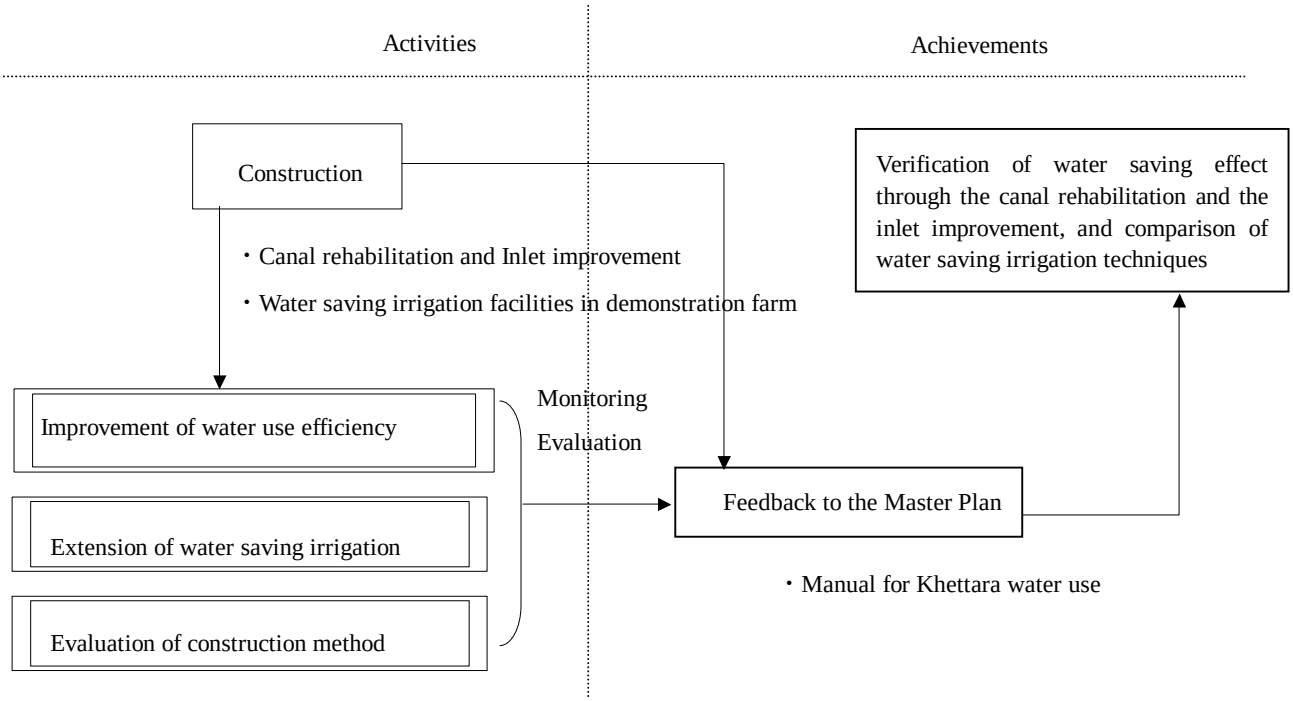
PVC pipe was proposed for two khettaras in the Verification study. PVC pipe was favorable because of its shorter installation time and economical advantage on material price compared to a concrete. The following conditions are examined for its use:

- Since the standard length of PVC pipe is 6.0 m, they does not suit to the galleries which have several bends in short extent.
- Some devices to flush out sediment in the pipe are necessary because sediment flow into pipe is inevitable. Opening with interval of around 20 m is proposed for this purpose.
- Small diameter pipe (e.g. less than 100 mm) requires large head difference between entrance

and outlet portions because of higher friction loss of pipe flow. Khettara, which has relatively steeper profile, shall be appropriate for small pipe installation.

6.5.3 Water Use

	Verification components
1)	Minimization of water conveyance loss on irrigation canal
2)	Evaluation on the construction methods for irrigation canal rehabilitation
3)	Demonstration and comparison of water saving irrigation techniques



(1) Minimization of water conveyance loss on irrigation canal

1) Outcome of the study

Master plan describes that minimizing water conveyance loss, which is achieved by lining existing earthen canal and improving inlet structure, leads to an increase the amount of available irrigation water amount and an expansion of cultivable farmland. In order to verify above-mentioned effects, rehabilitation works were implemented targeting on the main canals of three khettaras, Ait Ben Omar, Lambarkia and Taoumant. The effect of rehabilitation was evaluated based on water discharge measurement scheduled at before and after the rehabilitation works. Lining works of the earthen canal resulted in the reduction of water conveyance loss from 19 % to 8 % on average, consequently 11 % increase of water discharge. Improvement works of inlet structure also resulted in the reduction of water conveyance loss from 13 % to 6 % on average, consequently 7 % increase of water discharge.

Reduction of Water Loss by Canal Rehabilitation Works

Khettara	Canal name	Discharge without rehabilitation (lit/sec)				Discharge with rehabilitation (lit/sec)			
		Beginning point	End point	End point/ Beginning point		Beginning point	End point	End point/ Beginning point	
Ait Ben Omar	*Seguia Harch	7.8	6.4	82%	81% **(19%)**	7.3	6.6	90%	932% **(8%)**
Lambarkia	*Seguia Gauche	16.6	12.9	78%		19.9	18.5	93%	
	*Seguia Droite	17.4	14.3	82%		18.5	17.4	94%	
Ait Ben Omar	**Seguia Jdida	7.8	6.7	86%	88% **(13%)**	5.4	5.1	94%	94% **(6%)**
Taoumart	**Principal-1	2.8	2.5	89%		1.8	1.7	94%	

Notes: Percentages outside parentheses indicate the ratio of water discharge.
Percentages in parentheses indicate the ratio of water conveyance loss.

2) Feedback to the Master plan

The effectiveness and relevance of above-mentioned approach were confirmed through the Verification study. In the draft of Master plan, the increase of water discharge with canal rehabilitation was assumed at 5 %. Judging from the accomplishments of the Verification study, it could be concluded that water discharge increased 10% on the whole as shown in the table below.

The rehabilitation works were implemented on the main canals in Ait Ben Omar and Lambarkia. As a result, water flow was recovered at the farmlands devastated by desertification in above two khettaras and total 50 farmers restarted the cultivation of wheat and pasture. This fact ensures the target of 10 % increase of water discharge mentioned above.

It was concluded that main canal rehabilitation is not only an economical and quick-acting approach for the increase of available water discharge but also a reliable countermeasure against desertification.

Increase Rate of Water Discharge with the Rehabilitation Work

Classification of existing main canal	Rehabilitation work	Lenght ratio	Increase of water discharge	Result
Earthen canal	Canal lining	48%	19 % - 8 % = 11 %	0.48x11%+0.52x7% **- 10%**
Concrete canal	Inlet inprovement	52%	13 % - 6 % = 7%	

(2) Evaluation on the construction methods for irrigation canal rehabilitation

1) Outcome of the study

In the Verification study, design and construction method for the canal rehabilitation were reviewed from the viewpoints of construction cost, durability, and workability as well as operation and maintenance.

Four types of irrigation canal (rectangular canal, trapezoid canal, box culvert canal, and PVC pipe) and two types of inlet (simple steel gate and PVC pipe) were experimentally constructed in order to verify their adaptability for Khettara irrigation area.

Final Valuation on the Construction Methods for Irrigation Canal Rehabilitation

Classification	Method	Final evaluation	Construction cost
Irrigation canal lining	Rectangular canal	- Applicable at the site where soil accumulation is not so much. - Easy maintenance and reduction of maintenance burden.	B=0.4m×H0.4m 336DH/m
	Trapezoid canal	- Cheaper construction cost than rectangular canal type. - Applicable site is specified due to the limitation on construction method and canal structure. - Width of canal bed is kept more than 0.25m taking account of easy maintenance.	B=0.2-0.7m×H0.4m 201DH/m
	Box culvert canal	- Applicable in sand dune area because cover helps to prevent the canal from sand accumulation. - Construction cost is highest.	B=0.4m×H0.4m 454DH/m
	PVC pipe	- Applicable in sand dune area because concrete cover prevents the canal from sand accumulation. - Construction cost is not so high. - PVC pipe is favorable on quality due to pre-fabricated product. - To eliminate the accumulated sand, sand entrapped manholes must be installed at the interval of 30m or less.	PVC D=250mm 211DH/m
Inlet Improvement	Simple steel gate	- Complete waterproof is not guaranteed without additional soil. - Defects on waterproof and handling should be improved.	B=0.4m×H0.4m 184DH/site
	PVC pipe	- High evaluation is given to PVC pipe type because of the advantages in cost, waterproof, and handling. - Applicable in the canal where water discharge is 5 lit/sec or less. Furthermore, application to the canal with 5 lit/sec or more should be examined for the extension of this type.	PVC D=160mm 117DH/site

2) Feedback to the Master plan

Based on the final evaluation of each construction method for the canal rehabilitation, rectangular canal type is recommended to general section, and box culvert canal or PVC pipe is recommended to sand dune area. Concerning on the inlet improvement, PVC pipe is recommended due to the advantages of high water proof and easy handling.

The construction cost for the canal rehabilitation was reviewed with the data obtained by the actual rehabilitation work in the Verification study and following costs are applied to the economic analysis in the Master plan.

Canal lining construction cost: (336x50%+201x15%+454x10%+211x25%)=290 DH/m

Inlet improvement construction cost: (184x50%+117x50%)DH/site / 30m＝5 DH/m

(3) Demonstration and comparison of water saving irrigation techniques

1) Outcome of the study

Water saving on farm level is also important in order to enhance effective water use. Four types of irrigation method and on-farm reservoir were verified in terms of water saving and water management through actual farming practice. For this purpose, three demonstration farms established in Ait Ben Omar, Lambarkia, and Taoumart.

Irrigation method and on-farm reservoir

1) Basin irrigation without on-farm reservoir
2) Furrow irrigation without on-farm reservoir
3) Furrow irrigation with on-farm reservoir
4) Drip irrigation with on-farm reservoir

Cultivation stage and crops

1) 1st stage (from October 2004 to January 2005): carrot, turnip
2) 2nd stage (from April 2005 to July 2005): melon, water melon, tomato, gumbo

Irrigation Methods and On-Farm Reservoir

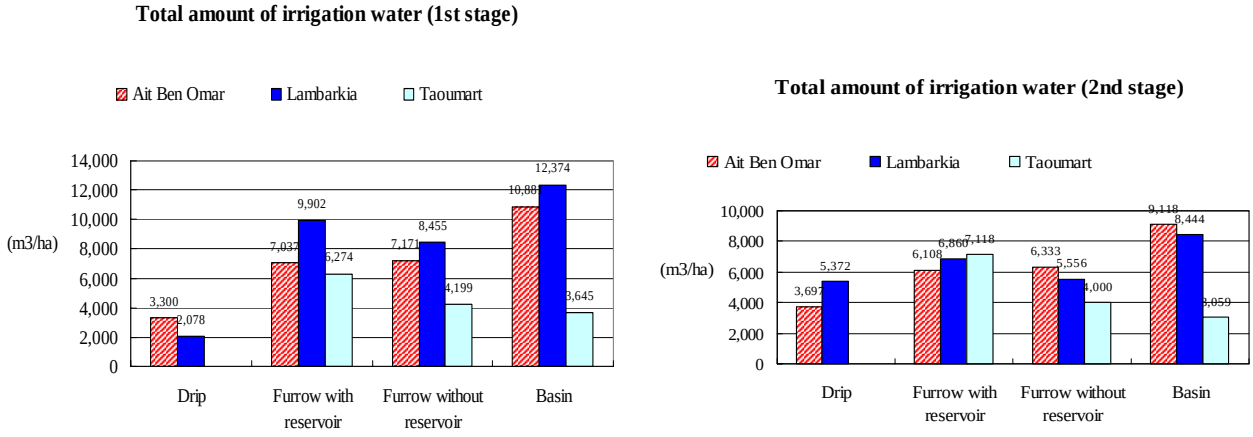
Traditional irrigation method	Basin irrigation without reservoir	Prevailing irrigation method. Low irrigation efficiency.
Water saving irrigation methods	Furrow irrigation without reservoir	More water saving technique than basin irrigation because impoundment is limited to partial area.
	Furrow irrigation with reservoir	To keep the optimum soil moisture content by shortening irrigation intervals with on-farm reservoir.
	Drip irrigation with reservoir	Most water saving irrigation technique. For the operation, on-farm reservoir and drip equipment must is equipped.

Water consumption was estimated based on the monitoring record which was collected in three demonstration farms. Total water consumption (m^3/ha) during 1st stage and 2nd stage is expressed by each irrigation method in the figures below. On the average of both stages, water consumption ratio of drip irrigation to basin irrigation is 38 %, and water consumption ratio of furrow irrigation to basin irrigation is 70 %. The result indicates that drip irrigation has a remarkable effect on water saving and

furrow irrigation is also categorized into water saving irrigation technique.

The verification study gave the technical endorsement that drip irrigation can be applied in khettara irrigation area, which is characterized by rotation irrigation system based on traditional water right.

Meanwhile, it was observed that traditional water right had flexibility in a certain range. The effectiveness of on-farm reservoir was confirmed by the fact-finding that crop growth in furrow irrigation plot with reservoir showed better yields than in furrow irrigation plot without reservoir during 2nd stage with high evapo-transpiration.



Irrigation Water Consumption in Demonstration Farms

Left: 1st stage / Right: 2nd stage

2) Feedback to the Master plan

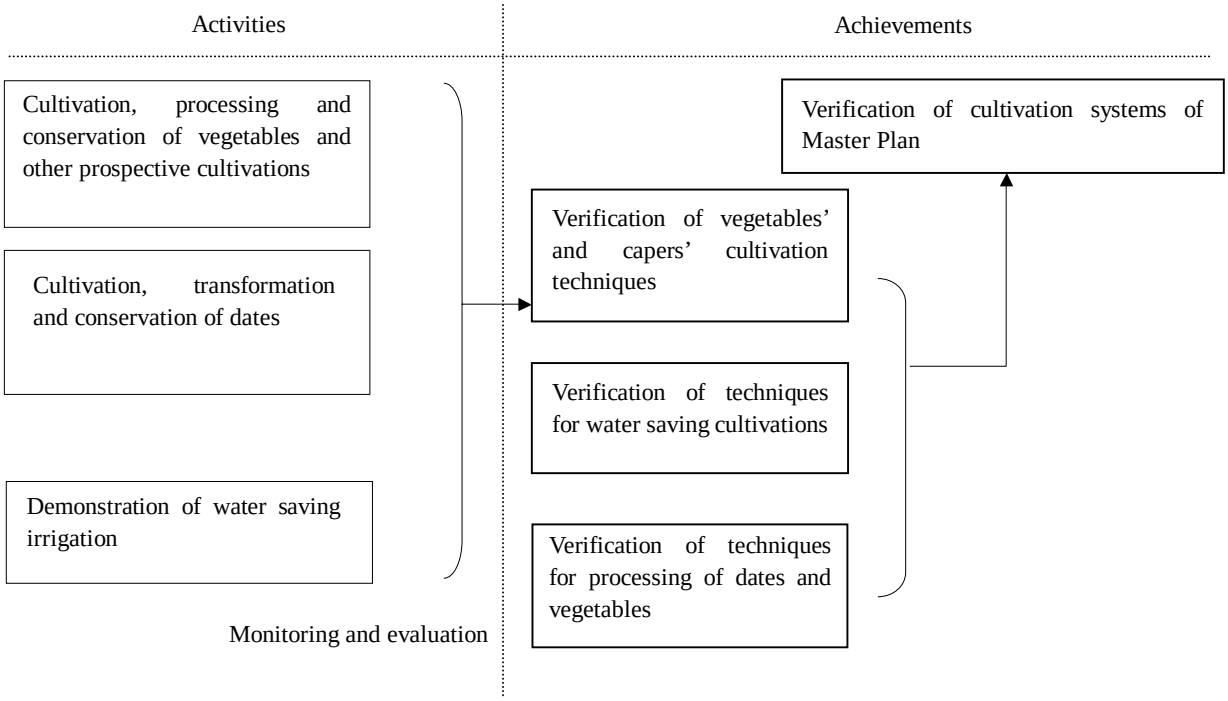
It is obvious that drip irrigation technique is a drastic water saving approach on farm level in khettara irrigation area as well as in other irrigation area. The Verification study furthermore shows other advantages of drip irrigation such as quality improvement of the products due to optimum soil moisture control and mitigation of irrigation labor and so forth. The study tours and seminars were held several times in order to extend the accomplishments of the demonstration farms. The participants showed their high interest in water saving techniques especially drip irrigation.

This was the first project for drip irrigation technique to be applied to the khettara irrigation area. For further extension, the following issues should be discussed, 1) scattered small farm lands, 2) traditional water right, 3) high initial cost, 4) application procedure of the subsidy for drip irrigation project.

Meanwhile farmers also understood the advantages of furrow irrigation technique in terms of water saving effect and low initial cost. Accordingly, demonstration farmers tried to spread furrow irrigation technique to their own farm lands on their initiative. Furrow irrigation technique combined with on-farm reservoir is recommendable to khettara irrigation area because this combination is more economical water saving approach than drip irrigation.

6.5.4 Agriculture and Extension Services

	Verification components
1)	Demonstration of vegetables and other prospective cultivations
2)	Selection, processing and conservation of vegetables and other prospective cultivations
3)	Dates processing
4)	Study tours



(1) Demonstration of high valued crop cultivation

1) Outcome of the study

It is clear that to utilize the water more efficiently is necessary for the individual farm, so a demonstration farm was installed at 3 khettaras communities (Ait Ben Omar, Lambarkia,Taoumart). The demonstration farm includes cultivations of turnips and carrots in the first season (October 2004 to January 2005), and cultivations of melons, water melons, tomatoes, and gombos in the second season (April to July 2005). That served for the comparison of 4 types of water saving irrigation and for the verification of the results of the water management with the reservoirs within the farm.

Objectives Achieved for Each Zone

Khettara	Irrigation method	Objectives achieved		
		Planned efficiency	B/C	Farmers' interest
			>1.1	Higher than50%
Ait Ben Omar (Tinejdad)	Drip irrigation	Achieved	Not achieved	Achieved
	Fallow Irrigation with Reservoir	Not achieved	Not achieved	Not achieved
	Fallow Irrigation without Reservoir	Not achieved	Not achieved	Not achieved
	Basin Irrigation	Achieved	Achieved	Not achieved
Lambarkia (Jorf)	Drip irrigation	Achieved	Achieved	Achieved
	Fallow Irrigation with Reservoir	Achieved	Achieved	Not achieved
	Fallow Irrigation without Reservoir	Achieved	Achieved	Not achieved
	Basin Irrigation	Achieved	Achieved	Not achieved
Taoumart (Alnif)	Fallow Irrigation with Reservoir	Achieved	Achieved	Achieved
	Fallow Irrigation without Reservoir	Achieved	Achieved	Not achieved
	Basin Irrigation	Achieved	Achieved	Not achieved

2) Feedback to the Master plan

The results of the Verification study prove that it is technically and financially possible to introduce the water saving irrigation for the cultivations of the vegetables in the study area and the farmers support this idea. The water saving irrigation is perfectly possible for the date palms cultivations such as Lambarkia, and there is a positive effect on the yields rendered by date palms. Therefore, the cultivation plan aiming at the increase of the areas of vegetables and applying water saving irrigation as proposed in the Master plan is fully adapted.

The development of the small demonstration farms and the study tours give farmers the opportunity to see and experiment with the new techniques. Those are good means of making farmers understand and appreciate those techniques, as well as to motivating farmers to undertake those techniques. Considering the financial charges of the demonstration farms and study tours, the Master plan recommends adding 2 experimental farms by year.

Otherwise, the Verification study proves that 1) farmers must be carefully selected because the results will be difficult to achieve in case farmers apply just the inefficient and traditional cultivation techniques (case of Ait Ben Omar), 2) it is necessary to study possibility of reducing the costs and re-dividing the lands because the investment costs for the installation of drip irrigation are high and it will be very difficult to achieve the appropriate benefits, 3) in the middle term, it is necessary to consider the extension of the

fallow irrigation, which is profitable from the financial point of view, and until now it has not been utilized in the area. The ORMVA/TF must study all those issues in the future.

(2) Demonstration of processing of agriculture products

1) Outcome of the study

In the Study area, it is recommended to promote the products' processing in order to increase their value and to achieve better revenue from agriculture. It is also recommended that in case of the dates' processing, the work load for women should be reduced. The demonstrations of the mechanical processing of dates, henna, gombos were organized for the groups of farmers under the technical supervision of the ORMVA/TF, in order to verify the technical and financial aspects of the products' conservation.

Objectives Achieved for Each Zone

Ksar	Processed products	Finished product	B/C	Willingness to continue
Objectives		Confirmed by demonstration	Superior to 1.0	More than 50% of participants
Beni Ouzième	Dates	Yes	Achieved	Achieved
Ait Moulay Lmamoune	Dates	Yes	Not achieved	Achieved
Taoumart	Henna	Yes	Achieved	Achieved
Sifa	Gombo	Yes	Not achieved	Achieved

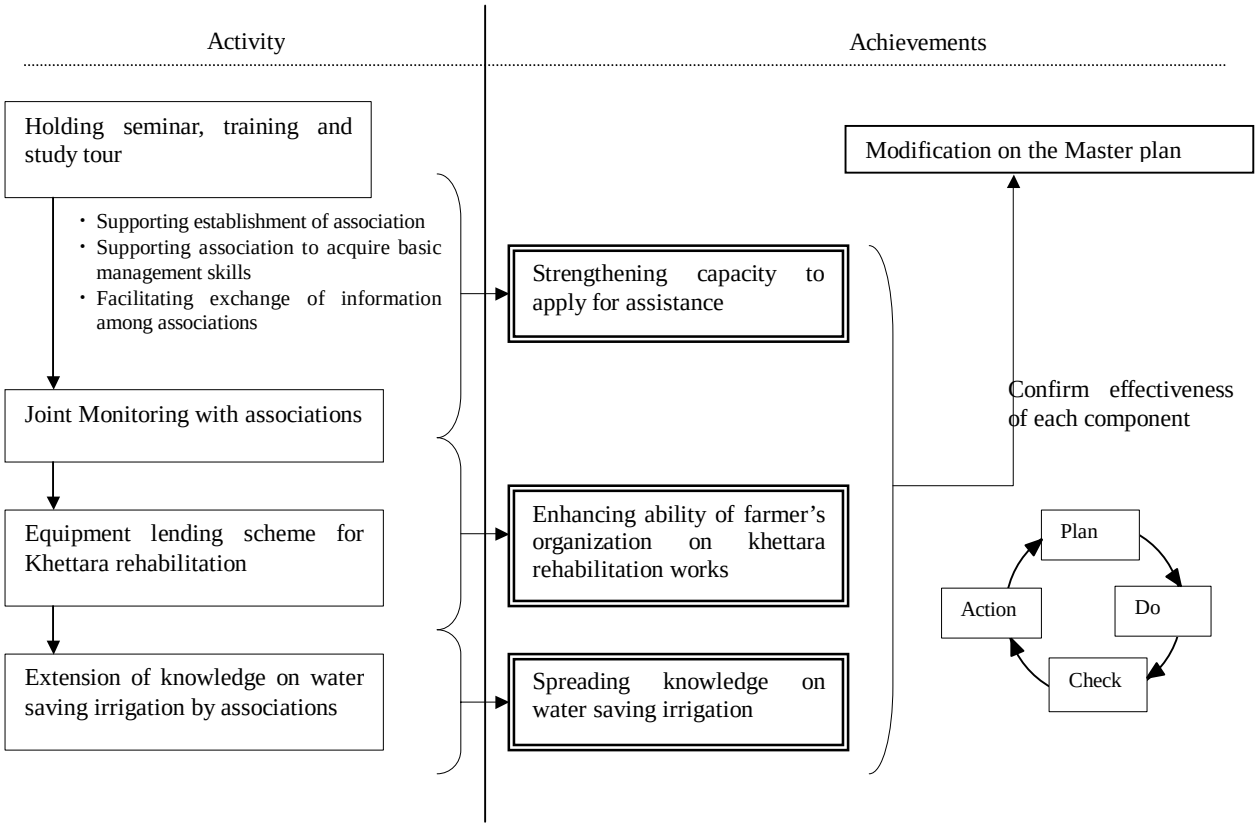
2) Feedback to the Master plan

The Verification study proved that the introduction of agriculture products' processing was technically possible and desired by the farmers. From the financial point of view, it is necessary to study at first the periods of introduction of dates processing machines and the demonstration zones (gombo processing) in order to increase and stabilize the benefits, provided that the production volumes are limited. Taking that approach into account, it was recommended to introduce utilization of machines from the financial point of view. The cultivation plan proposed in the Master plan, based on the cultivation of dates and vegetables, includes not only the issue of production increase, but also of combining the processing machines in order to increase the value added.

6.5.5 Organization Strengthening

Effectiveness of organization strengthening components proposed in the draft master plan was confirmed through the Verification study. Specific components are shown below.

	Verification components
1)	Facilitating establishment of association
2)	Training for association on basic knowledge and skills on association management
3)	Strengthening capacity of association for applying support from outside organizations
4)	Formulating monitoring system in cooperation with the ORMVA/TF, association and traditional khettara water user's organization
5)	Implementation of khettara rehabilitation work by association in cooperation with traditional khettara water user's organization（free equipment lending scheme）
6)	Spreading knowledge on water saving irrigation technique in cooperation with association
7)	Exchange of information and sharing knowledge and experience between associations

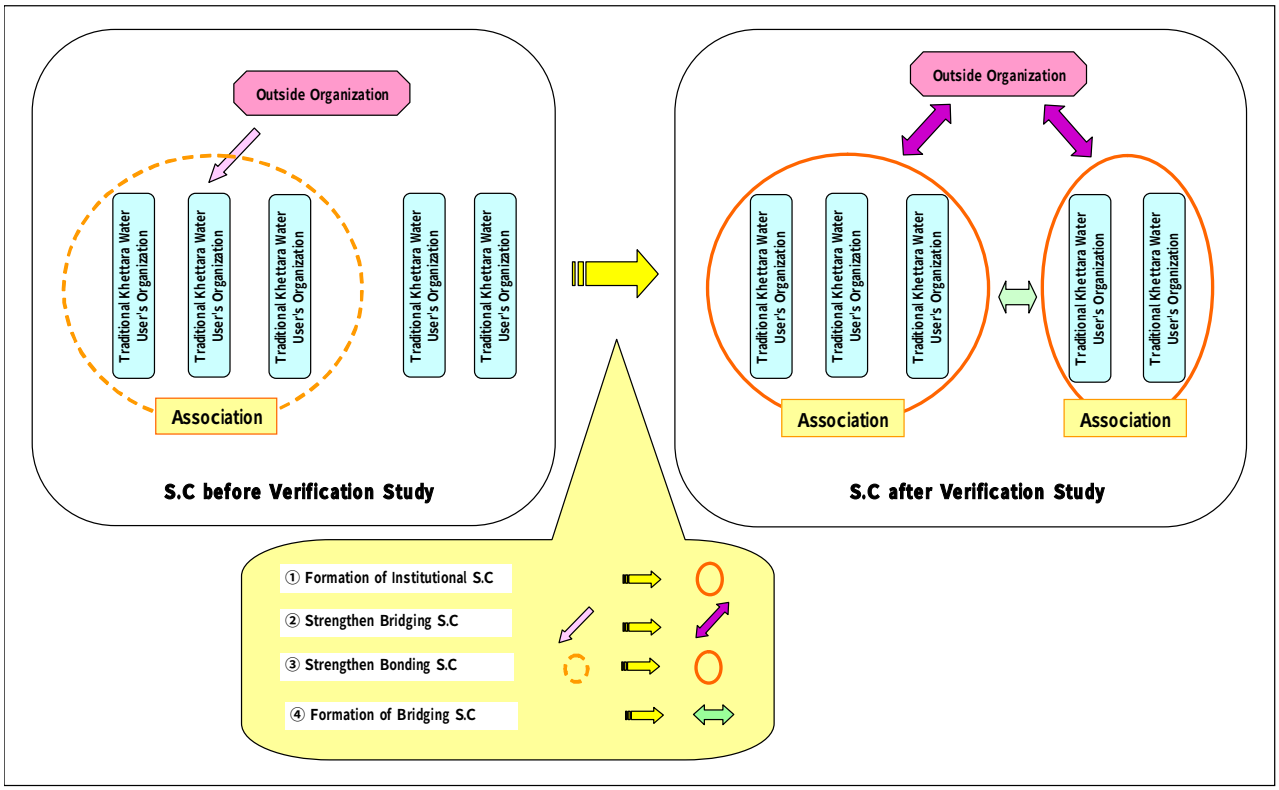


1) Outcome of the study

	Indicator for Output	Target	Achievement
1) Facilitating Establishment of Association	Activities carried out by traditional khettara water user's organization for establishing an association. （Number of meeting, consultation to outside organizations, preparation of documents, etc.）	More than 1/2 of traditional khettara water user's organization participated in seminar take action for establishing an association by July 2005. （Number of meeting, consultation to outside organization, preparation of documents, etc.）	100%
	Number of newly established association.	More than 1/3 of traditional khettara water user's organization participated in seminar establish associations by July 2005.	100% (17Ksars against 43 Ksars)
2) Training for Association	- Number of General Assembly held - Contents and quality of prepared documents including minute of meeting, activity report, and financial record.	More than 1/2 of associations participated in the training seminar hold general assembly and keep appropriate minutes of meeting, activity report and financial record according to a guideline provided by ODECO. （Except associations established within 1 year）	92% (12 against 1/2 of 26)
3) Strengthening Capacity of Association for Applying	Number of applications submitted to outside organizations for Khettara rehabilitation	More than 20% increase in the number of application submitted to outside organizations compared to the previous year.	100% (increased by 21%)
4) Joint Monitoring	Monitoring result by associations (period of monitoring activity, motoring results, difference from the plan）	Monitoring activities by associations are properly carried out following to the plan. When difference is observed, the cause is confirmed and countermeasures are considered.	100%
5) Implementation of Khettara Rehabilitation Work in cooperation with Association	Number of application submitted for the equipment lending scheme.	More than 8 applications are submitted from associations to ORMVA/TF by July 2005.	75% (6 applications)
	Number of realized project of rehabilitation	More than 5 projects of rehabilitation are realized by the new "Partnership" scheme by July 2005.	80% (4 Khettaras)
	Difference between rehabilitation plan and actual works (Work item and period)	Equipments are properly used according to original rehabilitation plan. (They should not be used for other purposes. Period of lending should not be extended without reasonable reason.)	100%
	Actual result of money collection by associations for operation of lent equipments.	All associations collect money from traditional khettara organization for covering expense on operation of equipments.	89% (100% for 1st Khettara, 67% for 2nd Khettara, 100% for 3rd Khettara)
6) Spreading Knowledge on Water Saving Irrigation	Actual activity by association (meeting, training and organized seminaries, etc.)	Associations located in 3 Ksars (Ait Ben Omar, Lambarkia, Taoumart), where verification studies on water saving irrigation are carried out, start any kind of activity for spreading knowledge on water saving irrigation, including seminar, technical guidance on farm land, meeting with ORMVA staff, etc.	100% (3 association out of 3)

	Indicator for Output	Target	Achievement
7) Exchange of Information between associations	Number of associations participating to the study tour.	More than 50% of association representatives concerned by this Verification study participate in the study tour.	100%
	Contribution (output) of study tours (change of attitude)	20% of associations participated in the tour starts applying new knowledge or technique obtained.	94% (7 out of 37 Associations)
	Development of information exchange between associations after the tours.	10% of associations participated in the tour start exchanging information with other associations by themselves.	246% (15 out of 37 Associations)

From the aspect of Social Capital (see Figure 6.5.1 for definition and classification of Social Capital), result of the Verification study can be overlooked as the diagram drawn below.



Social Capitals Formulated or Strengthened through the Verification Study

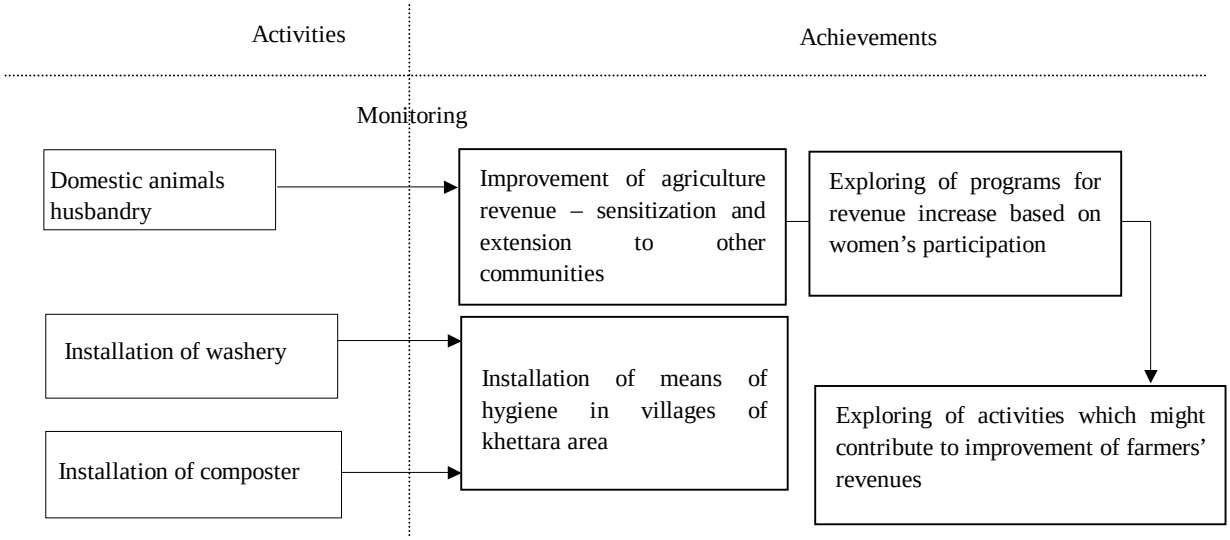
2) Feedback to the Master plan

Organization strengthening components proposed on the draft Master plan were tested on the Verification study. As a result, it is confirmed that Social Capitals effective for the future khettara rehabilitation works have been formulated and strenghtened as described above. Based on this, following organization strenghthening components are proposed to be implemented in accordance with the development stage on each zone.

- Continuous implementation of seminars on association establishment as well as the necesarry follow-up activities.
- Provision of training for newly establised assciations on basic association management.
- Active publication on institutional supports for the khettara rehabilitation work together with their application procedures.
- Implementation of joint monitoring system in cooperation with the ORMVA/TF, association and traditional Khettara water user's organization.
- Expansion of khettara rehabilitation works in cooperation with association and traditional Khettara water user's organization (making full use of equipment lending schems of the ORMVA/TF for khettara rehabilitation work).
- Cooperation with association on extension of water saving irrigation techniques.
- Continuous implementation of study tour among associations.

6.5.6 Improvement of Life Conditions

	Verification components
1)	Methods of aid for improvement and diversification of farmers' revenues
2)	Management of sanitary conditions of khettaras
3)	Hygiene control in villages



(1) Income generation activities

1) Outcome of the study

Agriculture is the main activity in the Study area. The profits should be increased by the diversification and exploration of new sources of revenues. In order to achieve that, the pigeons and rabbits keeping were proposed in this Verification study, and experimented from the technical and financial point of view. The results obtained in each zone are indicated below.

Results of the Verification Study

Animal husbandry	Zone	Achievements			
		Animal keeping	Animal sales	B/C	Willingness to continue
Objectives		Increase	Verification	＞1.0	＞70%
Rabbits	Tizougaghine, Goulmima	Achieved	Not achieved	Not achieved	Achieved
	Oukhite, Mellaab	Not achieved	Not achieved	Not achieved	Not achieved
	Jorf (Ouled Aissa, Ouled Moussa and Ouled Ghanem)	Not achieved	Not achieved	Not achieved	Achieved
	Dar Lbida, Rissani	Achieved	Not achieved	Not achieved	Achieved
	Boudenib	Almost achieved	Not achieved	Not achieved	Achieved
Pigeons	Boudenib	Not achieved	Not achieved	Not achieved	Achieved

2) Feedback to the Master plan

Rabbits and pigeons breeding were introduced between December 2004 and June 2005. The young rabbits born in January were all dead because of cold. For the following ones, the mortality rate was also very high because of the lack of proper care. Consequently, there were no sales and no benefits. As for the pigeons, the reproduction process still requires some more time. However, there is a positive tendency and the number of pigeons begins to increase since some time, which gives the farmers motivation for continuing.

Those results prove that there is a big degree of risk in finding new sources of revenue. Consequently, it is necessary to 1) find prospective sources of revenue, 2) introduce them on a small scale by the habitants, 3) improve the obtained experience with the verification, 4) expand the experience for the verification areas. Therefore, those results should be studied and introduced in the Master plan in the phase-wise manner, in the intermediate term perspective and not only in the short-term perspective.

(2) Management of sanitary conditions of khettaras

1) Outcome of the study

There is no washing place installed in khettaras and contaminated water after washing flows in the canals, and pollutes the agriculture waters. The project improved the washing place and sensitized the women on the subject in order to avoid washing water flowing back in the canals. The achieved results are indicated

in the following table.

Evaluation of Achievements

Areas	Achievements			
	Used washing water	Washing place	Respecting of rules for removal of used water	Prohibition of leaching out to canals
Objectifs	Reduction	Respected	Respected	Respected
Taoumart	Achieved	Achieved	Achieved	Achieved
Ait Ben Omar	Achieved	Achieved	Almost achieved	Achieved
Ait Moulay Lmamoune	Achieved	Achieved	Not achieved	Achieved

2) Feedback to the Master plan

The monitoring results of the hygiene management prove that the awareness campaigns concerning the quality of khettara water and related to the construction of washeries are well perceived and improve the conscience of the habitants. Therefore, in order to efficiently use the precious khettara water, the Master plan will have to consider actions combining improvement of washeries and improvement of water quality.

(3) Hygiene Management in khettaras communities

1) Outcome of the study

The livestock excrements and the garbage are found here and there in the khettaras villages, and those are causing a hygiene problem. The verification with the intermediary of associations, has allowed to implement the actions such as 1) installation of communal composters, 2) collection of separated non-recyclable garbage (plastics, etc.), and organization of information campaigns in that direction. The achieved results in each zone are indicated below.

Evaluation of Achievements

Sector	Achievements		
	Production of compost	Collection of non-recyclable garbage	Utilization of compost
Objectives	Launched	Respected	Over 10 m^3
Alnif	Achieved	Achieved	Not achieved
Bouya	Achieved	Achieved	Achieved
Ait Ben Omar	Achieved	Achieved	Achieved

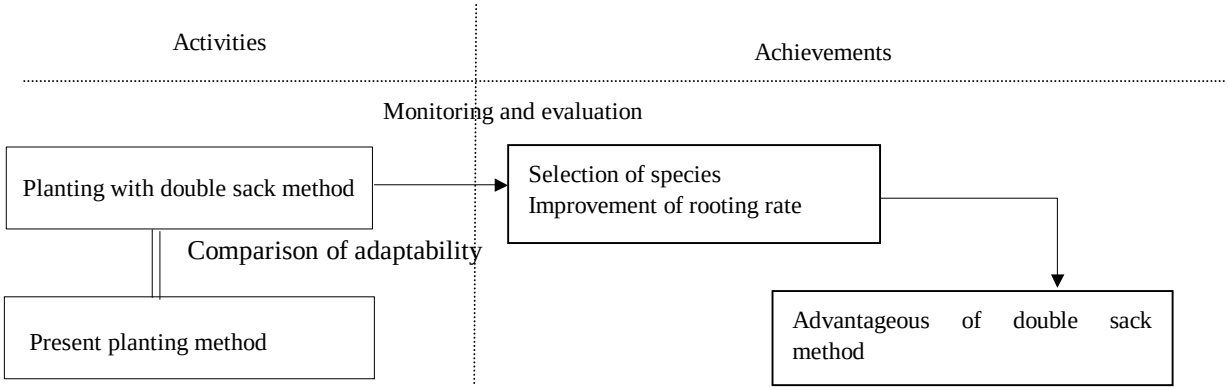
2) Feedback to the Master plan

Other than Alnif, all zones use more than 10 m^3 of compost for their farm, and the farmers involved appreciate it. It took time for Alnif, by June, to start generating compost. Consequently, if the composters are well managed, the hygiene of khettaras villages utilizing compost could be controlled by the associations.

The Verification study revealed the problem concerned with the group management. In case of Alnif and Bouya, the separation of compost materials (e.g. livestock excrements) and plastics was not well done. Through the discussion among stakeholders, it was proposed that one family should be responsible for the management of a composter, and they could use compost by priority. Implementation of the idea brought the appropriate separation and the stable production of compost. When the awareness campaign for environment and construction of composter are combined, it should be considered that 1) many composters are constructed and responsible families manage each of them, or 2) the management of composter is made by concerned families in turn to harmonize benefits of individual and community.

6.5.7 Prevention of Farmland Devastation

	Verification components
1)	Afforestation



(1) Outcome of the study

Adaptability of the planting by the double sack method was examined with comparison of present planting method. Total 200 nurseries have planted with both planting methods (Double sack method: 100 nurseries, present planting method: 100 nurseries). Two species were selected for the study, i.e., Tammarix and Atriplex. The following are indicators for monitoring and evaluation:

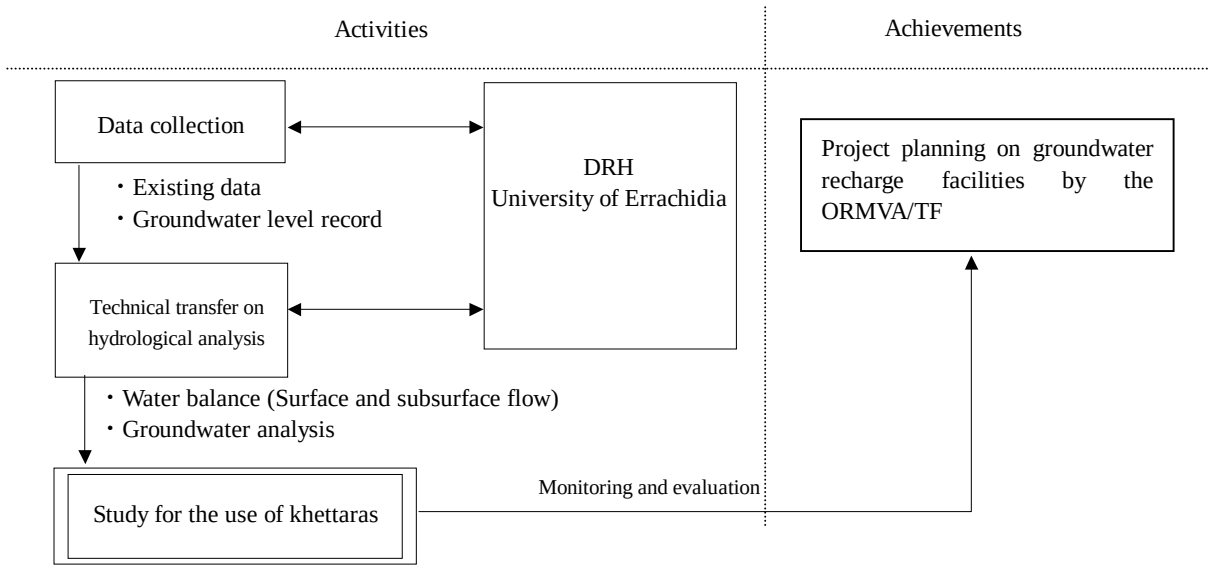
- Double sack method is advantageous on rooting.
- Roots grow even faster toward downward, and inhabitable in the arid area
- Both species are suitable for planting in the arid area

(2) Feedback to the Master plan

It is proposed to commence planting with double sack method from remote areas, such as Merzouga, Jorf (Fezna - Sifa), Tinejdad, etc. with making use of its characteristics, especially rooting. Double sack method is applicable to saline soil by the use of normal soil inside the sack.

6.5.8 Data Collection for Further Recharge Facility Planning

	Verification components
1)	Data collection of meteoro-hydrological
2)	Study for groundwater analysis



(1) Outcome of the study

1) Data collection of meteoro-hydrological and groundwater level records

Observation period and location of the stations are shown in Annexe A. The DRH and the ORMVA/TF are responsible for measurement of the meteoro-hydrological data. Although the DRH has suspended the measurement of the groundwater in the Tafilalet region, while the ORMVA/TF has been carrying out measurement of the groundwater level at particular well sites, such as common pump stations etc.

2) Survey for groundwater

Groundwater simulation model has developed in cooperation with the University of Errachidia aiming at technical transfer on the groundwater analysis. Details are shown on the manual in the report on technical transfer. The model is useful for 1) simulation of groundwater flow, specifying recharge area for the khettara, 2) analysis of necessary information for the planning of recharge pond, and diversion facilities.

(2) Feedback to the Master plan

The ORMVA/TF has seven (7) proposed plans related to the groundwater recharge. For project implementation of these plans, proposition of expected benefits, e.g., increase rate of khettara discharge or elevating rate of the groundwater level, in addition cost and benefit analysis shall be

verified in detail through an additional groundwater survey. In this regard, it is expected that a skill for groundwater analysis is improved by the ORMVA/TF.

It is expected that the ORMVA/TF starts to formulate the recharge facility plan for its implementation by utilizing information and knowledge on groundwater analysis obtained during the Verification study period.

Chapter 7 Establishment of the Project for Development of Rural Communities through Khettaras Rehabilitation

7.1 Establishment of the Basic Objectives of the Project

For the khettaras in the Study area, the irrigation water has decreased gradually because of the decline of ground water level, as a consequence of less rainfall, which is aggravating since 1980s. That has brought 50% decrease in the agriculture production other than vegetables during the last decade, and caused decrease of the incomes of rural households. Many farmers shifted to the pumping irrigation in uncontrolled and uncoordinated manner, and it caused further decline of the groundwater level. Moreover, the economic development is constrained by several natural factors, such as the severe environmental conditions and limited water resources. Therefore, according to the World Bank report (1998), the Tafilalet region has the highest rate of poor population in the whole Morocco.

The Ministry of Agriculture and Rural Development has presented "Strategy 2020 of the Rural Development" in December 1999 with the objective to alleviate poverty in the rural areas until 2020. This objective is taken as the highest priority in the Study area.

The fundamental objective of the present Project is to "stabilize and increase the revenues of the rural communities" with the consideration of the problems specific for the region and other regional programs. In order to realize the objective, two approaches are envisaged, one is to develop the external natural resources, which is rational use of underground water by maintaining or increasing of the khettaras discharge, and the other is the development for the initiatives of the ORMVA/TF and the farmers' organizations by strengthening of the implementation capacity.

7.2 Sustainable Development of Rural Communities of Khettaras

Within the 410 khettaras reported by present, the discharge was confirmed in around 190 khettaras, which presented about 47% of the total. Most of the cases have the discharge of lower than 5 lit/sec, which hardly responded to the water requirement. In order to attain the objective of stabilizing and increasing the revenues of the rural communities, it is necessary to increase the actual volume of khettara water and to utilize the water more effectively. It is difficult to rehabilitate the total of 410 khettaras during the short period due to financial limit, the phase-wise development is proposed based on the differences in the khettara discharge, as short-term (5 years), intermediate-term (6-10 years) and long-term (11-20 years).

Short-term scenario

The short-term scenario (5 years) includes the rehabilitation of khettaras and irrigation canals, formulation of the farmers organizations and improvement of the irrigation systems and farming practices (as khettaras with little discharge (less than 2 lit/sec) have smaller benefit to khettara rehabilitation cost, irrigation canal rehabilitation precedes khettara rehabilitation at those sites). It is essential to consider equity to have an opportunity to access to the khettara rehabilitation work to all khettara communities during project implementation, and also to realize project effect at earlier time. The ORMVA/TF will ensure the

monitoring and evaluation of the implementation of works, by effectively utilizing database prepared during the Verification study. That will facilitate to elaborate and implement the plan of khettara rehabilitation adapted to the local conditions. In parallel, the other studies will be undertaken for the conservation and development of groundwater, which will serve for elaborating of the sustainable development of water resources. The study includes facility planning of flood diversion, groundwater recharge and small scale retention basin. The construction of the small scale retention basin and recharge facilities will be studied as one of the possible resources for recharging for khettaras in the long-term. This plan is realized with proper monitoring and evaluation of the surface water and their recharge effects. Concerning the water resources development by the recharging facilities, it is necessary to take into consideration the progress of the Projects of the construction of 3 dams planned in the 5-Year Plan of the DRH, that is in charge of the study and the development planning for the water resources in the Tafilalet region. Concerning the irrigation and agriculture farming practices, the water saving irrigation is introduced in the khettara areas, based on the results of the Verification study and after having confirmed the economic potential of the region. From the organizational point of view, it is planned to strengthen the capacity of the water users organizations, in such a manner to empower them to be able to look for the external aid by themselves. Rural development components include to diversify the income generation activities and to develop the women's associations.

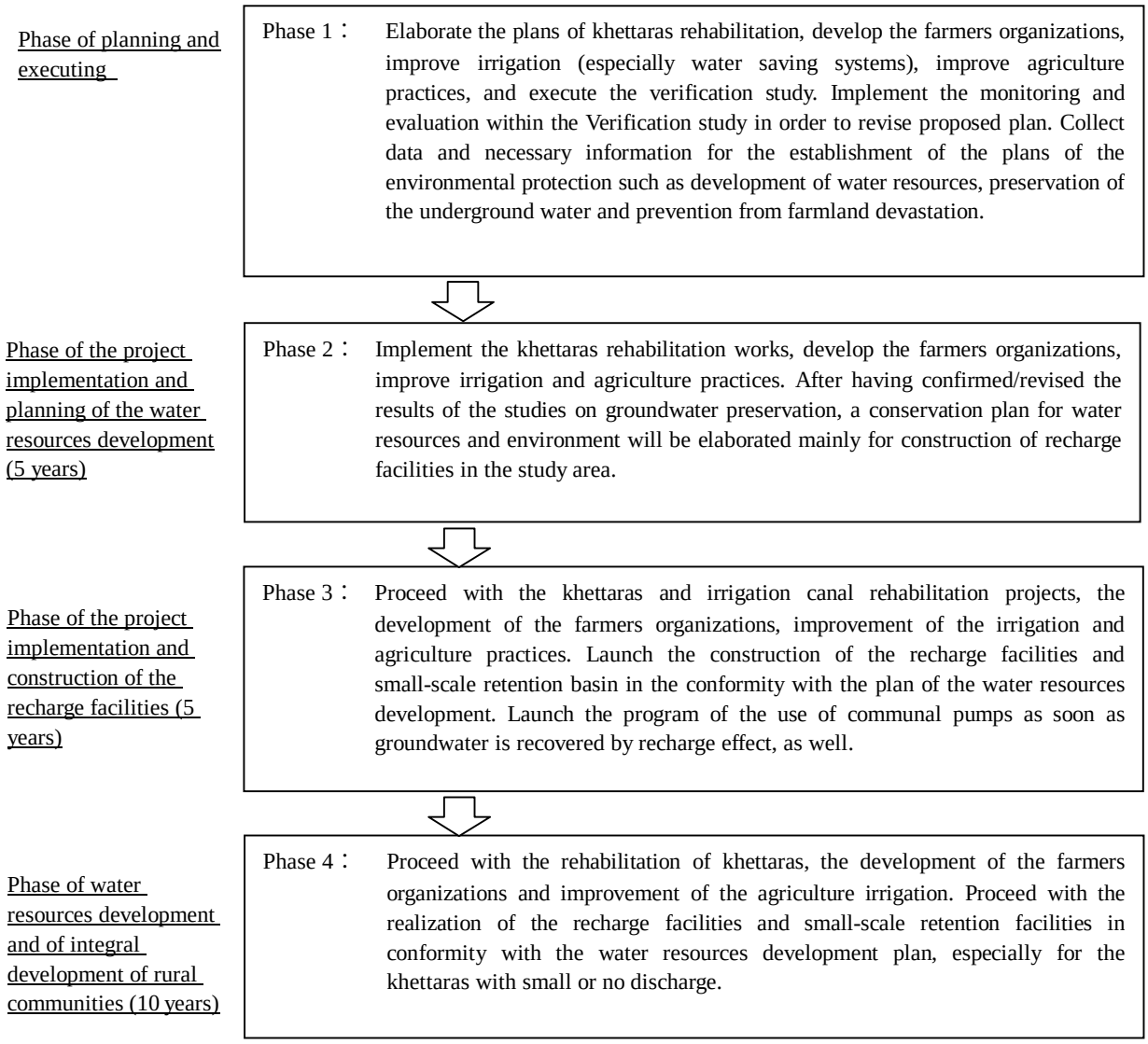
Intermediate-term scenario

The intermediate-term scenario (6 to 10 years) includes khettara rehabilitation work aiming at discharge increase and construction of the recharge and small-scale recharging facilities at the same time. The exploitation of the groundwater by pumping might be envisaged on the condition that the increase of the level of the underground water is confirmed by and after the realization of the recharge works for the groundwater. Communal pump is proposed from point of groundwater preservation. For the irrigation and the agriculture, the water saving irrigation system is introduced to the areas of khettaras with less discharge, and exploitation of the system in the target areas of the short-term scenario is proposed. In the organizational plan, it is planned to establish the collaboration system among khettara associations to reinforce the ability of whole associations. The income generation activities, planned in the short-term scenario, is spread to all rural communities to attain economic development of whole rural communities.

Long-term scenario

The long-term scenario (11 to 20 years) focuses on the rehabilitation of the khettaras those discharge is minimal or dried up at present. In principle, rehabilitation work is commenced as soon as khettara discharge is recovered by recharge effect, as well. With respect to irrigation, agriculture and organization, it is planned to extend the outcome on water saving irrigation and organization strengthening during the intermediate-term to the whole region.

Development Phasing of Khettara Rehabilitation and Rural Community Development Scheme



7.3 Project Phasing by Component

The following table presents classifications of the khettaras by discharge. As indicated in the paragraph 7.1, the timing of khettara rehabilitation is classified into three terms, as short-term, intermediate-term and long-term, according to their discharge.

Distribution of Khettara Discharges and Project Phasing

	Distribution of khettara discharge (number of locations)						
	20≦Q	10≦Q<20	5≦Q<10	2≦Q<5	0<Q<2	Q=0	Total
Zone A	1	3	25	26	25	57	137
Zone B	2	8	3	3	4	4	24
Zone C	1	3	3	1	0	0	8
Zone D	3	9	6	3	0	48	69
Zone E	2	2	0	7	3	11	25
Zone F	0	0	1	5	5	33	44
Zone G	0	2	2	9	24	66	103
Total	9 (2.2 %)	27 (6.6 %)	40 (9.8 %)	54 (13.2 %)	61 (14.9 %)	219 (53.4 %)	410 (100.0 %)
Phase of development	Short-term / intermediate-term (191)					Long-term (219)	

Khettaras are rehabilitated according to the phase of development as explained above. However some khettaras have urgent needs for rehabilitation because they are the major source of potable water or there is no alternative water source in the area. In those areas, implementation of khettara rehabilitation and other components should be considered within the period of the short-term. Irrigation facility rehabilitation should be implemented in the short-term due to the high cost-benefit performance by rehabilitation works. Extension of institutional strengthening and agricultural technology/ water management (dissemination of water saving irrigation) is planned through the activities for farmers group strengthening, mainly in the ORMVA/TF's management area. As for recharge facilities, the geo-hydrological examination is conducted at first as a basic survey, then the validity of the project (recharging effect) is studied. The facilities are constructed after the effect is confirmed.

Project Components in Respective Phase Related to the Khettaras Rehabilitation

Term		Short-term (5 years)	Mid-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*1	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 %*2, 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 send 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)

Note) *1: See chapter 7.5 for the rate of rehabilitation.
*2: Minimum 5% of extension rate of the drip irrigation is scheduled. It is possible to target this rate to 10% within 10 years.

Concerning the 1) installation of the social infrastructures (water supply, electrification, roads, schools and sanitary facilities), 2) income generating projects, 3) improvement of farms' agriculture practices (other than water saving irrigation), and 4) prevention from farmland devastation (Afforestation), it is proposed that they should be implemented differently from phasing program of khettara rehabilitation works, because these are not directly linked to the khettara rehabilitation works, and these works are to be

implemented in whole areas. The components of the gradual development other than the khettara rehabilitation are indicated in the following table.

Project Components in Respective Phase Not-Related to the Khettaras Rehabilitation

Term		Short-term (5 years)	Mid-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 whose 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 social infrastructures is ensured by other organizations other than the ORMVA/TF.

The detailed scheme of the components of the Master plan of the phase-wise development is presented in the Figures 7.3.1 and 7.3.2.

7.4 Role of ORMVA/TF and Interested Parties

7.4.1 Role for the Khettaras Rehabilitation and Works for Rural Development

(1) ORMVA/TF

The ORMVA/TF is the organization in charge of implementation of the Project of khettara rehabilitation and rural community development. It has also the important role for management of the Project. For the Project management, the ORMVA/TF will have to: 1) revise the plan, 2) update data base of khettaras, 3) ensure the monitoring evaluation of the Project, 4) prepare budget, 5) strengthen working network, 6) accumulate the heritage and gained experiences. The following table presents the roles of the ORMVA/TF in each phase of the development.

Role of the ORMVA/TF in the Project

<table>
<tr><th colspan="2">Term</th><th>Short-term（5 years）</th><th>Mid-term （6 to 10 years）</th><th>Long-term（11 to 20 years）</th></tr>
<tr><td rowspan="6">Roles of ORMVA/TF</td><td>Revision of Master Plan</td><td>Revision of mid- and long-term plans</td><td>Revision of long-term plan</td><td>Revision as required</td></tr>
<tr><td>Update of khettaras database</td><td colspan="3">● Update of khettaras data base
● Revision of annual plan based on khettaras data base
● Data collection on groundwater survey</td></tr>
<tr><td>Monitoring and evaluation</td><td colspan="3">● Feed-back of the monitoring and evaluation results into the annual program
● Revision of annual program</td></tr>
<tr><td>Preparation of budget</td><td colspan="3">● 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</td></tr>
<tr><td>Network strengthening</td><td colspan="2">● Educating the associations through the project implementation
● Strengthening of collaboration with the associations</td><td>---</td></tr>
<tr><td>Knowledge management</td><td>Collecting foreign experiences in the field of khettaras and agriculture, etc.</td><td colspan="2">Information transfer to other local areas and abroad concerning khettaras rehabilitation and agriculture.</td></tr>
</table>

(2) Farmer’s organization

Farmers represented by traditional khettara water user’s organization will remain as the main actor for implementation of khettara rehabilitation and maintenance works. However, the traditional organization will be strengthened on its institutional aspect through establishment and registration of association, so that they would become able to receive assistance from outside organizations more smoothly.

Associations will support traditional khettara water user’s organization on their rehabilitation works through sending application to outside organization for assistance, management and coordination of rehabilitation works, and joint monitoring activity with the ORMVA/TF. Furthermore, association will support introduction and extension of water saving irrigation techniques to khettara communities in close cooperation with the ORMVA/TF.

Role of each party in development phases are shown in the table below.

Role of Each Party 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.		

*: Assuming that association originally established for khettara rehabilitation would expand its activity to be rural development association.

7.4.2 Management Plan of Maintenance of Khettaras and Irrigation Facilities

(1) Operation and maintenance (O&M) of khettaras

The O&M of khettaras and irrigation canals has been implemented with cost sharing or labor supply of users (traditional water right holders and khettara associations) according to the water right regulations. Such a system, being implemented conventionally, does not have problems in particular, so it will be kept. On the other hand, it is observed that droughts cause income decrease of farmers and lack of O&M cost cause smaller discharge in many khettara communities. The economical capacity for khettaras' O&M cost is very essential factor to make the communities survive.

The following are the problems of O&M for implementation of khettara rehabilitation from now on.

1) Because of the budgetary constraints, the percentage of the rehabilitation realized in the short-and intermediate-term (10 years) of the khettaras is limited by the ceiling of 40% for the total length of the productive khettaras. Since sedimentation decreases in the rehabilitated sections, the least O&M work is required, while traditional O&M works by water users are required in the not rehabilitated sections.

2) Although khettaras rehabilitation will be implemented by the ORMVA/TF for 5 to 10 years, the difference of benefits between early rehabilitated khettaras and others may become large. The passage of time without any measures may affect survival of khettaras especially with little discharge.

3) It is planned that re-productive khettaras are rehabilitated after the effect of recharging facilities is

seen. If the O&M works such as sediment removal are not continued for the long time before rehabilitation work, the khettaras may have to be abandoned.

Among above, the most serious problem is the third one, the case that people give up O&M works. Khettaras with little or no discharge will be rehabilitated afterward, so their function is deteriorated year by year. The problem is observed in about 10 khettaras in Alnif. A little flood in continuous drought spell collapsed the side of gallery, but the damage has not been rehabilitated until now, after some years. So it is not possible to check its discharge at the exit of the gallery. As a possible countermeasure to keep the condition of khettara O&M at a certain level, the khettara communities, where rehabilitation works were finished, pay a certain amount of money as water fee, and the collected amount is used for O&M in khettara communities which are suffering economically. However, water fee has not been collected in Tafilalet by tradition, and the survey finds that khettara communities do not accept cost sharing for other khettara communities because of traditional water use custom and poverty of farmers in the villages.

Therefore the proposed khettara rehabilitation project does not consider the collection of water fee, and the present O&M system is maintained.

Rehabilitation and O&M System of Khettaras and Irrigation Facilities

O&M Works	Responsible Organization
1) Rehabilitation of khettaras and irrigation canals	ORMVA/TF and local government Implementation of rehabilitation work (Including providing project cost or material)
2) O&M of khettaras and irrigation canals	Khettara users and association members Providing labor according to water use custom, cost sharing or budget creation by water right lending

(Reference)

Although the ORMVA/TF has been rehabilitated khettaras by internal budget and external loans since its establishment, the share of beneficiaries (khettara water right holders) has been always granted, except beneficiaries group shoulder rehabilitation cost or labor works, as shown below. This is a result of preferential treatment for the area to create agricultural employment in arid desert area of Tafilalet and to minimize outflow of rural population.

Share on Labor Work by Water Right Holders Groups

Sponsor	No. of Rehabilitated Khettara	Type of Work	Cost (‘000 DH)	Share Rate (%)
IFAD	43	by ORMVA/TF	10,610	66
IFAD	11	Free material, groups shouldered labor	1,300	8
BID	8	by ORMVA/TF	4,177	26
Total	62		16,087	100

IFAD : International Fund for Agricultural Development
BID : Islamic Development Bank

7.5 Rehabilitation of Khettaras

7.5.1 Objectives of the Khettara Rehabilitation

Rehabilitation of the khettaras is mainly beneficial to 1) increase discharge, 2) reduce labor requirement for khettara rehabilitation, and 3) improve hygiene. Rehabilitation method is shown on Figure 7.5.1. The following points are considered for rehabilitation planning to maximize effect by the rehabilitation works.

- Selection of rehabilitation section (extents) based on the discharge measurement
- Standardization of gallery and shaft sections to economize the construction cost (e.g., use of pre-fabricated concrete)
- Prevention of sand inflow into gallery and protection from gallery wall collapse
- Improvement of construction supervisory works, quality control, safety control, especially working condition for tunnel works
- Material supply by the ORMVA/TF
- Replacement of decrepit khettaras (considering lifetime of concrete)

Proposed sections are shown on Figure 7.5.2.

(1) Increase of khettara discharge

The effect on water loss decrease of khettara discharge by the rehabilitation works is as follows:

The detailed discharge measurement indicates that a leakage loss from the khettara gallery varies by discharge. Measurement records are shown on Figure 7.5.3 with the classification of discharge amount of 10 lit/sec or more, 5 to 10 lit/sec and less than 2.0 lit/sec. From the discharge measurement, the leakage amount is estimated as follows.

Reduction Rate of Water Leakage by Rehabilitation Works

Present discharge: Q（lit/sec）	10≦Q	5≦Q<10	Q<5
Reduction of water leakage（lit/sec/km）	2.5	2.0	1.5

(2) Reduction of labor requirement for maintenance

Khettara rehabilitation work contributes to reduce labor requirement for maintenance. As shown in the table below, poor maintenance work also recently become one of the serious problems of decrease of the khettara discharge according to the inventory survey. Flood damages have occurred once a ten years frequency, however poor maintenance or repair work such as repair of gallery and shaft, removal of sediments have caused drying up or extremely decrease of the khettara discharge even after several years since floods had occurred. Decrease of the khettara discharge by flood damages are also considered as a poor maintenance, so the total of both damages by floods and poor maintenance occupies about 50 % of all factors.

Factors of Khettara Discharge Reduction

	No. of khettaras	Drought	Excessive pumpage	Flood damages	Poor maintenance	Desertification, leakage, others
Zone A	137	91	13	13	26	3
Zone B	24	20	0	1	5	4
Zone C	8	8	0	8	0	0
Zone D	69	68	14	34	32	6
Zone E	25	9	1	3	5	5
Zone F	44	35	9	10	39	7
Zone G	103	86	6	14	10	13
Total	410 (100.0 %)	317 (77 %)	43 (10 %)	83 (20 %)	117 (29 %)	38 (9 %)

Source: Khettara inventory survey (JICA, 2003)

Decrease of the agricultural productivity due to continuous drought has caused shortage of maintenance cost, and such a vicious circle, as decrease of farm income induces poor maintenance of the khettaras, becomes a serious problem in the khettara communities. It is necessary to reduce financial burden for khettara maintenance of farmers by implementing khettara rehabilitation works, and to secure stable farm income and improve living conditions of the farmers.

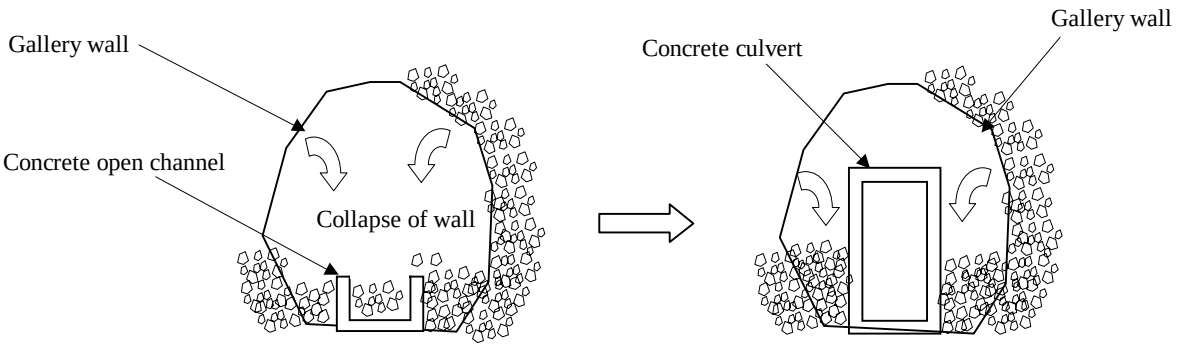
7.5.2 Scope of the Rehabilitation Works

In total length of 191 productive khettaras is 540.0 km, the ORMVA/TF and other governmental agencies have rehabilitated 55.1 km (10.2 %) and 22.3 km (4.1 %), respectively, and remaining 462.6 km is subject to the rehabilitation works.

Considering the rehabilitation purpose mentioned above, it is proposed to rehabilitate 30 % length of the total length of the khettaras. The following are the details:

Items	Descriptions
1) Reduction of leakage loss	Leakage is observed from 60 % section of the whole gallery on an average. It is proposed to select rehabilitation section from leakage section to maximize project benefit.
2) Longitudinal profile of khettara	Re-profiling work of the gallery is effective to increase khettara discharge. For this purpose, rehabilitation with concrete culvert (canal) is not applied to especially yield section.
3) Efficiency of investment	Considering a balance of whole budget and khettara rehabilitation budget of previous years of the ORMVA/TF, it is recommended to set rehabilitation length maximum 30 % of total length for effective expenditure of budget.
4) Equity for rehabilitation	Same rehabilitation rate is given for all khettaras considering equity to access to the khettara rehabilitation works.
Conclusion	Considering financial conditions and improvement of project efficiency of the khettara rehabilitation works, it is proposed to set rehabilitation length in 30 % of the total length. (Rehabilitation rate is 40 % in total including existing rehabilitation section.)

Concrete culvert is applicable to rehabilitation in principle to reduce labor requirement for the maintenance works.



Collapse of the gallery wall causes sediment accumulation in the gallery, thus rehabilitation work does not lead to lightening the maintenance work.

Culvert structure prevents from sediment deposits in the gallery, thus rehabilitation work lead to lightening the maintenance work.

(1) Reduction of leakage loss

Distribution of 30 khettara discharges observed in June, September 2003 and February 2004 is plotted on Figure 7.5.4. Figure 7.5.5 shows actual length in x-axis, and Figure 7.5.6 shows converted length to unit length of "1.0 (100%)" in x-axis in order to simply compare the rate of yield and leakage sections along each khettara gallery. In these figures, leakage pattern is categorizes into Category 1: Yield section is restricted in most upstream section, Category 2: Yield section is in upstream to mid-stream sections and Category 3: Yield section is along all gallery section.

With respect to the reduction of leakage loss, rehabilitation length is set to 60 % in maximum with the reasons below:

1) In Category 3, rehabilitation work aiming at reduction of a leakage loss is not necessary because higher groundwater level does not cause a leakage from a gallery base. Leakage pattern in Category 3 is observed at 5 khettaras (about 20 %) of whole 30 khettaras.

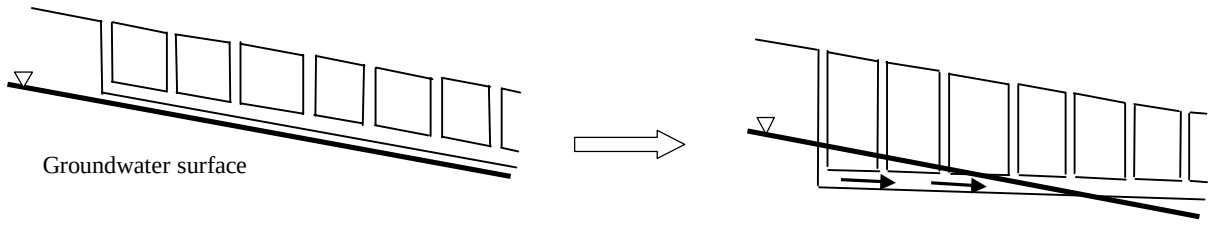
2) In Category 1, rehabilitation of whole gallery section maximizes rehabilitation effect of reducing a leakage loss. Leakage pattern in Category 1 is observed at 4 khettaras (about 10 %) of whole 30 khettaras.

3) In Category 2, a leakage is observed from 60 % of downstream section of a gallery, accordingly rehabilitation for this section maximizes rehabilitation effect of reducing a leakage loss. Leakage pattern in Category 2 is observed at 20 khettaras (about 70 %) of whole 30 khettaras.

4) Since number of khettara categorized in Categories 1 and 3 is few, rehabilitation length is proposed at 60 % in maximum (or 50 % excluding existing rehabilitated section).

(2) Longitudinal profile of khettara

As shown in Figure 7.5.1, it is possible to increase khettara flow if the khettara gallery is dug down below the water level (re-profiling). It is accordingly suggested that rehabilitation of upstream to midstream section with concrete structure is not applicable.



Re-profiling of galley (making longitudinal slope in gentle below groundwater surface) increases yield of groundwater.

(3) Efficiency of investment

Inventory survey indicates that a decrease of khettara discharge is also attributable to shortage of maintenance cost. It is therefore effective to rehabilitate the section that has large leakage loss and labor requirement due to geological and topographical constraints for maximizing investment efficiency.

The ORMVA/TF invested annual budget of about DH 5 million in recent 5 years from the fund sources of local and international organizations (IFAD, BID) for the khettara rehabilitation works, which was equivalent to about 8 % of the total annual budget of the ORMVA/TF. The ORMVA/TF is responsible for the project management and implementation of not only the khettara rehabilitation but construction and operation and maintenance of the flood diversion weirs and irrigation canal networks. Considering a balance of whole budget and khettara rehabilitation budget, it is recommended to select rehabilitation section in highly effective and profitable section from an economical point of view. Assuming that 10-year rehabilitation rate is 30 % (40 % including existing rehabilitated section of 10 %) of total khettara length, annual fund requirement is estimated at about DH30 million. In the case larger fund is disbursed to the khettara rehabilitation works, it causes unexpected delay of other project of the ORMVA/TF. In the study, it is recommended to set rehabilitation length in 30 % of total length, and periodically revise it in the course of the project.

(4) Equity for rehabilitation

It is not recommended to select economically advantageous khettara project because such a selection focusing on maximizing project benefits leaves weak communities in hazards such as collapse of community, farmland devastation, and finally allows desertification in the Study area. The rehabilitation work aims at increase of khettara flow and reduction of laborious maintenance work for all khettara communities on the basic policy that maintenance of the khettara flow is minimum requirement for sustainable khettara community development in whole Tafilalet region. In this regard, same rehabilitation rate is given for all 191 khettaras during short and intermediate term

7.6 Water Use

7.6.1 Basic Policy for Khettara Water Use

The objective of khettara water use plan is to create the rational water use system. That ensures the efficient utilization of water resource that is to be increased or stabilized through khettara rehabilitation works. To achieve this objective, following policies are proposed by each water use (potable, washing, livestock, and irrigation water) without change of present water right system.

1) Effective utilization of khettara water resource shall be encouraged by improving water use efficiency through the implementation of water saving measures in consideration of prevailing water management.

2) Potable use of khettara water shall be maintained in the villages where other water sources such as the ONEP is not available, and khettara water satisfies the quality criteria for potables.

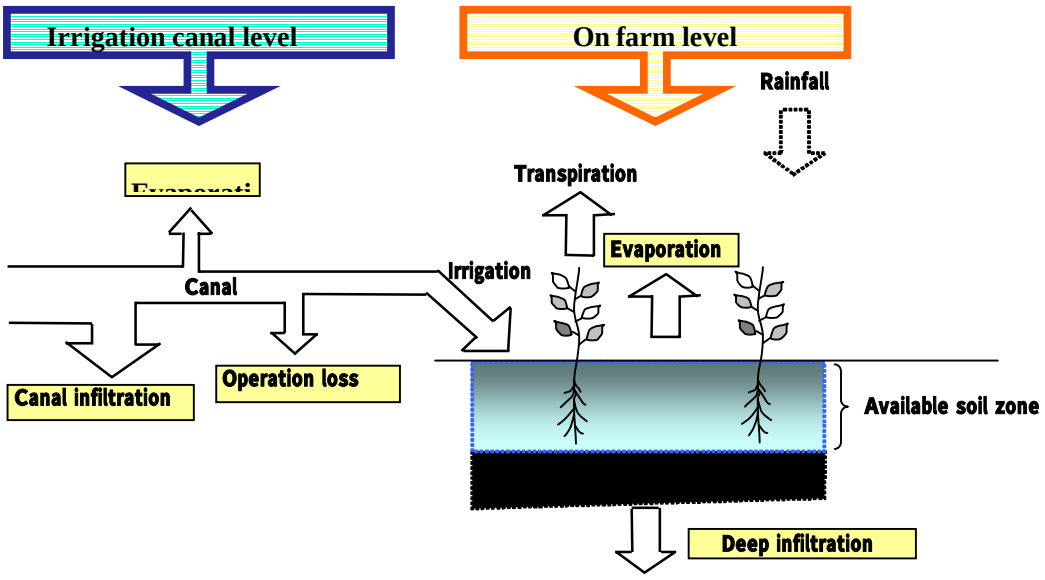
3) Concerning washery use of khettara water, the projects for washing place improvement shall be promoted in order to prevent the contamination of irrigation water.

4) Water use for the livestock shall be maintained as well.

7.6.2 Water Saving Measures

In water use plan mentioned above, effective utilization of the irrigation water is essential because the most amount of khettara water is consumed for irrigation purpose.

Water saving measure is divided into irrigation canal level and on farm level as shown in the concept chart of water balance on khettara irrigation system illustrated below:



Concept Chart on Water Balance of Khettara Irrigation System

(1) Implementation of the rehabilitation project of irrigation canal network（Irrigation canal level）

Reduction of infiltration loss and operation loss on irrigation canal network directly leads to improving water use efficiency and increasing available water amount. The Verification study proved that implementation of the rehabilitation work targeting on the main canals was a reliable and quick-acting water saving approach.

Accordingly, the rehabilitation work of main canals in 191 Khettaras is proposed as one of major project components in the Master plan. To attain the effect at an early stage, this component is scheduled to be completed in the short term (5 years). Following are the contents of this component:

1) Lining of earthen canal to reduce the infiltration loss (L=116km)

2) Inlet improvement of concrete canal to reduce the infiltration loss and operation losses (L=127km)

(2) Extension of water saving irrigation techniques and improvement of on farm water management (on farm level)

Final evaluation on the Verification study is concluded as follows: 1) drip irrigation technique is a drastic water saving measure, 2) furrow irrigation method is also recognized as a water saving technique, 3) installation of on-farm reservoir is an efficient approach for creating proper water management.

Water saving on farm level indicates a new direction to accelerate water saving in khettara irrigation area. It is the first experience that water saving techniques of drip irrigation and furrow irrigation were applied in Khettara irrigation area. Namely, it might be said that water saving on farm level is in the initial stage in the study.

The Master plan therefore proposes the following target in the short and medium term (10 years). Water saving irrigation technique is expected to expand to 10 % of the total farmlands being benefited by khettara water. Following table gives the extension target of each irrigation technique, taking account of the initial cost of irrigation facilities and the financial situation of farmer's groups.

Extension Target of Water Saving Irrigation Technique

Irrigation technique	Contents	Extension target
Drip irrigation	Extension with formulating drip irrigation cooperative	*5%
Furrow irrigation	Extension furrow irrigation method with on farm reservoir	2.5%
	Extension furrow irrigation without on farm reservoir	2.5%
Total		10%

* Extension target of drip irrigation is determined referring to the extension target for Haouz Plain located in arid area same as Tafilalet area. It is possible to increase target rate of 10 % by actual progress during short and intermediate term (10 years).
Source; ORMVA/Haouz. (drip irrigation area 24,000 ha / total irrigable area 473,000 ha = 5 %)

7.6.3 Irrigation Water Requirement Plan

(1) Water requirement

Total water requirement is obtained by summing up the following three sorts of requirements: irrigation water, potable water including domestic water, and livestock water.

Irrigation water requirement was estimated based on the water consumption of each crop in consideration of the cropping pattern in khettara irrigation area. Various methods are proposed for the estimation of reference evapo-transpiration (ETo) that is fundamental parameter of the water consumption. Blaney-Criddle method is commonly applied in Morocco because reference evapo-transpiration (ETo) can be estimated with temperature data, and Penman-Monteith equation is applicable when four sorts of meteorological data such as temperature, wind speed, humidity, and sun shine duration are available.

In the Master plan, Blaney-Criddle method is adopted because this method gives bigger value than Penman-Monteith equation.

Reference Evapo-Transpiration (ETo) Estimated by Blaney-Criddle Method (mm/day)

Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug
ETo (mm/day)	4.9	3.4	2.3	1.5	1.5	2.0	3.0	4.0	5.0	6.3	6.7	6.3

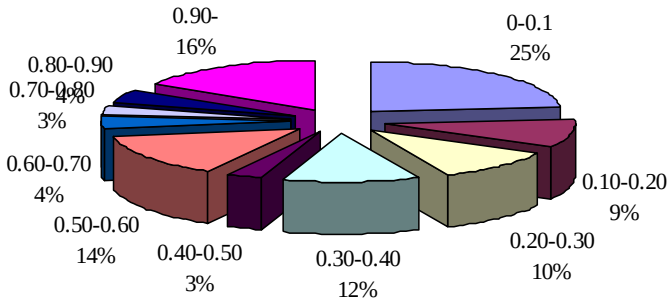
Meteorological data source: "ORMVA/TF SEMVA/Errachidia, 1982/83-2002/03"
Reference Manual: "Applications of Climatic Data for Effective Irrigation Planning" (FAO)

Water requirement for drinking and domestic use is calculated by multiplying the population of each village relying on Khettara by daily water consumption rate of 10 lit per person. This was given by a survey result conducted by the ONEP.
Water requirement for livestock is also calculated by multiplying average livestock number of one farmer's household by daily water consumption rate of each livestock. That is assumed as follows, 50 lit//day for one cattle, and 10 lit/day for one sheep or one goat. Average livestock number of one farmer's household is as follows, three head of cattle, eight head of sheep, and ten head of goat. That is based on the result of socio economic survey conducted by the Study team.

(2) Irrigable area

Water requirement can be calculated based on standard cropping patterns in the Khettara irrigation area. Figure 7.6.3 shows monthly water requirement (m^3/month/ha) of both present cropping pattern and proposed cropping pattern. As a result of this calculation, water requirement per unit irrigation area was obtained to be 0.4 lit/sec/ha on average.

Meanwhile, most of Khettaras does not satisfy with water requirement 0.4 lit/sec/ha mentioned above according to the figure below showing actual khettara discharge. 56% Khettaras have water discharge less than 0.4lit/sec/ha, and 34 % Khettaras have less than 0.2lit/sec/ha. In other words, one out of two Khettaras does not have enough water discharge, and one out of three khettaras does not have even half of the required water discharge 0.4 lit/sec/ha.



Khettara Water Discharge per hectare (lit/sec/ha)

Irrigable area of each khettara can be calculated from available water discharge on the premise that water requirement is 0.4lit/sac/ha. Available water discharge for irrigation use is obtained by deducting water requirement for potable and domestic water use, and livestock water use from khettara discharge.

In the Master plan, it is assumed that khettara discharge decreases by 20 % in 10 years in "without project condition". On the contrary, it is expected that khettara discharge increases by 10 % "with project condition". Based on this, total khettara discharge and irrigable area after 10 years are summarized in below table. Detail of each khettara is listed in Table 7.6.1.

Khettara Discharge and Irrigable Area "with" and "without" Project

Item	Present	After 10 years			
		Without project		With project	
Khettara discharge (lit/sec)	1,277	951	−326	1,533	+256
Irrigable are (ha)	3,012	2,378	−634	3,651	+639

7.7 Agriculture Development Plan

7.7.1 Agriculture Land Use Plan

For the formulation of the issues mentioned below, the cultivable areas for the case with and without rehabilitation are as follows:

(1) The cultivable lands are defined by the volumes of irrigation water in each khettara. Consequently, the actually cultivated areas of each zone irrigated by khettara are estimated based on the volume of irrigation water by khettara, the rate of efficiency of this irrigation and the system of the actual cultivation.

(2) If the rehabilitation works are not implemented, the maintenance of khettaras and canals will not be sufficient, and supply of irrigation water will decrease, meaning that the cultivated areas will also decrease by 20% in the 10 years.

(3) According to the inventory study, the agriculture areas (comprising non-cultivated lands) are of

6,600 ha, which is much more than the actually cultivated area of 3,012 ha. Consequently, it is necessary to utilize the non-cultivated lands by applying more efficient use of irrigation water.

(4) If the works are implemented, the water volumes supplied for irrigation will increase. That increase will be the result of the rehabilitation of khettaras and canals, and introduction of water saving irrigation. The additional areas brought by increase of irrigation water were calculated. The comparison is indicated in the following table.

Estimates of Cultivated Area "with" and "without" Project

Zones	Area actually cultivated by irrigation by khettara water	Cultivated area Case without Project	Cultivated area Case with Project
Zone A	922	728	1,082
Zone B	552	442	625
Zone C	249	196	309
Zone D	770	611	964
Zone E	269	210	353
Zone F	58	44	79
Zone G	192	147	239
TOTAL	3,012	2,378	3,651

7.7.2 Selection of Cultivations and Planned Cultivations System

The systems of cultivations was studied in case that works were implemented, assuming that the actual system of cultivations was kept. The irrigation water is extremely precious in the khettaras areas and the economic efficiency of the water is the priority for defining of the system of planned cultivation. Calculation was made for the unit water requirements by cultivation and the profitability by unit of water based on the benefits by hectare.

Profitability by Agriculture Product

		Wheat	Vegetables	Legumes	Alfalfa	Dates
Water needs by ha	M^3/ha	4 600	6 100	9 500	23 900	13 300
Benefit by ha	DH/ha	4 140	35 100	7 200	6 590	53 300
Profitability by m^3	DH/M^3	0,9	5,75	0,76	0,28	4,01

Note : For benefits by ha for the case with Project, see part 7.7.4 . For unit volumes, see part 7.6.

It turns out that the vegetables are the most profitable products from the view point of water economy. Therefore it is recommended to use the half of the area increased by the rehabilitation for the vegetables. The other half of the increased area could be used for the highly profitable cultivation of dates, which is strongly desired by the farmers. Since it is necessary to wait for 7 years before a date palm gives yield, the mixed cultivations are introduced. The mixed cultivations of dates and vegetables mentioned above are

definitely not efficient from the view point of water economy. However, the combination with the cultivation of alfalfa is recommended to maintain the level of soil fertility substances and to contribute to supply of fodder, which is now lacking for the livestock. The changes in the system of cultivation with the Project comparing to the actual system are indicated in Figures 7.7.1 and 7.7.2, which can be summarized as follows:

Changes in Cultivation System

Cultivation	Actual percentage	Percentage in case with Project (in 6 years)	Percentage in case with Project (7th year and beyond)
Wheat and cereals	62%	51%	51%
Vegetables (August to December)	6%	14%	14%
Vegetables and legumes (May to July)	3%	7%	7%
Alfa-alfa and other fodders	17%	23%	14%
Dates and fruit trees	15%	12%	21%
Total	103%	107%	107%

7.7.3 Planned Exploitation Techniques

Within the planned cultivation system, the vegetable cultivation should be profitable through cultivating vegetables intensively with the introduction of the water saving irrigation. The rehabilitation of irrigation canals, introduction of water saving irrigation and improvement of water management techniques contribute to reduction of risks related to the actual water supply. The water management, soils fertility, maintaining of soils productivity, efficient use of the manpower, production and administration of profitable cultivations are the main challenges of the agriculture holdings. The realization of works must allow for the extension of the cultivations and exploitation techniques as follows:

1) Continuing and reinforcing of the water management for the cultivations under the responsibility of the associations of khettara water rights holders. No pump irrigation using the groundwater because of the risk of running over its potential.

2) Necessary turning to the cultivation of vegetables using water saving irrigation and cultivations with high value added. It is necessary to form highly motivated model-farms. The techniques of model-farms will be installed in the demonstration zones for the education purpose and will be managed by the farmers in order to be well disseminated later on.

3) Promotion and utilization of the fertilizers (garbage) which can be bought locally. Utilization of chemical fertilizers according to methods promoted by the ORMVA/TF.

4) Maintaining the rotations of legumes, pasturelands, and fallows for preserving the fertility of soils.

5) Sensitization for agriculture production oriented for profitability and extreme water-saving.

6) Technical and administrative support using the techniques of demonstration zones.

7.7.4 Crop Budget

Crop budgets were calculated using the results of the interview questionnaire with the farmers and the data of the ORMVA/TF. The results of the calculations are indicated in Tables 7.7.1 and 7.7.2, and summarized below.

Crop Budgets at Present (DH/ha)

	Wheat	Vegetables	Legumes	Alfalfa	Dates
Gross revenu	7 680	33 200	11 340	6 900	28 980
Production costs	4 888	10 000	7 700	2 300	1 650
Net revenu	2 792	23 200	3 640	4 600	27 330

Crop Budgets with Project (DH/ha)

	Wheat	Vegetables	Legumes	Alfalfa	Dates
Gross revenu	12 000	56 800	16 200	14 700	57 600
Production costs	8 860	21 700	9 000	8 150	4 300
Net revenu	4 140	35 100	7 200	6 590	53 300

7.7.5 Marketing and Distribution

The marketing of dates and olives is ensured by the cooperatives. Most of remaining harvested products go for the self-consumption or are sold by each individual farm in the local market. Consequently, it is necessary to increase production and improve distribution of products other than olives and dates. The project of distribution improvement includes:

(1) Strengthening of cooperatives of dates and olives production

One cooperative has been created for the common processing of dates and olives after harvest. It was selling the processed products to the intermediaries on behalf of each family. Modification of this distribution structure is proposed so that the cooperative will be in charge of the common sales, that is to say the system which will be advantageous for the farmers and for the intermediaries. That will allow for the professionals to reduce the costs of collecting and handling of the products, which will guarantee the stable revenue for the farmers and the knowledge to negotiate the prices in a better way.

(2) Organizations of groups of vegetables producers

In the future, it will be very important for the vegetable production to cope with the narrow relations between the producer and the resellers. As a condition, the reseller demands that the producer ensures the regular and stable volumes. In fact the production of each individual farm is weak and it is difficult to guarantee that stability. That is why it is necessary to organize the farmers into the producers' groups. It is necessary to group the production of all the farmers and sell together with the aim of providing stable

volumes for the reseller. As the precondition, the increase in the vegetable production is necessary; the project will consider this aspect for the intermediate - and long-terms.

(3) Creation of simple collecting installations

Installation of at least a simple collection point is proposed in each rural community in order to improve the distribution of products in the zones irrigated by khettaras. The individuals or the enterprises might equally use the facility, which would make the sales of the products more dynamic. The exceeding production possible for sale could be sold by the intermediary at this collection point. It is desirable that the points are administered by the farmers' organizations such as the cooperatives. In order to lower the management costs there will be no building construction, and the collection points will be simply installed in the parcel of cleaned land. In this project, that aspect will be considered in the intermediate and long terms, since it is necessary to increase the production of vegetables at first.

7.7.6 Strengthening of Agriculture Extension

The system of extension of the ORMVA/TF is relatively well structured, but it should be further improved in order to achieve efficient water saving irrigation.

(1) Strengthening of the cooperation between applied research, extension services and farmers

At present the applied research laboratory of the ORMVA/TF works mostly for the dates. It is recommended that in the future, it expands the research for the vegetables and other high value crops as well as the introduction of water saving irrigation. It is necessary that the knowledge obtained in the laboratories is transferred to the demonstration areas and that the farmers get familiar with the techniques mainly in the demonstration areas. It is necessary to strengthen the collaboration between the research, extension services and farmers.

(2) Acceleration of the water management program in the zones

Introduction of the demonstration and extension of the water management is proposed as the element, which is lacking in the ORMVA/TF, in the areas managed by the farmers. The water management programs in the areas are comprised of:

1) the research applied in the site on all the water saving irrigation methods
2) the small-scale demonstrations of the preferred water saving irrigation method
3) holding the meetings for the exchange of techniques between the farmers of the demonstration areas
4) expansion of demonstration towards other areas

It would be desirable that the actions are expanded progressively. The areas will be managed by the farmers, and the ORMVA/TF will bring in the necessary material and technical supervision.

(3) Assistance for the distribution and marketing of vegetables

The implementation of support activities for farmers requires farmers' education in cultivation and harvesting techniques, as well as the products distribution. The education is based on three issues:

1) Cultivation techniques for quality improvement
2) Understanding of the prices fluctuations and relations between the quality and periods of the cultivations in order to obtain better revenues
3) Packaging techniques using local materials in order to avoid the decrease of quality as well as shipment methods.

As a precondition for this project, it is necessary to wait for the increase of the vegetables production. Therefore the above-mentioned actions will be undertaken in the intermediate and long-terms.

(4) Farmers' participation in the extension programs

The participation of the rural population must be made more systematic. The efforts can start from making farmers contribute to the extension activities and preparation of the extension programs. Contributing to the extension activities involves the administration of the demonstration areas, which requires sufficient communication and discussions between the extension services of the ORMVA/TF and farmers regarding the cultivated products, species, the cultivation methods, taking into consideration the preferences of farmers. The extension programs should include the results of monitoring and evaluation of the education techniques for participating farmers. It is necessary to determine the needs of the farmers based on the collaboration between the extension directorate of the ORMVA/TF and the farmers through management of demonstration areas.

7.8 Rural Communities Development Plan

7.8.1 Social Infrastructures Development Plan

Concerning the rural infrastructures, such as water, electricity, roads, education and health, each part of the Moroccan Government administration concerned prepares the development plan in its proper field of responsibility. The following table shows the appraisal of the development plans and organizations concerned in the study zone.

Rural Infrastructures and Responsible Organizations

Domain	Executing organization	Appraisal of plan
Potable water supply	ONEP (National Office of Potable Water)	The plan aiming to increase the rate of drinking water supply to 97% before the end of 2007 (program PAGER).
Electricity supply	ONE (National Office of Electricity)	Electrification of sectors with no service yet (111 Ksars/Douars) before the end of 2005.
Roads	Provincial Delegation of Equipment	Roads construction will be implemented according to the plan.
Scholl infrastructures	Provincial Delegation of Education	School infrastructures will be implemented according to the plan.
Sanitary infrastructures	Provincial Delegation of Helath	In the region, the norms of covering population with the health care institutions are beyond the norms for equipment defined by the Health Ministry. But in order to improve the geographical accessibility, it was planned to construct 21 sanitary installations at the level of rural communities before the end of 2004. Otherwise, there is a plan of strengthening services of mobile sanitary squads.

In this project of rural community development through the khettaras rehabilitation, the ORMVA/TF (project's counterpart) is not concerned with the above components, which are the domains in the focus of Moroccan Government to ensure the basic human needs of the poor regions. Consequently, the development of rural infrastructures is taken as the program of the development of rural communities through khettaras rehabilitation.

7.8.2 Details of Program of Support for Revenues Increase

As the core of the rural community development, the ORMVA/TF is formally the organization in charge of the assistance for the improvement of the farmers' revenues by playing the role of intermediary between the agriculture development, irrigation and agriculture production. Within this framework, the support program for the improvement of farmers' revenues in the Project area makes an agriculture development component of the Master plan for development of rural communities.

As given in Sub-chapter 3.8.5, the annual average revenue per farmer in the region was of DH6,064 in the khettaras rural communities, which was superior than the poverty line defined by the World Bank for the rural areas in Morocco (DH3,037), but in reality the revenues directly obtained from the agriculture represent only 40% of this amount, that was DH2,400 by year. This number does not allow for the farmers of the zone to depend only on the agriculture, and in reality the level of livelihoods depend on the remittances money sent by the emigrated families or the salaries coming from the sectors outside of agriculture.

The proposed program of support for the improvement of revenue will be based on 1) agriculture: cultivations of vegetables and products of high value added, 2) animal husbandry: sheep, goats and small poultry-yard animals, 3) small industry: weaving and processing of agriculture products, taking into

account the preferences of the farmers, the limited resources of the villages and the aids brought by the ORMVA/TF.

This support program will include the extension services of knowledge of the budget management next to the literacy courses given actually in order to accelerate the women participation which until now, in the khettaras villages, were not involved into the economic activities. The support program for the improvement of revenues is summarized below:

Support Plan for Revenues Increase

	Resource	Comments
Agriculture	Commercial garden vegetables' growing Profitable agriculture products (henna, cumin, medical plants, etc.)	・ Selection of products taking into accout the market accessibility and specialities, progressive increase of cultivated surfaces.
Animal husbandry	Sheeps Goats (milk) Small animals husbandry	・ Place activities of women associations in the center and linking with literacy. ・ Introduction and exploitation of the small poultry-yard animal husbandry (rabbits, pigeons, etc.). ・ Expanding of existing animal husbandry (sheeps, goats, etc.).
Small industries	Weaving Processing of agriculture products	・ Placing the activities of women associations in the center and linking with literacy. ・ For weaving, it is important to focus on quality, design, improvement of weaving techniques, etc. ・ Processing of agriculture products, especially in association with cultivations of new productive agriculture products mentioned above.

7.8.3 Implementation of Program of Support for Revenues Increase

In order to increase the revenues from agriculture as it is proposed in the Master plan, it is necessary to stabilize the livelihoods of the khettaras rural communities. Therefore, apart from increasing agriculture production by the efficient use of limited water resource, there exist very few of other ways to improve agriculture revenues. It is therefore essential to find the new types of revenues among the limited resources in the sector, trusting that the activities possible to implement with the simple techniques and small investments. It is also necessary to study the possibility of improving the role of women by empowering them for the income generating activities, while women were mostly devoted to the house-works and children education before, as well as to the aid for men in their agriculture works, into the income generating activities. The support program for the revenues increase is divided into three phases:

First phase （5 years）

- Explore the activities which contribute to increasing of farmers' revenues in the domain of agriculture, small animals' husbandry, and small industries.
- Improving women literacy in order to form the base of their participation in the economic activities.

- Introduction of the agriculture products processing tools in order to alleviate the workload for women.

Second phase（5 years)

- Improving economic benefits through education and structuring of enterprises
- Creating of marketing outlets (marketing network)
- Introducing extension techniques and know-how for management of enterprises which contribute to increasing for revenues and which accept participation of women.

Third phase（10 years）

- Production of specialties in each community (promotion of one product per village).

It is necessary that achieving increase of revenue is realized through better farmers' autonomy. Unfortunately, the support provided by the top-down approach often harms farmers' autonomy and risks giving the negative impact on the sustainability of the activities. In order to realize the support program for this project, it is necessary to proceed with the good understanding of how to improve the implementation capacity of farmers, and how to improvement farmers' autonomy and structuring. Otherwise, in order to accelerate this autonomy and women participation, it is necessary to consider the effects which could be achieved by the collaboration between the associations which work for the revitalization of the sector. It is therefore necessary to implement strengthening the capacities of the associations simultaneously (see Sub-chapter 7.9).

7.9 Organization Strengthening Plan

7.9.1 Basic approach

Objective of organization strengthening plan is to formulate organizational and institutional framework to realize more sustainable implementation of khettara rehabilitation and maintenance works, in the situation of traditional khettara water user's organization becoming unable to maintain their voluntary constructed irrigation facility, khettara. In order to achieve this objective, the traditional organization firstly needs to strengthen its institutional aspect and facilitate cooperation with outside organizations, including the government organizations, international aid agencies, NGOs, etc. Then, the traditional organization is expected to expand their activities to other rural development areas based on their accumulated trust with local people and ability on managing and coordinating development works in the community.

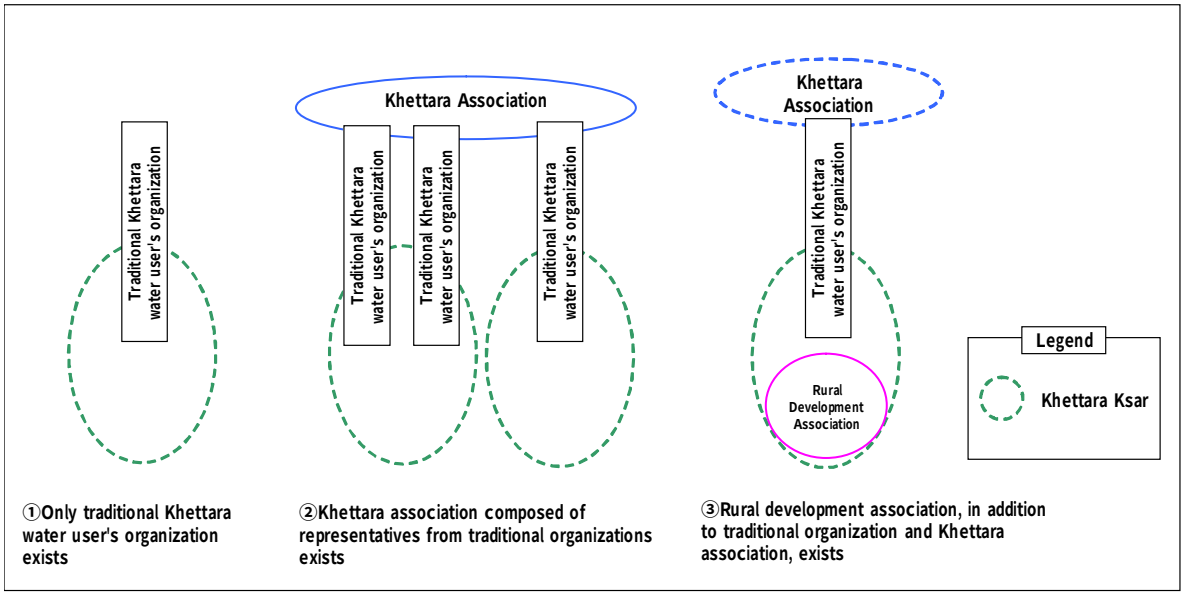
Present capacity of each farmer's organizations, including traditional khettara water user's organization, khettara association and rural development association, is analyzed and summarized on Sub-chapter 4.3 Development Potential, (5) Rural society / organization and institution in this report. However, these farmer's organizations do not exist with similar organizational capability. In fact, form and capacity of each organization are quite different on each location since existence of these organizations is based on their unique social backgrounds as well as the development stages.

Although formation process of farmer's organizations is multifarious, present forms of farmer's organizations in khettara community generally fall into following three (3) types.

(1) Community with only traditional khettara water user's organization exists.

(2) Community with khettara association composed of representatives from traditional khettara organizations.

(3) Community with rural development association in addition to traditional khettara organization and khettara association.



Note：There are two cases in ③, either Khettara association exist or Khettara association do not exist.

Present Forms of Farmer's Organizations in Khettara Communities

On implementing organization strengthening plan, present forms and capability of existing farmer's organizations are firstly confirmed. Then, these organizations are strengthened in the way of adding insufficient functions and capacities since form and capability of farmer's organization varies in each community.

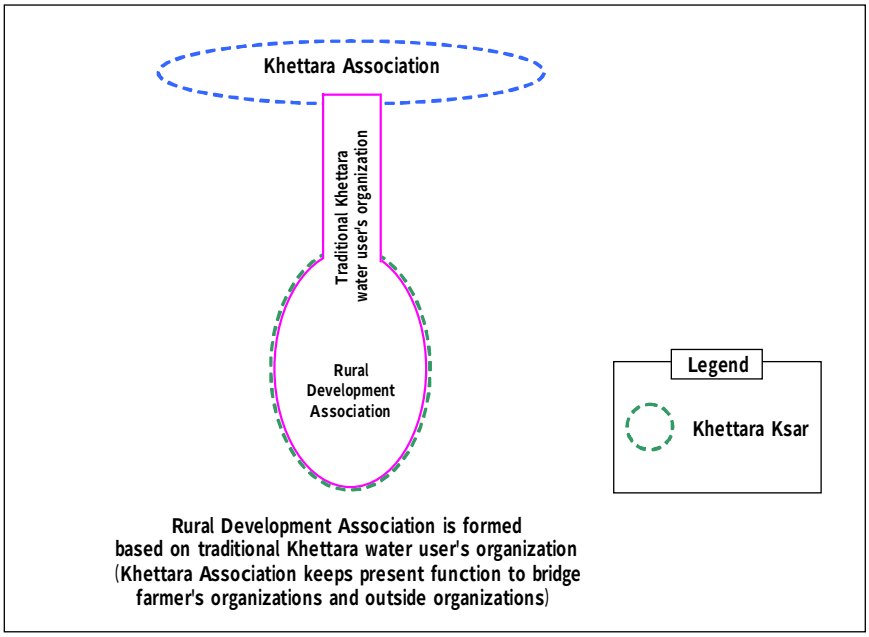
Following two (2) basic approaches are adopted in order to implement the plan more efficiently.

1. In the community where only traditional khettara water user's organization exists, an institutional aspect of the traditional organization is firstly strengthened. Traditional organization is registered as an association, and the management is modified in accordance with the contemporary laws. Furthermore, established association will expand its activity to rural development fields in the future from their original field of khettara rehabilitation and maintenance works.

2. In the community where khettara association or rural development association exists besides traditional Khettara water user's organization, coordination and cooperation among these organizations are facilitated. Organizational capacity of these organizations on khettara rehabilitation and maintenance works, as well as other rural development works, is strengthened by mutually

supplementing their shortcomings.

For carrying out rural development works, one rural development association in one community is desirably formulated in the future since khettara community is regarded as a basic unit for common benefit.



Form of Farmer's Organizations after Strengthened

7.9.2 Contents of Organization Strengthening Plan

Organization strengthening plan is implemented with following basic steps shown below.

However, these steps are taken after confirming present forms and capacity of existing farmer's organizations in each khettara community. Component of organizational strengthening is selected and implemented in the way of adding insufficient function and capacity on each organization.

1. Strengthening institutional aspect of traditional khettara water user's organization (registration as an association).
2. Acquiring basic knowledge and skills on association management.
3. Enhancing implementation ability on khettara rehabilitation works.
4. Expanding association activity to rural development field.

Activities to be implemented on each step are shown on the following table.

Activities on Organization Strengthening Plan

Steps	Activities to be implemented	Target organization	Implementing body
1. Strengthening institutional aspect of traditional khettara water user's organization (registration as an association)	1-1. Holding seminar on establishment of association and carrying out necessary follow-ups. （Necessity of association establishment, procedure for establishment, registration etc.）	Traditional khettara water user's organization	ORMVA/TF and ODECO
2. Acquiring basic knowledge and skills on association management.	2-1. Providing training for association on its basic management. （Annual/extraordinary general assembly, election of bureau members, preparation of minutes of meetings and accounting records, etc.）	Khettara/rural development association	ORMVA/TF and ODECO
3. Enhancing implementation ability on khettara rehabilitation works (Implementation of rehabilitation works in cooperation of traditional khettara water user's organization and association.）	3-1. Preparing application outside organization. 3-2. Managing and coordinating rehabilitation works and joint monitoring activity. 3-3. Expanding khettara rehabilitation works by farmer's organization （Utilizing equipment lending scheme by ORMVA/TF, etc.）	—	Khettara Association （ORMVA/TF and other outside organizations are supporting body）
4. Expanding association activity to rural development field	4-1. Spreading knowledge on water saving irrigation technique. 4-2. Supporting farmer's group on establishment of cooperatives. （Drip irrigation cooperative, cooperative on equipment lending for khettara rehabilitation work, etc.） 4-3. Promoting rural development works based on needs in each community. （Infrastructure (school, health post, roads, etc.), adult education, income generation activities, etc.）	—	Khettara Association （ORMVA/TF and other outside organizations are supporting body）

7.10 Recharge Facility Plan

7.10.1 Proposed Recharge Facilities

Aiming at increase of the khettara discharge, several recharge methods are proposed using run-off in the river (wadi).

Recharge Facility Plan

Recharge Facilities		Recharge Methods	
1) Construction of diversion weir	⇨	i)	Impounding in natural or artificial depressed ground
		ii)	Construction of small scale recharge pond
		iii)	Construction of larger dam by earth or gravity type
		iv)	Diversion to farmland aiming at infiltration to the ground
2) Construction of dam	⇨	i)	Release storage water to accelerate recharge through riverbed
		ii)	Natural infiltration from reservoir
3) Construction of flood dispersion weir (embankment)	⇨	i)	Enlargement of recharge area by dispersion weir to accelerate groundwater recharge
		ii)	Temporary storage of rainfall to effectively use rainfall for groundwater recharge

7.10.2 Recharge Facility Plan

Aiming at providing groundwater to the khettaras, several sites are proposed for recharge facility construction in full consideration of geographical and meteorological, geo-hydrological conditions in the Study area. In implementing recharge facility construction, verification of the project effects in terms of recharge area and recharge amount, etc. is inevitable. Accordingly project effects and economic evaluation shall be conducted to confirm its effectiveness prior their construction. The following are outline of the facilities and expected benefits to the khettaras.

Outline of the Facilities and Expected Benefits to the Khettaras

	Recharge facilities	Proposed sites	Relation to khettara
(1)	Impounding in artificial depressed ground	Tributaries of the Gheris river (Ferkla Soufla)	Directly supply groundwater to 10 to 15 khettaras located at its downstream
(2)	Small scale recharge pond (facility)	Hannabou, Sifa, El Batha areas	Directly supply groundwater to 25 to 30 khettaras
(3)	Recharge dam	Fezzou, Ahassia areas (Alnif)	Supply surface water to irrigable area and groundwater to 15 to 20 khettaras along the inundated area of the river
(4)	Flood diversion to irrigation areas	Boudenib area	6 to 8 khettaras are located along the inundated area of the river
(5)	Recharge dam	Tanguerfa area (Goulmima, Ferkla Soufla)	Supply surface water to irrigable area and groundwater to 15 to 20 khettaras along the inundated area of the river
(6)	Flood dispersion dike	Tributaries of the Gheris river (Ferkla Soufla)	Several khettaras in the deposits of the Gheris river and its tributaries obtain benefits.

7.10.3 Facility Planning

(1) Impounding in natural or artificial depressed ground

Upstream area of the Tizougaghine and Tiguido (Ksar) are proposed to divert floods of the Gheris river with its canal dimension of canal length about 11 km, canal width 20 m, and average excavation depth of 4 m (see Figure 7.10.1).

(2) Construction of small scale recharge pond

(a) Hannabou area

Flood water is diverted from the Hanich river (wadi). Recharge water is profitable at the khettaras located at Ksar Bouya, Krair and Hannabou. Diversion discharge to the ponds is 5.0 m^3/sec in peak flood discharge of 50 m^3/sec (see Figure 7.10.2).

Outline of Small Scale Recharge Pond (Hannabou Area)

	No. 1	No. 2	No. 3
Storage area	10 ha	7 ha	7 ha
Storage capacity	120,000 m^3 (in maximum), 62,000 m^3 (in average)		
Storage depth	0.50 m (in maximum), 0.25 m (in average)		
Elevation of dike	El. 825 m	El. 824 m	El. 823 m

Source: ETUDES DES EQUIPEMENTS HYDRO-AGRICOLES COMPLEMENTAIRES DU BASSIN VERSANT DE L'OUED GHERIS, PHASE III: EPANDAGE DES EAUX DES AFFLUENTS DE L'OUED GHERIS (June 1991)

(b) Sifa area

Diversion weir is constructed in the Gounat river (wadi). Available recharge volume is estimated at 100,000 m^3 per annum in Sifa area. Outline of the diversion weir and water conveyance canal are as follows: (see Figure 7.10.3)

Outline of Small Scale Recharge Facility (Sifa area)

	Diversion weir	Conveyance canal
Crest / canal length	154 m	3,700 m
Structure	Masonry structure (Floating type weir has anchorage in 2.5 m depth to prevent local riverbed scouring) Diversion gate: 2 gates Settlement basin (10 m long)	Downstream end of the canal is located at khettara El Haj Allal. Dispersed flood water is recharged through the ground surface.

Source: ETUDES DES EQUIPEMENTS HYDRO-AGRICOLES COMPLEMENTAIRES DU BASSIN VERSANT DE L'OUED GHERIS, PHASE III: EPANDAGE DES EAUX DES AFFLUENTS DE L'OUED GHERIS (June 1991)

(c) El Batha area

Flood water is impounded in the pond located at the El Batha river (wadi). Impounding capacity of 200,000 to 250,000 m^3 is expected from its watershed area of around 75 km^2 in a frequency of once in 4 to 5 years. Further survey shall be conducted for detailed recharge planning. (see Figure 7.10.4)

(3) Recharge dam (Maider river basin (Zone G))

River basins in the zone are divided into 4 basins as follows:

1) M'cissi river basin (Area = 525 km^2)
2) Fezzou river basin (Area = 1,962 km^2)
3) Ahassia river basin (Area = 1,395 km^2)
4) Taghbalt river basin (Area = 3,274 km^2)

The river basins of Fezzou and Ahassia are highly advantageous for groundwater recharge to the khettaras according to the distribution of the khettaras in Alnif area (Zone G). Locations of these dam sites are

plotted in Figure 7.10.5. The following table explains outline of the dam facilities from hydrological view points:

Hydrological Feature of Recharge Dams in Zone G

Drainage area	Dam sites	Annual run-off (Mm^3/year)	Storage capacity*1 (Mm^3/year)	Available water amount (Mm^3/year)		
				Recharge	Surface use	Total
Fezzou	Imin Tourza	3.9	1.85	0.55	0.92	1.47
Ahassia	Tiamzit	10.0	5.42	1.63	2.71	4.34

*1: Water volume when run-off is fully stored in the reservoir
Source: ETUDE DU PLAN DIRECTEUR DE L'AMENAGEMENT DES EAUX DES BASSINS DU GUIR, ZIZ, RHERIS ET DRAA (September 1994)

(4) Flood diversion to irrigation areas (Boudenib area)

El Ghaba irrigation plan is proposed to accelerate groundwater recharge using surplus water that infiltrates into the ground through the ground surface (see Figure 7.10.6). Run-off from the Guir river is expected at three (3) times per year, and this run-off is diverted to the command area for irrigation and recharge purposes. Diversion capacity is estimated at 725 m^3/ha (72.5 mm/ha or 12 lit/sec/ha) based on the soil characteristics in the command area. Recharge is accelerated by a part of the diverted water to the farmlands.

General Features of El Ghaba Irrigation Project

Facilities	Items	Descriptions	Remarks
El Ghaba diversion weir	Crest length	190 m(Fixed type weir)	Located at the Guir river with its drainage area of 2,900 km^2
	Dam height	2.9 m	
	Structure	Reinforced concrete	
	Diversion capacity	11.57 m^3/sec (in maximum)	Left bank: 2.4 m^3/sec, right bank: 9.17 m^3/sec
	Command area	1,250 ha	Left canal: 1.82 km, right canal: 17.25 km

Source: ETUDE D'EXECUTION DU BARRAGE DE DERIVATION ET RESEAU D'IRRIGATION EL GHABA, 2002

(5) Recharge dam (Tanguerfa area)

Recharge dam site is located at upstream area of the tributaries of the Tanguerfa river (wadi). Total storage capacity is estimated at 1.62 Mm^3. Seepage water through the riverbed released from the reservoir is effectively used for the recharge purpose. Outline of the dam facility is as follows: (see Figure 7.10.7)

Outline of Recharge Dam in Tanguerfa Area (Irrigation Project in Middle Gheris River Area)

Facilities	Items	Descriptions	Remarks
Ifegh diversion weir	Crest length	130 m	Diversion weir is located at the Ifegh river (wadi) with its drainage area of 700 km^2
	Diversion capacity	20 m^3/sec (in maximum)	Divert water to Tanguerfa dam
Tanguerfa dam	Drainage area	25.5 km^2	
	Storage capacity	1.62 Mm^3	Run-off from drainage area of dam is estimated at about 153,000 m^3/year
	Crest length	350 m	(Estimated from topographic map)
	Dam height	15 m	(Estimated from geological map)
Tanguerfa canal	Canal length	12.6 km	Divert water to Tinejdad area Command are: 562 ha
	Discharge	0.3 m^3/sec (in maximum)	Canal width: 1.0m, canal height: 0.7m

Source: PHASE II: AMENAGEMENTS COMPLEMENTAIRES DANS LE BASSIN VERSANT DU GHERIS MOYEN. ETUDES DES EQUIPEMENTS HYDRO-AGRICOLES COMPLEMENTAIRES DU BASSIN VERSANT DE L'OUED GHERIS

(6) Flood dispersion dike (Midstream area of the Gheris river)

The khettaras located at the midstream area of the Gheris river is delineated in three (3) areas from topographical characteristics.

- Northern area of Tinejdad
- Southern area of Goulmima
- Tilouine area

Groundwater that is a water source of the khettaras infiltrates to the subsurface from the inundated areas of the Geris river and small tributaries at the midstream of the Gheris river basin. Flood dispersion dike is installed in the small tributaries with its dimension of dike height of 2 to 3 m, length of 15 to 20 m. The dike tentatively storages flood water and accelerates groundwater recharge. A series of dikes is located at about 100 m upstream of the khettara mother well. Plural number of the dikes may effectively accelerate recharge phenomenon (see Figure 7.10.8). (Source: ETUDES DES EQUIPEMENTS HYDRO- AGRICOLES COMPLEMENTAIRES DU BASSIN VERSANT DE L'OUED GHERIS, PHASE III: EPANDAGE DES EAUX DES AFFLUENTS DE L'OUED GHERIS (June 1991))

7.10.4 Effect of Groundwater Recharge

The following are considered for the estimates of the groundwater recharge effects (recharge amount) because sufficient geo-hydrological information is not available at present.

			(Recharge amount)
1)	Impounding in artificial depressed ground	:	50 % of storage capacity
2)	Small scale recharge pond	:	50 % of storage (diversion) capacity
3)	Recharge dam	:	Respective designed recharge capacity
4)	Flood irrigation system	:	Command area times 30 mm
5)	Recharge dam (Surface water use)	:	Seepage amount of 5 % of the total storage capacity
6)	Flood dispersion dike	:	20 % of annual run-off amount from its drainage area

7) Flood occurrence: three (3) times per annum, cases of 1), 2) and 4) above

8) Annual rainfall amount of 100 mm is considered for run-off estimate for 6) Flood dispersion dike.

Table 7.10.1 shows recharge effect of respective facility and its summary is shown in table below. The table indicates that small scale recharge pond, flood irrigation system and recharge dam have a high potential for the groundwater recharge from an economical points of view. In the estimates, recharge effects of the flood irrigation system and recharge dam were estimated in corresponding to the cost allocation between surface water use and recharge use. It is therefore necessary to carefully review recharge effects in full consideration of a cost allocation between cost for surface water use and cost for recharge use that is recognized as a subsidiary effect. In addition it is noticed that recharge effects were estimated from a point of groundwater preservation, but not water use through khettaras. In case recharge effect is discussed from the khettara water use, a part of whole recharge amount contributes to an increase of the khettara flow, thus a smaller benefit only counted to the khettara water use.

Recharge Effects on Respective Facility

	Recharge facilities	Proposed sites	Water price (DH/m^3)	Evaluation from view point of water price	Effect to khettara discharge	
(1)	Impounding in artificial depressed ground	Tributaries of the Gheris river (Ferkla Soufla)	30	Construction cost is greatly restricted by topographic conditions	Recharge phenomenon directly contributes to raise groundwater level near the mother wells of the khettaras on condition that higher permeability is secured in the aquifers.	○
(2)	Small scale recharge pond (facility)	Hannabou area	7	High economical return is expected for the condition of facility location.	Recharge phenomenon directly contributes to rise groundwater level near the mother wells of the khettaras	△
		Sifa area	31	Longer canal length lifts construction cost, thus water price is high.	- ditto -	○
(3)	Recharge dam	Fezzou areas (Alnif)	22	Water price is affected with cost allocation method, e.g., ratio of water amount for surface water use and recharge use, etc.	Supplementary hydro-geological investigation is required to examine recharge effect for the khettaras.	○
		Ahassia areas (Alnif)	27			
(4)	Flood diversion to irrigation areas	Boudenib area	7	Since recharge effect is subsidiary, project benefit is high.	Recharged water is also utilized for the pump irrigation.	△
(5)	Recharge dam	Tanguerfa area (Goulmima, Ferkla Soufla)	4	- ditto -	High benefit is expected from subsidiary effect of storage dam.	○
(6)	Flood dispersion dike	Tributaries of the Gheris river (Ferkla Soufla)	50	Due to low permeability of the surface layer at the proposed site, water price is expensive.	Topographical and hydro-geological conditions drastically affect recharge effects.	△

7.11 Communal Pump Irrigation System

7.11.1 Outline of Communal Pump Irrigation System

In line with the basic concept of the Study, pump irrigation system is not introduced in the area at where khettara is solely utilized by the inhabitants, except the case the khettara is in dry at present but groundwater may be recovered in sustainable level by recharge effect in future. Meanwhile several khettara villages require alternative water source to maintain their life, and pump irrigation is the only means to solve the problem left. Actually several khettaras have dried up or their flows were extremely decreased due to continuous drought since 1997.

The following remedy and information are provided for future planning of communal pump irrigation systems. However a concrete plan is not made in this study due to the present social condition surrounding the khettara communities, such as,

1) pump irrigation may influence khettara discharge and traditional water right,

2) pump irrigation system has already been introduced for individual use, therefore shifting to

communal pump irrigation system may cause discord between inhabitants,

3) not all communal pump irrigation system are well operated due to a shortage of spare parts or other reasons according to the present operation record of the communal irrigation systems in the Study area. It is necessary to prove a relevance to shifting to the pump irrigation system from economical point of view.

7.11.2 Guideline for Pump Installation

(1) Present condition of khettaras

Present conditions of the khettaras whose discharge have dried up or extremely decreased are classified by various factors such as topographical, hydro-geological conditions as shown below:

1) Khettara discharge: Constant flow is observed through the year
   There is a flow in October to March, however decrease in April to September
   There is a flow in October to March and dry up after these months
   There is no flow through the year
2) Khettara location: Several khettaras are located adjacent to each other
   A khettara is individually located
3) Hydro-geology: River deposits (mainly composed of sand and gravel layers)
   River deposits (mainly composed of silty sand layer)
   Rock foundation (fissure water is available)
4) Water quality (salinity) Available or unavailable for irrigation use (see Figure 7.11.1)
5) Recharge effect Khettara is (or is not) located in the beneficial area of the recharge facilities

As shown above, khettaras are situated in various natural circumstances, like fluctuation of the discharge, geological variation of aquifers, salinity of groundwater, effect of groundwater recharge and so on. In this regard, the following guideline is referred to the pump irrigation planning.

(2) Reference for pump irrigation planning

Distribution of salinity water and other geological information related to groundwater use are explained in Figure 7.11.2. The khettaras of their discharge of more than 5.0 lit/sec (330 sites) are plotted in the figure. The table below refers to development of groundwater by pumpage.

Reference for Pump Irrigation Planning

Zone	Descriptions
Zone A	Tinejdad area: Recharge effect is expected by the construction of the Timkit dam or its regulating dam, e.g., Tanguerfa dam.
	Northern area of Mallaab area (The Gheris river basin): River deposits composed of sand and gravel layers are available as a aquifers.
	Southern area of Mallaab area (Right bank of the Todrha river): Less yield from rock foundation (Andesite) is expected.
Zone B	Water source is adequate in the basin of the tributaries of the Guir river. Pumpage from riverbed is recommended.
Zone C	Water source is adequate in the basin of the Guir river. Pumpage from inundated area of the Guir river is recommended.
Zone D, E	Pump irrigation systems by individual operation have been developed. River deposits of the Gheris river is hopeful as a water source, however yield may vary in different site.
Zone F	Higher salinity is observed according to the water quality test of 30 m to 100 m deep in the areas of Rissani and Taouz. It is not preferable for the irrigation use without particular treatment.
Zone G	Recharge effect is expected for the khettaras located downstream of proposed Fezzou, Ahassia dam sites.
	Several khettaras are scattered in and around the Alnif, M'cissi areas. There found thin sand and gravel layers, and fissure water in shallow depth is considerably small.

Pump wells are broadly categorized in shallow well (30 to 50 m deep, puits) and deep well (50 to 150 m deep, forage). Drilling records and water quality test records for potable water are available for further pump irrigation scheme.

7.12 Environmental Conservation

7.12.1 Initial Environmental Examination (IEE)

The Initial Environmental Examination (IEE) follows basically the JICA's guideline of environmental impact assessment issued in March 2002. The checklist of IEE is shown in Table 7.12.1. Although the new JICA's environmental guideline was issued as "Environmental and Social Considerations" in April 2004, however it was not applied to this study. In this study, social environmental impact was in addition assessed with reference to the new JICA's environmental guideline.

No item has significant or slight negative environmental impact in the checklist of the IEE. Some environmental impacts, which is needed to be monitored in future, are as follows,

- It is necessary to carefully observe spread of vascular disease (Bayoud). The disease is spread in the ground by excessive irrigation water supply and causes serious damage to palm tree.
- It is necessary to monitor the conductivity of irrigation water of khettaras in the area located from Jorf to Taouz (Merzouga), because saline water accelerates salinization of soil. The project recommends to apply water saving irrigation method to minimize salinization.

IEE for the plan of groundwater recharging facility was not undertaken, because there was no information

to assess its impact at present. Environmental Impact Assessment should be undertaken, when a specific plan is designed.

7.12.2 Prevention of Farmland Devastation (Plan of Afforestation)

(1) General

According to the khettara inventory survey, 24 % of khettaras and 18 % of irrigation canals were damaged by encroaching sand in the Study area. It is necessary to promote the installation of protection fence and afforestation to prevent from sand invasion and farmland devastation. Sand dunes are settled tentatively by protection fence. The ORMVA/TF has been placing the protection fence aiming at 500 ha farmland protection. It is effective to plant trees around protection fence to fix the sand dunes certainly. It is essential to take a step-by-step approach of afforestation plan in cooperation with several environmental associations in the Study area.

(2) Afforestation plan

The areas seriously damaged by sand dunes are concentrated in Tinejdad area, Mellaab area, Fezna - Jorf - Sifa area and Merzouga area, according to the khettara inventory survey as shown in Figure 7.12.1.

Effective places to protect farmland from sand dunes are shown on Figures 7.12.2 and 7.12.3. It is proposed to install plantation belt with 30m wide on the windward side of farmland.

The proposed afforestation area is estimated by the satellite image and field survey as shown in the following table.

Afforestation Area in the Study Area

Name	Afforestation Area (ha)
Tinejdad	40
Mellaab	10
Fezna - Jorf - Sifa	70
Merzouga	30
Total	150

It is proposed to afforest 15 ha by one year and to cover 150 ha area for 10 years as estimated in the above.

7.12.3 Rural Life Improvement

Based on the result of inventory survey, water of khettara is utilized as multi-purpose for domestic water, livestock and irrigation. Considering present water use, the following points should be improved.

1) Awareness campaign should be implemented in the community where the water supply projects such as ONEP's were completed. The water use of khettara for potable should be minimized or stopped through the awareness campaign.

2) Washing place should be properly equipped, and used water for washing should not be returned into irrigation canal through awareness campaign. The result of the Verification study indicates

that extension effects are enhanced when facility improvement of washing place was combined with awareness campaign.

3) To improve environmental condition in khettara villages, it is proposed to construct basins for organic manure for collection of livestock excrement with awareness campaign of segregation between livestock excrement and rubbish through local associations. The result of the Verification study indicates that an individually managed basin is more sustainable than a communal basin.

7.13 Project Management

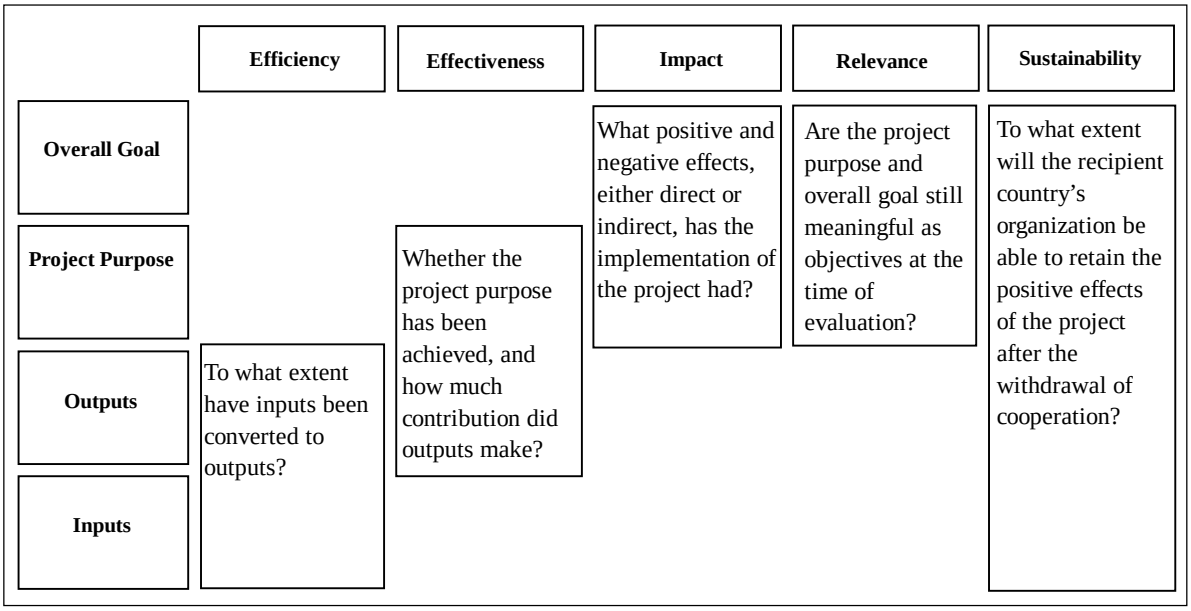
The implementer of the khettara rehabilitation and rural community development project is the ORMVA/TF. Adding to that, it will have full responsibility, being in charge of the project management of the whole program. The management roles of the ORMVA/TF are wide-ranging as; 1) plan restructuring, 2) khettara database update, 3) project monitoring and evaluation, 4) securing budget, 5) strengthening of implementation network, and 6) accumulation and improvement of intellectual property. Details of each item are explained below.

(1) It is important to revise the plan for the khettara rehabilitation and rural community development project from time to time, based on achievement of khettara rehabilitation, irrigation canal construction and recharge facilities, results of designing and construction works, annual budget and actual expenses, as well as situation of groundwater recovery by rainfall, etc. It is necessary to review the whole project especially in the former year of the start of the intermediate and long terms programs.

(2) Accurate information is very important for project planning. It is necessary to update the khettara database developed by the Study (including GIS information) and to reflect the results to the annual plan. Discharge data of khettaras is very important in particular. Therefore, the ORMVA/TF should accumulate accurate data and update the database with support from its Sub-Division offices, CMVs and water users associations. It is also important to store new data obtained from designing and construction works.

(3) The PCM method is proposed for project monitoring and evaluation (M&E). Evaluation criteria of the PCM method are; 1) efficiency, 2) effectiveness, 3) impact, 4) relevance and 5) sustainability. These five (5) evaluation criteria are corresponding to the items of the narrative summary of PDM as shown in the figure below. (PDM: Project Design Matrix)

Evaluation Criteria



In order to make clear the causal relation between 5 evaluation criteria survey and evaluation results, the evaluations should be carried out from many directions referring to the cross-cutting issues, as technology, environment, social and cultural character, institutional management, and economical and financial aspects. A general procedure is noted in the table below.

Procedure of Evaluation

Procedure	Activity
1. Formulation of the evaluation summary	1.1 Formulation of PDM_E 1.2 Formulation of the evaluation summary
2. Formulation of the evaluation design	2.1 Specifying survey items 2.2 Studying information collection method 2.3 Formulation of the evaluation design
3. Information collection and analysis of the results	3.1 Collecting information 3.2 Analyzing information and arranging the results 3.3 Conclusion in 5 evaluation criteria
4. Finalization of the evaluation result	4.1 Conclusion 4.2 Drawing suggestions and lessons 4.3 Presentation of the evaluation result

PDM_E: Project Design Matrix for evaluation

(4) To secure the budget is the most important task of the ORMVA/TF. Basically, the all budget should be shouldered by the government of Morocco. It is also necessary to seek for the support from international aid organizations and major donors for budget shortage, through explaining the importance of implementation and accomplishment of this project.

(5) Participation of farmers and associations as local NGOs is expected, adding to ORMVA/TF and water users associations of khettaras. It is necessary to strengthen associations considering future development in the region, and also it is important for the ORMVA/TF to support associations technically and, if possible, financially. On the other hand, it is also essential to deepen the relationships among associations and to strengthen the project network through coordination with international NGOs.

(6) The Study Team recognized the importance to learn the experiences of other countries and to utilize those obtained from the field trip for khettara agriculture in Oman. It is necessary to improve intellectual property through information collection regarding to khettara agriculture in the other countries, adding to the knowledge obtained from the implementation of the khettara rehabilitation and rural community development project. Moreover, it is also necessary in the long run to disseminate the said property to other areas and countries actively, and to utilize it as the international property.

Chapter 8 Project Implementation Plan and Fund Requirement

8.1 Selection of Rehabilitation Works

In line with the implementation program shown on Sub-chapter 7.1, khettara and irrigation canal rehabilitation works, as well as farm skill extension service and strengthening of farmers' organizations are implemented in phasing schedule.

Implementation schedule is determined as follows in due consideration of its economical viability, urgency, as well.

1) Implementation schedule of the khettara rehabilitation work is divided into three (3) phases by khettara discharge, i.e. short term (first 5 years), intermediate term (6 to 10 tears) and long term (10 to 20 years). The 191 productive khettaras are rehabilitated during short and intermediate terms, while 219 re-productive khettaras which have dried up recently however have had a potential to produce flow in future are rehabilitated during long term on condition that the khettara flow recovers by effect of recharge phenomenon, as well. Therefore these re-productive khettaras are excluded from scheduling of the implementation plan.

2) Rehabilitation length is limited to 30 % of each khettara length excluding the section already rehabilitated with concrete as mentioned in Sub-Chapter 7.5.2. In relation to 1) above, rehabilitation order in the short and intermediate term is determined as follows. The khettaras under 2.0 lit/sec discharge are scheduled in the intermediate term.

Implementation Schedule of Khettaras

Discharge of khettara	Short Term	Intermediate Term
Discharge is 2.0 lit/sec or more	Rehabilitation of 191 khettaras (Maximum 600 m is rehabilitated when khettara rehabilitation length is more than 600m.)	Rehabilitation of remaining section of the short term
Discharge is less than 2.0 lit/sec	not subject to rehabilitation	Rehabilitation of all khettaras

Rehabilitation works of 191 productive khettaras including irrigation canal rehabilitation work are listed in Table 8.1.1. In the table, the bald letter shows 7 khettaras selected for the khettara rehabilitation plan (see Chapter 10), and 30 khettaras selected from the points of 1) higher effectiveness and relevance for the earlier rehabilitation, 2) present discharge, 3) rehabilitation records since 1992, 4) an equity for access to the rehabilitation opportunity (see Data Book).

3) Rehabilitation works for the irrigation canals (primary canals) and diversion outlets are scheduled in the short term stage (first 5 years), because economic analysis proves that the benefit originated from a rehabilitation of the irrigation canal is more advantageous compared with that of the khettaras.

4) Construction works of the recharge facilities are commenced after detailed design including groundwater analysis for about 5 years. Construction of two to three proposed recharge facilities (small scale recharge pond in Hannabou, flood diversion weir in Boudenib and flood dispersion dike) are scheduled during the short term period in order to verify their effect on groundwater recharge.

5) Water saving plan is achieved by self-effort of the farmers (equity capital and application to governmental subsidy, etc). It takes aim at diffusion to 150 ha farmland which is equivalent to about 10 % (drip irrigation: 5 %, furrow irrigation: 5 %) of the whole khettara command area within 10 years (see Chapter 9 Project Evaluation). The drip irrigation devices are installed equally in whole project area during the short term (first 5 years) and intermediate term (6 to 10 years). Because of higher initial investment for installation of the drip irrigation system, only limited number of farmers can participate in the program, on the other hand, any farmers can commence furrow irrigation system because furrow irrigation requires less cost.

8.2 Implementation Plan

8.2.1 Work Volume

Total construction volume during the short and intermediate term is as follows:

Construction Volume of the Khettara and Irrigation Canal

	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
	Total length of khettaras		462,567 （100%）	Total length of irrigation canal 242,868

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 canal (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

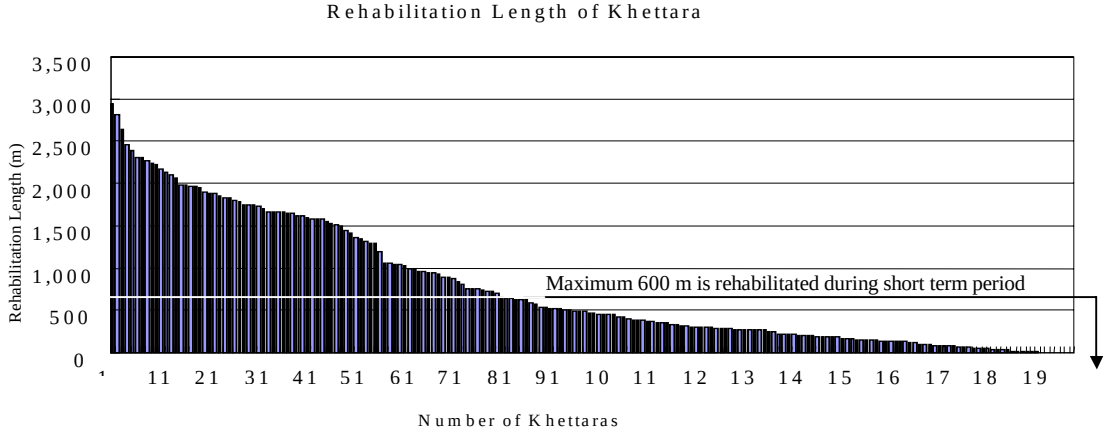
	Short-Term	Intermediate-Term
Farming, Water Use	1) Water saving irrigation 10% (Drip irrigation: 5% (minimum), 150ha, furrow irrigation: 5%, 150ha)	
	2) Training activities: Water use Demonstration farm Income generation program	
Organizational Strengthening	3) Seminar and training	

Afforestation

	Short-Term	Intermediate-Term
Afforestation	1) Afforestation for mitigating farmland devastation (Afforestation area: 150 ha)	

8.2.2 Construction Plan

There is no obstruction to smoothly carry out the rehabilitation works, because the khettaras are scattered in the Project area. Rehabilitation length of a khettara is about 3 km in maximum, and construction with several sectioning put supervisory work into practice with certainty. Table 8.1.1 shows rehabilitation length of the khettaras and irrigation canals of each khettara.



Construction machinery is used for recharge facility construction. Of all recharge facilities proposed in Sub-Chapter 8.2.1, small scale recharge pond and flood diversion weir are scheduled within 5 years during the short term period and construction of the flood dispersion dike is continuously carried out during the short and intermediate terms. Recharge dams are scheduled for 3 years construction and other facilities are for 2 years during the 5-year intermediate term period.

Afforestation for mitigating farmland devastation is scheduled for 10 year planting period. Planting is conducted with its density of 750 trees/ha (interval 3 to 4 m). Daily planting number of 100 trees enables to complete whole proposed planting area of 150 ha (112,500 trees) within 10 years. Project schedule is shown on Figure 8.2.1.

8.3 Cost Estimates

8.3.1 Assumptions

1) Unit prices are estimates on the basis of the Verification study. (October 2003)
2) The exchange rate used in estimates is as follows:

   US$1.00 = DH8.70 (DH1.00 = Yen12.64)
3) Construction cost is contract basis with local contractor
4) The physical contingency of ten (10) percent of the total cost of the construction cost, administrative/ engineering cost, and detailed design is included in the project cost.
5) Price contingency is also taken into account at an annual escalation rate of 1.3 percent according to the records for the previous 5 years.

8.3.2 Project Cost

Project cost is comprised of following items:

1) Construction cost

   Construction cost is composed of direct construction cost, cost for temporary and preparatory works, contractor's expense, etc.
2) Administration cost

   Detailed design and construction works including pre-construction works are undertaken by the governmental staff with assistance and advice of the consultants. Administration cost is estimated at three (3) percent of the direct construction cost for the expense of construction supervision, diffusion activities for farming, water use, organizational strengthening, etc.
3) Engineering service cost

   Engineering service cost is estimated for detailed design and construction supervisory works by the consultants. The consultants technically assist and advice the governmental staff during the detailed design and construction supervision periods. Engineering service cost is 5 % for the

construction works of the khettaras, irrigation canals and water saving systems, and 10 % for the construction of the recharge facilities.

4) Physical Contingency

The physical contingency 10 % of total cost of 1), 2) and 3) is taken into account.

5) Price Contingency

The price contingency 1.3 % is taken into account.

Project cost is estimated at DH568 million as detailed in Table 8.3.1, and summarized below.

Project Cost

(unit : DH'000)

	Short-Term	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 construction cost	151,450	278,940	430,390
II. Administration cost	4,560	8,370	12,930
III. Engineering service 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
Subsidy for water saving irrigation system (Drip irrigation)	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.

Chapter 9 Economic and Financial Analysis

9.1 Outline of Evaluation

This chapter is devoted to the economic and financial analysis of the Master plan. The implementation plan proposed for first 10 years concentrates on the rehabilitation of the 191 productive khettaras. During those 10 years, the discharge of the 219 khettaras, which are dry at the moment, might be restored, and then their rehabilitation will be undertaken. The analysis excludes those 219 khettaras, since at present it is impossible to calculate the cost and benefit. The recharge dam facilities are also excluded, since the study of their impact on the groundwater must be undertaken for 5 years.

For those reasons, the analysis of the Master plan presented in this chapter is focusing on the rehabilitation of the 191 khettaras over the period of 10 years (rehabilitation rate of 30%) and on the rehabilitation of the irrigation canals over the period of 5 years (upgrade to concrete of earth and masonry canals as well as outlets).

9.2 Economic Analysis

(1) Main assumptions

The cost – benefit analysis was undertaken in order to evaluate the net present value (NPV) and the economic internal rate of return (EIRR) of the Project.

At first, the costs and benefits were estimated (approximately) for two scenarios: "without" and "with" the Project. Next, the conversion factors[1] were estimated to translate the financial flows into economic values, which allowed the calculation the economic NPV and the EIRR.

The criteria for calculations :

(i) Implementation period: 10 years

(ii) Project duration: 30 years

(iii) Discound rate[2]: 10 %

(iv) Project's costs and benefits estimated based on the common prices in Morocco in September 2003 (DH)

(v) Exchange rate of US$1.00 = DH8.70 (DH1.00= Yen12.64)

(vi) Applied Standard Conversion Factor (SCF) is of 0.87.

[1] The ratio of the economic prices of group of goods to their domestic market prices (less indirect tax); calculation in table 9.2.1.
[2] Utilized to calculate the NPV and IRR of the Project; the "opportunity cost of capital"; for Morocco usually between 8 and 10 %.
[3] Tax of 14% for the value added for labor costs and of 20% for the value added for construction materials costs.

(vii) Economic costs do not include transfers, such as taxes[3]; the opportunity cost of labor was taken into consideration.

(viii) The average lifetime for the rehabilitation works is of 30 years.

(2) Economic benefits

The benefits of the Project quantified in the analysis result from the increase in the agriculture production. They materialize in: (i) increase in cultivated area, and (ii) increase in yield of agriculture production, according to the following assumptions:

Assumptions for Benefits Calculation

	Benefits	Assumptions
(i)	Increase in cultivated area:	Additional cultivated area (639 ha) bringing estimated benefit of DH 12 560 by khattara (1-6 year) and of DH 14 980 (7-30 year) (economic values) The cultivations include (i) 50% vegetables, (ii) 50% alfalfa (1-6 year) and dates (7-30 year)
	By rehabilitation of khettaras	Rehabilitation of 1km of khettara brings 2.5 lit/sec (if initial discharge >=10 lit/sec), 2 lit/sec (if initial discharge >=5 lit/sec), 1.5 lit/sec (if initial discharge <5 lit/sec)
	By rehabilitation of canals	Increase of 10% of initial water discharge after canals rehabilitation. Discharge of 0.4 lit/sec irrigates 1ha
	In case of no rehabilitation	Decrease of 20% of water discharge over 10 years in case of no action for rehabilitation (without Project)
(ii)	Increase in yield	Increase in yield within the land cultivated at present; benefit from increase in yield is of DH 8 820/ha (economic terms)

(3) Economic costs

The costs of the Project quantified in the analysis are: (i) costs for discharge loss reduction by the rehabilitation of khetaras and canals, and inlet installation, (ii) recurrent costs of operation and maintenance of khettaras and canals, (iii) technical assistance, (iv) administration costs, (v) physical contingency.

Assumptions for Cost Calculation

	Costs	Assumptions
(i)	Investment costs :	
	Rehabilitation of khettaras	Financial cost of rehabilitation of 1m of khettara : DH 1 200 /m
	Rehabilitation of canals	Financial cost of rehabilitation of 1m of ground/ masonry canal to concrete : DH 290/m ; modernization of concreted canals : DH 5/m
(ii)	Recurrent costs :	
	O&M of khettaras	Financial cost of O&M of 1km of khettara - Before rehabilitation : DH 17 000/km/year ; - After rehabilitation : DH 1 000/km/year
	O&M of canals	Financial cost of O&M of canals - Ground canals : DH 1 250/km/year - Masonry canals : DH 500/km/year - Concrete canals : DH 250/km/year
(iii)	Technical assistance	5% of (i) investment costs
(iv)	Administration costs	3% of (i) investment costs
(v)	Physical contingency	10 % of (i)+(iii)+(iv)

The costs of drip irrigation and incremental costs for farm production are already included in the farm economy analysis (irrigation costs and production costs, respectively).

The total economic cost of the Project is of DH 208 million, as shown in the following table.

Estimated Total Project Costs

('000 DH)

Project Costs by Component	Total Economic	Total Financial
I. Rehabilitation works		
1. Khettara rehabilitation	144,900	166,500
2. Canals rehabilitation	298,900	34,300
Total cost (I)	174,800	200,800
II. Technical assistance (5%)	8,700	10,000
III. Administrative costs (3%)	5,200	6,000
Total baseline costs (I+II+III)	188,700	216,800
IV. Physical contingency (10%)	18,870	21,680
V. Price contingency (1.3 %)	0	16,050
Total Amount of Project (I+II+III+IV)	**207,570**	**254,530**

Note: Attention - the costs of drip irrigation as well as the costs of recharge dam facilities are excluded.

(4) Results

The following table presents the summary of economic benefits and economic costs, in net present values, for the conditions of the Master plan indicated above, applying the discount rate of 10%.

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 %			

The economic internal rate of return (EIRR) for the whole Master plan is of about 12.2%. The cost benefit analysis of the Project is presented in the Table 9.2.2 and the ranking of khettaras according to their EIRR is presented in the Table 9.2.3. The results are considered acceptable for the rural development program, and taking into consideration the poverty in the Project area.

A sensitivity analysis was carried out to determine the impact of the changes in main variables of the NPV on the EIRR.

Sensitivity Analysis

Sensitivity Analysis	EIRR
Base case scenario :	**12.2%**
- Reduction of 10% in agricultural production	10.9%
- Increase of 10% in investment costs	11.0%
- Reduction of 10% in agriculture production and increase of 10% in investment costs	9.7%

9.3 Financial Analysis

(1) Farm economy analysis

According to the results of the socio-economic survey in June 2003, the average farm size in the study area is of 0.8ha. After the implementation of the Project, the size will increase by 0.16ha, bringing 0.96ha in total. Those values will be considered for the comparison of the economic situation with and without the Project.

Analysis of Farm Economy (financial values)

	Wheat	Vegetables	Beans	Alfalfa	Dates& 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

It is expected that the implementation of the Project brings the additional revenue of DH10 000 for one farm irrigated by khettara, which will bring the household average income to DH15 400. (see Table 9.3.1)

Moreover, the farmers will profit from the considerable reduction in the maintenance costs of khettaras and canals, which at present give them heavy burden. That can be utilized by the farmers for other activities, which consequently can further increase the incomes.

(2) Fiscal impact

The Master Plan analyzed in this chapter (taking into account the rehabilitation of 191 khettaras and excluding recharge dam facilities) requires the investment of DH292 million over the 10 years, which corresponds to about DH28.9 million per year during the first 5 years and DH29.6 million per year during the next 5 years. (see Table 8.3.2) The operation and maintenance charges have to be covered by the beneficiaries.

The ORMVA/TF dedicates the annual budget of DH5 million for the development of khettaras. It is supposed that this amount will remain unchanged from the 2004, which would cover 20% of the total costs of the Project. It is therefore necessary to consider the financial assistance from the donors or international organizations in order to obtain credit or grant for the remaining 80%.

Budget for Irrigation of the ORMVA/ TF (1999/2000 - 2003/2004)

Component	Budgetary Year (1000 DH)					
	99/00	00/01	01/02	02/03	03/04	TOTAL
Basic study	950	950	950	950	950	4750
Developemnt Works	26 000	47 500	56 00	50 900	35 700	216 100
Rehabilitation	37 978	13 357	1 127	0	0	52 462
Program PAGI II	5 240	0	0	0	0	5 240
Program PDRT	32 738	13 357	1 127	0	0	47 222
Current Program Small/ Medium Irrigation	13 770	10 000	10 000	10 000	10 000	53 770
Surface calans	4 770	3 000	3 000	3 000	3 000	16 770
Traditional works	4 000	2 000	2 000	2 000	2 000	12 000
Khettaras development	5 000	5 000	5 000	5 000	5 000	25 000
TOTAL	**78 698**	**71 807**	**68 077**	**61 850**	**46 650**	**327 082**

Source: ORMVA/ TF, October 2003.

The operation and maintenance[4] will be covered by the beneficiaries. The principle of the ORMVA/ TF is to involve the beneficiaries into covering the operation and maintenance costs, with the exception of the large scale rehabilitation of khettaras and main canals (beneficiaries should cover the rehabilitation cost of 100% for canal networks except for the main canals, and 80% for khettaras and main canals). Consequently, the financial charge for the operation and maintenance will not be significant for the Governments. Cost and work load for operation and maintenance will also decrease for the farmers after the rehabilitation works.

On the benefits side, the increase in tax revenues will be negligible since the agriculture activities are exempted from taxes[5]. In the long term, the improved productivity of rural populations and increase in the economic activity of the region will add to national income, which in turn will have a positive fiscal impact.

9.4 Number of Beneficiaries

Population of the khettara communities are estimated based on population census supervised by the Statistic Department (Direction de la Statistique). Population census is carried out in every 10 years, e.g., in 1994 and 2004, recently. Population in 2004 was published in rural commune basis only at present. Population in Ksar basis are necessary to estimate the number of population benefited by the khettara rehabilitation works, accordingly census in 1994 is referred to estimate the number of beneficiaries because of following conditions:

[4] The beneficiaries can also cover about 5% of investments, which is 5 000 DH if there are 100 persons by khettara. That is not considered in the above analysis.
[5] The agriculture revenues by 18 000 DH/year are exempted from taxes, which is an amount much higher than the average in the study area. This exemption will last by the year 2010, and most probably by 2020.

- Population in rural area does not changes much between 262,797 in 1994 and 260,739 in 2004. (see Table 9.4.1)

- Census in 1994 indicates population in Ksar basis, so it enables to estimate the number of the beneficiaries by the khettara rehabilitation work.

The number of beneficiaries directly by the khettara rehabilitation work is estimated at 129,500 living in 241 Ksars based on census and khettara inventory database. (see Table 9.4.2) The number of beneficiaries by a khettara is estimated at about 320 people, and inventory survey shows the largest of 1,200 people.

While whole rural population is subject to the beneficiaries of the project such as improvement of irrigation skill, farming and extension, strengthening of organizations, as well. In this regard, total number of beneficiaries of the project is estimated at about 260,000.

9.5 Evaluation

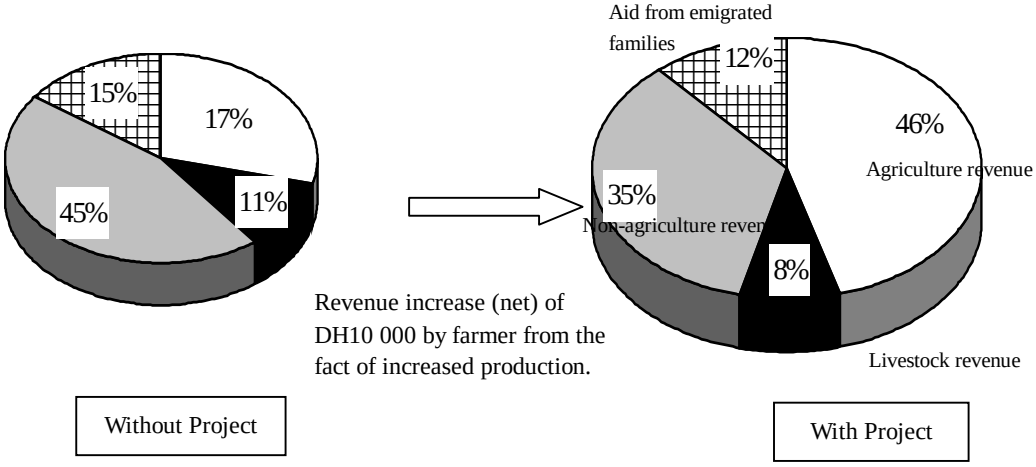
In conclusion, the economic and financial evaluation of the Master plan shows the following:

(1) The relevance of the Master plan is satisfied from the economic point of view. The EIRR of 12.2% is valid from the aspect of the rural development for poverty reduction in Morocco.

(2) The implementation of works is likely to also contribute to solving important social problems of the Tafilalet region, even though this contribution cannot be quantified. This impact includes issues such as the vitalization of the economic activities, improvement of the school attendance rate in the rural areas, the formation of the social capital (settling of the population, poverty reduction, and better status of women), and control over the desertification (afforestation). Those issues are related to the government program realized through the “Strategy for Agriculture Development 2020”.

The evaluation of the Master plan according to 5 DAC criteria is summarized in the following table.

Evaluation of the Master Plan according to DAC Criteria

Evaluation criteria	Contents
Efficiency	● The economic costs are of DH117 million, and economic benefits of DH140 million, which gives the benefit/ cost ratio of 1.2; that should give sufficient economic benefits, as well as the EIRR of 12.2%. **B/C=1.2** **EIRR (Economic Internal Rate of Return) =12.2 %** ● Simultaneously with the monitoring and evaluation of the works, the verification studies will be undertaken to check the technical unknowns and reflect the results in other projects. Otherwise, the ORMVA/ TF have planned to prepare budget, and there is a high possibility that the expected results will be achieved.
Effectiveness	● The objective of the khettaras rehabilitation and agriculture development is to stabilize and increase the agriculture revenues. The increase of the volumes of khettaras' water, rate of utilization of the water and exploitation techniques will bring about the real increase in the agriculture revenue, which will contribute to poverty reduction in the rural areas. ● According to the economic analysis, the revenue of the farm will change on average from DH5 400 to DH15 400, which is the increase of DH10 000 (indicated in % in the graphs below) 
Impact	● The realization of the Master Plan will contribute to poverty reduction and to improvement of the level of life of the rural communities, which are the objectives of the 5-year plan and the Rural Development Strategy 2020. ● In the long term, the Project will have 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. ● The results can be utilized for the sector of khettaras in South Atlas or in the arid regions of other countries. ● Indirect impacts expected from the implementation of the Master plan are : ✓ Vitalization of the economy in the sector and increase of the active population ✓ Control of the "depopulation" through poverty reduction and improvement of living environment ✓ Strengthening of the autonomy of the local communities and formation of social capital ✓ Improvement of the social and economic status of women ✓ Control of desertification processes (Afforestation) ✓ Improvement of the implementation capacity of the ORMVA/TF

Evaluation criteria	Contents
Relevance	● The reduction of rural poverty is the objective of the 5-year plan and the Rural Development Strategy 2020 has the strategic objectives of eliminating the inter- and intra-regional inequalities, through the 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, opportunities of the infrastructure development. The percentage of poor is very significant in the region of Tafilalet; the objectives of the Master plan perfectly match with those of the national programs. ● The farmers of the Project beneficiary area must immigrate to other cities or countries in order compensate for the insufficient incomes resulting from the decrease in agriculture production after the decrease in khettaras water. They are also the increasing extent the tributaries of the pump irrigation. Therefore, the farmers have high expectations towards the aid which would allow them to improve the volumes of khettaras water, leading to the increase of their revenues.
Sustainability	● The ORMVA/ TF, the Project implementing agency, has sufficient capacity for the implementation of the works of the Master plan. It consists of 5 Sub-Divisions, 22 CMVs or CEs, which allow for the extension on the exploitation techniques and formation of the organizations designated for the farmers. ● 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 works should be adjusted to the customary laws and regional customs, in the way that the life expectancy of the installations must be ensured. ● Considering the local situation and the capacities of the interested parties, the development objectives by phase were defined. That should contribute to maintaining the Project long-term sustainability. ● The Master plan includes the income generation 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 durable economic benefits.

Chapter 10 Khettaras Rehabilitation Plan

10.1 Purpose of Khettaras Rehabilitation Plan

The purpose of the khettaras rehabilitation plan is to study effectiveness and validity on the rehabilitation scale and components of rehabilitation in detail for all khettara communities covered by the Master plan, through selecting appropriate sites as a rehabilitation model. Actual study items are; 1) increase of discharge by khettara rehabilitation and decrease of O&M work load, 2) improvement of water use efficiency by irrigation canal rehabilitation, 3) increase of agricultural income through improvement of water use, and agricultural technologies and extension services, 4) strengthening of O&M and farmers associations, and 5) project evaluation. Improvement of living condition and income generation activities were excluded from study items, because they were not directly related to the khettara rehabilitation plan, but classified as general development indicators in the whole region, therefore they were not counted as direct benefit of khettara rehabilitation.

Details of each item are explained below.

(1) Khettara rehabilitation

The Master plan sets khettara rehabilitation length at 40 % of total khettara length, including 10 % rehabilitated portion based on the effects of khettara rehabilitation on discharge increase, O&M work load decrease and cost benefit analysis. The most appropriate plan should be formulated, referring to the discharge condition and O&M requirement of selected khettara on the study. The rehabilitation method and section are optimized considering workability of construction work and economical point of view.

(2) Irrigation canal rehabilitation

Irrigation canal rehabilitation and improvement of inlet structure are planned to improve irrigation efficiency (conveyance efficiency). Effectiveness and validity of rehabilitation works are verified through scrutinizing plans in selected sites.

(3) Water use and agricultural technology and extension

As for water use, introduction of water saving technologies (drip irrigation, furrow irrigation) are planned to improve irrigation efficiency, in addition to irrigation canal rehabilitation and improvement of inlet as noted in (2) above. As for agricultural technology and extension, upgrading of agricultural technologies should be considered and introduction of high value crops like date palm and vegetables should be brought into view to achieve increase of agricultural production of cereals and others with stable irrigation water supply and also to secure stable agricultural income. Effectiveness and validity are verified through conducting surveys on present cropping patterns and land use in selected sites.

(4) Operation, maintenance and farmer's organizations

Although the ORMVA/TF is in charge of overall management of large scale irrigation systems in the region, small and middle scale irrigation facilities are handed over and taken care by the AEUA (User's

Association of Agriculture Water) established in each beneficiary area, following the regulation in the country. Khettara, on the other hand, is an irrigation system voluntary constructed and maintained by traditional water user's organization. Therefore, legalized association has not been formulated before. However, aiming at extending governmental supports on khettara rehabilitation work, the Moroccan government has been facilitating to transform traditional khettara water user's organization to contemporary association in recent years.

On preparation of khettara rehabilitation plan, these background as well as present situation of khettara maintenance and rehabilitation activities in khettara community is carefully reviewed. An appropriate organizational structure for the future maintenance and rehabilitation works will be devised with paying due consideration to these issues.

10.2 Site Selection

The table below shows selected sites for khettara rehabilitation plan. The sites are selected as models from 191 khettaras and benefited villages, in terms of location (zone classification), discharge volume, progress of irrigation canal improvement, diversity of agriculture, existence and activities of farmers groups, etc., to verify effectiveness and validity of work components in the Master plan. Locations of selected sites are shown on Figure 10.2.1.

Selected Sites

	Area (Zone)	Ksar	Khettara	ID No.
1)	A	Ait Ben Omar	Ait Ben Omar	A-59
2)	A	Ksiba	Diba	A-58
3)	D	Monkara	Lambarkia	D-42
4)	D	Hannabou	Ouastania	D-61
5)	D	Hannabou	Lagrinia	D-64
6)	G	TimzarzitAlnif	Timarzit	G-64
7)	G	TaoumartAlnif	Jdida Taoumart	G-60

10.3 Study Items

(1) Khettara rehabilitation

Formulation of rehabilitation plan and cost estimate for construction works are carried out through surveying the following items on the study.

1) Number of discharge observation points is increased to scrutinize length and discharge of both yield and leakage sections. Through these activities, the most effective portions are confirmed to achieve discharge increase by the rehabilitation works.

2) Geographical condition around the khettara's mother well and upstream recharge area is surveyed to anticipate increase discharge by gallery extension.

3) Khettara rehabilitation works are classified into open excavation and tunnel works. The most appropriate implementation plan should be formulated considering workability and economical efficiency.

4) Discharge increase by reducing leakage loss above-mentioned and O&M cost saving are expected after rehabilitation works. Related to 3) above, the most appropriate rehabilitation plan should be formulated through analyses on project benefit calculated from construction cost, discharge increase and O&M cost saving.

(2) Irrigation canal rehabilitation

Formulation of rehabilitation plan and cost estimate for construction works are carried out through surveying the following details on the study.

1) As explained in the Master plan, the main canals are the subject to rehabilitation works and improvement of irrigation efficiency is attained by canal lining with concrete. Rehabilitation section and method are determined through field. Minimizing diversion loss and operational loss at inlets are realized by improvement of inlets along existing concrete main canal. Number of modified inlets is surveyed for cost estimates.

2) The optimum water requirement is estimated based on examination of irrigation efficiency associated with canal lining, etc. Increase rate of canal discharge is investigated carefully to verify the target rate of 10 % shown on the Master plan.

(3) Water use and agricultural technology and extension

1) Irrigation facility plan is formulated on water saving technologies (drip irrigation, furrow irrigation), considering water right, khettara discharge, adaptability for local condition and construction cost. Water saving technologies are applied to 10 % (5 % drip irrigation, 5 % furrow irrigation) of farmland of each khettara.

2) Effectiveness and validity for introduction of vegetables and high value crops are verified based on the survey results of present cropping pattern and land use.

(4) Operation, maintenance and farmer's organizations

In this study, following issues are examined in order to propose appropriate operation and management plan.

1) Operation and maintenance activities of khettara and irrigation canals are carefully examined in the selected khettara communities.

2) Information on present activities of the khettara water users' organizations and associations are collected aiming at preparing "Organization Strengthening Plan of farmer".

3) Responsibility of farmers' organizations (traditional khettara water users' organizations and associations) in operation and maintenance task is defined to prepare operation and

maintenance plan.

(5) Environmental Impact Assessment

1) The Environmental Impact Assessment (EIA) is conducted at selected sites based on the results of the Initial Environmental Examination (IEE) conducted during the field survey. Survey items are basically same as the ones used for the IEE screening and scoping.

2) Several items, not clearly assessed in the IEE are re-assessed in the selected khettara communities during the EIA survey. EIA results are utilized for review and revise of the Master plan, meanwhile EIA can propose additional survey for project implementation.

(6) Project evaluation

1) Project evaluation on model khettara communities is effectively utilized to review entire project evaluation in the Master plan. In this regard, assumptions for cost- benefit calculation are examined mainly from standpoints of its accuracy and reliability during the study. Same evaluation items in the Master plan are applied to the study.

2) As for the economical analysis for beneficial farmers, the economical balance of farmer household is analyzed based on the rural economical survey, conducted during the second field survey.

Details of survey results are explained in Annexe J.

10.4 Study Results

10.4.1 Khettara Rehabilitation

Khettara rehabilitation plan in terms of rehabilitation length and section proposed in the Master plan is verified with reference to this study result of selected khettaras. The following table summarizes the study results together with design of Master plan.

Comparison of Rehabilitation Section (length, section)

Master plan	Design of Master plan study	Results of survey
<u>Length</u> Rehabilitation level is set as 30 % (targeting total 40 % including 10 % of completed portion).	(1) The target of rehabilitation is the section where discharge loss is observed (60 % of total length of the khettara). (2) Rehabilitation rate (rehabilitated length/ total length) is basically set as the same for all khettaras in order to secure equitability. (3) Cost effective portions (30 % of total length of the khettaras) are planned for rehabilitation considering the balance between the annual budget of ORMVA/TF and rehabilitation cost.	(1) Discharge loss is shown in the table below. The survey indicated that there was severe leakage section and its average length is 30 % (10 - 50 %) of the total length. (2) Rehabilitation level is basically set as the same for all khettaras in order to secure equitability. (3) As for cost effectiveness, some methods were found such as culverts in possible portions for open excavation, concrete canal or PVC pipe at yield portions.
<u>Cross-section</u> Culvert type is applied basically.	(1) Culvert type is applied as section considering O&M. (2) In terms of longitudinal section, a rehabilitation method of concreting from upstream to midstream should be avoided to secure the needs for further re-profiling of khettara.	(1) Culvert type is applied in open excavation section at downstream. Culvert or canal type is suitable in gallery section from the economical view. (2) Concrete canal construction is suitable in the section where re-profiling is not expected in the future.
<u>Loss prevention</u>	Incremental discharge by khettara rehabilitation per km Present discharge Q (lit/sec) | 10≦Q | 5≦Q<10 | Q<5 Saved discharge (lit/sec/km) | 2.5 | 2.0 | 1.5	Saved discharge shown in the left table is deemed valid in 7 selected khettaras.

Survey Results on Khettara Leakage of Selected 7 Sites

	Khettara	Total length (L, m)	Exuding length (m)	Leaking length (Ll, m)	Ll/ L (%)	Discharge loss (lit/sec)	Note
1	Ait Ben Omar	1,050	300	300	30 %	1～2	
2	Diba	1,700	600	500	30 %	1	
3	Lambarkia	6,200	600	1,000	15 %	4～5	
4	Oustania	7,700	300	500	10 %	3～4	Discharge loss is observed during winter, when there is lot of discharge.
5	Lagrinia	6,500	200	2,000	30 %	2～3	
6	Timarzite	2,100	50	400	20 %	1	Loss is observed uniformly in all along the khettara.
7	Taomart	600	300	300	50 %	1	

The survey results point out the followings.

(1) Evaluation standard designed in the Master plan in the table below is deemed valid as the effect of loss prevention with rehabilitation.

Incremental Discharge by Khettara Rehabilitation per km

Present discharge Q (lit/sec)	10≦Q	5≦Q<10	Q<5
Saved discharge (lit/sec/km)	2.5	2.0	1.5

(2) The appropriate khettara rehabilitation cost was equivalent to those for 30 % rehabilitation of the whole khettara length as proposed in the Master plan. This was because, the ceiling was set from the financial view point, and rehabilitation works were focused on leakage portions to increase rehabilitation effect more efficiently. Leakage was commonly observed at downstream of khettaras and re-profiling was expected in the future at up to mid-stream portions to increase discharge. In these facts, it was confirmed that rehabilitation works are commenced from the downstream portion towards upstream.

The survey also found that there existed severe leakage sections at up to mid-stream, so that it was necessary to discover an appropriate rehabilitation section through field interview and detailed discharge measurement.

(3) O&M activities are carried out 3 to 4 times a year in each khettara. O&M cost per 1 km is calculated about DH 17,000 by the following formulation. It justified an appropriateness of the value used for the cost benefit calculation on the effect of O&M work load reduction in the Master plan.

(6 man-day/time/100 m) x 1,000 m x 3 to 4 times xDH80/ man-day = DH 17,000

O&M Cost Survey Results

	Omar	Diba	Lambarkia	Oustania	Lagrinia	Timarzite	Taoumart	Average
O&M cost (DH/km)	15,680	11,530	23,610	12,970	11,820	23,040	21,600	17,180

Source : Socio-economic Survey (JICA)

10.4.2 Irrigation Canal Rehabilitation

In order to verify the component and assumption proposed in the Master Plan, the field survey was conducted at the selected seven Khettaras. That gave the following fact-findings on actual situation of irrigation canal and water management.

- Rehabilitation of the main canal is effective to increase water use efficiency because irrigation water flows in the main canals with high frequency. Based on the study result of the investigation in seven khettaras, around half of main canals in length are left as earthen canal.

Therefore, the drastic reduction of infiltration loss with concrete lining contributes to the improvement of water use efficiency over the whole beneficial area.

- It is common operation that farmers divert water by blocking the inlet points with soil, and leakage loss and operation loss are observed in many portions. The improvement of the inlet structure aiming to restrain above water losses is important, and it provides a multiplier effect for concrete canal.

- Adaptability of the following assumption was confirmed.

(1) Dimension of the main canals in the seven khettaras was in the range of 0.35 to 0.60m wide and 0.20 to 0.50m high. This is similar to size of the main canal assumed in 0.40 to 0.50m wide and 0.40 to 0.50m high in the Master Plan.

(2) The length and structure type of main canal were investigated in the field survey. Total length of the earthen canal was obtained to be 3.05km. This result corresponds to 2.76km estimated from the average length per unit irrigation area (50m/ha).

(3) Interval of inlets varies in each irrigation canal and khettara. According to the random samplings from the seven khettaras, the inlets are installed at the interval of between 15 and 53 m. This fact indicates that standard interval of 30 m proposed in Master plan is applicable to further plan.

(4) According to the interview with water right holders in the seven Khettaras, 6 to 32 persons participate in the maintenance activities for irrigation canal at the rate of 2 to 6 times a year. Number of 25 participants assumed in Master Plan was also confirmed by the average number of 24 participants per year per km estimated from above data.

Investigation Result on Main Irrigation Canal in the Seven Khettaras

Khettara name	Investigation result (Main canal)				Remarks
	Canal dimension (m) (Width×Height)	Canal length (km)			
		Concrete canal	Earthen canal	Total	
Ait Ben Omar	0.40x0.40	0.68	0.83	1.51	
Diba	0.40x0.40	0.04	0.71	0.75	
Lambarkia	0.50x0.50	-	1.04	1.04	
Oustania	0.60x0.40	1.44	-	1.44	
Lagrinia	0.50x0.40	0.86	0.47	1.33	
Timarzite	0.40x0.20		-		
Jdida Taoumart	0.35x0.20		-		
Total			3.05		
Inventory survey		3.56	3.28	6.84	
Master Plan average		3.11 (52%)	2.76 (48%)	5.88	@50m/ha

10.4.3 Water Saving Irrigation

Farmers show much their interest in water saving technique because they are suffering from water shortage of khettaras.

Regulating reservoirs are installed at immediately downstream of outlet of khettara of the Khettara Diba, Timarzite, and Jdida Taoumart. The facility aims at minimizing water loss during water distribution and conveying much water to the farmland. After the temporary storage in the reservoir, the stored water is released towards farmland rapidly.

Farmer's strong intension for water saving is recognized in khettara Lambarkia. For example, two PVC pipes with the diameter of 150 mm has been installed under the ground from main canal to their farmlands in order to reduce water conveyance loss.

Basin irrigation method is applied in all of khettara irrigation area. Water saving techniques such as furrow irrigation and drip irrigation has been already applied to the other region in Morocco; however, few experience in khettara irrigation area so far. In accordance with the accomplishments of the demonstration farm, farmers show their understanding and interest in furrow irrigation technique which result in improvement of the productivity and quality of the crops.

It is well known that drip irrigation is the most suitable water saving technique. This technique has an advantage of controlling water amount and watering timing as well as water saving. In addition, National Government has formulated a support system with 40 % subsidy for the investment of drip irrigation facilities. Drip irrigation using groundwater by motor pump have been launched in the Tafilalet region. On the contrary, drip irrigation using khettara water does not need any water resource exploitation and operation cost; therefore, this method is recommended. It only requires on-farm reservoir to adjust irrigation hours under the given limitation of traditional water right system. It is necessary to continuously carry out demonstration farming to verify adaptability of the drip irrigation in the Study area.

10.4.4 Agriculture Production

The cropping patterns of selected 7 areas were established regarding the results of land use survey. The modified points from the Master plan are the increases of area for vegetables as high value crops, alfalfa, fodder crop for livestock, and cumin and henna in the zone of Alnif. The cycles of cultivation practically remain unchanged comparing to those established in the Master plan.

Among the 7 areas, the water requirements were estimated for 0.4 lit/sec on average, which allows to increase the cultivated area by 36% on average within those 7 areas.

10.4.5 Organizations for Khettara Maintenance

As a result of field survey, following facts are confirmed on farmer's organization concerned to khettara maintenance works, namely traditional khettara water user's organization and association.

- Even though traditional khettara water user's organization has not obtained legal status, it has been continuously carrying out khettara maintenance works including dredging of canal, as well

as simple rehabilitation works, for long time.

- Khettara water users have been contributed to the necessary maintenance works by providing work force according to their volume of water rights. In addition, the traditional organization has also been collecting necessary fund from water users to procure materials and additional workforce when required.
- The traditional organization will be able to continue these maintenance works even in the future.
- Under the situation of decreasing rainfall faced in the Study area, above mentioned simple maintenance works are not sufficient to secure the water volume for irrigation. Khettara rehabilitation works, including lining and re-profiling of khettara canal and extension of mother well, are considered necessary. However, these rehabilitation works requires a lot of money and work force which exceeds the capability of traditional khettara water user's organization.
- Support from outside organization(s) on khettara rehabilitation work is necessary in order to sustain people's life in khettara communities with minimum agriculture production.
- Although many associations have been established since 2000, most of them have not acquired basic knowledge and skills on association management, including holding general assembly, election of bureau members, amendment of charters, preparation of operation plan, minutes of meetings and accounting records, and so on.
- Khettara farmers, represented by traditional khettara water user's organization, are expecting newly established association only to prepare and send application to outside organizations and not regarding it as a partner for jointly implementing khettara maintenance and rehabilitation works.
- Judging from present activities and experience in the past, organizational capacity of association appeared not sufficient for directly supporting khettara maintenance and rehabilitation works, nor coordinating concerned farmer's organizations.

Based on these facts, objectives and roles of each farmer's organization proposed in the master plan, and presented on the table below, are confirmed feasible.

Objectives and Roles of Farmer's Organization on Khettara Maintenance and Rehabilitation Works

Organization	Objective	Roles
Traditional khettara water user's organization	Maintenance and rehabilitation of khettara	- Continuous implementation of khettara maintenance and rehabilitation works
Khettara association and rural development association	Expansion of khettara rehabilitation activity	- Preparation of application to outside organization - Support on khettara maintenance and rehabilitation works - Coordination with other khettara in the region

10.4.6 Project Evaluation

The economic evaluation result (value of EIRR) is calculated from; 1) khettara's discharge, 2) water requirement (cropping pattern) and 3) market prices. Since khettara's discharge is the only factor limiting the benefited area and affecting EIRR drastically, the economic evaluation for the Master plan should be conducted taking account of more accurate discharge measurement results.

Economic Evaluation Results of 7 Selected Sites

	Results	
	EIRR (%)	Discharge (lit/sec)
1. Ait Ben Omar	18.9	9.4
2. Diba	6.8	3.6
3. Lambarkia	16.0	20.6
4 Oustania	7.7	6.0
5. Lagrinia	6.5	4.9
6. Timarzite	5.1	2.3
7. Jdida Taoumart	18.0	3.1

10.4.7 Environmental Impact Assessment

The Environmental Impact Assessment (EIA) for selected sites was conducted based on "the Environmental Assessment Guideline for Agricultural Development Study (March, 1992, JICA)", because the project components do not fall into the coverage of the Environmental Impact Assessment Act (enacted on May, 2003), and detailed evaluation criteria based on the act are not ready yet so far. The outline of the assessment results is as follows:

- Conflict among residents

  It is proposed to rehabilitate all khettaras with same rate of length and section focusing on equity to access to the rehabilitation work for whole khettara communities. On the other hand, the whole rehabilitation work takes 10 years and the timing of implementation may vary, so it is possible for non-beneficiaries to have complaints for the order of implementation. Therefore, it is necessary to explain selection criteria of rehabilitation sites and the determination basis of the implementation order to the people thoroughly, before implementation.

- Influence to water right

  Although this project is carried out based on the traditional water right, change of water distribution management is necessary for introduction of water saving technologies. It is important to formulate a water management plan taking account of khettara's water right.

- Contamination of water quality, soil, caused by increase of chemical use

  Chemical use is limited in little amount and in limited areas at present. As the agriculture product increases with the project implementation, chemical use may increase. Therefore, careful monitoring

and effective instructions for chemical use by the ORMVA/TF are expected.

- Progress of salt injury due to saline irrigation water (Lambarkia, Oustania, Lagrinia)

This project adopts the irrigation method resistive to saline, like water saving technology. But careful monitoring for salt injury is important, especially in Lambarkia, Oustania and Lagrinia, because khettara water for irrigation includes 2,000 μs/m of saline in those areas.

10.5 Effectiveness and Relevance on Project Components

(1) Rehabilitation of khettaras and canals

Since it is necessary to use khettara water efficiently for agricultural production, to achieve the project purpose, "Stabilization and improvement of agricultural income", thus rehabilitation of khettaras and irrigation canals is the major component. The benefit of khettara rehabilitation consists of discharge increase and decrease of O&M work load. But the rehabilitation cost sometimes surpasses the expected benefit because rehabilitation works requires much cost for earth works and preparatory work in tunnel works. From the economical point of view, it is necessary to rehabilitate the section, where large leakage is observed and higher return is expected. It is recommendable to rehabilitate downstream of the khettara to increase flow and mitigate maintenance works because this portion has large leakage loss and also smaller section causes heavy work load for the maintenance in most khettaras.

As canal rehabilitation is cheaper and benefit by reducing leakage loss certainly appears, the rehabilitation has usually higher const-benefit performance than khettara rehabilitation. Therefore, as it is proposed in the Master plan, canals rehabilitation shall be competed within 5 years. Other canals, secondary and on-farm canals are excluded from rehabilitation plan, because they are small scale and the in-field facilities.

(2) Agricultural technology and water saving irrigation

As for the water saving irrigation (drip irrigation), it is necessary to combine 3 to 4 ha of farmland intensively in order to decrease facility cost per unit area. At present, farmland is divided into pieces, so integration of farmland and water right is necessary through establishment of a drip irrigation cooperative. According to the survey results on farmers group strengthening, preparation of fund and labor force for discharge increase of khettara and irrigation canal is the urgent task. The necessity to substantially support khettara associations for the purpose of its setup and capacity building is confirmed.

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

(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.

i) Strengthening of traditional khettara water user's organization on its institutional aspect (registration as an association)

ii) Acquiring basic knowledge and skills on association management

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

Chapter 11 Conclusions and Recommendations

11.1 Conclusions

The implementer of the khettara rehabilitation and rural community development project is the ORMVA/TF. The ORMVA/TF is responsible for review of the project based on periodical monitoring and evaluation, budget appropriation, strengthening of implementation networks in terms of water management and capacity building of farmers' organizations, etc. The following are details on implementation plan of the project.

For implementation of the 410 khettara rehabilitation work, rehabilitation schedule of each khettara is determined according to the discharge. Rehabilitation schedule is broadly divided into two groups, i.e., 191 productive khettaras that have a flow during the period 2003 to 2005 and remaining 219 re-productive khettaras which have dried up recently however have had a potential to produce flow in future by effect of recharge phenomenon, as well. Rehabilitation schedule is divided into three (3) phases, short term (first 5 years), intermediate term (6 to 10 tears) and long term (10 to 20 years) in the Master plan. Rehabilitation of re-productive khettaras is carried out on condition that the khettara flow recovers by effect of recharge phenomenon, as well. Productive khettaras are rehabilitated for 10 years during short and intermediate term periods. It is proposed to set rehabilitation length in 30 % of the total length of the khettaras in due consideration of financial viability and project efficiency. The khettaras below 2.0 lit/sec discharge (61 khettaras) are scheduled in the intermediate term because of their lower financial viability as the economic evaluation indicates. For the 130 khettaras that discharge is 2.0 lit/sec or more, maximum 600 m long is rehabilitated during short term period of first 5 years and remaining section is continuously rehabilitated during intermediate term period for 6 to 10-year taking account of an equity to equally access to the rehabilitation opportunity. From this implementation schedule, even 40 % of whole khettara section is rehabilitated including existing rehabilitated sections within 10 years short and intermediate term periods.

Rehabilitation works for irrigation canals (main 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).

Concerning the recharge facilities, detailed design including groundwater analysis are first conducted during short term period to verify project viability and relevance of the project implementation from hydro-geological view point. Construction is in principle commenced from intermediate term period.

With respect to farming and water use, 1) a research for the vegetables and other cultivations of strong value added, 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 from public health and hygiene viewpoints.

Total project cost is estimated at DH568 million for 10 years short and intermediate term plan. (Rehabilitation for 191 khettaras and irrigation canals shares DH292 million)

Considering the fact that khettara flow is too short in all 410 khettaras to maintain their communities, 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 during the recharge facility planning.

11.2 Recommendations

Increase of the water source by means of the khettara and irrigation canal rehabilitation, improvement of water use efficiency could be a very important factor to establish rural community development plan. 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. Furthermore groundwater itself has been drying up in several areas by excessive pumpage or other causes.

The following are recommendations for smooth project implementation considering various peculiarity of natural and human resources:

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. In relation to this, it is proposed to establish institutional monitoring system on khettaras to consecutively monitor the present conditions such as discharge fluctuation, damages by floods, water use and maintenance condition, etc. as introduced in the Manual for Khettara Rehabilitation and Maintenance Works, annex of the study report.

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

2) Activities on excessive pumpage control, shifting to communal pump irrigation system and diffusion of water saving irrigation system are strongly encouraged aiming at groundwater conservation together with a financial support from the government, such as subsidy system for the drip irrigation system. Communal pump irrigation system has been developed in the area where khettaras were not closely located. It is necessary to extend this system to the khettara areas at where khettaras have been drying up utilizing on the operation and management experiences in existing communal pump irrigation systems.

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 shall positively support farmers to utilize subsidy system, such as support for preparation of land registration, etc.

4) Flood diversion and recharge facilities shall be constructed to improve water use efficiency in collaboration with the DRH. 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. GIS (Geographical Information System) is also updated because GIS data is developed with linkage to the khettara database.

   Daily basis discharge measurement is being conducted for 30 khettaras. It is suggested to continuously conduct discharge measurement for a long period so as to effectively utilize its results for 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' organizations 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, they are 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.

Tables

Table 3.2.1 Stratigraphy in the Study Area

River Basins	Geologic Time		Stratigraphy
Guir	Quaternary ~ Neogene	Recent	Forming unconfined aquifers.lacustrine deposit is travertin and tufa: partly thin layers distribut in the area.
		Pontico-Pliocene	Terrestrial formations; various type of rocks (Sandstone, Conglomerate, Marl and lacustrine deposit Limestone); thickness 300~500m
		Villafranchien	relatively widely extending in the area: Conglomerate and clastic rocks. Aquitard.
	Paleogene	Upper Eocene	Lagoonal~continental red clastic formations. Marly calcareous Sandstone, Pink gypsiferous Marl. Maximum thickness is 200m.
		Middle Eocene	Limestone intercalated with Marl. Thickness 30~40m. Relatively high permeability forming deep aquifer.
		Lower Eocene	Marine deposits. Partly sandy, calcareous, coarse clastic formations. Thickness is around 40 m in general.
Guir	Mesozoic	Cretaceous	Mainly 4 Formations ・Senonien: Lagoonal Clay~Sandstone, Thickness 50~120m in average, at Boudenib, reaches 500m. ・Cenornano-Turonien: Marine formations, Dolomite. Thickness 20~30m, at Boudenib 100m。 ・Upper Cenomanien: Upper level is Sandstone, others Claystone. Thickness 60m. ・Lower Cenomanien: Red sandstones, Conglomerate, Gypsum, and Lagoonal deposits. Thickness 100~500m.
		Jurassic	Limestone, Dolomite, and Marl
		Lias	Marl, Marly Limestone, Dolomitic Limestone, and Siltstone.
	Paleozoic		Schists, Limestone, and Sandstone.
ZizGheris	Quaternary ~ Neogene	Recent	・Mainly Flood deposits, silty soil. ・Small sand dunes (derived from river deposits, ancient sand dunes (Siffa, Right bank of Rheriss, Western Hannabou, Northern to Northwestern Tizimi)). ・Deposits derived from the erosion and transported material of Rharbian~Recent deposits.
		Rharbian~Recent	・Outcrop is not so much in the area (surface crust layer and Travertine, Alluvial terrace deposits). Post-soltanien travertins: Partly distributing at Ziz riverbed.
		Soltanien	・outcrops in the main deposited portion of the area. Sandy silt~Gravelly alluvium. Thickness 30m; include fossil ・never forming surface crust layers ・Subrecent sand dunes
		Tensiftien	・widely distributing in the area. Thickness 約 20m. Well-consolidated. not receiving erosion so much. ・covered by soltaniens deposits, then outcrops is relatively few (seen on the riverbed) ・In the eastern side of Tafilalt, not outcrops. ・Subrecent sand dunes. Cementation and hard crustization of the surface layer is progressing. Mainly extending in the area of Northern Tafilalt Plain and Upstream of Rheriss-Goulmima Palmeria (Tifounassine). In the northern Tizimi, silty small hill of this deposit exists (very thin hard surface crust develops)
		Amirien	・cobered by soltanienne deposits (around Rissani: Sigilmassa gravelly layer) ・Sand dunes are few ・forming gentle slope at the foot of Limestone cliffs in the northern part (northern Jorf and Tizimi: lacustrine deposit Limestone). generally intercalated with many sandy to silt-clayey layers. forming middle-level terraces. strata is nodulous and porous.
		Saletien	・very fewly ditributing in the area (only forming one portion of terrace gravelly deposits). ・coarse deposits include landslide mass of jbel Erfoud.
		Moulouyen (Villafrancien, plio-villafrancien)	・only partial distribution; thickness is 200m. ・relatively thin layer of gravelly layer of jbel Erfoud (130~140m). Supplying material for the deposits to middle-level and low-level terrace deposits.
	Cretaceous	cenomano-turonien	Platy Limestone, Mudstone and Siltstone (Thickness 30~50m)
		Upper cenomanien	White Marl, Marly Limestone
		Lower cenomanien	Gypsum, Marl (Thickness about 700m)
		Infracenomanian	Mainly Continental Red Sandstone. Thickness about 200m
	Jurassic		Limestone, Dolomite, and Marl
	Lias		Marl, Marly Limestone, Dolomitic Limestone, and Siltstone.
	Paleozoic	Ordovician	Sandstone (Gara, Ouled-Zohra)
		Devonian	Limestone (Rich, Gaouz)
Maider	Quaternary	Recent~Subrecent	Coarse Alluvial deposits, Sand dune deposits, Gravelly layers, lacustrine deposit Limestone, and Silt. Silty layers are formed by irrigation, etc, and distributing in the palmeraie. Due to strong wind, sand dunes are formed at many places: equal grain size (fine size); existing from subrecent.
	Mesozoic	Cretaceous	Existing in the southern side of Bain; Kem-Kems (Cenomanien and Turonien); overlying on Paleozoic.
	Paleozoic	Carboniferous	Green Schist and Sandstone with some strata intercated thin Limestone with nodulous layers.
		Devonian	occupies the central area of the basin; lowest level is Schist, as going to the upper Black Limestone exists (thickness 100~150m: Gedinnnien・Siegenien). Further upper level, Sciste and Sandstone interbedded with Limestone (thickness 100m: Emsien), Limestone (thick. 50~100m), and in the uppermost level, Calcareous Schist (thick. 100m) and Sandy Schist ~ Sandstone stratifying.
		Silurian	Fine grained rocks are superiour, partially platy Sandstone and Limestone existes; thickness about 500m and descreasing its thickness gradually to eastward.
		Ordovician	occupies almost half area of the basin; hard Schist (thick. 500m) = Feijases Schist; some Sandstone = First Bani; Ktaoua (Caradoc) formation・equal grain size, and Quartzite (thick. 300m); Second Bani Sandstone is very hard but very few.
		Middle Cambrian	the strata of marine degression era's deposits, outcropping in the western border area of the basin of Jbel Sarho and Jbel Ougnate; thickness 300~400m; Limestone, Schist, upper half level is occupied by Sandstone and uppermost portion is Sandy Quartzite.
		Lower Cambrian	In the basin, these formations are relatively thinly distributed comparing to the other Anti Atlas area; obserbed only in southern border area of Jbel Sarho and Jbel Ougnate; very few fossills exist; Limestone ~ Dolomite; Sandstone-rich formations.
	Precambrian		forming the mass of Jbel Sargho and Jbel Ougnate; Quartzitic Schist, Granite, Ryolite, and Andesite.

Table 3.2.2 Hydrogeology and Groundwater Distribution in the Study Area

River Basin	Aquifers	Description	Hydrogeologic Properties
Guir Basin	Plio-Quaternary Aquifers	discharging to surface flow and being recharged from surface water: recharging also to Cretaceous formations. Especially in Boudenib basin Cretaceous formations and Quaternary deposits are recharged each other.	gravelly river deposits (k=1.5E-2 m/s) ; silt and calcareous Sandstone (k=5E-5、2E-4m/s) : average hydraulic gradient 2~6%: groundwater flow velocity along Guir river at Boudenib = 4m/day; total groundwater flow volume 400~600ℓ/s.
	Turonien Limestone karst	The quantity of groundwater in this aquifer is not stable: in autumn, groundwater level goes up rapidly in short term, while in springs, it goes up slowly in long term due to snowmelt water recharging. Groundwater level is highest in May and June: forms Errachidia-Boudenib basin: some portion is intervened by some aquictard such as Cenomanien Marl, Senonien Marl etc,. Limestone in deep portion is massive: Turonien Limestone exists in the depth between 250~310m; porous, thickness 40~50m, flow rate is 800~1000ℓ/s at Ubasstnlau by the survey of 1993.	
	Cretaceous Sandstone	Aquifers exist in Continental Red formations and Upper and Lower Cretaceous Sandstone, however their properties are depend on places.	
Ziz Gheris Basin	<<Tafilalt Quaternary Basin>>: largely divided into three; (1)Todrha－Ferkla Basin (Tinerhir~Touroug) (2)Rheriss River Mid-stream Basin (Gouimima~Jorf) (3)Ziz River and Tafilalt s.s Basin		
	Quaternary Aquifers: Several levels	Unconfined aquifers. Main aquifer is in Soltanienne formations.	
		(Recent Quaternary) forming good type of aquifers as the followings; ･A little consolidated gravel layers and basement portions lacustrine deposit Limestone form the main part of aquifers (Tafilalet) ･Upper sand and gravel layers ･Alluvium is partly very coarse so that it may form very good layered or lens-like underground water passage. Interbedded silty layers form capillary fringe portion, in these area hydrogeological consideration against evaporation from groundwater is necessary.	sand and gravel layer: (k=1~3×10-1cm/s)
		(Middle Quaternary) widely extending in the area, and forming aquifers in general. Gravelly terrace deposits (upstream of Todrha River); well consolidated; covered by Recent Quaternary (Todrha、Ferkla、Tafilalet). forming lower aquifers: in the area Anti Atlas, this is gravel layers and forms good aquifers. This gravel layers sometimes outcrop in gorge, and show very high permeability (Imitere river ~ Tarhia gorge).	
		(Ancient Quaternary) generally aquitard. lacustrine deposit Limestone; exists in Rheriss river, Ifere river, and northern side of Tizimi (hard suface crust layer develops). Very few aquifers. (northern side of Tizimi) ――― (lacustrine deposit Limestone and Conglomerate): slightly indurated, partly forms karstic groundwater flow.	lacustrine deposit Limestone: (k = 10-3~5×10-2cm/s) ; as far as the groundwater passage portion is concerned, its permeability is high; lacustrine deposit Marl, low porosity Limestone and silty soil (k =10-4cm/s)
	Downstream area of the basin (Tafilalt Plain)	Groundwater from Ziz & Rheriss river basin gathers this area.	
	Northern area: Infracenomanien sandy rocks	somewhere forms aquifers, somewhwere aquitard.	
	Paleozoic Bedrocks (Schist, Marl, Sandstone and cconsolidated Limestone)	generally aquitard. basement complex: Paleozoic partly Precambrian formations; Crystalline Schist and Granite (Ougnate), Georgien Quartzite, Silurian & Viseen Schist, Middle Devonien Marl. Semi-permeable formations (Ordovicien & Viseen Sandy Scist, Devonien Limestone): comparing to Quaternary, their permeability is low, then almost negligible, however in some portions they act a role some important water supply. In Tafilalet Plaain, Devonian Limestone forms protuberance shape like a natural underground dam.	(Rheriss Valley ~ northern Tizimi, Goulmima ~Tilouine, Upstream of Tanguerfa Valley, Right bank side of Ferkla River basin) --- some part of bedrocks show groundwater leakage and partly form aquifers.
Maider Basin	Groundwater in Maider basin area were developped mainly in Pliocene-Quaternary area. Generally in the mountain area composed of Pre-Pliocene formations, their permeability is low so that aquifers may exist few. However in some portion, they are faulted and sheared, then those area developps many fissures. In these area there is some potential to develop groundwater.		
	Alluvial deposits	Groundwater level is usually 5~8m depth from ground surface. In the downstream area (Daya el Maider), though groundwater flow can be observed, it is very few.	

Table 3.2.3 Hydrometrical Stations and Hydrology in the Study Area

River Basin		Main Tributary or Area	Catchments Area km^2	Hydrometric station		Average Rainfall Mm^3/year
				Main	Simple	
Guir Basin	1	Guir river	**4520**: upto confluent point with Bouanane river.	Tazouguert (1961 ~)	Kadoussa	679
	2	Bouanane river (main tributary Ait-Aissa river)	**8460**: upto confluent point with Guir river	Tit N'Aissa, Bni-Yatti (1961 ~)	Ait Haddou (1970 ~), Jbal Lagnul, Bouanane	1,636
	3	Midstream of Guir river	**13380**: upto Ain Chouater (25 km from confluence of Bouanane and Guir river.		Ain Chouatter	2,349
Ziz Gheris Basin	1	Todrha river, Imitate river Tarhia river	**655**: upto Ait Bouijane **910**: upto the confluence of Imitate **2300**: upto the confluence of Tarhia (just downstream of El Hart)	Ait Bouijane		356
	2	Tanguerfa-Ferkla-Ichem river ~ Gheris river confluent point	**4675**: upto Touroug palmairaie (theconfluence of Gheris river)	Merroutcha	Ifer, Ferkla	686
	3	Upstream of Gheris river	**2210**: upto Tadighost	Tadighoust	Amousder Taghia, El Haroun	478
	4	Midstream of Gheris river (Gheris & Tarda river)	**9850**: upto the confluence of Tarda river			1,577
	5	Midstream of Ziz river (Ziz and Aoufous river)	**7200**: upto the confluence of Aoufous river	F.Tlicht, Mzizel, F.Zabll, Amezouj, B.H Addakhil	Zaouia Sidi Hamza, Aoufous	1,150
	6	Midstream fo Ziz river (Tizimi)	**7630**: upto just downstream of Ziz bridge (Radier d'Erfoud)	Radier d'Erfoud		1,186
	7	Right bank of the Upstream of Tafilalet plain (Gheris river)	**10760**: upto Hannabou	L'Hmida		1,674
	8	Left bank of the upstream of Tafilalet plain (Ziz and Gheris river)	**18550**: the area of Gheris river upto Hannabou, and of Ziz river upto Erfoud			2,869
	9	Mid- to Downstream of Tafilalet plain (Tafilalet s.s.)	**20200**: upto Jbel Bou Maiz and Tamellaht in the southern end of Tafilalet plain		Megta Sfa	2,986
	10	Rivers in the Chebbi dune area (Beida river)	**1075**: upto the connecting line between the outlets of Oued el Beida, Merzougha and Khemiliya		Taouz	70
			km^2	Main	Simple	Mm^3/year
Maider Basin	1	Msisi (el-Mharch) river	**1570**: upto the confluence of Maider **525**: upto the gorge just downstream of Msisi			60: upto Msisi
	2	Regg (Fezzou) river	**2870**: upto the most downstream of Daya el Maider **1962**: upto the gorge just down- stream of Fezzou			219: upto Fezzou 117: upto Achbarou
	3	Ahssia (Hassaia) river	**1970**: upto the most downstream of Daya el Maider **1395**: upto the gorge just down- stream of Ahssia			119: upto Fecht
	4	Tarhbalt river	**3760**: upto the most downstream of Daya el Maider **3274**: upto the gorge just down- stream of Tarhbalt		Tazarine	248: upto Tazarine
	5	Bou-Haiara river	**1790**: upto the most downstream of Daya el Maider			78: upto the confluence of Maider
	6	Daya el Maider				30: only Daya area

Table 3.2.4 Observation Wells of the DGH in Each Zone

Basin		Main Tributary or Area	Main Palmairaie	No. of Functioning Observation Wells	Obtained Data (N°IRE)
Guir Basin	**1**	Guir River	Tiouzaguine、Gourrama、Boudenib、Taouses、B'Ouzims、Oulad Alis、Sahli	14	547, 596, 553, 992, 952, 941, 49
	2	Bouanane River (Main Tributary Ait-AissaRiver)	Bni-Tadjit、Anoual、Talsint、Beni Bassia、Aourir、Bouanane		
	3	MiddleBain Guir River	Ain Chouater		
Gheris Ziz Basin	**1**	Todrha River・Imitate River Tarhia River	Todrha-Tinrhir		
	2	Upto Confluent point of Tanguerfa-Ferkla-Ichem River ～ Gheris River	Tinejdad Mellab・Touroug～Ksar El Kebir	20	1476, 1485, 1445, 1357, 1360, 1358, 1361, 1363, 1373, 1368, 1510
	3	Upper Basin of Gheris River	Assoul、Amellago、Tadirhost、	5	755, 682
	4	Middle Basin of Gheris River (Gheris River＆Tarda River)	Goulmima、Tilouine、Tarda	12	670, 678, 663, 691, 764
	5	Up- and Middle Basin of Ziz River (Ziz River、Aoufous River)	Rich、Errachidia、Meski、Aoufous	44	597, 498, 587, 1195 98, 1204, 29, 581, 1210, 1343, 1511
	6	Middle Basin of Ziz River (Tizimi)	Zrigat、Zaouia Jedida、Douira	6	4093, 4096, 4035, (4034)
	7	Right Bank side of Upper Tafilalet Plain (Gheris River)	Fezna、Jorf、Bouia・Krair、Hannabou	6	1028, 3628, 3630, 1029, 1048
	8	Left Bank Side of Upper Tafilalet Plain (Ziz River、Gheris River)	El Maadid、Erfoud	7	1307, 457, 3904, 3907
	9	Mid- to Lower Area of Tafilalet Plain (Tafilalet s.s.)	Sifa、Oulad Zohras、Rissani	23	525, 1038, 3254, 3107, 2379, 3669, 3666, 3887,3640,3659
	10	River of Chebbi Sand Dune Area (Beida River)	Merzouga、Erg-Chebbi、Khemlia Taouz、Hassi-Remlia、Ouzina、Ait-Khebbache		
Maider Basin	**1**	Msisi River (el-Mharch River)	Msisi、Tarherat、Azag		
	2	Regg River (Fezzou River)	Alnif, Achbaro, Fezzou, Boudib		
	3	Ahssia River (Hassaia River)	Downstream side Fecht, midstream area Amougguer、El Hasbane、Ait Saadane、Aguddimi、Tazgzaout		
	4	Tarhbalt River	Outlet of Taghbalt mouth, upstream of Tazzarine、Bou Felouane		
	5	Bou-Haiara River	Tagouki、Mackouda		
	6	Daya el Maider		6	192, 187, 185, 178

Table 3.3.1 Water Resources and Water Use in Each River Basin

Water Resources and Water Use in Ziz-Gheris river basin

River Name		Ziz River	Gheris River	Remarks
Total Surface Discharge		243	105.7	
Utilization	Upper Basin	68	39.4	Irrigating to Cultivated Area 11,170 ha with Groundwater 26 Mm^3
	Middle Basin	61	11.8	Irrigating to Cultivated Area 8,470 ha with Groundwater 72.7Mm^3
	Lower Basin	94	22.8	Irrigating to Cultivated Area 19,440 ha with Groundwater 41.1Mm^3. 11.4Mm^3 of Gheris River is diverting to Ziz River.
Evaporation & Infiltration		20	5.6	The volume of Ziz River is evaporation from Hassan d'Akhil Dam Reaservoir.
Total		243	79.6	Total Utilization Ratio is 92.5%
%		100%	75%	

Unit: Mm^3/year

Water Resources and Water Use in Guir river basin

River Name		Guir River	Bouanane River	Remarks
Total Surface Discharge		58.3	130.3	
Utilization	Upper Basin	7.8	8.3	Irrigating to Cultivated Area 1,643 ha.
	Middle Basin	5.5	12.0	Irrigating to Cultivated Area 2,170 ha.
	Lower Basin	15.8	3.5	Irrigating to Cultivated Area 979 ha with Groundwater 8.8 Mm^3
	After Confluence	1.7		Irrigating to Cultivated Area 281 ha
Total		54.6		Ratio of Utilization is 50% along Guir River and 18% along Bouanane River
%		29%		

Unit: Mm^3/year

Water Resources and Water Use in Maider river basin

River Name	Maider River		Remarks
	Surface Discharge	Utilization	
Upper Basin	40	25	Irrigating to Cultivated Area 3,360 ha
Lower Basin	24	20	Irrigating to Cultivated Area 1,630 ha

note) If the whole difference of surface discharge and utilization in the upper basin flows into the lower basin, caught water volume in the lower basin is 9 Mm^3/year {24-(40-25)}. Then, total surface discharge in Maider Basin is 49 Mm3/year and 45 Mm^3/year is utilized for Irrigation actually.
Percentage of utilization of surface discharge water is 92%.

Unit: Mm^3/year

Table 3.4.1 Characteristics of Khettara in Each Zone

Zone	Characteristics of Khettara
Zone A	There are 80 productive khettaras out of total 137 khettaras, however water volume occupies only 11 % of the total water requirement for irrigation. Khettara discharge has been reducing year by year, and inhabitants made efforts to maintain the discharge by means of reducing leakage loss and development of the pumpage, etc. Comparing with other khettaras in other zones, there is no khettara that discharge extremely deceased or dried up. However discharge of the khettaras located at Tinejdad area have extremely decreased or dried up due to excessive pumpage along the upstream area of the Todrha river in the Ouarzazate Province (Out of the administration area of the ORMVA/TF)
Zone B	Available khettara discharge of 225.7 lit/sec in total is enough to irrigate 552 ha farmland. Khettara discharge meets total water requirement for the irrigation use. Extension of the gallery, construction of the collecting gallery were applied to maintain khettara discharge with financial support by the ORMVA/TF. In Zone B, adequate water is available in the drainage area of the Guir river rather than the drainage areas of the Gheris and Ziz rivers, accordingly there is no khettaras that have dried up or its discharge has extremely decreased. Extension of the farmland is attained by increase of the khettara discharge.
Zone C	All 8 khettaras have a flow. Average discharge is estimated at about 11.6 lit/sec. Khettara discharge is rather adequate than those in the river basins of the Gheris and Ziz rivers. Khettara gallery is located in the inundated area of the Guir river.
Zone D	Out of total 69 khettaras, 48 Khettaras (about 70 %) have dried up at present. Reduction of the khettara flow has observed since 1950s, and all 16 khettaras have dried at the most upstream area of this zone. It is assumed excessive pumpage along the Todrha river might cause this phenomenon as shown in the area in and around Tinejdad. The ORMVA/TF and foreign donors have provided financial assistance to rehabilitated these khettaras with canal lining located at southern area of the zone. Pump irrigation system has developed in this zone to cover a water shortage for irrigation purpose.
Zone E	Out of total 25 khettaras, 11 Khettaras (about 44 %) have dried up at present. Khettara discharge has extremely decrease or dried up in about half number of the khettaras. The khettaras are definitely divided into two groups by discharge according to their discharges, i.e., khettaras with adequate discharge and those with minimal discharge.
Zone F	Out of total 44 khettaras, 33 Khettaras (about 75 %) have dried up at present. Average discharge is estimated at about 2.3 lit/sec only. The command are of this zone is located at outside of the irrigable area of the Hassan Addakhil dam. Drought condition is more severe rather than Zones D and E.
Zone G	Out of total 103 khettaras, 66 Khettaras (about 64 %) have dried up at present. Most of khettaras are located in the hilly area and average discharge is estimated at about 2.0 lit/sec only. Khettara discharge is fluctuated due to a small watershed and rainfall amount. Several khettara galleries were constructed in the shallow rock foundation, however water from fissures is extremely insufficient for the irrigation use.

Table 3.4.2 Khettara Rehabilitation Works under Japanese Small Scale Grant Aid Program

Name of Khettara	Commune Rural	Rehabilitation Works	Cost	Year
Tighfert (Command area: 40ha) (Irrigable area: 10ha) (Discharge: 6 lit/sec)	Ferkia Oulia	Enlargement of gallery and covering 1,000m Protection of shafts 40m interval Rehabilitation of potable water tap area	DH475,060	2002
Ighzer (Command area: 20ha) (Irrigable area: 4ha) (Discharge: 2 lit/sec)	Sifa	Enlargement of gallery and covering 500m Protection of shafts 40m interval	DH477,690	2002
Lagrinia (Command area: 60ha) (Irrigable area: 15ha) (Discharge: 6 lit/sec)	Hannabou	Re-profiling of gallery base 200m Rehabilitation of damaged portions 50m Protection of shafts 40m interval Enlargement of gallery and covering 200m	DH469,455	2002
Souihla Ouled Ghanem (Command area: 100ha) (Irrigable area: 30ha) (Discharge: 10 lit/sec)	Jorf	Enlargement of gallery and covering 200m Protection of shafts 40m interval Irrigation canal 1,500m	DH454,047	2002
Talaabast (Command area: 25ha) (Irrigable area: 7ha) (Discharge: 5 lit/sec)	Taouz	Enlargement of gallery and covering 500m Protection of shafts 50m interval	DH488,250	2002
Toufassamame (Command area: 50ha) (Irrigable area: 6ha) (Discharge: 3 lit/sec)	Alnif	Construction of regulating basin Enlargement of gallery and covering 500m Protection of shafts 40m interval	DH497,330	2002
Bakassia (Command area: 50ha) (Irrigable area: 25ha) (Discharge: 8 lit/sec)	Ferkla Soufla	Enlargement of gallery and covering 400m	DH498,900	2004
Agoumad (Command area: 400ha) (Irrigable area: 10ha) (Discharge: 20 lit/sec)	Beni Tadjit	Galley protection 800m Protection of shafts	DH495,770	2004
Almou Chorfa (Command area: 100ha) (Irrigable area: 50ha) (Discharge: 10 lit/sec)	Beni Tadjit	Galley protection 850m Irrigation canal 1,000m Protection of shafts	DH500,000	2004
Lakdima Bouya (Command area: 150ha) (Irrigable area: 25ha) (Discharge: 9 lit/sec)	Jorf	Galley protection 300m Gallery construction (new) 450m Protection of shafts	DH550,000	2004
Jdida Taoumart (Command area: 60ha) (Irrigable area: 30ha) (Discharge: 2 lit/sec)	Alnif	Galley protection 300m Dredging of gallery 1,000m Protection of shafts	DH629,750	2004
Timarzit (Command area: 100ha) (Irrigable area: 15ha) (Discharge: 3 lit/sec)	Alnif	Galley protection 1,000m Protection of shafts	DH577,200	2004

Source: RAPPORT D'ACHEVEMENT DES TRAVAUX DE REHABILITATION DES KHETTARAS ENTREPRISES DANS LE CADRE DU DON JAPONAIS, ORMVA/TF

Table 3.10.1 Outline of the System of Impact studies on the Environment in Morocco

Criteria of functionality	Situation
Legal framework of the EIE	
1 Skeleton law governing the EIE	Bill on the environmental protection deposit at the parliament.
2 Decree of application relating to the EIE	Project of decree on the EIE
3 Provision relating to strategic evaluation of impact.	None
4 Guides or directives relating to the implementation of EIE	Seven sectoral directives are elaborate
Institutional framework of the EIE	
5 Institution responsible for the management of the EIE	Department of the environment
6 Proper authority as regards environmental acceptance	The national Committee of EIE deliberates and subjects the decision for adoption and signature by the minister in charge of environment.
7 Structure of examination of EIE	Division PP&EIE / Service EIE
8 Method of coordination with the structures of environmental control.	None
Procedure	
9 Selection Category of projets	Single positive list. In the event of project not mentioned on the list of constraint, there is possibility of subjection it to the EIE according to its nature, its scale and the sensitivity of the environment.
10 Framing Method of framing	Development of terms of reference by the division of the EIE, in collaboration with the promoter.
Contents of the report of EIE	
11 Components of report	Executive summary; presentation of applicant & BET(consultant) ; legal, lawful and institutional reference frame of the project; description of the activity; perimeters of studies and impacts ; temporal horizon of the activity; description of the environment and its sensitivities, foreseeable evolution (without project) ; identification and analysis of impacts and tendencies of their evolution; presentation of the alternatives studies; analysis of their foreseeable impacts and justification of the choice among the various alternatives; determination of measurements of mitigation; environmental assessment and residual impacts (with measurements); monitoring, monitoring and environmental management of the impacts; appendices.
12 Requirement of a nontechnical summary	None
13 Requirement of a catch in consideration of the alternatives to the project.	No requirement in the decree, but not raised in practice (ex case of the projects of discharges).
14 Requirement of environmental management plan.	Measurements of attenuation and compensation mentioned in the specifications and the study.
15 Requirement of analysis of the transborder impacts.	None
16 Requirement of analysis of global impacts.	None
Examination of EIE report, consultation of the public and decision-making:	
17 Checking method of the quality of EIE reports subjected for examination.	Examination of admissibility and reliability of the report (checking of conformity in TdR, reliability of the data and the results).
18 Requirement of the participation of the public in the process of EIE.	Public investigation stipulated in the law and the decree of EIE.
19 Access to EIE reports.	By way of posting and local press.
20 Method of decision-making.	Decision pronounced by the Minister of the Environment, on proposal of the national Committee of EIE.
Monitoring	
21 Organization in charge of the monitoring of the implementation of EIE.	Administration supervision
National capacities in EIE	
22 National appraise as regards realization of the EIE.	The promoter is responsible for the realization of EIE which is assisted by private engineering and design departments. Several consultants are interested in the EIE .
23 Training in EIE	Programs and training schemes on an international and national scale, on a mediterranean scale, framework of program METAP. Other programs are carried out by the structures of the department of the environment.

Source: METAP NEWS LETTER, Oct 2002
(METAP: MEDITERRANEAN ENVIRONMENTAL TECHNICAL ASSISTANCE PROGRAM)

Table 6.2.1 Indicator, Target and Monitoring Method of the Verification Study

1 Capacity building for ORMVA/TF

Verification Items	Collection	Collector	Analysis	Conclusion	Target	Method for monitoring data collection	Monitoring Period	
							During Verification study	After Verification study
1. Capacity building for ORMVA/TF								
Establishing network between ORMVA/TF and farmers' organization	Oct. 2004 and Feb. 2005	Sub-Division (Errachidia,, Beni-Tajit Erfoud, Goulmima)	ORMVA/TFS (SER)	Study team	Inventory data base file is maintained by SER, ORMVA/TF. Sub-Division and CMVs open data base to farmers to raise their motivation against the rural development. - Inventory data base files are distributed to 4 Sub-division by October 2004. - Update manual for inventory data base is distributed to Sub-Division and utilized by them.	● Following are monitored from staff of Sub-division and CMVs by questionnaire: - Staff of Sub-division and CMVs comprehend the purpose and contents of inventory. ● Following are monitored from associations and farmers by questionnaire: - Accessibility of the associations and farmers to inventory database.	○	
Update of inventory data and GIS data distribution	Feb. 2000 and Jul. 2005	Sub-Division (Errachidia,, Beni-Tajit Erfoud, Goulmima)	ORMVA/TF (SER)	Study team	- Inventory data is periodically updated by ORMVA/TF. Items to be updated are: 1) Khettara discharge 2) Irrigable area 3) Rehabilitation records Discharge measurement is carried out at more than 50% of khettaras out of 191 khettaras by February 2005. Discharge measurement is carried out at more than 70% of khettaras out of 191 khettaras by July 2005.	● Number of khettaras which inventory data (discharge) is updated is monitored. ● Progress of farmland measurement by means of GIS (satellite image) is monitored. ● Progress of record input work on khettara rehabilitation is monitored.	○	○
Data collection and information sharing on agricultural development scheme	Feb. 2005 and Jul. 2005	ORMVA/TF (SER)	ORMVA/TF (SER)	Study team	Workshop about progress of verification study is held twice a year. Participants of the workshops correctly understand the study progress of water saving irrigation method, farming practice, life improvement plan, etc.	● Frequency of workshop opening is surveyed. ● Contents of workshop is surveyed by questionnaire	○	○
Strengthening of project evaluation and monitoring capability	Oct. 2004 and Feb. 2005	ORMVA/TF (SER) Sub-Division (Errachidia, Beni-Tajit、Erfoud、Rich、Goulmima)	ORMVA/TF (SER)	Study team	ORMVA/TF staff including Sub-division and CMVs learn knowledge on monitoring and evaluation method during the seminar. Monitoring and evaluation related V/S is carried out by ORMVA/TF staff	● Knowledge improvement of seminar participants is surveyed by questionnaire. ● Knowledge on monitoring and evaluation is surveyed through monitoring and evaluation practice during the verification study.	○	
Technical seminar on project evaluation and monitoring related to V/S	Oct. 2005	Sub-Division (Errachidia, 、Beni-Tajit、Erfoud、Rich、Goulmima)	ORMVA/TF (SER)	Study team	ORMVA/TF staff including Sub-divisions and CMVs enhance their understandings on khettara rehabilitation and rural community development scheme during seminar. 70% of participants comprehend the contents of the Master Plan on khettara rehabilitation and rural community development scheme.	● Achievement or level of participants on their understand of the project purpose and components is surveyed by questionnaire.	○	

2. Rehabilitation works of Khettaras

Verification Items	Collection	Collector	Analysis	Conclusion	Target	Method for monitoring data collection	Monitoring Period	
							During Verification study	After Verification study
2. Rehabilitation works of khettaras								
Evaluation and feedback on khettara rehabilitation (Master Plan)	Jul. 2005	ORMVA/TF (SER) Sub-Division (Errachidia, Beni-Tajit, Erfoud, Goulmima)	ORMVA/TF (SER)	Study team	Scope of khettara rehabilitation is decided principally from financial point of view. Proposed rehabilitation length shall be revised and reflected to the Master Plan from economical and technical points of views based on the study results of the Verification study. In addition, maintenance ability (financial) of water user' groups shall be discussed to accomplish sustainable used of the khettara systems.	● Evaluate the study report consisting of previous rehabilitation record, e.g., costs, rehabilitation method, sections, etc. ● Evaluate the data which includes analysis of rehabilitation effect regarding water loss and lightening of maintenance work ● Study of financial capability of water users' associations on khettara maintenance (removal of soil, degradation of gallery bed, etc.) ● Analysis of above data and reflection of these data to rehabilitation plan in Master Plan	○	○
Verification of benefits by khettara rehabilitation (Water loss)	Dec. 2004 and Jan. 2005	Sub-Division (Erfoud、Goulmima) CMV (Jorf, Tinejdad)	ORMVA/TF (SER)	Study team	No water loss is observed along the rehabilitation section. Khettara rehabilitation works are composed of concrete lining of gallery aiming at decrease of water loss. Increase of khettara discharge directly arises agricultural productivity.	● Observe a khettara discharge before and after the rehabilitation works	○	○
Verification of benefits by khettara rehabilitation (Labor for maintenance)	Feb. 2005 and Jul. 2005	Sub-Division (Erfoud、Goulmima) CMV (Jorf, Tinejdad)	ORMVA/TF (SER)	Study team	Maintenance cost (number of labor, or payment) reduces more than 20 % of previous one. Decrease of maintenance cost is included in the benefit generated from the khettara rehabilitation works with concrete culvert and canal. It is necessary to survey the benefits after and before the rehabilitation works.	● Questionnaire survey shall be conducted to the water users' associations. Baseline survey was conducted for whole khettara sections during the feasibility study. A survey shall be conducted limited to the rehabilitation sections. Survey results shall be reflected in the economic evaluation in the Master Plan	○	○
Capacity building on khettara rehabilitation planning	Feb. 2005 and Jul. 2005	Sub-Division (Erfoud、Goulmima)	ORMVA/TF (SER)	Study team	The following items has been selected so as to continuously carry out the khettara rehabilitation works and also revise the rehabilitation plan itself from time to time. These studies are achieved though implementation of the rehabilitation works during the Verification study. 1) Preparation of standard design (drawing, etc.) 2) Preparation of material supply plan 3) Reconstruction plan for decrepit structures of khettaras 4) Improvement of supervision activities of rehabilitation works	● Examine the contents of the standard design. ● Examine the contents of material supply plan. (attached into standard design) ● Study report includes 10 sites analysis on reconstruction plan for decrepit structures of khettaras (attached into standard design) ● Confirm the supervisory activities of the ORMVA/TF by questionnaire, especially quality control of concrete)	○	

3. Water use

Verification Items	Collection	Collector	Analysis	Conclusion	Target	Method for monitoring data collection	Monitoring Period	
							During Verification study	After Verification study
3. Water use								
Water transmission loss is reduced by rehabilitation of primary irrigation canals and outlets	Jul. 2004 and Nov. 2004	CMV Study team	Sub-division	Study team	Water discharge increases 10 % due to less transmission loss by concrete lining of the primary canals together with installation of stop-log gates at the outlets. Water discharge increases 5 % due to less water diversion loss by installation of stop-log gates at the outlets for existing concrete lining canals.	● Discharge measurement is carried out at constant interval points along the primary canals before and after the rehabilitation works. ● Operation time for water diversion is measured before and after the stop-log installation.	○	
Standard design for irrigation canal rehabilitation is prepared.	Nov. 2004	CMV ORMVA/TF Study team	Sub-division	Study team	Standard design is prepared based on the study results of canal type comparison through the canal rehabilitation works	● Improvement points in terms of canal operation and maintenance activities on each proposed canal rehabilitation plan are gathered by questionnaires to the water users' associations. ● Standard design is prepared referring to the improvement points of hydraulic and structural restriction of the existing canal systems. The survey is carried out by the Study team and ORMVA/TF.	○	
Effectiveness of water saving irrigation is verified comparing with basin, furrow and drip irrigations at the demonstration farms.	Sep. 2004～ Jan. 2005 Mar. 2005～ Jun. 2005	CMV Association	Sub-division	Study team	Water saving effect by furrow and drip irrigation methods is demonstrated with comparison of the traditional basin irrigation. (10% saving by furrow irrigation, 20 % by drip irrigation) Moisture content is properly maintained in the soil by a drip irrigation.	● Water consumption, soil moisture contents are observed during irrigation time. In addition, frequency of water tank use is examined according to the monitoring form. ● Daily evaporation and precipitation data are recorded at the demonstration farms.	○	

4 Farming and Extension

Verification Items	Collection	Collector	Analysis	Conclusion	Target	Method for monitoring data collection	Monitoring Period	
							During Verification study	During Verification study
4.Farming and Extension								
Adaptability test and demonstration for water saving irrigation (vegetables)	Feb 2005 and July 2005	Farmers、CMV Alnif, CMV, Tinejidat, CMV Jorf	CMV Alnif, CMV, Tinejidat, CMV Jorf Or Sub-division Erfoud, Goulmima	JICA Study Team SVOP	The selection and expansion of water saving irrigation method, and vegetable cultivation will be assessed in terms of technical aspect, financial aspect and willingness of farmers. The following targets are set-up. Technical Aspect More than 70% of target yield Confirmation of caper crop cultivation Financial Aspect More than 1.1 of Benefit/cost ratio Farmers' Willingness More than 50% of f participants of study tour indicate their interesting in vegetable cultivation under water saving irrigation	● Cultivation record to be prepared by farmers (Work content, and labor requirement etc.), ● Harvest record to be prepared by farmers (Production, sales information etc.), ● Record of CMV (Cultivation Area, inputs, growth condition etc.), ● Purchased record (fertilizer and seeds) of JICA Study Team, ● Questionnaire survey results in the study tour.	○	
Adaptability test and demonstration for water saving irrigation (tree crops including date palm)	Feb 2005 and July 2005	Farmers、CMV Alnif, CMV, Tinejidat, CMV Jorf	CMV Alnif, CMV, Tinejidat, CMV Jorf Or Sub-division Erfoud, Goulmima	JICA Study Team SVOP	The expansion of tree crop cultivation with annual crops under water saving irrigation method will be assessed in terms of technical aspect, financial aspect and willingness of farmers. The following targets are set-up. Technical Aspect Confirmation of growth condition Farmers' Willingness More than 50% of f participants of study tour indicate their interesting in date palm cultivation with annual crop cultivation under water saving irrigation.	● Cultivation record to be prepared by farmers (Work content, and labor requirement etc.), ● Record of CMV (Growth condition etc.), ● Questionnaire survey results in the study tour.	○	
Demonstration of agro-processing (henna and gumbo)	Feb 2005 (July 2005, if necessary)	CMV Alnif、CMV Erfoud	CMV Alnif、CMV Erfoud Or Sub-division Erfoud,	JICA Study Team SVOP	The feasibility of agro-processing for gumbo and henna will be assessed in terms of technical aspect, financial aspect and willingness of farmers. The following targets are set-up. Technical Aspect Confirmation of those participants could complete processing. Financial Aspect More than 1.0 of Benefit/cost ratio Farmers' Willingness More than 50% of participants indicate their willingness to continue gumbo or henna processing.	● Demonstration record to be prepared by Association/Cooperative (Production and satisfaction of participants etc.), ● Demonstration record to be prepared by CMV (Content of demonstration, quality of products etc.), ● Purchased record (processing ,machine with attachments) of JICA Study Team	○	○
Demonstration of agro-processing (Dates)	Feb 2005	CMV Boudnib, CMV Tinejdad,	CMV Boudnib, CMV Tinejdad, Or Sub-division Erfoud, Boudnib	JICA Study Team SVOP	The feasibility of agro-processing for dates will be assessed in terms of technical aspect, and willingness of farmers. The following targets are set-up. Technical Aspect Confirmation of those participants could complete processing. Financial Aspect More than 1.0 of Benefit/cost ratio Farmers' Willingness More than 50% of participants indicate their willingness to continue gumbo or henna processing.	● Demonstration record to be prepared by Association/Cooperative (Production and satisfaction of participants etc.), ● Demonstration record to be prepared by CMV (Content of demonstration, quality of products etc.), ● Purchased record (processing ,machine with attachments) of JICA Study Team	○	○

5 Organization Strengthening

Verification Item	Time	Collection of data	Aggregation of data	Judgment	Target	Method for data collection	Monitoring Period	
							During verification study	After verification study
5. Organization Strengthening								
Facilitating establishment of association (Alnif)	Jan. 2005 and Jul. 2005	CMV Alnif	Sub-division Erfoud	JICA study team	More than 1/2 of traditional Khettara water user's group participated in seminar take action for establishing an association by July 2005. (Number of meeting, consultation to outside organization, preparation of documents, etc.)	● Carry out questionnaire survey for traditional Khettara water use's groups which participated in the seminar.	○	
					More than 1/3 of traditional Khettara water user's group participated in seminar establish associations by July 2005.	● Confirm registered documents regarding establishment of association and the number at local authority.		
Training for association on basic knowledge and skills for management (Jorf, Tinejdad, Alnif)	Jan. 2005 and Jul. 2005	CMV Jorf, Tinejdad, Alnif	Sub-division Erfoud, Goulmima	JICA study team	More than 1/2 of associations participated in the training seminar hold general assembly and keep appropriate minutes of meeting, activity report and financial record according to a guideline provided by ODECO. (Except associations established within 1 year)	● Carry out questionnaire survey for associations which participated in the training seminar. ● Confirm contents of minutes of meeting for general assembly, activity reports and accounting reports registered at local authority.	○	
Strengthening capacity of association for applying support from outside organizations	Jan. 2005 and Jul. 2005	CMV Jorf, Tinejdad, Alnif	Sub-division Erfoud, Goulmima	JICA study team	More than 20% increase in the number of application on Khettara rehabilitation works submitted to outside organizations compared to the previous year.	● Carry out questionnaire survey for associations and confirm contents and number of submitted application for Khettara rehabilitation work.	○	
Implementation of Khettara rehabilitation work by association in cooperation with traditional Khettara water user's group	Jan. 2005 and Jul. 2005	CMV Jorf, Tinejdad, Alnif	Sub-division Erfoud, Goulmima	JICA study team	More than 8 applications are submitted from associations to ORMVA/TF by July 2005.	● Confirm number of submitted applications (or "demand") to each CMVs and sub-divisions.	○	○
					More than 5 projects of rehabilitation are realized by the new "Partnership" scheme by July 2005.	● Confirm number of concluded contracts in each CMVs and sub-divisions.		
					Equipments are properly used according to original rehabilitation plan. (They should not be used for other purposes. Period of lending should not be extended without reasonable reason.)	● Association keeps "record of operation" for lent equipment weekly. ● ORMVA/TF staffs confirm progress of rehabilitation work, condition of equipment, financial situation of association, and other problem based on the record.		
					All associations collect money from traditional Khettara organization for covering expense on operation of equipments.	● Same as above.		
Formulating monitoring system in cooperation with ORMVA/TF, association and traditional Khettara water user's group	Jan. 2005 and Jul. 2005	CMV Jorf, Tinejdad, Alnif	Sub-division Erfoud, Goulmima	JICA study team	Monitoring activities by associations are properly carried out following to the plan. When difference is observed, the cause is confirmed and countermeasures are considered.	● Confirm monitoring results collected by associations (including monitoring activities for other verification study components)	○	○
Spreading knowledge on water saving irrigation technique supported by association	Jan. 2005 and Jul. 2005	CMV Jorf, Tinejdad, Alnif	Sub-division Erfoud, Goulmima	JICA study team	Associations located in 3 Ksars (Ait Ben Omar, Lambarkia, Taoumart), where verification studies on water saving irrigation are carried out, start any kind of activity for spreading knowledge on water saving irrigation, including seminar, technical guidance on farm land, meeting with ORMVA staff, etc.	● Carry out questionnaire survey for associations and confirm their activity for spreading knowledge on water saving irrigation.	○	○
Exchange of information and sharing knowledge and experience between associations	Jan. 2005 and Jul. 2005	CMV Jorf, Tinejdad, Alnif	Sub-division Erfoud, Goulmima	JICA study team	More than 50% of association representatives concerned by this verification study participate in the study tours.	● List of Participants are prepared in each study tour.	○	
	Jul. 2005				More than 20% of associations participated in the tour starts applying new knowledge or technique obtained.	● Carry out questionnaire survey for participants of study tour and confirm if they have applied any new technique or knowledge obtained in the tour.	○	○
					More than 10% of associations participated in the tour start exchanging information with other associations by themselves.	● Carry out questionnaire survey for participants of study tour and confirm if they have started any activity for exchanging information between associations.	○	○

6. Rural life improvement

Verification Items	Collection	Collector	Analysis	Conclusion	Target	Method for monitoring data collection	Monitoring Period	
							During Verification study	During Verification study
6. Rural Life Improvement								
Income Generation Activity (Rabbits)	July 2005	Association Concerned	CMV or Sub-division	JICA Study Team SVOP	The feasibility of rabbit rearing will be assessed in terms of technical aspect, financial aspect and willingness of farmers. The following targets are set-up. <u>Technical Aspect</u> More than 70% of participants indicate their rabbits increased. More than 30% of participants indicate their rabbits were sold. <u>Financial Aspect</u> More than 1.0 of benefit/cost ratio <u>Farmers' Willingness</u> More than 70% of participants indicate their willingness to continue rabbit breading	● Bi-weekly record to be prepared by association (Number of rabbits, food consumption, sales information and issues etc.), ● Record to be prepared by association (Willingness of participants to continue the activity in July 2005), ● Purchased record (materials for rabbit houses and rabbits) of JICA Study Team	○	○
Income Generation Activity (Pigeons)	July 2005	Association Concerned	CMV or Sub-division	JICA Study Team SVOP	The feasibility of rabbit rearing will be assessed in terms of technical aspect, financial aspect and willingness of farmers. The following targets are set-up. <u>Technical Aspect</u> Number of pigeons increased. Pigeons were sold. <u>Financial Aspect</u> More than 1.0 of benefit/cost ratio <u>Farmers' Willingness</u> A participant indicates her willingness to continue pigeon breeding.	● Bi-weekly record to be prepared by association (Number of pigions, food consumption, sales information and issues etc.), ● Record to be prepared by association (Willingness of participants to continue the activity in July 2005), ● Purchased record (construction for pigeon houses and pigeons) of JICA Study Team	○	○
Hygiene Control of Khettara	January 2005	Association Concerned	CMV or Sub-division	JICA Study Team SVOP	<u>Quantity of rinsed water poured into Khettara from laundry place</u> Quantity of rinsed water poured into Khettara is reduced. <u>Change on peoples' behavior at laundry place</u> It is confirmed that people have started doing laundry with following ways. ● Do laundry at laundry place ● Do not pour rinsed water to Khettara canal, or return it to the canal according to a new rule ● Do not do laundry inside Khettara canal	● Monitoring record to be prepared by association, ● Condition before and after construction of washing basin (photos and interviews)	○	
Environmental Improvement of Khettara Ksar using manure basin	July 2005	Association Concerned	CMV or Sub-division	JICA Study Team SVOP	<u>Production of organic manure using manure basin</u> Production of organic manure using manure basin is confirmed. <u>Change on peoples' behavior at laundry place</u> It is confirmed that people have started doing laundry with following ways. ● Do segregation between livestock dung and rubbish ● Do application of organic manure in farm land	● Monitoring record to be prepared by association, ● Condition before and after construction of washing basin (photos and interviews)	○	

7. Prevention of farmland devastation

Verification Items	Collection	Collector	Analysis	Conclusion	Target	Method for monitoring data collection	Monitoring Period	
							During Verification study	After Verification study
7. Prevention of farmland devastation								
Planting with double sack method	Feb. 2005 and Jul. 2005	CMV Jorf	ORMVA/TF (SVOP)	Study team	Nursery planted with double sack method grows in the arid region. Staff of the ORMVA/TF and Forestry and water Department acquires planting with double sack method.	● Examine the observation record prepared by staff of CMV. ● Examine the planting record by the staff of the ORMVA/TF and Forestry and water Department.	○	○

8 Data collection for further recharge facility planning

Verification Items	Collection	Collector	Analysis	Conclusion	Target	Method for monitoring data collection	Monitoring Period	
							During Verification study	After Verification study
8. Data collection for further recharge facility planning								
Data collection of meteoro-hydorological and groundwater level records	Feb. 2005 and Jul. 2005	Sub-Division （Errachidia、Beni-Tadjit、Erfoud、Rich、Goulmima）	ORMVA/TF (SER)	Study team	Meteoro-hydrological data in Tafilalet region are collected and analyzed.	● Examine the survey results of the ORMVA/TF (data collection and analysis of meteoro-hydrological and groundwater level records)	○	○
Study for groundwater analysis	Feb. 2005 and Jul. 2005	ORMVA/TF (SER) CMV （Beni-Tadjit、Jorf、Tinejdad、Alnif、Merzougha）	ORMVA/TF (SER)	Study team	Capability of groundwater analysis is improved amongst the ORMVA/TF. Trial groundwater simulation is carried out using a model of Jorf area with collaboration of the DRH and Errachidia University.	● Examine the groundwater simulation results by the ORMVA/TF.	○	○

Table 7.6.1 Irrigable Area of Each Khettara (1/2)

No		Khettara Name	Discharge Q1(l/s)	Other Demand q(l/s)	Present Irrigable Area Q1(l/s)	QI1(l/s) Q1-q	A1(ha) QI1/ 0.4	Irrigable Area "without Project" condition Q2(l/s) Q1* 0.80	QI2(l/s) Q2-q	A2(ha) QI2/ 0.4	DA2(ha) A2-A1	Irrigable Area "with Project" condition Q3C(l/s) Q1* 0.10	Q3K(l/s) RL* Qh	QI3(l/s) Q3C+Q3K-q	A3(ha) QI3/ 0.4	DA3(ha) A3-A1
A	1	Taoutoutoute	2.30	0.00	2.30	2.30	5.75	1.84	1.84	4.60	-1.15	0.23	0.21	0.44	1.10	-4.65
A	2	Iminkine	1.10	0.09	1.10	1.01	2.53	0.88	0.79	1.98	-0.55	0.11	0.21	0.23	0.58	-1.95
A	3	Ait oulhou	2.30	0.07	2.30	2.23	5.57	1.84	1.77	4.42	-1.15	0.23	0.23	0.38	0.95	-4.61
A	4	Toufaghantaste	3.40	0.05	3.40	3.35	8.36	2.72	2.67	6.66	-1.70	0.34	0.11	0.39	0.98	-7.39
A	5	Akkerouz	1.70	0.00	1.70	1.70	4.25	1.36	1.36	3.40	-0.85	0.17	0.19	0.36	0.90	-3.35
A	6	Amgane	2.30	0.00	2.30	2.30	5.75	1.84	1.84	4.60	-1.15	0.23	0.48	0.71	1.78	-3.98
A	7	Tighramt	1.70	0.00	1.70	1.70	4.25	1.36	1.36	3.40	-0.85	0.17	0.08	0.25	0.61	-3.64
A	8	Ighrane	7.30	0.00	7.30	7.30	18.25	5.84	5.84	14.60	-3.65	0.73	0.08	0.81	2.01	-16.24
A	9	Ikachrane	1.70	0.00	1.70	1.70	4.25	1.36	1.36	3.40	-0.85	0.17	0.09	0.26	0.65	-3.60
A	10	Ouine Oufroukh	1.80	0.08	1.80	1.72	4.30	1.44	1.36	3.40	-0.90	0.18	0.01	0.11	0.27	-4.03
A	11	Ouinigui	3.60	0.15	3.60	3.45	8.64	2.88	2.73	6.84	-1.80	0.36	0.03	0.25	0.62	-8.01
A	12	Oukhite	10.10	0.34	10.10	9.76	24.39	8.08	7.74	19.34	-5.05	1.01	0.41	1.07	2.68	-21.71
A	13	Ami Ali	1.00	0.00	1.00	1.00	2.50	0.80	0.80	2.00	-0.50	0.10	0.41	0.51	1.26	-1.24
A	14	Tiguida	3.10	0.00	3.10	3.10	7.75	2.48	2.48	6.20	-1.55	0.31	0.30	0.61	1.53	-6.22
A	15	Aghroud	10.60	0.00	10.60	10.60	26.50	8.48	8.48	21.20	-5.30	1.06	1.24	2.30	5.75	-20.75
A	41	Bakassia	0.50	2.15	0.50	0.00	0.00	0.40	0.00	0.00	0.00	0.05	0.88	0.00	0.00	0.00
A	42	Maamrya	6.80	0.00	6.80	6.80	17.00	5.44	5.44	13.60	-3.40	0.68	1.58	2.26	5.64	-11.36
A	43	Ami Hassan	1.60	0.65	1.60	0.95	2.38	1.28	0.63	1.58	-0.80	0.16	1.59	1.10	2.76	0.38
A	44	Lakbira	22.30	0.00	22.30	22.30	55.75	17.84	17.84	44.60	-11.15	2.23	1.30	3.53	8.83	-46.92
A	45	El Mehdia	10.00	0.80	10.00	9.20	22.99	8.00	7.20	17.99	-5.00	1.00	1.80	2.00	4.99	-18.00
A	46	Atti Kida	7.60	0.88	7.60	6.72	16.80	6.08	5.20	13.00	-3.80	0.76	1.11	0.99	2.47	-14.33
A	47	Regaga	7.70	0.44	7.70	7.26	18.15	6.16	5.72	14.30	-3.85	0.77	1.40	1.73	4.31	-13.84
A	48	Mouyjna	2.30	0.46	2.30	1.84	4.60	1.84	1.38	3.45	-1.15	0.23	1.20	0.97	2.42	-2.18
A	49	Ait My Mamoun	6.80		6.80	6.80	17.00	5.44	5.44	13.60	-3.40	0.68	0.48	1.16	2.90	-14.10
A	50	Litama	4.50		4.50	4.50	11.25	3.60	3.60	9.00	-2.25	0.45	0.27	0.72	1.81	-9.44
A	51	Ait Oulghoume	8.20	0.19	8.20	8.01	20.02	6.56	6.37	15.92	-4.10	0.82	0.47	1.10	2.74	-17.28
A	52	Dar Omira Lakdima	5.20	0.20	5.20	5.00	12.50	4.16	3.96	9.90	-2.60	0.52	0.00	0.32	0.80	-11.70
A	53	Ikhf N'lghir	8.50		8.50	8.50	21.25	6.80	6.80	17.00	-4.25	0.85	0.45	1.30	3.25	-18.00
A	54	Dar Omira Jdida	11.40		11.40	11.40	28.50	9.12	9.12	22.80	-5.70	1.14	1.80	2.94	7.35	-21.15
A	55	Azag N'ouchen	1.80	0.47	1.80	1.33	3.31	1.44	0.97	2.41	-0.90	0.18	0.95	0.65	1.63	-1.69
A	56	Izilf	0.70	0.93	0.70	0.00	0.00	0.56	0.00	0.00	0.00	0.07	2.07	1.20	3.00	3.00
A	58	Diba	7.90	1.22	7.90	6.68	16.70	6.32	5.10	12.75	-3.95	0.79	0.45	0.02	0.05	-16.65
A	59	Ait Ben Omar	4.50	0.71	4.50	3.79	9.48	3.60	2.89	7.23	-2.25	0.45	0.27	0.01	0.03	-9.45
A	60	Cheikh	4.50		4.50	4.50	11.25	3.60	3.60	9.00	-2.25	0.45	1.84	2.29	5.73	-5.52
A	61	Tamagourte	4.10		4.10	4.10	10.25	3.28	3.28	8.20	-2.05	0.41	0.14	0.55	1.36	-8.89
A	63	Khamssine	10.90	0.57	10.90	10.33	25.83	8.72	8.15	20.38	-5.45	1.09	0.48	1.00	2.51	-23.33
A	64	El Mach	12.50		12.50	12.50	31.25	10.00	10.00	25.00	-6.25	1.25	0.75	2.00	4.99	-26.26
A	70	Ami Lhoussa	1.30	0.64	1.30	0.66	1.64	1.04	0.40	0.99	-0.65	0.13	0.45	0.00	0.00	-1.64
A	73	Taghouchte	1.40		1.40	1.40	3.50	1.12	1.12	2.80	-0.70	0.14	0.19	0.33	0.83	-2.67
A	74	Taghya	2.30	0.25	2.30	2.05	5.12	1.84	1.59	3.97	-1.15	0.23	0.37	0.35	0.88	-4.25
A	65	Ait M'hmed	1.40	0.33	1.40	1.07	2.67	1.12	0.79	1.97	-0.70	0.14	0.54	0.34	0.86	-1.81
A	66	Ihandar	9.70	0.00	9.70	9.70	24.25	7.76	7.76	19.40	-4.85	0.97	0.45	1.42	3.55	-20.70
A	67	Tighfarte	9.70		9.70	9.70	24.25	7.76	7.76	19.40	-4.85	0.97	2.43	3.40	8.51	-15.74
A	98	Kdima Assoul	2.30	1.07	2.30	1.23	3.07	1.84	0.77	1.92	-1.15	0.23	0.36	0.00	0.00	-3.07
A	100	Drain Tamtatouchte	6.80	0.00	6.80	6.80	17.00	5.44	5.44	13.60	-3.40	0.68	1.58	2.26	5.64	-11.36
A	104	Drain imider	5.40	0.00	5.40	5.40	13.50	4.32	4.32	10.80	-2.70	0.54	2.70	3.24	8.10	-5.40
A	105	Idmouma	8.40	0.30	8.40	8.10	20.25	6.72	6.42	16.05	-4.20	0.84	0.70	1.24	3.10	-17.16
A	106	Agoudime	2.30	0.34	2.30	1.96	4.91	1.84	1.50	3.76	-1.15	0.23	0.04	0.00	0.00	-4.91
A	107	Ouj	9.10	0.09	9.10	9.01	22.53	7.28	7.19	17.98	-4.55	0.91	0.40	1.22	3.05	-19.47
A	108	Tasskountite	0.60	0.01	0.60	0.59	1.47	0.48	0.47	1.17	-0.30	0.06	0.04	0.09	0.23	-1.24
A	109	Outalamine	9.10	0.08	9.10	9.02	22.56	7.28	7.20	18.01	-4.55	0.91	0.18	1.01	2.53	-20.03
A	110	Oukhalk	6.80	0.05	6.80	6.75	16.88	5.44	5.39	13.48	-3.40	0.68	0.25	0.88	2.20	-14.68
A	112	Idelssene	6.80	0.48	6.80	6.32	15.79	5.44	4.96	12.39	-3.40	0.68	0.11	0.30	0.76	-15.03
A	113	Taltafroute	1.80	0.63	1.80	1.17	2.92	1.44	0.81	2.02	-0.90	0.18	0.38	0.00	0.00	-2.92
A	114	Laaouina	7.90	0.26	7.90	7.64	19.11	6.32	6.06	15.16	-3.95	0.79	0.43	0.97	2.42	-16.69
A	115	Bouhadachia	6.20	0.03	6.20	6.17	15.42	4.96	4.93	12.32	-3.10	0.62	0.50	1.08	2.71	-12.70
A	116	El maghzen	2.40	1.79	2.40	0.61	1.54	1.92	0.13	0.34	-1.20	0.24	0.58	0.00	0.00	-1.54
A	117	Elboutahiri	6.30	0.00	6.30	6.30	15.75	5.04	5.04	12.60	-3.15	0.63	0.27	0.90	2.25	-13.50
A	118	Chrif	0.80	0.08	0.80	0.72	1.79	0.64	0.56	1.39	-0.40	0.08	0.14	0.14	0.35	-1.44
A	119	Lhaj Thami	3.70	0.31	3.70	3.39	8.49	2.96	2.65	6.64	-1.85	0.37	0.29	0.36	0.89	-7.60
A	120	El arb	2.40	0.23	2.40	2.17	5.42	1.92	1.69	4.22	-1.20	0.24	0.27	0.28	0.70	-4.73
A	121	El Hassania	23.50	2.71	23.50	20.79	51.98	18.80	16.09	40.23	-11.75	2.35	1.00	0.64	1.59	-50.39
A	126	Oultamayoust	4.30	0.26	4.30	4.04	10.10	3.44	3.18	7.95	-2.15	0.43	0.08	0.25	0.62	-9.47
A	127	Tourtite	0.10	0.43	0.10	**0.00**	0.00	0.08	0.00	0.00	0.00	0.01	0.26	0.00	0.00	0.00
A	128	Taldounte	4.50	0.16	4.50	4.34	10.85	3.60	3.44	8.60	-2.25	0.45	0.15	0.45	1.11	-9.74
A	129	Imider	2.30	0.00	2.30	2.30	5.75	1.84	1.84	4.60	-1.15	0.23	1.84	2.07	5.17	-0.59
A	130	Iguerguit	1.10	0.10	1.10	1.00	2.50	0.88	0.78	1.95	-0.55	0.11	0.05	0.06	0.14	-2.36
A	131	Taourirte	2.20	0.12	2.20	2.08	5.20	1.76	1.64	4.10	-1.10	0.22	0.09	0.19	0.47	-4.73
A	132	Ihouna	1.70	0.00	1.70	1.70	4.25	1.36	1.36	3.40	-0.85	0.17	0.02	0.19	0.47	-3.78
A	68	Lakdima (Ait Maamer)	6.80	0.24	6.80	6.56	16.40	5.44	5.20	13.00	-3.40	0.68	1.07	1.51	3.78	-12.62
A	23	Ami Ahmed	3.40	0.09	3.40	3.31	8.28	2.72	2.63	6.58	-1.70	0.34	0.39	0.64	1.60	-6.68
A	134	Imider	6.80	0.05	6.80	6.75	16.87	5.44	5.39	13.47	-3.40	0.68	0.06	0.68	1.70	-15.16
A	25	Darte Dghouvaues	4.50	1.01	4.50	3.49	8.73	3.60	2.59	6.48	-2.25	0.45	0.34	0.00	0.00	-8.73
A	111	Ait Mkhoun	1.10	0.08	1.10	1.02	2.56	0.88	0.80	2.01	-0.55	0.11	0.29	0.32	0.80	-1.76
A	101	Tamajjal Nouaoulzi	4.00	0.00	4.00	4.00	10.00	3.20	3.20	8.00	-2.00	0.40	0.23	0.63	1.56	-8.44
A	136	Lagar	0.60	0.36	0.60	0.24	0.59	0.48	0.12	0.29	-0.30	0.06	0.06	0.00	0.00	-0.59
A	31	Bou ouguiss	2.30	0.06	2.30	2.24	5.60	1.84	1.78	4.45	-1.15	0.23	0.02	0.19	0.47	-5.13
A	102	Aoulzi Tamazirte	1.70	2.31	1.70	0.00	0.00	1.36	0.00	0.00	0.00	0.17	0.14	0.00	0.00	0.00
A	135	Oul N'tnayouste	1.70	0.26	1.70	1.44	3.60	1.36	1.10	2.75	-0.85	0.17	0.09	0.00	0.00	-3.60
A	103	Tamda	0.20	2.31	0.20	0.00	0.00	0.16	0.00	0.00	0.00	0.02	0.14	0.00	0.00	0.00
B	1	Agoummad	27.30	0.43	27.30	26.87	67.18	21.84	21.41	53.53	-13.65	2.73	0.50	2.81	7.02	-60.17
B	2	Tamazaroute	20.50	0.43	20.50	20.07	50.17	16.40	15.97	39.92	-10.25	2.05	0.06	1.68	4.19	-45.98
B	3	Ait Sbaa	1.50	0.26	1.50	1.24	3.11	1.20	0.94	2.36	-0.75	0.15	0.01	0.00	0.00	-3.11
B	4	EL Ain	6.80	0.16	6.80	6.64	16.61	5.44	5.28	13.21	-3.40	0.68	0.13	0.65	1.63	-14.97
B	5	Bousfssaf	11.40	0.00	11.40	11.40	28.50	9.12	9.12	22.80	-5.70	1.14	0.60	1.74	4.35	-24.15
B	6	El Majen	6.80	0.15	6.80	6.65	16.62	5.44	5.29	13.22	-3.40	0.68	0.14	0.67	1.67	-14.95
B	7	El Fougania	1.10		1.10	0.00		0.88	0.88	2.20	2.20	0.11	0.30	0.41	1.03	1.03
B	8	Ait Yakoub (2)	2.80	0.15	2.80	2.65	6.63	2.24	2.09	5.23	-1.40	0.28	2.81	2.94	7.34	0.71
B	10	Roda	17.00	0.46	17.00	16.54	41.35	13.60	13.14	32.85	-8.50	1.70	0.78	2.02	5.05	-36.30
B	14	Jdida	22.70	0.15	22.70	22.55	56.37	18.16	18.01	45.02	-11.35	2.27	1.25	3.37	8.42	-47.95
B	16	Tafejjaret	20.50	0.04	20.50	20.46	51.15	16.40	16.36	40.90	-10.25	2.05	0.91	2.92	7.31	-43.85
B	17	Ain Chouater	20.50	0.11	20.50	20.39	50.96	16.40	16.29	40.71	-10.25	2.05	0.70	2.63	6.58	-44.39
B	18	Douimniaa	4.20	0.17	4.20	4.03	10.07	3.36	3.19	7.97	-2.10	0.42	0.72	0.97	2.42	-7.65
B	19	El Hajoui	4.50	0.08	4.50	4.42	11.06	3.60	3.52	8.81	-2.25	0.45	0.51	0.88	2.21	-8.85
B	12	Beni Tajit	21.90	0.46	21.90	21.44	53.60	17.52	17.06	42.65	-10.95	2.19	0.40	2.13	5.33	-48.27
B	20	Talssinte	11.40	0.23	11.40	11.17	27.93	9.12	8.89	22.23	-5.70	1.14	0.11	1.02	2.56	-25.37
B	15	El Hajoui Sidi Abrerrahmane	12.30	0.15	12.30	12.15	30.37	9.84	9.69	24.22	-6.15	1.23	0.08	1.16	2.90	-27.47
B	13	Ait My Hachem	0.60	0.08	0.60	0.52	1.30	0.48	0.40	1.00	-0.30	0.06	0.20	0.18	0.45	-0.86
B	22	Ait Boubker / Youssef	10.20	0.21	10.20	9.99	24.97	8.16	7.95	19.87	-5.10	1.02	0.24	1.05	2.63	-22.35
B	23	Talhamsoust	1.70	0.13	1.70	1.57	3.92	1.36	1.23	3.07	-0.85	0.17	0.06	0.10	0.25	-3.67

Table 7.6.1 Irrigable Area of Each Khettara (2/2)

Diminution 0.4 l/s/ha 20 %

Augmentation Q=>10 2.0 l/s/km; 10% 5<=Q<10 1.5; Q<=5 1.0

No		Nom de Khettara	Pertes Q1(l/s)	Demenda-non irrigation q(l/s)	Superficie Irrigulle Presente Q1(l/s)	Q1(l/s) Q1-q	A1(ha) Q1/ 0.4	Superficie Irrigulle-Condition"Sans Project" Q2(l/s) Q1* 0.80	Q2-q	A2(ha) Q2/ 0.4	DA2(ha) A2-A1	Superficie Irrigulle-Condition"Avec Project" Q3C(l/s) Q1* 0.10	Q3K(l/s) RL* Qh	Q3C+Q3K-q	A3(ha) Q3/ 0.4	DA3(ha) A3-A1
C	1	Oued Naam	10.20	0.06	10.20	10.14	25.35	8.16	8.10	20.25	-5.10	1.02	2.58	3.54	8.85	-16.50
C	2	Ouled Ali	16.70	0.81	16.70	15.89	39.73	13.36	12.55	31.38	-8.35	1.67	4.92	5.78	14.45	-25.28
C	3	Taouz	19.30	0.00	19.30	19.30	48.25	15.44	15.44	38.60	-9.65	1.93	1.20	3.13	7.83	-40.43
C	4	Lakbira	10.20	0.77	10.20	9.43	23.58	8.16	7.39	18.48	-5.10	1.02	3.18	3.43	8.58	-15.00
C	5	Lakdima	13.60	1.23	13.60	12.37	30.94	10.88	9.65	24.14	-6.80	1.36	0.45	0.58	1.46	-29.48
C	6	Jdida	22.70	0.88	22.70	21.82	54.54	18.16	17.28	43.19	-11.35	2.27	3.51	4.90	12.24	-42.30
C	7	Torba	3.90	0.01	3.90	3.89	9.73	3.12	3.11	7.78	-1.95	0.39	0.42	0.80	2.00	-7.73
C	8	Lahcen	8.40	1.76	8.40	6.64	16.60	6.72	4.96	12.40	-4.20	0.84	2.61	1.69	4.23	-12.38
D	31	Lakbira	9.10	0.60	9.10	8.50	21.26	7.28	6.68	16.71	-4.55	0.91	1.26	1.57	3.93	-17.33
D	34	Souihla	13.60	0.44	13.60	13.16	32.89	10.88	10.44	26.09	-6.80	1.36	0.30	1.22	3.04	-29.85
D	35	Aissaouia	2.30	0.99	2.30	1.31	3.27	1.84	0.85	2.12	-1.15	0.23	0.95	0.18	0.46	-2.81
D	36	Saidia	3.90	0.51	3.90	3.39	8.48	3.12	2.61	6.53	-1.95	0.39	1.31	1.19	2.98	-5.51
D	41	El Aissaouia	6.40	0.56	6.40	5.84	14.60	5.12	4.56	11.40	-3.20	0.64	3.03	3.11	7.78	-6.82
D	42	Lambarkia	23.40	0.60	23.40	22.80	57.00	18.72	18.12	45.30	-11.70	2.34	2.40	4.14	10.35	-46.65
D	44	Lambarkia	19.70	0.54	19.70	19.16	47.90	15.76	15.22	38.05	-9.85	1.97	4.27	5.70	14.24	-33.66
D	47	Lahloua	21.50	0.75	21.50	20.75	51.88	17.20	16.45	41.13	-10.75	2.15	4.50	5.90	14.76	-37.13
D	53	Kdima	28.20	0.00	28.20	28.20	70.50	22.56	22.56	56.40	-14.10	2.82	4.44	7.26	18.15	-52.35
D	54	jdida	16.50	0.40	16.50	16.10	40.25	13.20	12.80	32.00	-8.25	1.65	3.24	4.49	11.23	-29.03
D	55	Kdima	16.70	0.58	16.70	16.12	40.30	13.36	12.78	31.95	-8.35	1.67	2.22	3.31	8.27	-32.03
D	56	Jdida	14.00	0.35	14.00	13.65	34.13	11.20	10.85	27.13	-7.00	1.40	2.40	3.45	8.63	-25.50
D	58	Khtitira	21.00	0.45	21.00	20.55	51.38	16.80	16.35	40.88	-10.50	2.10	2.30	3.95	9.87	-41.51
D	59	Sayed	11.70	0.41	11.70	11.29	28.23	9.36	8.95	22.38	-5.85	1.17	2.50	3.27	8.17	-20.06
D	60	Fougania	50.20	0.55	50.20	49.65	124.13	40.16	39.61	99.03	-25.10	5.02	3.40	7.87	19.66	-104.46
D	61	Quastania	6.80	0.47	6.80	6.33	15.81	5.44	4.97	12.41	-3.40	0.68	2.93	3.13	7.83	-7.99
D	62	Kdima	10.90	0.39	10.90	10.51	26.28	8.72	8.33	20.83	-5.45	1.09	3.51	4.21	10.53	-15.75
D	64	Lgrinia	6.40	0.54	6.40	5.86	14.66	5.12	4.58	11.46	-3.20	0.64	1.86	1.96	4.90	-9.76
D	65	Laalouia (Hannabou)	8.20	0.46	8.20	7.74	19.34	6.56	6.10	15.24	-4.10	0.82	2.93	3.28	8.20	-11.14
D	66	Mostafia	5.30	0.17	5.30	5.13	12.82	4.24	4.07	10.17	-2.65	0.53	2.50	2.86	7.14	-5.68
D	69	Kdima	22.10	0.40	22.10	21.70	54.25	17.68	17.28	43.20	-11.05	2.21	3.78	5.59	13.98	-40.28
E	1	El Ghanamia	1.10		1.10	1.10	2.75	0.88	0.88	2.20	-0.55	0.11	1.75	1.86	4.66	1.91
E	2	El bour	4.90	0.70	4.90	4.20	10.51	3.92	3.22	8.06	-2.45	0.49	2.27	2.06	5.16	-5.35
E	4	Laagaya	2.30		2.30	2.30	5.75	1.84	1.84	4.60	-1.15	0.23	1.44	1.67	4.18	-1.58
E	5	Jdida Bel Houcine	0.60	0.39	0.60	0.21	0.53	0.48	0.09	0.23	-0.30	0.06	2.14	1.81	4.52	3.99
E	6	Jdida Bel Houcine	4.50		4.50	4.50	11.25	3.60	3.60	9.00	-2.25	0.45	2.39	2.84	7.09	-4.16
E	7	Ramlia	14.40	0.57	14.40	13.83	34.58	11.52	10.95	27.38	-7.20	1.44	2.70	3.57	8.93	-25.65
E	8	Lakdima Douar	27.10	1.55	27.10	25.55	63.88	21.68	20.13	50.33	-13.55	2.71	3.58	4.74	11.85	-52.03
E	9	Lihoudia	1.40	0.00	1.40	1.40	3.50	1.12	1.12	2.80	-0.70	0.14	1.78	1.92	4.81	1.31
E	10	Laglaglia	3.40	0.79	3.40	2.61	6.52	2.72	1.93	4.82	-1.70	0.34	1.64	1.19	2.97	-3.55
E	12	Jdida Lhaj El Madani	3.40		3.40	3.40	8.50	2.72	2.72	6.80	-1.70	0.34	1.30	1.64	4.09	-4.41
E	13	Laaguilia Kbour Lihoud	4.00	0.57	4.00	3.43	8.57	3.20	2.63	6.57	-2.00	0.40	1.96	1.79	4.47	-4.10
E	14	Lhaj Alal	28.30	2.92	28.30	25.38	63.44	22.64	19.72	49.29	-14.15	2.83	5.27	5.18	12.95	-50.49
E	15	Ighzer	2.30	0.79	2.30	1.51	3.76	1.84	1.05	2.61	-1.15	0.23	1.67	1.10	2.75	-1.01
E	16	Charchmia	21.10	2.89	21.10	18.21	45.53	16.88	13.99	34.98	-10.55	2.11	2.87	2.09	5.23	-40.30
F	1	Loujarchia	4.50	1.26	4.50	3.24	8.10	3.60	2.34	5.85	-2.25	0.45	0.56	0.00	0.00	-8.10
F	24	Harounia	0.60	0.00	0.60	0.60	1.50	0.48	0.48	1.20	-0.30	0.06	1.90	1.96	4.89	3.39
F	27	Agaroum	1.10	0.17	1.10	0.93	2.32	0.88	0.71	1.77	-0.55	0.11	0.08	0.01	0.04	-2.29
F	32	Talaabast	6.80	0.87	6.80	5.93	14.83	5.44	4.57	11.43	-3.40	0.68	0.67	0.48	1.20	-13.62
F	33	Tamaright	2.30	0.17	2.30	2.13	5.32	1.84	1.67	4.17	-1.15	0.23	1.54	1.60	3.99	-1.33
F	34	Tamazante	2.30	1.00	2.30	1.30	3.26	1.84	0.84	2.11	-1.15	0.23	0.99	0.23	0.56	-2.70
F	35	Taachaboute	0.60	0.19	0.60	0.41	1.03	0.48	0.29	0.73	-0.30	0.06	0.54	0.41	1.03	0.00
F	36	Hassi Labied	4.50	0.71	4.50	3.79	9.47	3.60	2.89	7.22	-2.25	0.45	1.10	0.84	2.10	-7.37
F	38	ElBagaa	1.70	0.20	1.70	1.50	3.74	1.36	1.16	2.89	-0.85	0.17	1.36	1.33	3.32	-0.43
F	42	Ait Taghla	2.90	0.20	2.90	2.70	6.76	2.32	2.12	5.31	-1.45	0.29	1.02	1.11	2.79	-3.98
F	40	Tamaright	1.10	0.24	1.10	0.86	2.16	0.88	0.64	1.61	-0.55	0.11	0.59	0.46	1.14	-1.01
G	1	M'Cissi	0.60	0.00	0.60	0.60	1.50	0.48	0.48	1.20	-0.30	0.06	0.76	0.82	2.04	0.54
G	3	Bouadil	5.70	0.20	5.70	5.50	13.74	4.56	4.36	10.89	-2.85	0.57	0.41	0.77	1.93	-11.81
G	4	Azag	1.10	0.00	1.10	1.10	2.75	0.88	0.88	2.20	-0.55	0.11	0.46	0.57	1.43	-1.32
G	13	Taghroute	1.20	0.23	1.20	0.97	2.43	0.96	0.73	1.83	-0.60	0.12	0.11	0.00	0.00	-2.43
G	14	Agoumad	0.80	0.12	0.80	0.68	1.70	0.64	0.52	1.30	-0.40	0.08	0.04	0.00	0.01	-1.70
G	15	Alnif	3.00	1.68	3.00	1.32	3.29	2.40	0.72	1.79	-1.50	0.30	1.11	0.00	0.00	-3.29
G	17	Ait Lahbib	0.30	0.00	0.30	0.30	0.75	0.24	0.24	0.60	-0.15	0.03	0.83	0.86	2.14	1.39
G	18	Tizi Lakdima	3.10	0.46	3.10	2.64	6.60	2.48	2.02	5.05	-1.55	0.31	1.06	0.91	2.27	-4.34
G	21	Jdida Ammar	12.60	0.00	12.60	12.60	31.50	10.08	10.08	25.20	-6.30	1.26	1.92	3.18	7.95	-23.55
G	22	Azrag	0.60	0.07	0.60	0.53	1.33	0.48	0.41	1.03	-0.30	0.06	0.30	0.29	0.73	-0.60
G	37	Ait Ben Said	5.70	0.34	5.70	5.36	13.39	4.56	4.22	10.54	-2.85	0.57	1.60	1.82	4.56	-8.83
G	46	Tanoute Noumardoul	1.10	0.07	1.10	1.03	2.57	0.88	0.81	2.02	-0.55	0.11	0.15	0.18	0.46	-2.11
G	47	Tagualgoulte	1.20	0.20	1.20	1.00	2.49	0.96	0.76	1.89	-0.60	0.12	0.48	0.39	0.98	-1.51
G	48	Jorf	1.10	0.06	1.10	1.04	2.61	0.88	0.82	2.06	-0.55	0.11	0.84	0.89	2.23	-0.38
G	52	Iminouzrou	0.80	0.16	0.80	0.64	1.60	0.64	0.48	1.20	-0.40	0.08	0.29	0.21	0.52	-1.07
G	53	Tiguirna	2.20	0.60	2.20	1.60	4.01	1.76	1.16	2.91	-1.10	0.22	0.32	0.00	0.00	-4.01
G	55	Tinififfe	5.50	0.15	5.50	5.35	13.37	4.40	4.25	10.62	-2.75	0.55	0.63	1.03	2.58	-10.79
G	56	Afrou	1.10	0.13	1.10	0.97	2.43	0.88	0.75	1.88	-0.55	0.11	0.33	0.31	0.77	-1.66
G	57	Talghazit	0.60	0.05	0.60	0.55	1.37	0.48	0.43	1.07	-0.30	0.06	0.15	0.16	0.40	-0.97
G	58	Tihammate	2.30	0.00	2.30	2.30	5.75	1.84	1.84	4.60	-1.15	0.23	0.27	0.50	1.25	-4.50
G	59	Lakbira	0.50	0.38	0.50	0.12	0.29	0.40	0.02	0.04	-0.25	0.05	0.17	0.00	0.00	-0.29
G	60	JdidaTaoumarte	2.00	0.38	2.00	1.62	4.04	1.60	1.22	3.04	-1.00	0.20	0.18	0.00	-0.01	-4.05
G	61	Afrou	0.60	0.00	0.60	0.60	1.50	0.48	0.48	1.20	-0.30	0.06	0.23	0.29	0.71	-0.79
G	62	Tassamamte	3.50	0.22	3.50	3.28	8.19	2.80	2.58	6.44	-1.75	0.35	0.22	0.34	0.86	-7.34
G	63	Toufassamman	1.50	0.30	1.50	1.20	3.00	1.20	0.90	2.25	-0.75	0.15	0.48	0.33	0.82	-2.18
G	64	Timzarzit	2.00	0.31	2.00	1.69	4.23	1.60	1.29	3.23	-1.00	0.20	0.54	0.43	1.08	-3.14
G	65	Tajohrate	1.70	0.05	1.70	1.65	4.13	1.36	1.31	3.28	-0.85	0.17	0.08	0.20	0.51	-3.62
G	67	Ait Mouhou	0.20	0.00	0.20	0.20	0.50	0.16	0.16	0.40	-0.10	0.02	0.36	0.38	0.95	0.45
G	77	Izougaghine	0.20		0.20	0.20	0.50	0.16	0.16	0.40	-0.10	0.02	0.63	0.65	1.63	1.13
G	78	Tamlalt	2.80	1.30	2.80	1.50	3.74	2.24	0.94	2.34	-1.40	0.28	0.96	0.00	0.00	-3.74
G	80	Tissamoumine	1.80	0.25	1.80	1.55	3.88	1.44	1.19	2.98	-0.90	0.18	0.01	0.00	0.00	-3.88
G	83	Takacha	3.40	0.41	3.40	2.99	7.47	2.72	2.31	5.77	-1.70	0.34	1.41	1.34	3.34	-4.13
G	87	Aachich Ait Iaza	11.40	2.56	11.40	8.84	22.11	9.12	6.56	16.41	-5.70	1.14	1.06	0.00	0.00	-22.11
G	89	Fouk Talilate	0.60	0.26	0.60	0.34	0.85	0.48	0.22	0.55	-0.30	0.06	0.63	0.43	1.08	0.24
G	94	Battou	2.30	0.28	2.30	2.02	5.06	1.84	1.56	3.91	-1.15	0.23	0.81	0.76	1.91	-3.15
G	95	Khtart Battou	1.70	0.20	1.70	1.50	3.75	1.36	1.16	2.90	-0.85	0.17	0.64	0.61	1.52	-2.24
G	103	Tizagarne	2.30	0.92	2.30	1.38	3.45	1.84	0.92	2.30	-1.15	0.23	0.65	0.00	0.00	-3.45
			1,277	76	1,277	1,205	3,012	1,022	951	2,378	- 634.10	128	195	256	639	- 2,373.01

Table 7.7.1 (1/4) Present Crop Budget

Items	Unit	Carrot Price	Carrot Quantity	Carrot Subtotal	Onion Price	Onion Quantity	Onion Subtotal
Input				6,720			7,980
1. Labour fee	DH/day			1,600			800
Plow	DH/hr	100	8	800	100	8	800
Seed bed	DH/hr	40	20	800	40	0	0
Sowing / Planting	DH/hr	40	0	0	40	0	0
Fertilizing	DH/hr	28	0	0	28	0	0
Maintenance	DH/hr	28	0	0	28	0	0
Irrigation	DH/day	32	0	0	32	0	0
Harvest	DH/day	28	0	0	28	0	0
2. Materials				4,800			6,450
Seeds / Seedlings	DH/kg	100	5	500	800	0.4	320
Chemicals	DH/kg						
Fertilizer	DH/kg	50	3	150	100	3	300
Fertilizer	DH/kg						
Compost	DH/ton	175	10	1,750	175	10	1,750
Water fee	DH/M3	0.48	5,000	2,400	0.48	8,500	4,080
3. Others (5% of item 1.+2.)				320			730
Gross product				18,900			49,140
Harvest	Kg			14,000			18,200
Proportion for commercial products	%			90%			90%
Unit price	DH/kg			1.50			3.00
Net income				12,180			41,160

Items	Unit	Tomato Price	Tomato Quantity	Tomato Subtotal	Red pepper Price	Red pepper Quantity	Red pepper Subtotal
Input				13,990			11,270
1. Labour fee	DH/day			1,600			1,480
Plow	DH/hr	100	8	800	100	8	800
Seed bed	DH/day	40	0	0	40	0	0
Sowing / Planting	DH/day	40	0	0	40	10	400
Fertilizing	DH/day	28	0	0	28	0	0
Furrowing	DH/day	40	20	800			
Maintenance	DH/day	28	0	0	28	0	0
Irrigation	DH/day	32	0	0	32	0	0
Harvest	DH/day	28	0	0	28	10	280
2. Materials				11,720			8,765
Seeds / Seedlings	DH/kg	1100	1	1,100	50000	0	2,500
Chemicals	DH/lit	7	110	770			
Fertilizer	DH/kg	300	3	900	100	3	285
Fertilizer	DH/kg				50	3	150
Compost	DH/ton	175	10	1,750	175	10	1,750
Water fee	DH/M3	0.48	15,000	7,200	0.48	8,500	4,080
3. Others (5% of item 1.+2.)				670			1,020
Gross product				33,080			31,500
Harvest	Kg			21,000			14,000
Proportion for commercial products	%			90%			90%
Unit price	DH/kg			1.75			2.50
Net income				19,090			20,230

Table 7.7.1 (2/4) Present Crop Budget

Items	Unit	Wheat Price	Wheat Quantity	Wheat Subtotal	Bean Price	Bean Quantity	Bean Subtotal
Input				4,888			7,700
1. Labour fee	DH/day			840			560
Plow	DH/hr	70	12	840	70	8	560
Seed bed	DH/day						
Sowing / Planting	DH/day	28	0	0	28	0	0
Fertilizing	DH/day	28	0	0	28	0	0
Leveling	DH/day	28	0	0			
Maintenance	DH/day	28	0	0	28	0	0
Irrigation	DH/day	32	0	0	32	0	0
Harvest	DH/day	20	0	0	20	0	0
Threshing	DH/day	50	0	0			
2. Materials				3,818			6,435
Seeds / Seedlings	DH/kg	140	4	560	150	8	1,200
Chemicals	DH/lit	0	110	0	50		50
Fertilizer	DH/kg	0	3	0			
Fertilizer	DH/kg	50	4	175			
Compost	DH/ton	175	5	875	125	5	625
Water fee	DH/M3	0.48	4,600	2,208	0.48	9,500	4,560
3. Others (5% of item 1.+2.)				230			700
Gross Product				7,680			11,340
Harvest	Kg			1,800			2,100
Proportion for commercial products	%			90%			90%
Unit price	DH/kg			4.00			6.00
Straw	DH/kg			1,200			
Net income				2,792			3,640

Table 7.7.1 (3/4) Present Crop Budget

Date Palm

Items	First year Planting	1st year	2nd	3rd	4th	5th	6th	7th	8th	9th	10th - 30th	Average
Input	32,485	1,495	1,185	1,605	1,605	1,605	1,605	1,730	1,730	1,650	1,650	2,710
1. Labour fee	560	300	0	0	0	0	0	0	0	0	0	
Plow	560	0	0	0	0	0	0	0	0	0	0	
Preparation	0	300	0	0	0	0	0	0	0	0	0	4
Seedling / Seeds	0	0	0	0	0	0	0	0	0	0	0	
Maintenance	0	0	0	0	0	0	0	0	0	0	0	
Irrigation	0	0	0	0	0	0	0	0	0	0	0	
Harvest	0	0	0	0	0	0	0	0	0	0	0	
2. Materials	30,375	1,125	1,125	1,525	1,525	1,525	1,525	1,650	1,650	1,650	1,650	
Seeds / Seedlings	30,000	0	0	0	0	0	0	0	0	0	0	
Compost	375	1,125	1,125	1,125	1,125	1,125	1,125	1,250	1,250	1,250	1,250	
Fertilizer	0	0	0	0	0	0	0	0	0	0	0	
Chemicals	0	0	0	400	400	400	400	400	400	400	400	
Irrigation fee	0	0	0	0	0	0	0	0	0	0	0	
3. Others (5% of item 1.+2.)	1,550	70	60	80	80	80	80	80	80	0	0	
Gross product	0	0	0	0	0	0	0	11,592	17,388	23,184	28,980	22,020
Harvest	0	0	0	0	0	0	0	920	1,380	1,840	2,300	
Proportion for commercial products	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
Unit price	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	
Net income	-32,485	-1,495	-1,185	-1,605	-1,605	-1,605	-1,605	9,862	15,658	21,534	27,330	19,310

Olive

Items	First year Planting	1st year	2nd	3rd	4th	5th	6th	7th	8th	9th	10th - 30th	Average
Input	7,140	0	0	0	0	0	0	0	0	0	0	240
1. Labour fee	800	0	0	0	0	0	0	0	0	0	0	
Plow	800	0	0	0	0	0	0	0	0	0	0	
Preparation	0	0	0	0	0	0	0	0	0	0	0	
Seedling / Seeds	0	0	0	0	0	0	0	0	0	0	0	
Maintenance	0	0	0	0	0	0	0	0	0	0	0	
Irrigation	0	0	0	0	0	0	0	0	0	0	0	
Harvest	0	0	0	0	0	0	0	0	0	0	0	
2. Materials	6,000	0	0	0	0	0	0	0	0	0	0	
Seeds / Seedlings	1,000	0	0	0	0	0	0	0	0	0	0	
Compost	5,000	0	0	0	0	0	0	0	0	0	0	
Fertilizer	0	0	0	0	0	0	0	0	0	0	0	
Chemicals	0	0	0	0	0	0	0	0	0	0	0	
Irrigation fee	0	0	0	0	0	0	0	0	0	0	0	
3. Others (5% of item 1.+2.)	340	0	0	0	0	0	0	0	0	0	0	
Gross Product	0	0	0	1,800	3,600	5,400	7,200	10,800	10,800	10,800	10,800	9,240
Harvest	0	0	0	500	1,000	1,500	2,000	3,000	3,000	3,000	3,000	
Proportion for commercial products	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
Unit price	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
Net income	-7,140	0	0	1,800	3,600	5,400	7,200	10,800	10,800	10,800	10,800	9,000

Table 7.7.1 (4/4) Present Crop Budget

Alfalfa Items	First year Planting	1st year	2nd	3rd	4th	Average
Input	8,110	790	790	790	790	2,300
1. Labour fee	1,240	0	0	0	0	
Plow	840	0	0	0	0	
Preparation	400	0	0	0	0	
Seedling / Seeds	0	0	0	0	0	
Maintenance	0	0	0	0	0	
Irrigation	0	0	0	0	0	
Harvest	0	0	0	0	0	
2. Materials	6,480	750	750	750	750	
Seeds / Seedlings	1,200	0	0	0	0	
Compost	5,000	750	750	750	750	
Fertilizer	280	0	0	0	0	
Chemicals	0	0	0	0	0	
Irrigation fee	0	0	0	0	0	
3. Others (5% of item 1.+2.)	390	40	40	40	40	
			0			
Gross product	0	7,938	8,820	8,820	8,820	6,900
Harvest	0	25	28	28	28	22
Proportion for commercial products	90%	90%	90%	90%	90%	
Unit price	350.00	350.00	350.00	350.00	350.00	
Net income	-8,110	7,148	8,030	8,030	8,030	4,630

Table 7.7.2 (1/4) Future Crop Budget

Items	Unit	Carrot Price	Carrot Quantity	Carrot Subtotal	Onion Price	Onion Quantity	Onion Subtotal
Input				9,240			20,480
1. Labour fee	DH/day			1,600			1,600
Plow	DH/hr	100	8	800	100	8	800
Seed bed	DH/hr	40	20	800	40	20	800
Sowing / Planting	DH/hr	40	0	0	40	0	0
Fertilizing	DH/hr	40	0	0	40	0	0
Maintenance	DH/hr	40	0	0	40	0	0
Irrigation	DH/day	40	0	0	40	0	0
Harvest	DH/day	40	0	0	40	0	0
2. Materials				7,200			17,020
Seeds / Seedlings	DH/kg	100	5	500	800	0	320
Chemicals	DH/kg						
Fertilizer	DH/kg	400	3	1,200	200	3	600
Fertilizer	DH/kg						
Compost	DH/ton	250	10	2,500	250	10	2,500
Water fee	DH/M3	2.0	4,000	3,000	2.0	6,800	13,600
3. Others (5% of item 1.+2.)				440			1,860
Gross product				32,400			84,240
Harvest	Kg			20,000			26,000
Proportion for commercial products	%			90%			90%
Unit price	DH/kg			1.80			3.60
Net income				23,160			63,760

Items	Unit	Tomato Price	Tomato Quantity	Tomato Subtotal	Red pepper Price	Red pepper Quantity	Red pepper Subtotal
Input				33,360			23,620
1. Labour fee	DH/day			1,600			2,000
Plow	DH/hr	100	8	800	100	8	800
Seed bed	DH/day	40	0	0	40	0	0
Sowing / Planting	DH/day	40	0	0	40	20	800
Fertilizing	DH/day	40	0	0	40	10	400
Furrowing	DH/day	40	20	800			
Maintenance	DH/day	40	0	0	40	0	0
Irrigation	DH/day	40	0	0	40	0	0
Harvest	DH/day	40	0	0	40	0	0
2. Materials				30,170			19,470
Seeds / Seedlings	DH/kg	1100	1	1,100	50000	0	2,500
Chemicals	DH/lit	7	110	770			
Fertilizer	DH/kg	600	3	1,800	200	3	570
Fertilizer	DH/kg				100	3	300
Compost	DH/ton	250	10	2,500	250	10	2,500
Water fee	DH/M3	2.0	12,000	24,000	2.0	6,800	13,600
3. Others (5% of item 1.+2.)				1,590			2,150
Gross product				56,700			54,000
Harvest	Kg			30,000			20,000
Proportion for commercial products	%			90%			90%
Unit price	DH/kg			2.10			3.00
Net income				23,340			30,380

Table 7.7.2 (2/4) Future Crop Budget

Items	Unit	Wheat Price	Wheat Quantity	Wheat Subtotal	Bean Price	Bean Quantity	Bean Subtotal
Input				7,860			9,000
1. Labour fee	DH/day			1,200			800
Plow	DH/hr	100	12	1,200	100	8	800
Seed bed	DH/day						
Sowing / Planting	DH/day	40	0	0	40	0	0
Fertilizing	DH/day	40	0	0	40	0	0
Leveling	DH/day	40	0	0			
Maintenance	DH/day	40	0	0	40	0	0
Irrigation	DH/day	40	0	0	40	0	0
Harvest	DH/day	40	0	0	40	0	0
Threshing	DH/day	100	0	0			
2. Materials				6,290			8,200
Seeds / Seedlings	DH/kg	140	4	560	150	8	1,200
Chemicals	DH/lit	7	110	770	50	1	50
Fertilizer	DH/kg	200	3	600			
Fertilizer	DH/kg	100	4	350			
Compost	DH/ton	250	5	1,250	250	5	1,250
Water fee	DH/M3	0.6	4,600	2,760	0.6	9,500	5,700
3. Others (5% of item 1.+2.)				370			0
Gross Product				12,000			16,200
Harvest	Kg			3,000			3,000
Proportion for commercial products	%			90%			90%
Unit price	DH/kg			4.00			6.00
Straw	DH/kg			1,200			
Net income				4,140			7,200

Table 7.7.2 (3/4) Future Crop Budget

Date Palm

Items	First year Planting	1st year	2nd	3rd	4th	5th	6th	7th	8th	9th	10th - 30th	Average
Input	33,585	10,945	10,945	10,945	10,945	10,945	10,945	3,545	4,295	4,295	4,295	6,720
1. Labour fee	560	1,200	1,200	1,200	1,200	1,200	1,200	0	720	720	720	
Plow	560	0	0	0	0	0	0	0	0	0	0	
Preparation	0	600	600	600	600	600	600	0	0	0	0	
Seedling / Seeds	0	0	0	0	0	0	0	0	0	0	0	
Maintenance	0	0	0	0	0	0	0	0	720	720	720	
Irrigation	0	600	600	600	600	600	600	0	0	0	0	
Harvest	0	0	0	0	0	0	0	0	0	0	0	
2. Materials	31,425	9,225	9,225	9,225	9,225	9,225	9,225	3,375	3,375	3,375	3,375	
Seeds / Seedlings	30,000	0	0	0	0	0	0	0	0	0	0	
Compost	375	1,125	1,125	1,125	1,125	1,125	1,125	1,250	1,250	1,250	1,250	
Fertilizer	750	4,500	4,500	4,500	4,500	4,500	4,500	1,125	1,125	1,125	1,125	
Chemicals	0	1,800	1,800	1,800	1,800	1,800	1,800	400	400	400	400	
Irrigation fee	300	1,800	1,800	1,800	1,800	1,800	1,800	600	600	600	600	
3. Others (5% of item 1.+2.)	1,600	520	520	520	520	520	520	170	200	200	200	
Gross product	0	0	0	0	0	0	0	23,040	34,560	46,080	57,600	43,780
Harvest	0	0	0	0	0	0	0	1,600	2,400	3,200	4,000	
Proportion for commercial products	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
Unit price	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	
Net income	-33,585	-10,945	-10,945	-10,945	-10,945	-10,945	-10,945	19,495	30,265	41,785	53,305	37,060

Olive

Items	First year Planting	1st year	2nd	3rd	4th	5th	6th	7th	8th	9th	10th - 30th	Average
Input	8,930	6,290	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,760
1. Labour fee	1,200	600	0	0	0	0	0	0	0	0	0	
Plow	800	0	0	0	0	0	0	0	0	0	0	
Preparation	0	300	0	0	0	0	0	0	0	0	0	
Seedling / Seeds	400	0	0	0	0	0	0	0	0	0	0	
Maintenance	0	0	0	0	0	0	0	0	0	0	0	
Irrigation	0	300	0	0	0	0	0	0	0	0	0	
Harvest	0	0	0	0	0	0	0	0	0	0	0	
2. Materials	7,300	5,390	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	
Seeds / Seedlings	1,000	0	0	0	0	0	0	0	0	0	0	
Compost	5,000	0	0	0	0	0	0	0	0	0	0	
Fertilizer	1,000	3,200	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	
Chemicals	0	750	600	600	600	600	600	600	600	600	600	
Irrigation fee	300	1,440	600	600	600	600	600	600	600	600	600	
3. Others (5% of item 1.+2.)	430	300	160	160	160	160	160	160	160	160	160	
Gross Product	0	0	0	4,320	8,640	12,960	17,280	25,920	25,920	25,920	25,920	22,180
Harvest	0	0	0	1,000	2,000	3,000	4,000	6,000	6,000	6,000	6,000	
Proportion for commercial products	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
Unit price	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	
Net income	-8,930	-6,290	-3,360	960	5,280	9,600	13,920	22,560	22,560	22,560	22,560	18,420

Table 7.7.2 (4/4) Future Crop Budget

Alfalfa						
Items	First year Planting	1st year	2nd	3rd	4th	Average
Input	9,030	7,930	7,930	7,930	7,930	8,150
1. Labour fee	400	0	0	0	0	
Plow	0	0	0	0	0	
Preparation	400	0	0	0	0	
Seedling / Seeds	0	0	0	0	0	
Maintenance	0	0	0	0	0	
Irrigation	0	0	0	0	0	
Harvest	0	0	0	0	0	
2. Materials	8,200	7,550	7,550	7,550	7,550	
Seeds / Seedlings	1,200	0	0	0	0	
Compost	5,000	750	750	750	750	
Fertilizer	1,400	800	800	800	800	
Chemicals	0	0	0	0	0	
Irrigation fee	600	6,000	6,000	6,000	6,000	
3. Others (5% of item 1.+2.)	430	380	380	380	380	
Gross product	0	17,010	18,900	18,900	18,900	14,740
Harvest	0	54	60	60	60	47
Proportion for commercial products	90%	90%	90%	90%	90%	
Unit price	350.00	350.00	350.00	350.00	350.00	
Net income	-9,030	9,080	10,970	10,970	10,970	6,590

Table 7.10.1 Recharge Effects by Recharge Facility Construction

	Recharge Facilities	Proposed Sites	Features	Recharge Amount	Construction Cost ('000DH)	Water Price (DH/m^3)
(1)	Depressed ground	Tributaries of the Gheris river (Ferkla Soufla)	Length: 1km, canal width: 20m, Canal depth: 2m	1,000m×20m×2m×50% × 3times = 60,000m^3	1,800	30
(2)	Recharge pond (Small scale)	Hannabou area	Storage capacity: 62,000 m^3	62,000 m^3×50%× 3times=93,000m^3	658	7
		Sifa area	Drainage area: 12 km^2 Annual rainfall: 85 mm Run-off rate: 10 %	0.085×10%×12×10^6 = 102,000m^3	3,200*1	31
(3)	Recharge dam	Fezzou area (Alnif)	Crest length: about 150m Dam height: maximum 20m (for a geomorphic condition)	550,000 m^3	32,000 × 0.55/1.47*2 =12,000	22
		Ahassia area (Alnif)	Crest length: about 200m Dam height: maximum 30m (for a geomorphic condition)	1,630,000 m^3	117,000×1.63/4.34*2 =43,900	27
(4)	Flood irrigation system	Boudenib area	Irrigable area: 1,250ha Recharge: 30mm	12,500,000m^2×0.03×3times= 1,125,000m^3	27,900×30/100*3 = 8,340	7
(5)	Recharge dam	Tanguerfa area (Goulmima, Ferkla Soufla)	Storage capacity: 1.62 Mm^3	1.62×1,000,000×5% =81,000m^3	6,840×5%=340	4
(6)	Flood dispersion dike	Tributaries of the Gheris river (Ferkla Soufla)	Slope of terrain: 1/200 Recharge area: 20,000m^2	20,000m^2 × 100mm × 20% × 100sites=40,000m^3 (Estimated with 100 sites)	10,000	50

*1: Canal material is changed from original wet masonry to dry masonry, and 50 % cost estimated in the existing report is applied to the estimates.

*2: Cost allocation (Allocated with storage capacity for recharge against total storage volume)

*3 Cost allocation (Allocated with water depth for recharge (30mm) and irrigation (70mm) in total depth of 100mm)

Table 7.12.1 Initial Environment Examination (the Master Plan) (1/5)

Segment of the environment	Evaluation	Underpinning
I Social environment **1. Social life** 1-1 Life of populations		
1. Programed displacements of population	D	This project does not envisage displacements of population.
2. No voluntary displacements of population	D	No expulsion is necessary.
3. Modification of life modes	D	The program should not change on the way of life. On the other hand for the advance of income generation projects and life improvement projects in the Master Plan, it is considered that the social status and role of women are changed. It is not evaluated as negative impact.
4. Frictions between inhabitants	D	The Master Plan takes into account the fairness of the opportunity of khettara and irrigation canal rehabilitation. Because it is possible that inhabitants whose khettara is include in the long term plan (it will be rehabilitated after 10 years later) complain that their khettara's rehabilitation is implemented more earlier, it is necessary that the ORMVA/TF should explain inhabitants the selection criteria and basis of priority for khettara and canal rehabilitations.
5. Natives, minorities and nomads	D	This project will not have effect on the life of nomads.
1-2 Demographic problems		
1. Increase in the population	D	Because of its function first which is to guarantee the water of irrigation of the current arable lands, the project should not have effect over the increase in the population or the changes of the demographic composition (the stabilization of the incomes should on the hand dam up the rural migration towards the cities.
2. Abrupt modification of the demographic composition	D	idem
1-3 Economic activities		
1.Displacement of the bases of the economic activity	D	Of share its objective which is to help those which take part in the bases of agricultural economics, it will not cause unemployment or displacements of the economic bases.
2. Economic conversions, unemployment	D	idem
3. Digging of disparities of incomes	D	The increase in the income of farmers through the increase in the production of the farmers' lower-income group and the stabilization of their standard life being an objective of this project, the disparities should on the contrary grow blurred.

Table 7.12.1 Initial Environment Examination (the Master Plan) (2/5)

Segment of the environment	Evaluation	Underpinning
1-4 Institution and custom		
1. Adjustment of water right	D	The rehabilitation projects in the Master plan are implemented on the basis of the traditional water right system. Because the traditional water right system has wide flexibility, irrigation schedule is available to be adjusted in the water right system, even if the condition of irrigation schedule is changed by the khettara or canal rehabilitation.
2. Conversion of community structure by unionisation and so on	D	It is possible that organizing farmers' groups make influence to community structure. It is not evaluated as negative impact.
3. Conversion of existing institution and custom	D	The Master Plan does not have negative impact to existing institution and custom
2. Health, hygiene		
1. Increase of agricultural chemicals	D	Currently agriculture chemicals are scarcely used in the Study Area. On the other hand, chemical fertilizer is used in a matter in the Study Area. The quantity consumed of chemical fertilizer will not increased rapidly, because the utilization of organic fertilizer, such as straw, green manure, barnyard manure is considered to be promoted by implementation of the Mater Plan. Therefore, negative impact to environment hardly occurs.
2. Appearance of endemics	D	In the surroundings there are no diseases endemic or serious contagious and the project should not reveal some.
3. Propagation of the contagious diseases	D	The project should not cause the appearance or the propagation of new contagious diseases. As measures of fight against the disease of the fly on the eyes which is a local problem of health we let us envisage constituting of compost with the household refuse. This should cause to prevent the appearance of contagious diseases.
4. Residual toxicity (accumulation of phytosanitary products)	D	Currently agriculture chemicals are scarcely used in the Study Area. On the other hand, chemical fertilizer is used in a matter in the Study Area. The quantity consumed of chemical fertilizer will not increased rapidly, because the utilization of organic fertilizer, such as straw, green manure, barnyard manure is considered to be promoted by implementation of the Mater Plan. Therefore, negative impact to environment hardly occurs.
5. Increase in waste and dejections	D	This project having for objective to maintain volumes of agricultural water useful for the current farms (the number of owners is fixed) it will not have there abrupt flow of the population.
6. Others (drinking water)	—	Currently in the majority of the villages, the khettara's water is used as drinking water whereas the analyses show that it is unsuitable with consumption. It is necessary to convince the population served by ONEP not to drink more the khettara water.

Table 7.12.1 Initial Environment Examination (the Master Plan) (3/5)

Segment of the environment	Evaluation	Underpinning
3. Historic sites, cultural inheritance, landscapes		
1. Deterioration or destruction of the historic sites or cultural inheritance	D	One does not know historic sites or masonry indexed with the cultural inheritance in surroundings of the site (but they will have all the same to be taken into account if they are discovered under study). The khettaras themselves are regarded as forming part of the cultural inheritance, on which of this fact tour project will have a positive impact (maintenance and conservation)
2. Degradation of nice landscapes	D	There is not in the surroundings of the site of the rare landscapes and our project will not deteriorate the landscape.
3. Underground resources	D	No buried object is indexed in the surroundings of the site.
II. Natural Environment		
4. Rare species and ecological sites		
1. Modification of vegetable cover	D	Measurements against the desertification should somewhat improve or reconstitute vegetable cover. (Positive effect). That will not have effect on the ecological system.
2. Rare and particular vegetable species	D	idem
3. Biodiversity	D	idem
4. Invasion and proliferation of the harmful species	C	The areas of date culture will increase with the project; it will be necessary to pay attention so that the disease of the Bayoud caused by a bacterium of the soil
5. Soils and lands		
5-1 Soils		
1. Erosion of soils	D	The project will not have new incidence on erosion of the soil.
2. Salinity of soils	C	The project will introduce the water saving irrigation which is a method which does not have any impact on salinity, it will be necessary however to remain attentive because the water of khettara contains salts.
3. Decrease of soil fertility	D	The utilization of organic fertilizer, such as straw, green manure, barnyard manure and crop rotation are planned in the Master Plan. It is considered that soil fertility is increased by implementation of the Master Plan.
4. Soils pollution	D	Currently agriculture chemicals are scarcely used in the Study Area. On the other hand, chemical fertilizer is used in a matter in the Study Area. The quantity consumed of chemical fertilizer will not increased rapidly, because the utilization of organic fertilizer, such as straw, green manure, barnyard manure is considered to be promoted by implementation of the Mater Plan. Therefore, negative impact to environment hardly occurs.

Table 7.12.1 Initial Environment Examination (the Master Plan) (4/5)

Segment of the environment	Evaluation	Underpinning
5-2 Lands		
1. Degradation of lands (including desertification)	D	The rehabilitation of khettaras and other shutters of the project will take part in protection against the degradation of the lands and against desertification; they will absolutely not cause a fall of productivity of the lands or the progress of desert. Moreover the afforestation is envisaged like measures of fight against desertification. Its results will have to be supervised.
2. Degradation of back-country (wood, pastures)	D	There will be no increase in the population, no increase in the wood of heating and no increase in pasture likely to deteriorate the back-country.
3. Subsidence of the ground	D	There is no soft foundation in the Study Area and thus it should not occur subsidence. Moreover it has until now never deferred case of subsidence because of water collecting in the underground.
6. Hydrogeology		
6-1 Hydrology		
1. Modification of surface flows	D	Surface flows are not influenced by khettara or canal rehabilitations. It is possible that surface flows are influence by construction of recahrge facility to underground water. The influence should be evaluated in future. (Zones A, C, D, E, G)
2. Modification of the underground flows and level of the water sheets	D	A gallery of collecting will be built close of the water sheet for water storage on a great surface and to send it by gravity. This type of installation should slightly modify the level of the water sheet without having a very large incidence on the underground flows or the modification of the level. The equipment of recharge which they will be used to reload the overdrawn water sheet with surface water will not have either negative impact. It will be necessary to study the consequences which could have of the equipment of big size. There will be no impact because of the rehabilitation of khettaras. It will be necessary well to study the installation of the equipment of recharge so that they do not have repercussions (zones A, C, D, E, G).
3. Appearance of floods	D	There will be no impact because of the rehabilitation of khettaras. It will be necessary well to study the implementation of equipment of so that they do not have repercussions (zones A, C, D, E, G)
4. Sand accumulation	D	There will be no impact because of the rehabilitation of khettaras. The influence of recharge facilities to underground water should be evaluated in future.
5. Subsidence of bed of rivers	D	idem

Table 7.12.1 Initial Environment Examination (the Master Plan) (5/5)

Segment of the environment	Evaluation	Underpinning
6-2 Quality and water temperature		
1. Water polution	D	The water pollution will not occur by implementation of the Master Plan. Wastewater after washing and feces and food scraps as one of the sources of water pollution is expected to be reduced by enlightenment activities planned in the life improvement plan. The water quality is expected to be improved by implementation of the Master Plan.
2. Eutrophication	D	Nutritive salts which constitute the enrichment of the water sheet should not increase.
3. Temperature change	D	The temperature of the water sheet is stable, and should not change much after the rehabilitation and installation of recharge equipment.
6-3 Atmosphere		
1. Atmosphere pollution	D	The rehabilitations of khettaras are work of relatively small scale which should not have negative effect. In case of big scale recharge facilities, it will be necessary to take in consideration this factor, and to study the working methods to measurement of the progress of the study.

Added Components in the New the JICA's Guideline

Segment of the environment	Evaluation	Underpinning
Bottom Material	D	It is not influenced by khettara or canal rehabilitation In case construction of recharge facility to underground water, it is necessary to consider this factor.
Accidents	D	It is planned in the Master Plan that existing khettaras and canals are rehabilitated. The techniques of khettara and canals rehabilitation were stocked well through the long experience. We can prevent accidents from paying attention well to safety at implementation of rehabilitation works.
Greenhouse warming	D	The rehabilitation of khettaras and canals are small scale works, and they don't influence to greenhouse warming
Children's entitlement	D	The rural life is expected to be improved by implementation of the Master plan. Advancement rate is expected to be increased by the improvement of rural life. Therefore, they are evaluated as positive impact.

Table 8.1.1 Volume of Khettara and Irrigation Canal Rehabilitation Works (1/4)

No.	Zone	ID No.	Khettara	Ksar	Discharge lit/sec	Irrigation Area ha	Khettara Rehabilitation Length m	Canal Rehabilitation Length m
1	A	1	Taoutoutoute	Taoutoutoute	2.3	5.8	210	600
2	A	2	Iminkine	Iminkine	1.1	2.5	210	600
3	A	3	Ait oulhou	Ait oulhou	2.3	5.6	230	400
4	A	4	Toufaghantaste	Ait khlifa	3.4	8.4	110	500
5	A	5	Akkerouz	Akkerouz	1.7	4.3	190	1,100
6	A	6	Amgane	Amgane	2.3	5.8	480	190
7	A	7	Tighramt	Tighramt	1.7	4.3	80	140
8	**A**	**8**	**lghrane**	**lghrane**	**7.3**	**18.3**	**50**	**280**
9	A	9	lkachrane	lkachrane	1.7	4.3	90	140
10	A	10	Ouine Oufroukh	Ouine Oufroukh	1.8	4.3	10	500
11	**A**	**11**	**Ouinigui**	**Ouinigui**	**3.6**	**8.6**	**30**	**0**
12	**A**	**12**	**Oukhite**	**Oukhite**	**10.1**	**24.4**	**200**	**0**
13	A	13	Ami Ali	El Galta	1.0	2.5	410	430
14	**A**	**14**	**Tiguida**	**Tiguida**	**3.1**	**7.8**	**300**	**1,000**
15	**A**	**15**	**Aghroud**	**Aghroud**	**10.6**	**26.5**	**620**	**300**
16	A	23	Ami Ahmed	Ami Ahmed	3.4	8.3	390	0
17	A	25	Darte Dghouvaues		4.5	8.7	340	2,000
18	A	31	Bou ouguiss		2.3	5.6	20	1,000
19	A	41	Bakassia	Tizagaghine	0.5	-	880	460
20	A	42	Maamrya	Tizagaghine	6.8	17.0	1,050	1,300
21	A	43	Ami Hassan	Tizagaghine	1.6	2.4	1,590	0
22	**A**	**44**	**Lakbira**	**Tizagaghine**	**22.3**	**55.8**	**650**	**4,500**
23	A	45	El Mehdia	Tizagaghine	10.0	23.0	900	800
24	A	46	Atti Kida	Tizagaghine	7.6	16.8	740	1,000
25	A	47	Regaga	Ait Ba Maati	7.7	18.2	930	2,500
26	A	48	Mouyjna	Ait Ba Maati	2.3	4.6	1,200	300
27	**A**	**49**	**Ait My Mamoun**	**Ait My Mamoun**	**6.8**	**17.0**	**320**	**800**
28	A	50	Litama	Litama	4.5	11.3	270	0
29	**A**	**51**	**Ait Oulghoume**	**Dar Oumira**	**8.2**	**20.0**	**310**	**160**
30	A	52	Dar Omira Lakdima	Dar Oumira	5.2	12.5	0	700
31	A	53	Ikhf N'lghir	Dar Oumira	8.5	21.3	300	500
32	A	54	Dar Omira Jdida	Dar Oumira	11.4	28.5	900	0
33	A	55	Azag N'ouchen	Azag N'ouchen	1.8	3.3	950	3,500
34	A	56	lzilf	lzilf	0.7	-	2,070	2,800
35	**A**	**58**	**Diba**	**Ksiba**	**7.9**	**16.7**	**300**	**30**
36	**A**	**59**	**Ait Ben Omar**	**Ait Ben Amar**	**4.5**	**9.5**	**270**	**200**
37	A	60	Cheikh	Ktaa Oued	4.5	11.3	1,840	290
38	A	61	Tamagourte	Tamagourte	4.1	10.3	140	0
39	A	63	Khamssine	Assoul	10.9	25.8	240	0
40	A	64	El Mach	Ait Ben Omar	12.5	31.3	370	500
41	A	65	Ait M'hmed	Ait M'hmed	1.4	2.7	540	1,000
42	A	66	Ihandar	Ihandar	9.7	24.3	300	190
43	A	67	Tighfarte	Tighfarte	9.7	24.3	1,620	2,000
44	A	68	Lakdima (Ait Maamer)	Lakdima (Ait Maamer)	6.8	16.4	710	1,000
45	A	70	Ami Lhoussa	Agoudime	1.3	1.6	450	500
46	**A**	**73**	**Taghouchte**	**Taghouchte**	**1.4**	**3.5**	**190**	**700**
47	A	74	Taghya	Taghya	2.3	5.1	370	3,000
48	A	98	Kdima Assoul	Assoul	2.3	3.1	360	0

Table 8.1.1 Volume of Khettara and Irrigation Canal Rehabilitation Works (2/4)

No.	Zone	ID No.	Khettara	Ksar	Discharge lit/sec	Irrigation Area ha	Khettara Rehabilitation Length m	Canal Rehabilitation Length m
49	A	100	Drain Tamtatouchte	Tamtatouchte	6.8	17.0	1,050	760
50	A	101	Tamajjal Nouaoulzi		4.0	10.0	230	80
51	A	102	Aoulzi Tamazirte		1.7	-	140	1,600
52	A	103	Tamda	Tamda	0.2	-	140	820
53	A	104	Drain imider	Imider	5.4	13.5	1,800	570
54	A	105	Idmouma	Idmouma	8.4	20.3	470	220
55	A	106	Agoudime	Agoudime	2.3	4.9	40	1,300
56	A	107	Ouj	Oje	9.1	22.5	270	700
57	A	108	Tasskountite	Tasskountite	0.6	1.5	40	1,200
58	A	109	Outalamine	Outalamine	9.1	22.6	120	1,800
59	A	110	Oukhalk	Tiguida	6.8	16.9	170	1,800
60	A	111	Ait Mkhoun	Ait Mkhoun	1.1	2.6	290	400
61	A	112	Idelssene	Idelssine	6.8	15.8	70	280
62	A	113	Taltafroute	Taltafrout	1.8	2.9	380	640
63	A	114	Laaouina	Laaouina	7.9	19.1	290	1,770
64	A	115	Bouhadachia	Bouhadachia	6.2	15.4	330	90
65	A	116	El maghzen	El maghzen	2.4	1.5	580	0
66	A	117	Elboutahiri	El boutahiri	6.3	15.8	180	190
67	A	118	Chrif	Chrif	0.8	1.8	140	200
68	A	119	Lhaj Thami	Lhaj Tahami	3.7	8.5	290	660
69	A	120	El arb	El arb	2.4	5.4	270	300
70	**A**	**121**	**El Hassania**	**Tilioulne**	**23.5**	**52.0**	**500**	**0**
71	A	126	Oultamayoust	Oultamayoust	4.3	10.1	80	0
72	A	127	Tourtite	Tourtite	0.1	-	260	240
73	A	128	Taldounte	Taldounte	4.5	10.9	150	240
74	A	129	Imider	Imider	2.3	5.8	1,840	180
75	A	130	Iguerguit	Iguerguit	1.1	2.5	50	810
76	A	131	Taourirte	Taourirte	2.2	5.2	90	250
77	A	132	Ihouna	Ait taghi	1.7	4.3	20	160
78	A	134	Imider	Imider	6.8	16.9	40	200
79	A	135	Oul N'tnayouste	Oul N'tnayouste	1.7	3.6	90	0
80	A	136	Lagar	Taoudaate	0.6	0.6	60	50
81	B	1	Agoummad	Ait wazag	27.3	67.2	250	1,400
82	**B**	**2**	**Tamazaroute**	**Ait wazag**	**20.5**	**50.2**	**30**	**510**
83	B	3	Ait Sbaa	Ait sbaa	1.5	3.1	10	0
84	B	4	EL Ain	Almou chorfa	6.8	16.6	90	0
85	**B**	**5**	**Bousfssaf**	**Almou chorfa**	**11.4**	**28.5**	**300**	**700**
86	B	6	El Majen	Almou chorfa	6.8	16.6	90	0
87	B	7	El Fougania	Almou Vhorfa	1.1	-	300	0
88	B	8	Ait Yakoub (2)	Ait Yaakoub	2.8	6.6	2,810	4,500
89	B	10	Roda	Sbaik	17.0	41.4	390	0
90	B	12	Beni Tajit	Beni Tajit	21.9	53.6	200	0
91	B	13	Ait My Hachem	Almou chorfa	0.6	1.3	200	0
92	B	14	Jdida	Zaouit El Hajoui	22.7	56.4	630	1,000
93	B	15	El Hajoui Sidi Abrerrahmane	Zaouit El Hajoui	12.3	30.4	40	600
94	B	16	Tafejjaret	Tafejaret	20.5	51.2	460	0
95	B	17	Ain Chouater	Chouater	20.5	51.0	350	0
96	B	18	Douimniaa	Chouater	4.2	10.1	720	500
97	B	19	El Hajoui	Chouater	4.5	11.1	510	0
98	B	20	Talssinte		11.4	27.9	60	0

Table 8.1.1 Volume of Khettara and Irrigation Canal Rehabilitation Works (3/4)

No.	Zone	ID No.	Khettara	Ksar	Discharge lit/sec	Irrigation Area ha	Khettara Rehabilitation Length m	Canal Rehabilitation Length m
99	B	22	Ait Boubker / Youssef	Talsint	10.2	25.0	120	0
100	B	23	Talhamsoust	Talsint	1.7	3.9	60	950
101	C	1	Oued Naam	Beni Ouzieme	10.2	25.3	1,290	450
102	C	2	Ouled Ali	Oued Naam	16.7	39.7	2,460	1,110
103	**C**	**3**	**Taouz**	**Oued Naam**	**19.3**	**48.3**	**600**	**330**
104	C	4	Lakbira	Labkira	10.2	23.6	1,590	2,000
105	**C**	**5**	**Lakdima**	**Oued Naam**	**13.6**	**30.9**	**220**	**570**
106	C	6	Jdida	Jida	22.7	54.5	1,760	720
107	C	7	Torba	Torba	3.9	9.7	420	1,400
108	C	8	Lahcen	CR	8.4	16.6	1,740	160
109	D	31	Lakbira	Taraa	9.1	21.3	840	2,000
110	D	34	Souihla	Oulad Ghanem	13.6	32.9	150	2,000
111	D	35	Aissaouia	Oulad Ghanem	2.3	3.3	950	0
112	D	36	Saidia	Oulad Ghanem	3.9	8.5	1,310	0
113	**D**	**41**	**El Aissaouia**	**Oulad Aissa**	**6.4**	**14.6**	**2,020**	**1,800**
114	**D**	**42**	**Lambarkia**	**Mounkara**	**23.4**	**57.0**	**1,200**	**440**
115	**D**	**44**	**Lambarkia**	**Oulad M'barek**	**19.7**	**47.9**	**2,130**	**0**
116	**D**	**47**	**Lahloua**	**Mounkara**	**21.5**	**51.9**	**2,250**	**4,730**
117	D	53	Kdima	Bouya	28.2	70.5	2,220	1,840
118	**D**	**54**	**jdida**	**Bouya**	**16.5**	**40.3**	**1,620**	**0**
119	**D**	**55**	**Kdima**	**Krair**	**16.7**	**40.3**	**1,110**	**2,000**
120	**D**	**56**	**Jdida**	**Krair**	**14.0**	**34.1**	**1,200**	**0**
121	**D**	**58**	**Khtitira**	**Hannabou**	**21.0**	**51.4**	**1,150**	**900**
122	**D**	**59**	**Sayed**	**Hannabou**	**11.7**	**28.2**	**1,250**	**800**
123	**D**	**60**	**Fougania**	**Hannabou**	**50.2**	**124.1**	**1,700**	**0**
124	**D**	**61**	**Quastania**	**Hannabou**	**6.8**	**15.8**	**1,950**	**1,000**
125	D	62	Kdima	Krair	10.9	26.3	1,760	400
126	**D**	**64**	**Lgrinia**	**Hannabou**	**6.4**	**14.7**	**1,240**	**1,400**
127	D	65	Laalouia (Hannabou)	Hannabou	8.2	19.3	1,950	400
128	D	66	Mostafia	Hannabou	5.3	12.8	1,670	0
129	D	69	Kdima	0	22.1	54.3	1,890	0
130	E	1	El Ghanamia	A.S. Ziz	1.1	2.8	1,750	0
131	E	2	El bour	Sifa	4.9	10.5	2,270	0
132	E	4	Laagaya	Sifa	2.3	5.8	1,440	0
133	E	5	Jdida Bel Houcine	Sifa	0.6	0.5	2,140	30
134	E	6	Jdida Bel Houcine	Sifa	4.5	11.3	2,390	0
135	**E**	**7**	**Ramlia**	**Sifa**	**14.4**	**34.6**	**1,350**	**590**
136	**E**	**8**	**Lakdima Douar**	**Sifa**	**27.1**	**63.9**	**1,790**	**0**
137	E	9	Lihoudia	Sifa	1.4	3.5	1,780	0
138	E	10	Laglaglia	Sifa	3.4	6.5	1,640	0
139	E	12	Jdida Lhaj El Madani	Sifa	3.4	8.5	1,300	0
140	E	13	Laaguilia Kbour Lihoud	Sifa	4.0	8.6	1,960	710
141	E	14	Lhaj Alal	Sifa	28.3	63.4	2,640	0
142	E	15	Ighzer	Sifa	2.3	3.8	1,670	400
143	**E**	**16**	**Charchmia**	**Sifa**	**21.1**	**45.5**	**1,430**	**3,030**
144	**F**	**1**	**Loujarchia**	**Loujarcha**	**4.5**	**8.1**	**560**	**1,000**
145	F	24	Harounia	Haroun	0.6	1.5	1,900	0
146	F	27	Agaroum	Tagaroumte	1.1	2.3	80	0
147	F	32	Talaabast	Merzouga	6.8	14.8	450	0
148	F	33	Tamaright	Merzouga	2.3	5.3	1,540	1,000

Table 8.1.1 Volume of Khettara and Irrigation Canal Rehabilitation Works (4/4)

No.	Zone	ID No.	Khettara	Ksar	Discharge lit/sec	Irrigation Area ha	Khettara Rehabilitation Length m	Canal Rehabilitation Length m
149	F	34	Tamazante	Merzouga	2.3	3.3	990	0
150	F	35	Taachaboute	Khamlia	0.6	1.0	540	200
151	**F**	**36**	**Hassi Labied**	**Hasi Labied**	**4.5**	**9.5**	**1,100**	**0**
152	F	38	ElBagaa	ElBagaa	1.7	3.7	1,360	100
153	F	40	Tamaright	0	1.1	2.2	590	500
154	F	42	Ait Taghla	Ramlia	2.9	6.8	1,020	780
155	G	1	M'Cissi	M'Cissi	0.6	1.5	760	0
156	G	3	Bouadil	Bouadil	5.7	13.7	270	0
157	G	4	Azag	Azag	1.1	2.8	460	0
158	G	13	Taghroute	Taghroute	1.2	2.4	110	80
159	G	14	Agoumad	Taghroute	0.8	1.7	40	300
160	G	15	Alnif	Alnif	3.0	3.3	1,110	0
161	G	17	Ait Lahbib	Taghroute	0.3	0.8	830	0
162	G	18	Tizi Lakdima	Tizi	3.1	6.6	1,060	800
163	G	21	Jdida Ammar	Ammar	12.6	31.5	960	280
164	G	22	Azrag	Azrag	0.6	1.3	300	200
165	G	37	Ait Ben Said	Ait Ben Said	5.7	13.4	1,070	0
166	G	46	Tanoute Noumardoul	Tanout	1.1	2.6	150	300
167	G	47	Tagualgoulte	Taguelgout	1.2	2.5	480	0
168	G	48	Jorf	Jorf	1.1	2.6	840	700
169	G	52	lminouzrou	lminouzrou	0.8	1.6	290	0
170	G	53	Tiguirna	Tiguirna	2.2	4.0	320	0
171	**G**	**55**	**Tinififte**	**Tinififte**	**5.5**	**13.4**	**420**	**800**
172	G	56	Afrou	Afrou-AdLghazi	1.1	2.4	330	1,800
173	G	57	Talghazit	Talghazite	0.6	1.4	150	500
174	G	58	Tihammate	Talghazite	2.3	5.8	270	600
175	G	59	Lakbira	Taoumart	0.5	0.3	170	140
176	**G**	**60**	**JdidaTaoumarte**	**Taoumart**	**2.0**	**4.0**	**180**	**50**
177	G	61	Afrou	Taoumart	0.6	1.5	230	1,200
178	G	62	Tassamamte	Tassamamte	3.5	8.2	220	0
179	G	63	Toufassamman	Toufassamame	1.5	3.0	480	0
180	**G**	**64**	**Timzarzit**	**Timarzit**	**2.0**	**4.2**	**540**	**160**
181	G	65	Tajohrate	Tajouhart	1.7	4.1	80	600
182	G	67	Ait Mouhou	Ouihlane	0.2	0.5	360	20
183	G	77	Izougaghine	Ramlia	0.2	0.5	630	20
184	G	78	Tamlalt	Hsia	2.8	3.7	960	0
185	G	80	Tissamoumine	Tissamoumine	1.8	3.9	10	450
186	G	83	Takacha	Takacha	3.4	7.5	1,410	1,500
187	**G**	**87**	**Aachich Ait Iaza**	**Aachich**	**11.4**	**22.1**	**530**	**1,500**
188	G	89	Fouk Talilate	Aachich	0.6	0.8	630	1,300
189	G	94	Battou	Battou	2.3	5.1	810	470
190	G	95	Khtart Battou	Battou	1.7	3.8	640	50
191	G	103	Tizagarne	Tizagarne	2.3	3.4	650	2,000
Total							138,890	116,190

Table 8.3.1 Fund Requirement (All proposed components)

				Short Term (5 years)					Intermediate Term (5 years)					
		Year		1	2	3	4	5	6	7	8	9	10	Total
I.	Construction Cost													
	1.	Rehabilitation work for khettaras		15,570	15,570	15,570	15,570	15,570	22,450	22,450	22,450	22,450	22,450	190,100
	2.	Rehabilitation work for irrigation canals		7,830	7,830	7,830	7,830	7,830						39,150
	3.	Construction of recharge facilities												
		Recharge pond (Hannabou area)			700									700
		Flood irrigation system (Boudenib area)				9,300	9,300	9,300						27,900
		Flood diversion canal (Gheris area)							900	900				1,800
		Flood diversion canal (Sifa area)							1,600	1,600				3,200
		Recharge dam (Fezzou area, Alnif)*1							16,000	16,000				32,000
		Recharge dam (Ahassia area, Alnif)*2									39,000	39,000	39,000	117,000
		Recharge dam (Tanguerfa area)*3									2,280	2,280	2,280	6,840
		Flood dispersion dike (Gheris area)*4		1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	10,000
	4.	Afforestation*5		170	170	170	170	170	170	170	170	170	170	1,700
		Total (I)		24,570	25,270	33,870	33,870	33,870	42,120	42,120	64,900	64,900	64,900	430,390
II.	Adiministration cost (3%)		3	740	760	1,020	1,020	1,020	1,260	1,260	1,950	1,950	1,950	12,930
III.	Engineering cost													
		Khettara and irrigation system (5%)	5	1,170	1,170	1,170	1,170	1,170	1,120	1,120	1,120	1,120	1,120	11,450
		Recharge facilities (10%)	10	100	170	1,030	1,030	1,030	1,950	1,950	4,230	4,230	4,230	19,950
		Total (III)		1,270	1,340	2,200	2,200	2,200	3,070	3,070	5,350	5,350	5,350	31,400
		Total (I+II+III)		26,580	27,370	37,090	37,090	37,090	46,450	46,450	72,200	72,200	72,200	474,720
IV.	Physical contingency (10%)		10	2,660	2,740	3,710	3,710	3,710	4,650	4,650	7,220	7,220	7,220	47,490
		Total (I+II+III+IV)		29,240	30,110	40,800	40,800	40,800	51,100	51,100	79,420	79,420	79,420	522,210
V.	Price contingency (1.3%)		1.3	380	790	1,610	2,160	2,720	4,120	4,840	8,650	9,790	10,950	46,010
		Total (I+II+III+IV+V)		29,620	30,900	42,410	42,960	43,520	55,220	55,940	88,070	89,210	90,370	568,220
		Drip irrigation system (Subsidy) *6		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	60,000

*1: 50% of total cost is applied for recharge facility construction cost by storage capacity proportion.

*2: 10% of total cost is applied for recharge facility construction cost by storage capacity proportion.

*3: 5% of total cost is applied for recharge facility construction cost by storage capacity proportion.

*4: Cost for construction cost for 1 km^2 par year is estimated.

*5: DH11,250/ha×15ha/year

*6: DH100,000/ha×150ha×40%=DH6,000,000/10 year

Table 8.3.2 Fund Requirement (Components for khettara and irrigation canal rehabilitation)

				Short Term (5 years)					Intermediate Term (5 years)					
		Année		1	2	3	4	5	6	7	8	9	10	Total
I.	Construction Cost													
	1.	Rehabilitation work for khettaras		15,570	15,570	15,570	15,570	15,570	22,450	22,450	22,450	22,450	22,450	190,100
	2.	Rehabilitation work for irrigation canals		7,830	7,830	7,830	7,830	7,830						39,150
		Total (I)		23,400	23,400	23,400	23,400	23,400	22,450	22,450	22,450	22,450	22,450	229,250
II.	Adiministration cost (3%)		3	700	700	700	700	700	670	670	670	670	670	6,850
III.	Engineering cost													
		Khettara and irrigation system (5%)	5	1,170	1,170	1,170	1,170	1,170	1,120	1,120	1,120	1,120	1,120	11,450
		Total (III)		1,170	1,170	1,170	1,170	1,170	1,120	1,120	1,120	1,120	1,120	11,450
		Total (I+II+III)		25,270	25,270	25,270	25,270	25,270	24,240	24,240	24,240	24,240	24,240	247,550
IV.	Physical contingency (10%)		10	2,530	2,530	2,530	2,530	2,530	2,420	2,420	2,420	2,420	2,420	24,750
		Total (I+II+III+IV)		27,800	27,800	27,800	27,800	27,800	26,660	26,660	26,660	26,660	26,660	272,300
V.	Price contingency (1.3%)		1.3	360	730	1,100	1,470	1,850	2,150	2,520	2,900	3,290	3,680	20,050
		Total (I+II+III+IV+V)		28,160	28,530	28,900	29,270	29,650	28,810	29,180	29,560	29,950	30,340	292,350
		Drip irrigation system (Subsidy) *[1]		6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	60,000

*[1]: DH100,000/ha×150ha×40%=DH6,000,000/10 year

Table 9.2.1 Economic Prices

Calculations of Standard Conversion Factor

Year	A	B	C
	Total Import Value (CIF)	Total Import Taxes - Total Export Susbsidy	Total Export Value (FOB)
1997	90,712	25,402	67,057
2001 price	96,064	26,901	71,013
1998	98,676	26,792	68,608
2001 price	103,708	28,158	72,107
1999	105,931	26,496	73,617
2001 price	108,897	27,238	75,678
2000	122,527	28,134	78,827
2001 price	124,855	28,669	80,325
2001	124,081	28,134	80,440
5-year av. 2001 price	111,521	27,820	75,913

CIF - Cost, Insurance, Freight

FOB - Free on Board

Source: Statistical Yearbook Morocco, 2002, p.605 and 680

$$SCF = \frac{A + C}{A + B + C} = \mathbf{0.87}$$

Table 9.2.2 Cost-Benefit Analysis

Duration	30 years		
Discount rate	6%	8%	10%
NPV	99,860	53,402	22,613
EIRR	12.2%		
B/C	1.74	1.43	1.19

unit: 000 DH

Year		Economic Costs					Economic Benefits					
		Investment costs		Recurrent costs			Increase in cultivated area					
No	Year	Khettaras rehabilitation	Canals rehabilitation	O&M canal	O&M khettara	Total cost [DH]	From khettaras	From canals	From rehabilitation	Increase in yield	Total benefit	B-C
1	2005	14,113	7,095	0	0	21,208	0	0	0	0	0	21,208-
2	2006	14,113	7,095	23-	158-	21,027	621	802	599	557	2,579	18,448-
3	2007	14,113	7,095	46-	317-	20,845	1,242	1,604	1,197	1,114	5,157	15,688-
4	2008	14,113	7,095	70-	475-	20,663	1,863	2,406	1,796	1,671	7,736	12,927-
5	2009	14,113	7,095	93-	634-	20,482	2,485	3,208	2,395	2,228	10,315	10,167-
6	2010	20,309		116-	792-	19,401	3,106	4,009	2,993	2,785	12,893	6,508-
7	2011	20,309		116-	1,020-	19,173	3,846	4,782	3,707	3,342	15,678	3,496-
8	2012	20,309		116-	1,248-	18,945	4,587	4,782	4,421	3,899	17,689	1,256-
9	2013	20,309		116-	1,476-	18,717	5,328	4,782	5,135	4,456	19,701	984
10	2014	20,309		116-	1,704-	18,489	6,069	4,782	5,849	5,013	21,713	3,224
11	2015			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
12	2016			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
13	2017			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
14	2018			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
15	2019			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
16	2020			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
17	2021			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
18	2022			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
19	2023			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
20	2024			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
21	2025			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
22	2026			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
23	2027			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
24	2028			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
25	2029			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
26	2030			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
27	2031			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
28	2032			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
29	2033			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951
30	2034			116-	1,932-	2,048-	7,408	4,782	7,143	5,570	24,903	26,951

Table 9.2.3 (1/5) Khettara Ranking by EIRR

Rank	Zone	No	Name of Khettara	Ksar	Discharge lit/sec	Irrigation Area ha	Khettara Length m	Canal Length m	EIRR
1	A	11	Ouinigui	Ouinigui	3.60	8.64	116	0	49.4%
2	A	134	Imider	Imider	6.80	16.87	124	200	44.9%
3	A	8	lghrane	lghrane	7.30	18.25	168	284	38.6%
4	A	12	Oukhite	Oukhite	10.10	24.39	675	0	34.8%
5	A	126	Oultamayoust	Oultamayoust	4.30	10.10	269	0	32.4%
6	A	63	Khamssine	Assoul	10.90	25.83	800	0	31.6%
7	A	112	Idelssene	Idelssine	6.80	15.79	236	280	29.7%
8	A	121	El Hassania	Tilioulne	23.50	51.98	1,660	0	28.8%
9	A	61	Tamagourte	Tamagourte	4.10	10.25	450	0	25.9%
10	A	66	Ihandar	Ihandar	9.70	24.25	1,000	189	25.1%
11	A	117	Elboutahiri	El boutahiri	6.30	15.75	600	189	24.8%
12	A	132	Ihouna	Ait taghi	1.70	4.25	57	160	24.8%
13	A	64	El Mach	Ait Ben Omar	12.50	31.25	1,246	500	23.9%
14	A	52	Dar Omira Lakdima	Dar Oumira	5.20	12.50	0	700	22.7%
15	A	51	Ait Oulghoume	Dar Oumira	8.20	20.02	1,038	160	22.2%
16	A	53	Ikhf N'lghir	Dar Oumira	8.50	21.25	1,000	500	20.3%
17	A	107	Ouj	Oje	9.10	22.53	890	700	20.1%
18	A	115	Bouhadachia	Bouhadachia	6.20	15.42	1,107	86	19.2%
19	A	128	Taldounte	Taldounte	4.50	10.85	514	240	19.0%
20	A	58	Diba	Ksiba	7.90	16.70	1,000	28	18.5%
21	A	15	Aghroud	Aghroud	10.60	26.50	2,068	300	18.5%
22	A	50	Litama	Litama	4.50	11.25	912	0	18.0%
23	A	101	Tamajjal Nouaoulzi		4.00	10.00	750	80	17.7%
24	A	105	Idmouma	Idmouma	8.40	20.25	1,550	220	17.3%
25	A	54	Dar Omira Jdida	Dar Oumira	11.40	28.50	3,000	0	17.1%
26	A	7	Tighramt	Tighramt	1.70	4.25	250	142	16.6%
27	A	109	Outalamine	Outalamine	9.10	22.56	400	1,800	16.0%
28	A	49	Ait My Mamoun	Ait My Mamoun	6.80	17.00	1,068	800	15.4%
29	A	9	lkachrane	lkachrane	1.70	4.25	300	142	15.3%
30	A	4	Toufaghantaste	Ait khlifa	3.40	8.36	350	500	15.3%
31	A	135	Oul N'tnayouste	Oul N'tnayouste	1.70	3.60	288	0	14.7%
32	A	44	Lakbira	Tizagaghine	22.30	55.75	2,172	4,500	14.6%
33	A	131	Taourirte	Taourirte	2.20	5.20	289	250	14.5%
34	A	10	Ouine Oufroukh	Ouine Oufroukh	1.80	4.30	32	500	12.5%
35	A	110	Oukhalk	Tiguida	6.80	16.88	550	1,800	12.5%
36	A	45	El Mehdia	Tizagaghine	10.00	22.99	3,000	800	12.3%
37	A	114	Laaouina	Laaouina	7.90	19.11	964	1,770	12.1%
38	A	59	Ait Ben Omar	Ait Ben Amar	4.50	9.48	900	200	11.7%
39	A	23	Ami Ahmed	Ami Ahmed	3.40	8.28	1,299	0	11.7%
40	A	68	Lakdima (Ait Maamer)	Lakdima (Ait Maamer)	6.80	16.40	2,380	1,000	10.3%
41	A	100	Drain Tamtatouchte	Tamtatouchte	6.80	17.00	3,500	757	9.7%
42	A	3	Ait oulhou	Ait oulhou	2.30	5.57	750	400	9.3%
43	A	46	Atti Kida	Tizagaghine	7.60	16.80	2,460	1,000	9.2%
44	A	119	Lhaj Thami	Lhaj Tahami	3.70	8.49	971	660	9.0%
45	A	31	Bou ouguiss		2.30	5.60	60	1,000	8.8%
46	A	42	Maamrya	Tizagaghine	6.80	17.00	3,500	1,300	8.8%
47	A	1	Taoutoutoute	Taoutoutoute	2.30	5.75	700	600	8.8%
48	A	67	Tighfarte	Tighfarte	9.70	24.25	5,405	2,000	8.5%

Table 9.2.3 (2/5) Khettara Ranking by EIRR

Rank	Zone	No	Name of Khettara	Ksar	Discharge lit/sec	Irrigation Area ha	Khettara Length m	Canal Length m	EIRR
49	A	120	El arb	El arb	2.40	5.42	900	300	8.3%
50	A	14	Tiguida	Tiguida	3.10	7.75	1,010	1,000	7.8%
51	A	6	Amgane	Amgane	2.30	5.75	1,600	189	7.6%
52	A	47	Regaga	Ait Ba Maati	7.70	18.15	3,100	2,500	7.3%
53	A	104	Drain imider	Imider	5.40	13.50	6,000	568	7.2%
54	A	73	Taghouchte	Taghouchte	1.40	3.50	635	700	5.5%
55	A	118	Chrif	Chrif	0.80	1.79	479	200	5.4%
56	A	60	Cheikh	Ktaa Oued	4.50	11.25	6,140	290	5.4%
57	A	5	Akkerouz	Akkerouz	1.70	4.25	630	1,100	4.8%
58	A	111	Ait Mkhoun	Ait Mkhoun	1.10	2.56	960	400	4.4%
59	A	13	Ami Ali	El Galta	1.00	2.50	1,350	434	4.0%
60	A	106	Agoudime	Agoudime	2.30	4.91	120	1,300	3.9%
61	A	2	Iminkine	Iminkine	1.10	2.53	700	600	3.8%
62	A	103	Tamda	Tamda	0.20	-	455	820	3.8%
63	A	129	Imider	Imider	2.30	5.75	6,120	180	3.8%
64	A	130	Iguerguit	Iguerguit	1.10	2.50	156	806	3.3%
65	A	48	Mouyjna	Ait Ba Maati	2.30	4.60	4,000	300	3.1%
66	A	25	Darte Dghouvaues		4.50	8.73	1,120	2,000	2.6%
67	A	43	Ami Hassan	Tizagaghine	1.60	2.38	5,310	0	1.8%
68	A	41	Bakassia	Tizagaghine	0.50	-	2,921	460	1.4%
69	A	127	Tourtite	Tourtite	0.10	-	871	240	1.4%
70	A	102	Aoulzi Tamazirte		1.70	-	450	1,600	1.3%
71	A	65	Ait M'hmed	Ait M'hmed	1.40	2.67	1,785	1,000	1.3%
72	A	136	Lagar	Taoudaate	0.60	0.59	195	47	0.7%
73	A	113	Taltafroute	Taltafrout	1.80	2.92	1,275	640	0.7%
74	A	74	Taghya	Taghya	2.30	5.12	1,237	3,000	0.5%
75	A	116	El maghzen	El maghzen	2.40	1.54	1,932	0	-0.2%
76	A	98	Kdima Assoul	Assoul	2.30	3.07	1,200	0	-0.5%
77	A	108	Tasskountite	Tasskountite	0.60	1.47	144	1,200	-0.6%
78	A	70	Ami Lhoussa	Agoudime	1.30	1.64	1,500	500	-0.8%
79	A	55	Azag N'ouchen	Azag N'ouchen	1.80	3.31	3,150	3,500	-0.9%
80	A	56	lzilf	lzilf	0.70	-	6,885	2,800	-1.3%
1	B	20	Talssinte		11.40	27.93	188	0	75.8%
2	B	2	Tamazaroute	Ait wazag	20.50	50.17	100	507	60.0%
3	B	12	Beni Tajit	Beni Tajit	21.90	53.60	670	0	53.0%
4	B	22	Ait Boubker / Youssef	Talsint	10.20	24.97	402	0	44.4%
5	B	4	EL Ain	Almou chorfa	6.80	16.61	292	0	44.2%
6	B	6	El Majen	Almou chorfa	6.80	16.62	312	0	42.6%
7	B	3	Ait Sbaa	Ait sbaa	1.50	3.11	44	0	40.7%
8	B	15	El Hajoui Sidi Abrerrahmane	Zaouit El Hajoui	12.30	30.37	135	600	39.7%
9	B	17	Ain Chouater	Chouater	20.50	50.96	1,160	0	38.8%
10	B	16	Tafejjaret	Tafejaret	20.50	51.15	1,519	0	33.7%
11	B	1	Agoummad	Ait wazag	27.30	67.18	840	1,400	31.9%
12	B	10	Roda	Sbaik	17.00	41.35	1,300	0	31.7%
13	B	14	Jdida	Zaouit El Hajoui	22.70	56.37	2,084	1,000	23.8%

Table 9.2.3 (3/5) Khettara Ranking by EIRR

Rank	Zone	No	Name of Khettara	Ksar	Discharge lit/sec	Irrigation Area ha	Khettara Length m	Canal Length m	EIRR
14	B	5	Bousfssaf	Almou chorfa	11.40	28.50	1,000	700	23.2%
15	B	19	El Hajoui	Chouater	4.50	11.06	1,700	0	11.9%
16	B	18	Douimniaa	Chouater	4.20	10.07	2,400	500	7.6%
17	B	7	El Fougania	Almou Vhorfa	1.10	-	1,000	0	5.8%
18	B	23	Talhamsoust	Talsint	1.70	3.92	210	946	5.1%
19	B	13	Ait My Hachem	Almou chorfa	0.60	1.30	657	0	5.0%
20	B	8	Ait Yakoub (2)	Ait Yaakoub	2.80	6.63	9,350	4,500	1.2%
1	C	3	Taouz	Oued Naam	19.30	48.25	2,000	330	26.0%
2	C	5	Lakdima	Oued Naam	13.60	30.94	749	570	25.1%
3	C	6	Jdida	Jida	22.70	54.54	5,850	720	15.3%
4	C	1	Oued Naam	Beni Ouzieme	10.20	25.35	4,300	450	12.6%
5	C	2	Ouled Ali	Oued Naam	16.70	39.73	8,200	1,110	10.9%
6	C	4	Lakbira	Labkira	10.20	23.58	5,300	2,000	8.8%
7	C	7	Torba	Torba	3.90	9.73	1,400	1,400	7.1%
8	C	8	Lahcen	CR	8.40	16.60	5,800	160	6.9%
1	D	60	Fougania	Hannabou	50.20	124.13	5,659	0	26.5%
2	D	42	Lambarkia	Mounkara	23.40	57.00	4,000	440	19.5%
3	D	34	Souihla	Oulad Ghanem	13.60	32.89	500	2,000	18.5%
4	D	58	Khtitira	Hannabou	21.00	51.38	3,830	900	17.7%
5	D	69	Kdima	0	22.10	54.25	6,300	0	16.1%
6	D	56	Jdida	Krair	14.00	34.13	4,000	0	15.9%
7	D	54	jdida	Bouya	16.50	40.25	5,400	0	14.9%
8	D	53	Kdima	Bouya	28.20	70.50	7,400	1,839	14.9%
9	D	44	Lambarkia	Oulad M'barek	19.70	47.90	7,110	0	14.2%
10	D	55	Kdima	Krair	16.70	40.30	3,700	2,000	13.5%
11	D	59	Sayed	Hannabou	11.70	28.23	4,174	800	12.4%
12	D	62	Kdima	Krair	10.90	26.28	5,850	400	11.1%
13	D	47	Lahloua	Mounkara	21.50	51.88	7,500	4,727	10.0%
14	D	31	Lakbira	Taraa	9.10	21.26	2,800	2,000	9.0%
15	D	65	Laalouia (Hannabou)	Hannabou	8.20	19.34	6,500	400	8.1%
16	D	66	Mostafia	Hannabou	5.30	12.82	5,550	0	7.7%
17	D	64	Lgrinia	Hannabou	6.40	14.66	4,125	1,400	6.9%
18	D	61	Quastania	Hannabou	6.80	15.81	6,500	1,000	6.7%
19	D	41	El Aissaouia	Oulad Aissa	6.40	14.60	6,735	1,800	5.7%
20	D	36	Saidia	Oulad Ghanem	3.90	8.48	4,360	0	5.0%
21	D	35	Aissaouia	Oulad Ghanem	2.30	3.27	3,160	0	1.5%
1	E	8	Lakdima Douar	Sifa	27.10	63.88	5,965	0	17.4%
2	E	7	Ramlia	Sifa	14.40	34.58	4,500	591	13.8%
3	E	14	Lhaj Alal	Sifa	28.30	63.44	8,789	0	13.7%
4	E	16	Charchmia	Sifa	21.10	45.53	4,783	3,028	10.5%
5	E	12	Jdida Lhaj El Madani	Sifa	3.40	8.50	4,323	0	5.9%
6	E	6	Jdida Bel Houcine	Sifa	4.50	11.25	7,951	0	4.9%
7	E	4	Laagaya	Sifa	2.30	5.75	4,800	0	4.5%
8	E	2	El bour	Sifa	4.90	10.51	7,570	0	4.2%
9	E	13	Laaguilia Kbour Lihoud	Sifa	4.00	8.57	6,540	710	3.4%

Table 9.2.3 (4/5) Khettara Ranking by EIRR

Rank	Zone	No	Name of Khettara	Ksar	Discharge lit/sec	Irrigation Area ha	Khettara Length m	Canal Length m	EIRR
10	E	10	Laglaglia	Sifa	3.40	6.52	5,473	0	3.3%
11	E	9	Lihoudia	Sifa	1.40	3.50	5,940	0	3.2%
12	E	1	El Ghanamia	A.S. Ziz	1.10	2.75	5,847	0	3.0%
13	E	15	Ighzer	Sifa	2.30	3.76	5,550	400	1.8%
14	E	5	Jdida Bel Houcine	Sifa	0.60	0.53	7,120	30	1.4%
1	F	32	Talaabast	Merzouga	6.80	14.83	1,490	0	14.5%
2	F	27	Agaroum	Tagaroumte	1.10	2.32	250	0	12.4%
3	F	36	Hassi Labied	Hasi Labied	4.50	9.47	3,667	0	5.7%
4	F	42	Ait Taghla	Ramlia	2.90	6.76	3,400	780	4.3%
5	F	38	ElBagaa	ElBagaa	1.70	3.74	4,530	100	3.2%
6	F	1	Loujarchia	Loujarcha	4.50	8.10	1,875	1,000	3.1%
7	F	33	Tamaright	Merzouga	2.30	5.32	5,125	1,000	2.9%
8	F	24	Harounia	Haroun	0.60	1.50	6,325	0	2.4%
9	F	40	Tamaright	0	1.10	2.16	1,950	500	2.2%
10	F	35	Taachaboute	Khamlia	0.60	1.03	1,800	200	1.7%
11	F	34	Tamazante	Merzouga	2.30	3.26	3,302	0	1.5%
1	G	3	Bouadil	Bouadil	5.70	13.74	900	0	20.6%
2	G	21	Jdida Ammar	Ammar	12.60	31.50	3,200	284	16.6%
3	G	62	Tassamamte	Tassamamte	3.50	8.19	720	0	15.6%
4	G	55	Tinififte	Tinififte	5.50	13.37	1,410	800	11.7%
5	G	80	Tissamoumine	Tissamoumine	1.80	3.88	49	450	10.3%
6	G	37	Ait Ben Said	Ait Ben Said	5.70	13.39	3,550	0	9.5%
7	G	87	Aachich Ait Iaza	Aachich	11.40	22.11	1,765	1,500	9.3%
8	G	60	JdidaTaoumarte	Taoumart	2.00	4.04	600	47	9.0%
9	G	65	Tajohrate	Tajouhart	1.70	4.13	270	600	8.5%
10	G	13	Taghroute	Taghroute	1.20	2.43	358	80	8.1%
11	G	58	Tihammate	Talghazite	2.30	5.75	900	600	8.0%
12	G	46	Tanoute Noumardoul	Tanout	1.10	2.57	490	300	6.5%
13	G	4	Azag	Azag	1.10	2.75	1,539	0	5.5%
14	G	53	Tiguirna	Tiguirna	2.20	4.01	1,056	0	5.4%
15	G	14	Agoumad	Taghroute	0.80	1.70	140	300	5.3%
16	G	64	Timzarzit	Timarzit	2.00	4.23	1,810	160	4.9%
17	G	95	Khtart Battou	Battou	1.70	3.75	2,120	47	4.8%
18	G	63	Toufassamman	Toufassamame	1.50	3.00	1,600	0	4.4%
19	G	47	Tagualgoulte	Taguelgout	1.20	2.49	1,590	0	4.2%
20	G	94	Battou	Battou	2.30	5.06	2,700	473	4.1%
21	G	52	lminouzrou	lminouzrou	0.80	1.60	968	0	4.0%
22	G	18	Tizi Lakdima	Tizi	3.10	6.60	3,520	800	3.6%
23	G	1	M'Cissi	M'Cissi	0.60	1.50	2,525	0	3.2%
24	G	22	Azrag	Azrag	0.60	1.33	1,000	200	3.2%
25	G	83	Takacha	Takacha	3.40	7.47	4,700	1,500	3.0%
26	G	67	Ait Mouhou	Ouihlane	0.20	0.50	1,200	19	2.7%
27	G	48	Jorf	Jorf	1.10	2.61	2,800	700	2.5%
28	G	17	Ait Lahbib	Taghroute	0.30	0.75	2,750	0	2.5%

Table 9.2.3 (5/5) Khettara Ranking by EIRR

Rank	Zone	No	Name of Khettara	Ksar	Discharge lit/sec	Irrigation Area ha	Khettara Length m	Canal Length m	EIRR
29	G	77	Izougaghine	Ramlia	0.20	0.50	2,100	19	2.3%
30	G	57	Talghazit	Talghazite	0.60	1.37	513	500	2.3%
31	G	59	Lakbira	Taoumart	0.50	0.29	577	142	1.2%
32	G	78	Tamlalt	Hsia	2.80	3.74	3,200	0	0.7%
33	G	61	Afrou	Taoumart	0.60	1.50	753	1,200	0.4%
34	G	56	Afrou	Afrou-AdLghazi	1.10	2.43	1,093	1,800	0.0%
35	G	15	Alnif	Alnif	3.00	3.29	3,700	0	-0.5%
36	G	89	Fouk Talilate	Aachich	0.60	0.85	2,114	1,300	-0.7%
37	G	103	Tizagarne	Tizagarne	2.30	3.45	2,160	2,000	-1.3%
	Total				1,277	3,012	462,567	116,172	

Table 9.3.1 (1/3) Farm Economy - Without Project Condition -

Cultures		Product						Charges		Net Value
		Area		Harvest		Unit Price	Value	Unit Price	Value	[DH]
		ha	%	Qt.	[kg/ha]	[DH/kg]	[DH]	[DH/ha]	[DH]	
Cereal	Wheat	0.50	62%	1,620	[kg/ha]	4.00 [DH/kg]	3,809	4,888	2,424	1,385
Vegetables		0.05	6%				1,591		480	1,112
Vegetable 1	Carrot			12,600	[kg/ha]	1.50 [DH/kg]	18,900	6,720		
Vegetable 2	Onion			16,380	[kg/ha]	3.00 [DH/kg]	49,140	7,980		
Vegetable 3	Tomato			18,900	[kg/ha]	1.75 [DH/kg]	33,075	13,990		
Vegetable 4	Green pepper			12,600	[kg/ha]	2.50 [DH/kg]	31,500	11,270		
Vegetable 5	Bean	0.02	3%	1,890	[kg/ha]	6.00 [DH/kg]	272	7,700	185	87
Forage	Alfalfa	0.14	17%	19,656	[kg/ha]	0.35 [DH/kg]	936	2,250	306	630
Arboriculture		0.12	15%				2,185		28	2,157
Arb. 1	Date Palm	0.08	70%	1,575	[kg/ha]	14.00 [DH/kg]	22,050	2,710		
Arb. 2	Olive	0.04	30%	2,313	[kg/ha]	4.00 [DH/kg]	9,252	240		
		0.8	103%							**5,370**

Table 9.3.1 (2/3) Farm Economy - With Project Condition -
Financial prices (1-6 year)

Cultures		Product						Charges		Net Value
		Area		Harvest		Unit Price	Value	Unit Price	Value	[DH]
		ha	%	Qt.	[kg/ha]	[DH/kg]	[DH]	[DH/ha]	[DH]	
Cereal	Wheat	0.49	51%	2,700	[kg/ha]	4.00 [DH/kg]	5,875	7,860	3,848	2,027
Vegetables		0.13	14%				7,639		2,913	4,726
Vegetable 1	Carrot			18,000	[kg/ha]	1.80 [DH/kg]	32,400	9,240		
Vegetable 2	Onion			23,400	[kg/ha]	3.60 [DH/kg]	84,240	20,480		
Vegetable 3	Tomato			27,000	[kg/ha]	2.10 [DH/kg]	56,700	33,360		
Vegetable 4	Green pepper			18,000	[kg/ha]	3.00 [DH/kg]	54,000	23,620		
Vegetable 5	Bean	0.07	7%	2,700	[kg/ha]	6.00 [DH/kg]	1,089	9,000	605	484
Forage	Alfalfa	0.22	23%	42,120	[kg/ha]	0.35 [DH/kg]	3,255	8,150	1,800	1,456
Arboriculture		0.12	12%				4,296		77	4,219
Arb. 1	Date Palm	0.08	70%	2,736	[kg/ha]	16.00 [DH/kg]	43,776	6,720		
Arb. 2	Olive	0.03	30%	4,617	[kg/ha]	4.80 [DH/kg]	22,162	3,760		
		0.96	107%							**12,910**

Table 9.3.1 (3/3) Farm Economy - With Project Condition -
Financial prices (7-30 year)

Cultures		Product						Charges		Net Value
		Area		Harvest		Unit Price	Value	Unit Price	Value	[DH]
		ha	%	Qt.	[kg/ha]	[DH/kg]	[DH]	[DH/ha]	[DH]	
Cereal	Wheat	0.49	51%	2,700	[kg/ha]	4.00 [DH/kg]	5,875	7,860	3,848	2,027
Vegetables		0.13	14%				7,639		2,913	4,726
Vegetable 1	Carrot			18,000	[kg/ha]	1.80 [DH/kg]	32,400	9,240		
Vegetable 2	Onion			23,400	[kg/ha]	3.60 [DH/kg]	84,240	20,480		
Vegetable 3	Tomato			27,000	[kg/ha]	2.10 [DH/kg]	56,700	33,360		
Vegetable 4	Green pepper			18,000	[kg/ha]	3.00 [DH/kg]	54,000	23,620		
Vegetable 5	Bean	0.07	7%	2,700	[kg/ha]	6.00 [DH/kg]	1,089	9,000	605	484
Forage	Alfalfa	0.13	14%	42,120	[kg/ha]	0.35 [DH/kg]	1,981	8,150	1,095	886
Arboriculture		0.20	21%				7,518		237	7,281
Arb. 1	Date Palm	0.14	70%	2,736	[kg/ha]	16.00 [DH/kg]	43,776	6,720		
Arb. 2	Olive	0.06	30%	4,617	[kg/ha]	4.80 [DH/kg]	22,162	3,760		
		0.96	107%				0			**15,400**

Table 9.4.1 Rural Population in the Study Area

Province	Commune Rural	Year 1994	Year 2004
Errachidia Province	Boudnib	8,294	9,867
	Jorf	12,143	12,135
	Aarab Sebbah Gheris	5,060	4,937
	Aarab Sebbah Ziz	18,522	18,332
	Alnif	19,023	20,175
	Es-Sifa	9,159	7,881
	Fezna	4,120	4,087
	H'ssyia	10,151	11,237
	M'ssici	6,836	7,043
	Ait Hani	9,054	9,578
	Amellagou	5,090	5,273
	Assoul	8,062	6,553
	Bni M'hamed Sijelmassa	22,600	16,709
	Er-Rissani	4,673	5,575
	Es-Sfalat	22,258	16,163
	Et-Taous	4,666	5,337
	Aghbalou N'kerdous	8,249	9,357
	Ferkla El Oulia	18,889	20,214
	Ferkla Es-Soufla	12,653	12,624
	Gheris Es-Soufli	6,521	6,742
	Melaab	14,604	16,681
	Tadighoust	7,959	7,346
	Ain Chouater	1,332	1,144
Figuig Province	Bni Tadjite	12,316	14,931
	Bouanane	10,563	10,818
	Total	262,797	260,739

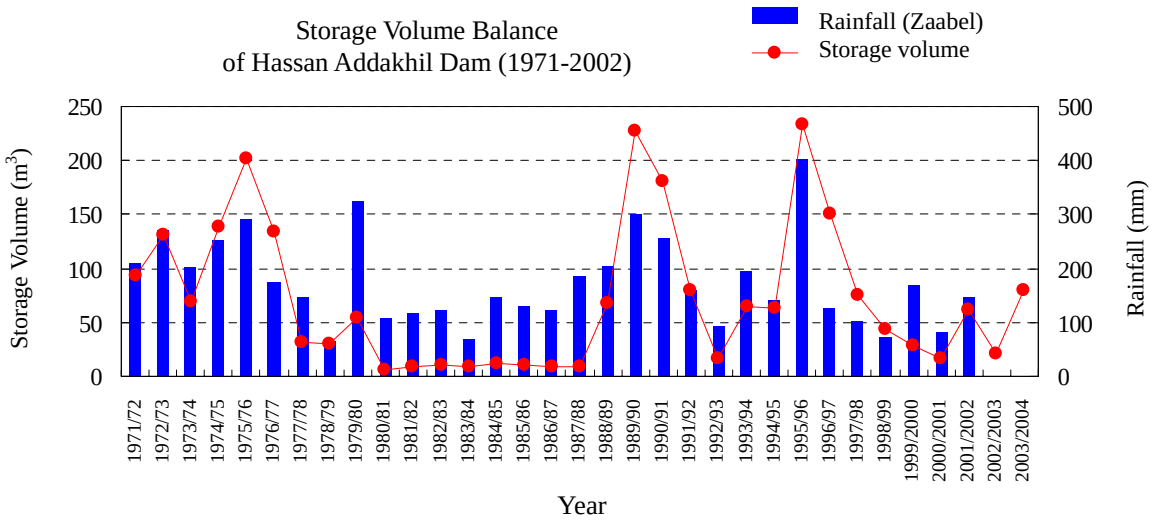
Source: Recensement Général de la Population et de l'Habitat, 1994 (Direction de la Statistique)
Recalculation by the JICA Study team

Table 9.4.2 The Number of Beneficiaries directly benefited by Khettara Rehabilitation Works

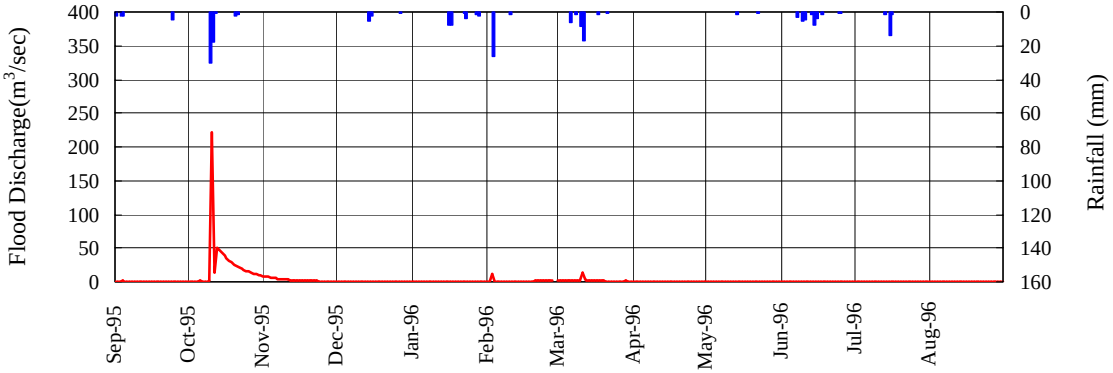
Province	Circle	Commune	Khettara villages (Ksar)	Population	Household
Errachidia	Erfoud	Aarab Sebbah Gheris	3	4,755	584
		Aarab Sebbah Ziz	9	3,970	541
		Alnif	44	18,562	1,994
		Essifa	1	852	103
		Fezna	6	3,917	537
		H'ssyia	16	8,700	871
		M'ssici	13	5,068	427
	Assoul	Ait Hani	6	2,575	407
		Amellagou	9	1,537	222
		Assoul	1	1,214	210
	Errachidia	Ouad Naam	7	3,509	561
	Errich	Gourrama	1	202	37
		Guers Tiallaline	2	152	30
	Errissani	Bni M'hamed Sijelmassa	7	3,999	497
		Errissani	5	2,517	338
		Essfalat	3	1,066	113
		Ettaous	6	2,641	382
		Sidi Ali	2	534	60
	Goulmima	Aghbalou N'kerdous	11	2,611	381
		Ferkla El Oulia	15	10,708	1,435
		Ferkla Essoufla	12	12,194	1,505
		Gheris Essoufli	7	3,277	487
		Melaab	26	14,184	1,876
		Tadighoust	5	1,879	309
Errachidia	Erfoud	Jorf (Municipality)	1	12,143	1,864
Figuig	Beni Tadjid	Ain Chouater	2	71	10
		Beni Tadjite	8	2,647	490
		Bouanane	1	251	35
		Boumerieme	8	2,048	453
		Talsint	4	1,724	377
Total			241	129,507	17,136

Source: Recensement Général de la Population et de l'Habitat, 1994 (Direction de la Statistique)
Recalculation by the JICA Study team

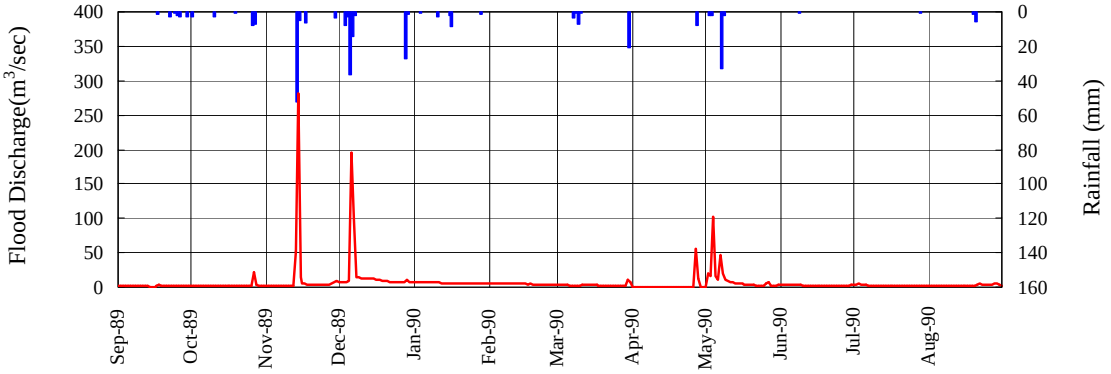
Figures



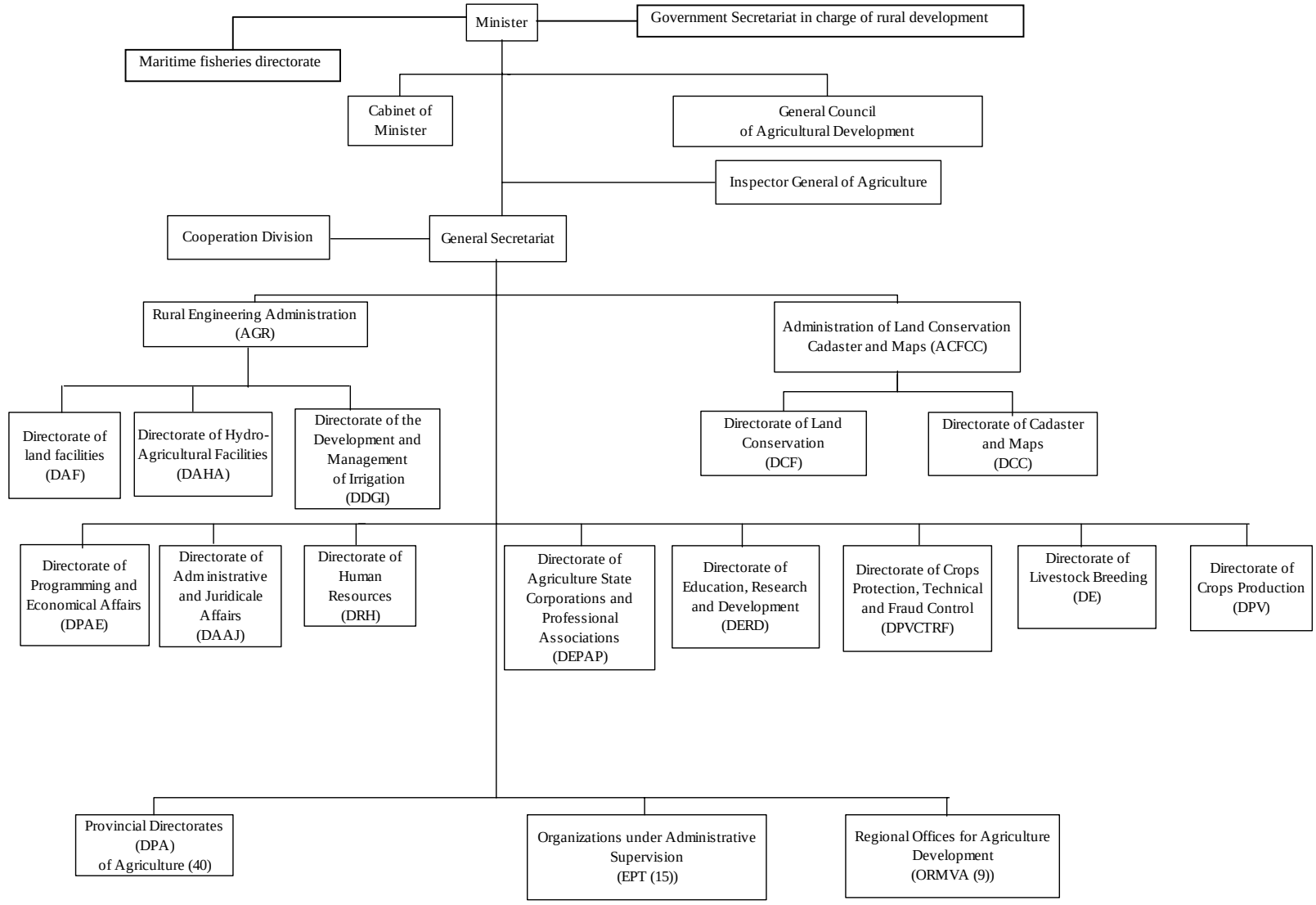
Rainfall - Flood Discharge (Site: Tadighoust)
(1995-1996)



Rainfall - Flood Discharge (Site: Tadighoust)
(1989-1990)



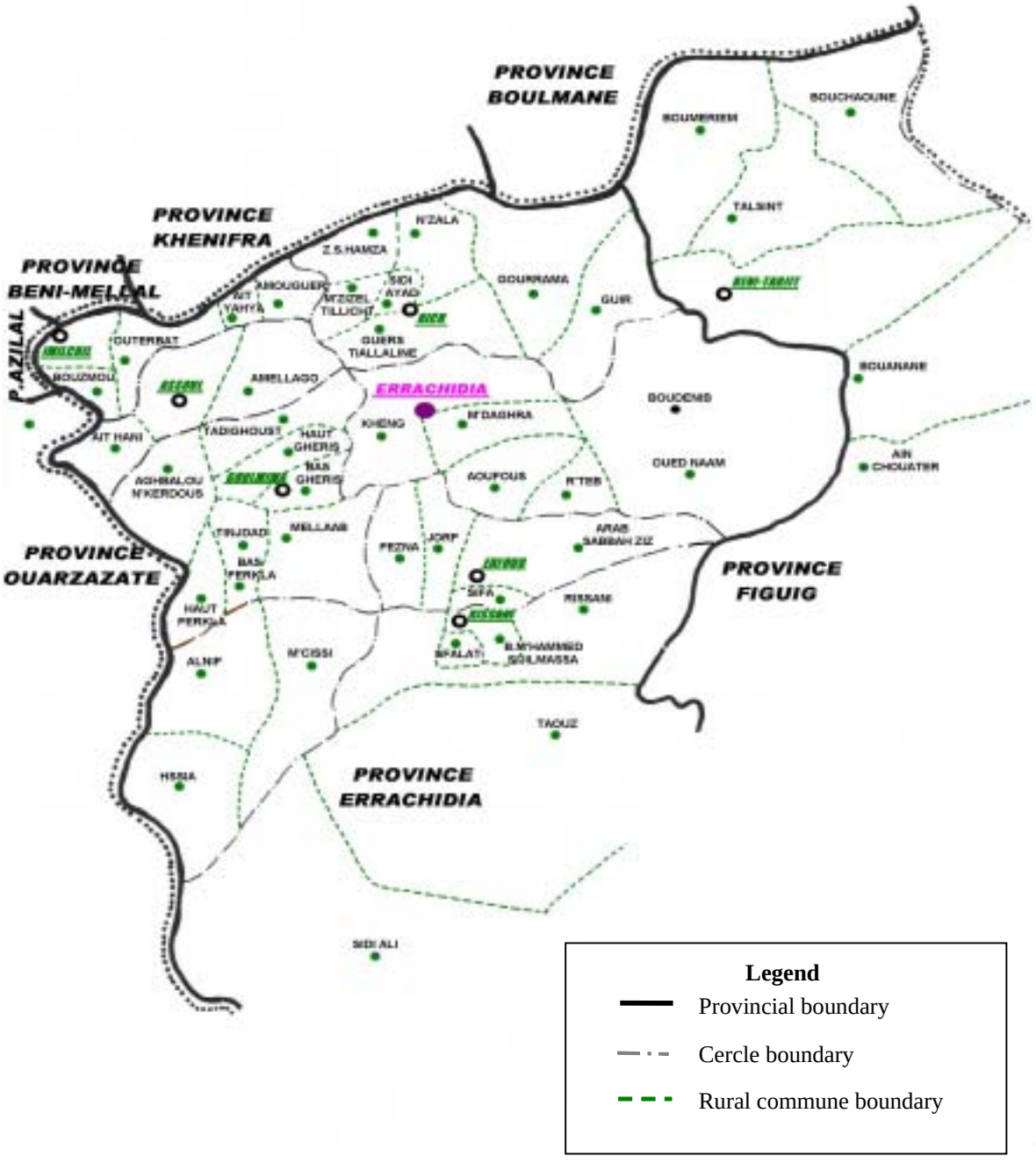
The Development Study on Rural Community Development Project in Semi-Arid Atlas Regions with Khettara Rehabilitation in the Kingdom of Marocco	Figure 1.3.1 Storage Volume Balance of Hassan Addakhil Dam and Flood Occurrence
Japan International Cooperation Agency	



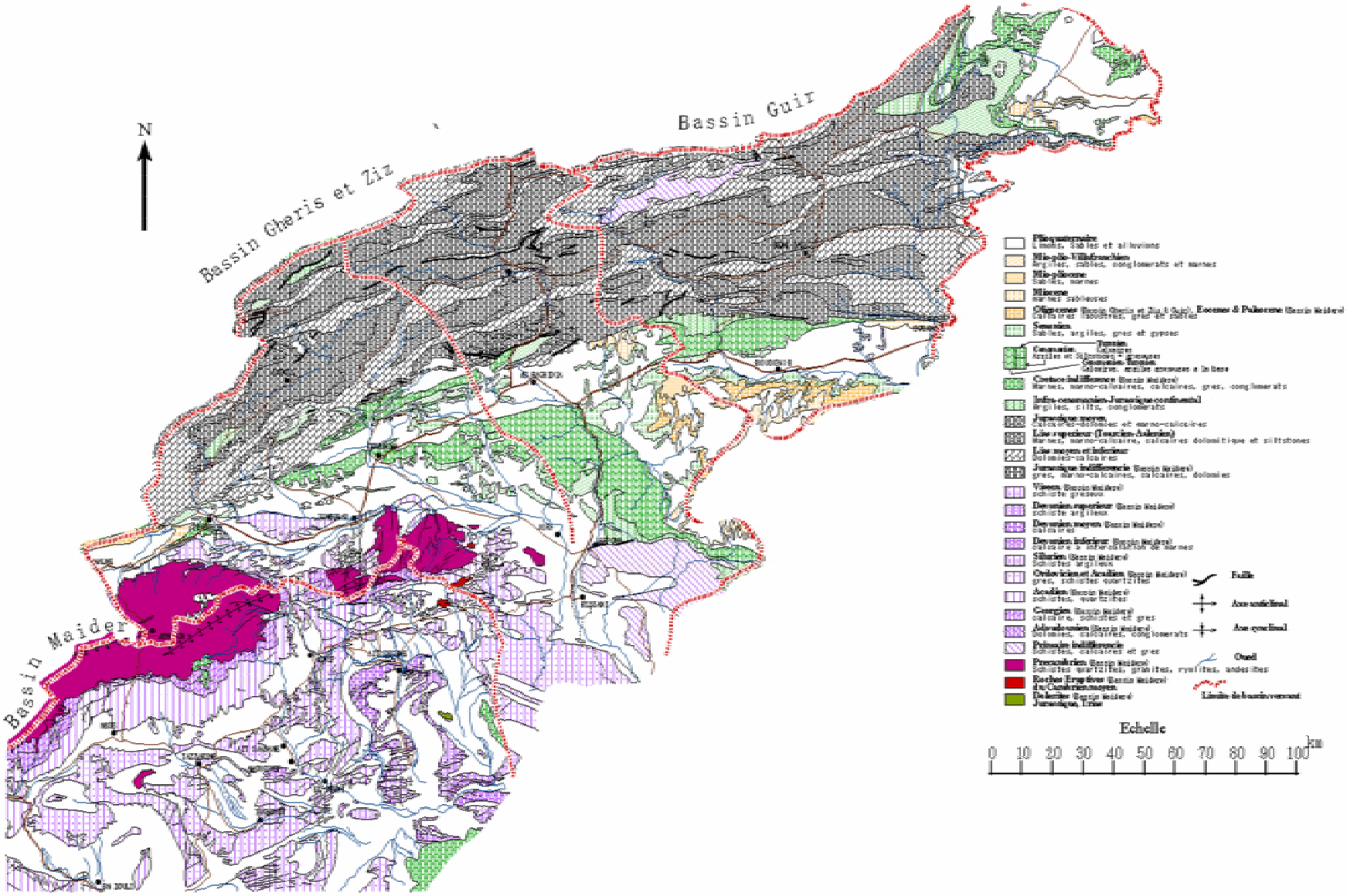
The Development Study on Rural Community Development Project in Semi-Arid Atlas Regions with Khettara Rehabilitation in the Kingdom of Marocco

Japan International Cooperation Agency

Figure 2.3.1
Organization Chart of Ministry of Agriculture, Rural Development and Sea Fisheries



The Development Study on Rural Community Development Project in Semi-Arid Atlas Regions with Khettara Rehabilitation in the Kingdom of Marocc	Figure 3.1.1 Administrative Boundary fo ORMVA/TF
Japan International Cooperation Agency	



The Development Study on Rural Community Development Project in Semi-Arid Atlas Regions with Khettara Rehabilitation in the Kingdom of Marocc	Figure 3.2.1 Geological Map of the Study Area
Japan International Cooperation Agency	