Annexe H Implementation Plan

Annexe H Implementation Plan

Contents

Tables

Figures

H.1 General Consideration

In the Master plan, staged development plan composed of short-term (first 5 years), intermediate-term (6 to 10 years) and long-term (11 to 20 years) stages are proposed in due consideration of the discharge of the khettaras. It is remarkable point that an equity to access to the khettara and irrigation canal rehabilitation work shall be emphasized during the implementation planning considering social characteristics of the khettara communities. It is not applied to give a higher priority to the economically higher khettara communities that may generally have a larger khettara discharge.

The table blow shows discharge classification of khettara proposed in the draft Master plan report.

Staging Plan concerning Khettara Rehabilitation Plan

Year		Short-term (5 years)	Intermediate-term (6 to 10 years)	Long-term (11 to 20 years)
Khettaras		130 khettaras (2 lit/sec =< Q)		219khettaras (Q=0 lit/sec)
		(max. 600mrehabilitation)	(Remaining portion of short-term plan)	
			61 khettaras (0 <Q<2 lit/sec)	
Khettara rehabilitation	Work items	Rehabilitation of shafts and galleries	Rehabilitation of shafts and galleries	(Communal pump installation after recharge effect realized)
	Rehabilitation rate	30 % (40% including present rehabilitation length)	30 % (40% including present rehabilitation length)	―
Irrigation system	Work items and target	Rehabilitation of earth lined and masonry canals, and improvement of diversion structures (Rehabilitation works is limited to primary canal)		
		Rehabilitation Length=116 km (Rate: 100% rehabilitation)	―	―
		Improvement of diversion structures of concrete canal		
		Rehabilitation Length L=126 km （Rate: 100% rehabilitation）	―	―
Recharge facility	Work items	Design and construction of promising plan	Plan and investigation for newly implemented project	- ditto -
		2 projects	6 project	- ditto -

As to the rehabilitation of the irrigation canal, it is proposed to preferentially rehabilitate the irrigation canal during the first five (5) years in short term period. The following are principal policy for the rehabilitation of the irrigation canal:

- Project benefit is originated from mainly increase of water flow by both rehabilitation works of the khettaras and irrigation canals, and the economic analysis proves that the benefit by a rehabilitation of the irrigation canal is more advantageous because of its less cost compared with that for the khettaras.
- The khettaras which discharges are less than 2.0 lit/sec is rehabilitated in mid-term period, 6 to 10 year according to the Master plan. Considering an equality of opportunity for the rehabilitation works, irrigation canals of these khettaras shall be launched in the first five (5)

years.

With respect to the recharge facilities, it is proposed to commence facility construction of small scale pond at Hannabou and flood diversion weir construction at Boudenib in an early stage because basic design of these plans were already conducted and certain benefit on groundwater recharge is expected. Other facilities such as dam and flood dispersion dike are commenced from first detailed investigation to obtain persuasive evidence to confirm the recharge effect. (see Sub-Chapter 7.10 in the main report)

H.2 Rehabilitation of Khettaras

Concerning topographical distribution of 191 khettaras, some are located at inundated area in the past adjoining to the large rivers with their catchment area of thousands square km, like the rivers Gheris and Todrha, on contrary to those, some are located at downstream of several square km catchment area in the hilly terrain, e.g., the right side of the Todrha and Ferkla rivers in Zone A and northern terrain of Alnif in Zone G. Rehabilitation works shall take considerably longer years for example 5 to 10 years because budget allocation is limited and furthermore the total rehabilitation length reached about 139 km for 191 khettaras.

Rehabilitation length is listed in Table H.2.1 and summarized as follows:

Proposed Rehabilitation Length of Khettaras

Zone	Total length (m) (excluding present concrete section)	Proposed rehabilitation length (m)
Zone A	117,147	35,144
Zone B	25,363	7,609
Zone C	33,599	10,080
Zone D	105,153	31,546
Zone E	85,151	25,545
Zone F	33,714	10,114
Zone G	62,440	18,732
Total	462,567	138,770

Note: Proposed rehabilitation length is 30 % of total length of khettara

It is therefore necessary to give particular direction of the rehabilitation plan to each khettara taking account of its specific characteristics such as location, potential of recharge phenomena, urgency for rehabilitation while considering equity to giving an opportunity of the rehabilitation works as is described above. On the other hand, it is also necessary to select appropriate khettaras for the earlier rehabilitation from the points of effect of public investment, needs for rehabilitation from standpoints of limitation of the budget and implementation period of local and foreign assistances.

Following points are taken for the preparation of the implementation plan: (see Figure H 2.1 and H.2.2)

1. Recharge facility planning shall be simultaneously carried out together with the rehabilitation of the khettaras for the area where recharge facilities effectively increase khettara flow. (e.g., downstream of the Timkit and Tanguerfa dams in Zone A and Fezzou and Ahassia dams in Zone G)

The DRH (the Ministry of territory development, water and environment) is responsible for the water resources development planning including surface and subsurface water. The DRH has already commenced the study of the Timkit dam, and recharge effect by the construction of the Timkit dam is extended to the Tinejdad area and amount of the recharge is estimated at about 5 % of the storage capacity. Furthermore, three dams proposed by the ORMVA/TF (Tanguerfa: located at upstream of Tinejdad (a part of Zone A), Fezzou, Ahassia: located at Alnif (a part of Zone G)) are hopeful for recharge.

General Feature of Dams

	Dams	Catchment area	Effective capacity	Recharge amount	Annual run-off	Cost (Dhs. million)
1	Timkit	592 km^2	27.5 Mm^3	1.12 Mm^3 (36 lit/sec)	21.4 Mm^3	250
2	Tadighoust	2,239 km^2	54.0 Mm^3	---	36.8 Mm^3	1,100
3	Tanguerfa	592 km^2	1.62 Mm^3	---	---	13
4	Fezzou (M'cissi)	142 km^2	1.85 Mm^3	0.55 Mm^3 (17 lit/sec)	3.9 Mm^3	41
5	Ahassia	529 km^2	5.42 Mm^3	1.63 Mm^3 (52 lit/sec)	10.0 Mm^3	146
	Total			3.30 Mm^3 (105 lit/sec)		1,550

Source: All data in table are quoted from reports published.

Command Area of Dams

	Dams		Command area (ha)	Command area of khettara (ha)	Total (ha)
1	Timkit	→	1,300	110	1,410
2	Tadighoust	→	（1,500）	---	（1,500）
3	Tanguerfa	→	---	---	---
4	Fezzou (Msissi)	→	90	50	140
5	Ahassia	→	270	160	430
		合計*	1,660	320	1,980

Source: All data in table are quoted from reports published.

* Tadighoust and Tanguerfa dams are excluded from command area calculation.

Water price by recharge (Construction cost to produce one cubic meter water) is estimated Dhs 686,000 /lit on condition that the cost and benefit of the the Tadighoust dam inferior in economic analysis and Tanguerfa dam which is a regulation pond of the Timkit dam are excluded from the estimates.

437 (Dhs. million)×320/1,980=71 (Dhs. million)→105 lit/sec increase → water price Dhs. 680,000/lit

While water price by khettara rehabilitation is estimated at Dhs. 750,000/lit assuming that rehabilitation cost of khettara is Dhs. 1,500/m and 2 lit/sec increase of water is expected by one (1) km rehabilitation of khettara gallery.

1,500(Dhs.)×1,000m÷2 (lit/sec)→Water price Dhs.750,000/lit

It is said both of works, i.e. rehabilitation of the khettaras and construction of recharge facilities necessitate almost

same cost to increase one (1) lit/sec of khettara water, therefore both plan shall be carried out conjunctively.

2. Acceleration of recharge by flood irrigation (Zone C)

Most of khettaras in Boudenib (Zone C) are located in the inundated area of the Guir river. Increase of the khettara flow is realized by both of rehabilitation work for khettaras themselves and increase of recharge water by the flood irrigation system. Water price introduced by flood irrigation system is estimated at about Dhs. 700,000/lit assuming that 30 % of total flood irrigation effectively filtrates into ground and flowing out to the khettaras.

3. Basin of the Guir river (Zone B)

The Guir river basin has about 188 Mm^3 run-off per annum, and 30 % of its run-off has been utilized. Considering such a higher water source potential of the Guir river basin, pump irrigation system is proposed to meet most requirement of irrigation water use together with the water use of khettaras. As to khettara rehabilitation work, prevention from flood damages, such as construction of flood protection dikes and shaft reinforcement are proposed.

4. Downstream are of the Ziz river basin (Zones F and G)

Most of the farmlands in the Rissani area are located at the command area of the Hassan Addakhill dam, therefore released water from the dam is able to irrigate these areas except eastern area of the Rissani and Taouz. It is therefore proposed to install communal pump stations in the areas of Rissani and Taouz so as to secure the water supply because increase volume of water by the khettara rehabilitation is minimal.

5. Selection of khettaras for rehabilitation taking account of their higher investment effects and appropriateness for rehabilitation

30 khettaras are shown in bold letter in the attached table. These khettaras have been selected based on the inventory survey results and also taking into consideration equity to meet equal rehabilitation opportunity for whole khettara villages.

Economic benefits originated by the rehabilitation works are estimated in detail on each khettara basis, especially in terms of work extent of rehabilitation work for the khettara and irrigation canals.

6. Rehabilitation works for the khettaras which have limited water flow.

The Master plan includes organization strengthening scheme as a project component. In the component, an official registration of existing traditional khettara users' groups to khettara associations is a main purpose aiming at collecting a rehabilitation fund from local and foreign agencies. Taking this policy into consideration, the number of requests of khettara rehabilitation to the governmental agencies should increase, especially from the khettara villages which have less khettara water. It is therefore not recommended to give lower priority to these small water khettara due to their economic disadvantage because such a plan delays registration of the khettara

association and also obstructs sound activities of these associations. The ORMVA/TF has been implementing the rehabilitation works equally so as to give an equity of rehabilitation opportunity to the whole khettaras, and his policy is not largely modified. With respect to these matters, the following are considered during the rehabilitation planning for the small water khettaras.

1) Rehabilitation of irrigation canals is promoted to expect higher and earlier return of the benefit.

2) Remarkably damaged or leaked portion shall be first rehabilitated from an economical point of view.

3) Installation of concrete lining canal or PVC pipe is recommended for gallery rehabilitation. (Special attention in terms of cost and construction schedule shall be paid in the case work is carried out in tunnel.)

7. Limit of rehabilitation works

Rehabilitation works of khettara are broadly divided into 1) rehabilitation of gallery and shaft, 2) extension of gallery, 3) re-profiling of gallery bed (including excavation of outcrop of bed rock), 4) dike construction, gallery and shaft reinforcement to reduce flood damage and so on. Extension of gallery and re-profiling of gallery bed are effective to increase yield of the khettara taking into consideration of present condition that khettara flow has been gradually decreasing. Meanwhile, it is by tradition prohibited to extend gallery without mutual understanding at where many khettaras are conjugated because a khettara extension causes water decrease of adjoining khettaras. On the other hand, extension and re-profiling of khettara gallery have been strongly requested at where each khettara separately exists and there is no traditional restriction on rehabilitation works, such as 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

3) Following rehabilitation cost collected during the verification study is applicable to estimate entire project cost.

Rehabilitation Cost for Khettara Gallery Construction

Khettara	Constructyion	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) = DH1,650/m, (Concrete culvert in tunnel) = DH1,360/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 disadvantage 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. Review of rehabilitation cost is necessary to estimate a proper cost for further rehabilitation planning.

Table H.2.1 shows details of the khettara rehabilitation work considering various water resources potential shown in 1. to 4. in this Sub-chapter.

H.3 Rehabilitation of Irrigation Canals

The following are considered during the planning of the irrigation canal rehabilitation:

1) Rehabilitation work is limited to the primary irrigation canal.

Primary canals which are owned by several farmers are subject for the rehabilitation works. Secondary canal is excluded from the rehabilitation works of the project because the secondary canal has huge length and they are categorized in an on-farm level.

2) Khettara is selected regardless of the discharge

For short and intermediate-term rehabilitation schedule, proper rehabilitation scope has been proposed based on the project evaluation on whole khettaras with water flow at present. The project targets 5 year completion of the irrigation canal rehabilitation during the short term period, however ordering by discharge of each khettara is not applied to the rehabilitation schedule.

Canal rehabilitation work for large flow khettara is highly advantageous from economic point of view because reduction volume of water leakage from large flow canal is larger than those khettaras with small discharge. On the other hand, it is obviously understood that reduction of water leakage by concrete lining is equally important for the small flow khettaras because the farmers exerted their ingenuity in the water conveyance method, e.g., passing storage water in the regulating basin quickly to the farmland, which method highly improves conveyance efficiency. The said method is more effective for small flow khettaras, and therefore canal rehabilitation with concrete lining is inevitable to support the villagers of the small flow khettaras.

3) Both khettara and irrigation canal are not simultaneously rehabilitated.

It is advantageous to simultaneously rehabilitate both the khettara and downstream irrigation canal to maximize agricultural productivity, and it becomes model case on implementation plan of the khettara rehabilitation plan. It is however assumed that a large difference of the benefits may be originated between the khettaras rehabilitated earlier and those not rehabilitated through a 10 year proposed rehabilitation period of 10 years. Starting with the basic recognition that a project implementation plan has should be established through a participatory approach, and it is emphasized that the khettara association which are composed of plural traditional khettara users' groups should establish rehabilitation plan. Considering these concerns, it is recommendable to rehabilitate several khettaras and irrigation canals with certain steps, but not concentrate the work to the particular khettaras. The step by step process is advisable to apply this idea to activate the associations' activities and attain his independency.

H.4 Construction Volume and Cost Estimates

H.4.1 Construction 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 （100%）
	Total length of khettaras		462,567 （100%）	Total length of irrigation canal 242,868 （100%）

Project for Recharge Facilities

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

Activities on Farming, Water Use and Organizational Strengthening

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

Afforstation

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

H.4.2 Cost Estimates

(1) Assumptions

a) Unit prices are estimates on the basis of the Verification study.

b) The exchange rate used in estimates is as follws:

US$1.00 = DH8.70 (DH1.00 = Yen12.64)

c) Construction cost is contract basis with local contractor

d) The physical contingency of ten (10) percent of the total cost of the construction cost, administrative/ engineering cost, detailed design is included in the project cost.

e) 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.

(2) Project cost

Project cost is comprised of following items:

a) Construction cost

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

b) Administration cost

Detailed design, 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.

c) 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.

d) Contingency

The physical contingency 10 % and price contingency 1.3 % is taken into account.

Project cost is estimated at DH568 milliom as detailed in Table H.4.1.

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.

H.5 Implementation Schedule

Annual fund requirement and project implementation schedule are shown on Table H.5.1 and Figure H.5.1, respectively. Cost of rehabilitation work for khettara and irrigation rehabilitation works is explained in Annexe I Project Justification.

The following are considered during preparation of the implementation schedule:

1) Khettara rehabilitation work is divided into the short-term (first 5 years), intermediate term (second 5 years) and long term (11 to 20 years) for the implementation scheduling. The 191 productive khettaras are rehabilitated during short and intermediate terms. About 220 sites of the re-productive khettaras which have dried up recently however have had a potential to produce flow in future are rehabilitated during the long term plan.

2) Rehabilitation length is limited to 30 % of each khettara length excluding the section already rehabilitated with concrete. 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 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

3) Rehabilitation works for the irrigation canals (primary canals) and diversion outlets are scheduled in the short term stage (first 5 years).

4) Construction works of the recharge facilities are commenced after detailed design including groundwater analysis for about 5 years. Two (2) of proposed recharge facilities, i.e. small scale recharge pond in Hannabou and flood diversion weir in Boudenib 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 of 150 ha farmland which is equivalent to about 10 % (drip irrigation: 5 %, furrow irrigation: 5 %) of the whole khettara command area within 10 years.

6) As explained in Sub-Chapter H.2 Khettara Rehabilitation, it is necessary to select appropriate khettaras for the earlier rehabilitation from the points of effect of public investment, needs for rehabilitation from standpoints of limitation of the budget and implementation period of local and foreign assistances. In the Study, 30 khettaras are selected for earlier implementation project. The detailed information of these khettaras is attached in "Data Book" for further preparation of the planning report. Table below shows list of the 30 khettaras, and the location map is shown in Figure H.4.2.

30 Khettaras for Detailed Investigation

No	Zone	ID No	Name of Khettara	Name of Ksar
1	A	8	lghrane	lghrane
2	A	11	Ouinigui	Ouinigui
3	A	12	Oukhite	Oukhite
4	A	14	Tiguida	Tiguida
5	A	15	Aghroud	Aghroud
6	A	44	Lakbira	Tizagaghine
7	A	49	Ait My Mamoun	Ait My Mamoun
8	A	51	Ait Oulghoume	Dar Oumira
9	A	73	Taghouchte	Taghouchte
10	A	121	El Hassania	Tilioulne
11	B	2	Tamazaroute	Ait wazag
12	B	5	Bousfssaf	Almou chorfa
13	C	3	Taouz	Oued Naam
14	C	5	Lakdima	Oued Naam
15	D	41	El Aissaouia	Oulad Aissa
16	D	44	Lambarkia	Oulad M'barek
17	D	47	Lahloua	Mounkara
18	D	54	jdida	Bouya
19	D	55	Kdima	Krair
20	D	56	Jdida	Krair
21	D	58	Khtitira	Hannabou
22	D	59	Sayed	Hannabou
23	D	60	Fougania	Hannabou
24	E	7	Ramlia	Sifa
25	E	8	Lakdima Douar	Sifa
26	E	16	Charchmia	Sifa
27	F	1	Loujarchia	Loujarcha
28	F	36	Hassi Labied	Hasi Labied
29	G	55	Tinififte	Tinififte
30	G	87	Aachich Ait Iaza	Aachich

Tables

Table H.2.1 Rehabilitation Work for Khettaras and Irrigation Canals

No.	Zone	ID No.	Khettara Name	Ksar	Discharge	Irrigable area	Khettara rehabilitation length (m)	Irrigation canal rehabilitation length (m)
1	A	1	Taoutoutoute	Taoutoutoute	2.3	6	210	600
2	A	2	Iminkine	Iminkine	1.1	3	210	600
3	A	3	Ait oulhou	Ait oulhou	2.3	6	230	400
4	A	4	Toufaghantaste	Ait khlifa	3.4	8	110	500
5	A	5	Akkerouz	Akkerouz	1.7	4	190	1100
6	A	6	Amgane	Amgane	2.3	6	480	190
7	A	7	Tighramt	Tighramt	1.7	4	80	140
8	**A**	**8**	**lghrane**	**lghrane**	**7.3**	**18**	**50**	**280**
9	A	9	lkachrane	lkachrane	1.7	4	90	140
10	A	10	Ouine Oufroukh	Ouine Oufroukh	1.8	4	10	500
11	**A**	**11**	**Ouinigui**	**Ouinigui**	**3.6**	**9**	**30**	**0**
12	**A**	**12**	**Oukhite**	**Oukhite**	**10.1**	**24**	**200**	**0**
13	A	13	Ami Ali	El Galta	1.0	3	410	430
14	**A**	**14**	**Tiguida**	**Tiguida**	**3.1**	**8**	**300**	**1000**
15	**A**	**15**	**Aghroud**	**Aghroud**	**10.6**	**27**	**620**	**300**
16	A	23	Ami Ahmed	Ami Ahmed	3.4	8	390	0
17	A	25	Darte Dghouvaues		4.5	9	340	2000
18	A	31	Bou ouguiss		2.3	6	20	1000
19	A	41	Bakassia	Tizagaghine	0.5	0	880	460
20	A	42	Maamrya	Tizagaghine	6.8	17	1050	1300
21	A	43	Ami Hassan	Tizagaghine	1.6	2	1590	0
22	**A**	**44**	**Lakbira**	**Tizagaghine**	**22.3**	**56**	**650**	**4500**
23	A	45	El Mehdia	Tizagaghine	10.0	23	900	800
24	A	46	Atti Kida	Tizagaghine	7.6	17	740	1000
25	A	47	Regaga	Ait Ba Maati	7.7	18	930	2500
26	A	48	Mouyjna	Ait Ba Maati	2.3	5	1200	300
27	**A**	**49**	**Ait My Mamoun**	**Ait My Mamoun**	**6.8**	**17**	**320**	**800**
28	A	50	Litama	Litama	4.5	11	270	0
29	**A**	**51**	**Ait Oulghoume**	**Dar Oumira**	**8.2**	**20**	**310**	**160**
30	A	52	Dar Omira Lakdima	Dar Oumira	5.2	13	0	700
31	A	53	Ikhf N'lghir	Dar Oumira	8.5	21	300	500
32	A	54	Dar Omira Jdida	Dar Oumira	11.4	29	900	0
33	A	55	Azag N'ouchen	Azag N'ouchen	1.8	3	950	3500
34	A	56	lzilf	lzilf	0.7	0	2070	2800
35	**A**	**58**	**Diba**	**Ksiba**	**7.9**	**17**	**300**	**30**

No.	Zone	ID No.	Khettara Name	Ksar	Discharge	Irrigable area	Khettara rehabilitation length (m)	Irrigation canal rehabilitation length (m)
36	**A**	**59**	**Ait Ben Omar**	**Ait Ben Amar**	**4.5**	**9**	**270**	**200**
37	A	60	Cheikh	Ktaa Oued	4.5	11	1840	290
38	A	61	Tamagourte	Tamagourte	4.1	10	140	0
39	A	63	Khamssine	Assoul	10.9	26	240	0
40	A	64	El Mach	Ait Ben Omar	12.5	31	370	500
41	A	65	Ait M'hmed	Ait M'hmed	1.4	3	540	1000
42	A	66	Ihandar	Ihandar	9.7	24	300	190
43	A	67	Tighfarte	Tighfarte	9.7	24	1620	2000
44	A	68	Lakdima (Ait Maamer)	Lakdima (Ait Maamer)	6.8	16	710	1000
45	A	70	Ami Lhoussa	Agoudime	1.3	2	450	500
46	**A**	**73**	**Taghouchte**	**Taghouchte**	**1.4**	**4**	**190**	**700**
47	A	74	Taghya	Taghya	2.3	5	370	3000
48	A	98	Kdima Assoul	Assoul	2.3	3	360	0
49	A	100	Drain Tamtatouchte	Tamtatouchte	6.8	17	1050	760
50	A	101	Tamajjal Nouaoulzi		4.0	10	230	80
51	A	102	Aoulzi Tamazirte		1.7	0	140	1600
52	A	103	Tamda	Tamda	0.2	0	140	820
53	A	104	Drain imider	Imider	5.4	14	1800	570
54	A	105	Idmouma	Idmouma	8.4	20	470	220
55	A	106	Agoudime	Agoudime	2.3	5	40	1300
56	A	107	Ouj	Oje	9.1	23	270	700
57	A	108	Tasskountite	Tasskountite	0.6	1	40	1200
58	A	109	Outalamine	Outalamine	9.1	23	120	1800
59	A	110	Oukhalk	Tiguida	6.8	17	170	1800
60	A	111	Ait Mkhoun	Ait Mkhoun	1.1	3	290	400
61	A	112	Idelssene	Idelssine	6.8	16	70	280
62	A	113	Taltafroute	Taltafrout	1.8	3	380	640
63	A	114	Laaouina	Laaouina	7.9	19	290	1770
64	A	115	Bouhadachia	Bouhadachia	6.2	15	330	90
65	A	116	El maghzen	El maghzen	2.4	2	580	0
66	A	117	Elboutahiri	El boutahiri	6.3	16	180	190
67	A	118	Chrif	Chrif	0.8	2	140	200
68	A	119	Lhaj Thami	Lhaj Tahami	3.7	8	290	660
69	A	120	El arb	El arb	2.4	5	270	300
70	**A**	**121**	**El Hassania**	**Tilioulne**	**23.5**	**52**	**500**	**0**

No.	Zone	ID No.	Khettara Name	Ksar	Discharge	Irrigable area	Khettara rehabilitation length (m)	Irrigation canal rehabilitation length (m)
71	A	126	Oultamayoust	Oultamayoust	4.3	10	80	0
72	A	127	Tourtite	Tourtite	0.1	0	260	240
73	A	128	Taldounte	Taldounte	4.5	11	150	240
74	A	129	Imider	Imider	2.3	6	1840	180
75	A	130	Iguerguit	Iguerguit	1.1	2	50	810
76	A	131	Taourirte	Taourirte	2.2	5	90	250
77	A	132	Ihouna	Ait taghi	1.7	4	20	160
78	A	134	Imider	Imider	6.8	17	40	200
79	A	135	Oul N'tnayouste	Oul N'tnayouste	1.7	4	90	0
80	A	136	Lagar	Taoudaate	0.6	1	60	50
81	B	1	Agoummad	Ait wazag	27.3	67	250	1400
82	**B**	**2**	**Tamazaroute**	**Ait wazag**	**20.5**	**50**	**30**	**510**
83	B	3	Ait Sbaa	Ait sbaa	1.5	3	10	0
84	B	4	EL Ain	Almou chorfa	6.8	17	90	0
85	**B**	**5**	**Bousfssaf**	**Almou chorfa**	**11.4**	**29**	**300**	**700**
86	B	6	El Majen	Almou chorfa	6.8	17	90	0
87	B	7	El Fougania	Almou Vhorfa	1.1	0	300	0
88	B	8	Ait Yakoub (2)	Ait Yaakoub	2.8	7	2810	4500
89	B	10	Roda	Sbaik	17.0	41	390	0
90	B	12	Beni Tajit	Beni Tajit	21.9	54	200	0
91	B	13	Ait My Hachem	Almou chorfa	0.6	1	200	0
92	B	14	Jdida	Zaouit El Hajoui	22.7	56	630	1000
93	B	15	El Hajoui Sidi Abrerrahmane	Zaouit El Hajoui	12.3	30	40	600
94	B	16	Tafejjaret	Tafejaret	20.5	51	460	0
95	B	17	Ain Chouater	Chouater	20.5	51	350	0
96	B	18	Douimniaa	Chouater	4.2	10	720	500
97	B	19	El Hajoui	Chouater	4.5	11	510	0
98	B	20	Talssinte		11.4	28	60	0
99	B	22	Ait Boubker / Youssef	Talsint	10.2	25	120	0
100	B	23	Talhamsoust	Talsint	1.7	4	60	950
101	C	1	Oued Naam	Beni Ouzieme	10.2	25	1290	450
102	C	2	Ouled Ali	Oued Naam	16.7	40	2460	1110
103	**C**	**3**	**Taouz**	**Oued Naam**	**19.3**	**48**	**600**	**330**
104	C	4	Lakbira	Labkira	10.2	24	1590	2000
105	**C**	**5**	**Lakdima**	**Oued Naam**	**13.6**	**31**	**220**	**570**

No.	Zone	ID No.	Khettara Name	Ksar	Discharge	Irrigable area	Khettara rehabilitation length (m)	Irrigation canal rehabilitation length (m)
106	C	6	Jdida	Jida	22.7	55	1760	720
107	C	7	Torba	Torba	3.9	10	420	1400
108	C	8	Lahcen	CR	8.4	17	1740	160
109	D	31	Lakbira	Taraa	9.1	21	840	2000
110	D	34	Souihla	Oulad Ghanem	13.6	33	150	2000
111	D	35	Aissaouia	Oulad Ghanem	2.3	3	950	0
112	D	36	Saidia	Oulad Ghanem	3.9	8	1310	0
113	**D**	**41**	**El Aissaouia**	**Oulad Aissa**	**6.4**	**15**	**2020**	**1800**
114	**D**	**42**	**Lambarkia**	**Mounkara**	**23.4**	**57**	**1200**	**440**
115	**D**	**44**	**Lambarkia**	**Oulad M'barek**	**19.7**	**48**	**2130**	**0**
116	**D**	**47**	**Lahloua**	**Mounkara**	**21.5**	**52**	**2250**	**4730**
117	D	53	Kdima	Bouya	28.2	71	2220	1840
118	**D**	**54**	**jdida**	**Bouya**	**16.5**	**40**	**1620**	**0**
119	**D**	**55**	**Kdima**	**Krair**	**16.7**	**40**	**1110**	**2000**
120	**D**	**56**	**Jdida**	**Krair**	**14.0**	**34**	**1200**	**0**
121	**D**	**58**	**Khtitira**	**Hannabou**	**21.0**	**51**	**1150**	**900**
122	**D**	**59**	**Sayed**	**Hannabou**	**11.7**	**28**	**1250**	**800**
123	**D**	**60**	**Fougania**	**Hannabou**	**50.2**	**124**	**1700**	**0**
124	**D**	**61**	**Quastania**	**Hannabou**	**6.8**	**16**	**1950**	**1000**
125	D	62	Kdima	Krair	10.9	26	1760	400
126	**D**	**64**	**Lgrinia**	**Hannabou**	**6.4**	**15**	**1240**	**1400**
127	D	65	Laalouia (Hannabou)	Hannabou	8.2	19	1950	400
128	D	66	Mostafia	Hannabou	5.3	13	1670	0
129	D	69	Kdima		22.1	54	1890	0
130	E	1	El Ghanamia	A.S. Ziz	1.1	3	1750	0
131	E	2	El bour	Sifa	4.9	11	2270	0
132	E	4	Laagaya	Sifa	2.3	6	1440	0
133	E	5	Jdida Bel Houcine	Sifa	0.6	1	2140	30
134	E	6	Jdida Bel Houcine	Sifa	4.5	11	2390	0
135	**E**	**7**	**Ramlia**	**Sifa**	**14.4**	**35**	**1350**	**590**
136	**E**	**8**	**Lakdima Douar**	**Sifa**	**27.1**	**64**	**1790**	**0**
137	E	9	Lihoudia	Sifa	1.4	4	1780	0
138	E	10	Laglaglia	Sifa	3.4	7	1640	0
139	E	12	Jdida Lhaj El Madani	Sifa	3.4	9	1300	0
140	E	13	Laaguilia Kbour Lihoud	Sifa	4.0	9	1960	710

No.	Zone	ID No.	Khettara Name	Ksar	Discharge	Irrigable area	Khettara rehabilitation length (m)	Irrigation canal rehabilitation length (m)
141	E	14	Lhaj Alal	Sifa	28.3	63	2640	0
142	E	15	Ighzer	Sifa	2.3	4	1670	400
143	**E**	**16**	**Charchmia**	**Sifa**	**21.1**	**46**	**1430**	**3030**
144	**F**	**1**	**Loujarchia**	**Loujarcha**	**4.5**	**8**	**560**	**1000**
145	F	24	Harounia	Haroun	0.6	2	1900	0
146	F	27	Agaroum	Tagaroumte	1.1	2	80	0
147	F	32	Talaabast	Merzouga	6.8	15	450	0
148	F	33	Tamaright	Merzouga	2.3	5	1540	1000
149	F	34	Tamazante	Merzouga	2.3	3	990	0
150	F	35	Taachaboute	Khamlia	0.6	1	540	200
151	**F**	**36**	**Hassi Labied**	**Hasi Labied**	**4.5**	**9**	**1100**	**0**
152	F	38	ElBagaa	ElBagaa	1.7	4	1360	100
153	F	40	Tamaright		1.1	2	590	500
154	F	42	Ait Taghla	Ramlia	2.9	7	1020	780
155	G	1	M'Cissi	M'Cissi	0.6	2	760	0
156	G	3	Bouadil	Bouadil	5.7	14	270	0
157	G	4	Azag	Azag	1.1	3	460	0
158	G	13	Taghroute	Taghroute	1.2	2	110	80
159	G	14	Agoumad	Taghroute	0.8	2	40	300
160	G	15	Alnif	Alnif	3.0	3	1110	0
161	G	17	Ait Lahbib	Taghroute	0.3	1	830	0
162	G	18	Tizi Lakdima	Tizi	3.1	7	1060	800
163	G	21	Jdida Ammar	Ammar	12.6	32	960	280
164	G	22	Azrag	Azrag	0.6	1	300	200
165	G	37	Ait Ben Said	Ait Ben Said	5.7	13	1070	0
166	G	46	Tanoute Noumardoul	Tanout	1.1	3	150	300
167	G	47	Tagualgoulte	Taguelgout	1.2	2	480	0
168	G	48	Jorf	Jorf	1.1	3	840	700
169	G	52	lminouzrou	lminouzrou	0.8	2	290	0
170	G	53	Tiguirna	Tiguirna	2.2	4	320	0
171	**G**	**55**	**Tinififte**	**Tinififte**	**5.5**	**13**	**420**	**800**
172	G	56	Afrou	Afrou-AdLghazi	1.1	2	330	1800
173	G	57	Talghazit	Talghazite	0.6	1	150	500
174	G	58	Tihammate	Talghazite	2.3	6	270	600
175	G	59	Lakbira	Taoumart	0.5	0	170	140

No.	Zone	ID No.	Khettara Name	Ksar	Discharge	Irrigable area	Khettara rehabilitation length (m)	Irrigation canal rehabilitation length (m)
176	**G**	**60**	**JdidaTaoumarte**	**Taoumart**	**2.0**	**4**	**180**	**50**
177	G	61	Afrou	Taoumart	0.6	2	230	1200
178	G	62	Tassamamte	Tassamamte	3.5	8	220	0
179	G	63	Toufassamman	Toufassamame	1.5	3	480	0
180	**G**	**64**	**Timzarzit**	**Timarzit**	**2.0**	**4**	**540**	**160**
181	G	65	Tajohrate	Tajouhart	1.7	4	80	600
182	G	67	Ait Mouhou	Ouihlane	0.2	1	360	20
183	G	77	Izougaghine	Ramlia	0.2	1	630	20
184	G	78	Tamlalt	Hsia	2.8	4	960	0
185	G	80	Tissamoumine	Tissamoumine	1.8	4	10	450
186	G	83	Takacha	Takacha	3.4	7	1410	1500
187	**G**	**87**	**Aachich Ait Iaza**	**Aachich**	**11.4**	**22**	**530**	**1500**
188	G	89	Fouk Talilate	Aachich	0.6	1	630	1300
189	G	94	Battou	Battou	2.3	5	810	470
190	G	95	Khtart Battou	Battou	1.7	4	640	50
191	G	103	Tizagarne	Tizagarne	2.3	3	650	2000
Total							138890	116190

Table H.2.2 Khettara Rehabilitation Work considering Various Water Resources Potential

	Water resources	Direction of rehabilitation plan	Groundwater recharge
Zone A	Khettaras are located at 1) mid-stream area of the Gheris river (north of the Ferkla river) and 2) eastern hilly area of the High Atlas and south of the Todrha river. Relatively large discharge is observed at the khettaras located at the inundated area of mid-stream of the Gheris river.	Rehabilitation for mitigating water leakage is proposed. Enlargement of gallery section is effective to lighten maintenance works.	Recharge can be accelerated by dams of Timkit, Tanguerfa. Extension of galleries is also effective to increase yield for the khettaras located in the inundated area of the rivers Gheris and Todrha.
Zone B	The area has high potential for water resource of the Guir river basin (largest tributary). 60 % of khettaras have their discharge of 5 lit/sec or more. Since the khettaras are located along the river, they are susceptible to flood damages.	Rehabilitation against flood damages is first proposed. (ex. Reinforcement of shafts to prevent flood flow into the khettaras)	Water use of the Guir river. Water pumpage for 10 m from the river enables to irrigate.
Zone C	The area has high potential for water resource of the Guir river basin. All khettaras have their discharge of 5 lit/sec or more. Since the khettaras are located at inundated area of the river, they are susceptible to flood damages.	Rehabilitation against flood damages is first proposed. (ex. Reinforcement of shafts to prevent flood flow into the khettaras)	Flood irrigation through intake weir indirectly contributes to recharge phenomena.
Zone D	Most khettaras are located at downstream of confluence of the Ghris and Ferkla rivers. Khettara water is abundant (average discharge is 15 lit/sec). Khettaras of 16 numbers located at Fezna have dried up, and alternatively pump irrigation has been applied.	Rehabilitation for mitigating water leakage is proposed. Enlargement of gallery section is effective to lighten maintenance works. In addition removal of outcrop also contributes to increasing khettara discharge.	Diversion of flood water from the tributaries of the Gheris and Ferkla rivers accelerates groundwater recharge.
Zone E	Khettaras are located at downstream of the Gheris river. Khettara water is abundant (average discharge is 15 lt/sec). There is a large difference in the range of the khettara discharge.	Rehabilitation for mitigating water leakage is proposed. Enlargement of gallery section is effective to lighten maintenance works. In addition removal of outcrop also contributes to increasing khettara discharge.	Diversion of flood water from the rivers Hanich and Gounat is available for groundwater recharge.
Zone F	Most of khettaras have dried up in Rissani. Khettaras in Taouz are located in the desert area, and they have small flow, i.e., less than 5 lit/sec.	Shaft rehabilitation is mostly effective to prevent from sand going into the gallery. Rehabilitation for mitigating water leakage is also proposed.	Released water from H. Addakhill dam is insufficient to the area due to their location. Communal pumpage is recommended for irrigation purpose.
Zone G	Location of the khettaras is divided into 1) those along the rivers, and 2) those along the small tributaries in hilly area. Regional difference in terms of khettara discharge is not observed, however relatively large flow khettaras are located at northern hilly area of Alnif and M'cissi.	Rehabilitation for mitigating water leakage is proposed. Enlargement of gallery section is effective to lighten maintenance works. Reinforcement of galleries and shafts is recommended to prevent from flood damages.	Storage water of the Fezzou and Ahassia dam is available for groundwater recharge though river deposits. Fezzou: 30 khettaras Ahassia: 4 khettaras

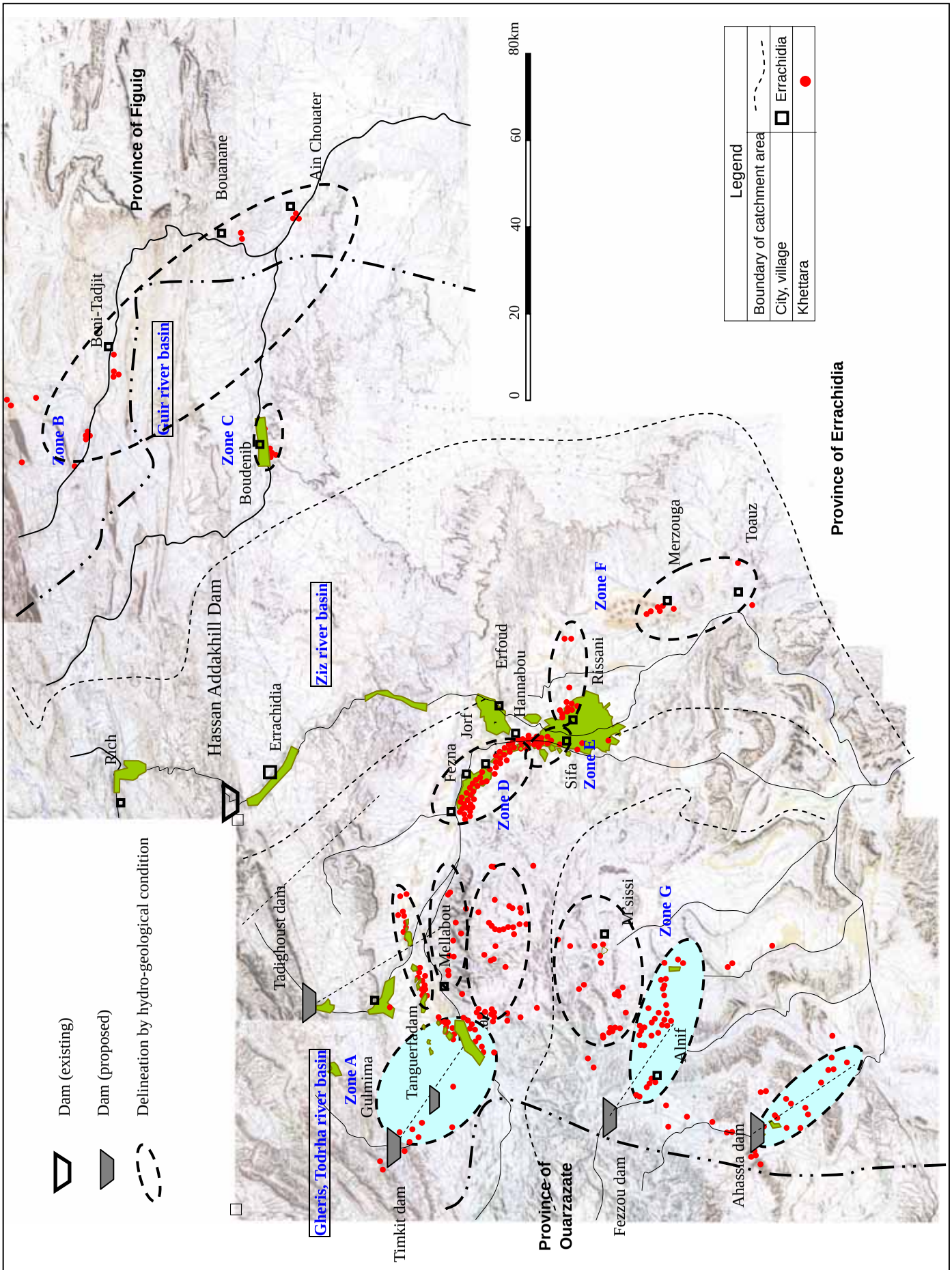
Table H.4.1 Annual Fund Requirement

(unit : DH'000)

			Short-Term (5 years)					Intermediate-Term (5 years)					Total
		Year	1	2	3	4	5	6	7	8	9	10	
I.	Construction cost												
	1.	Rehabilitation of 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 of irrigation canal	7,830	7,830	7,830	7,830	7,830						39,150
	3.	Recharge facility construction											
		Small scale recharge pond (Hannabou)		700									700
		Flood diversion weir (Boudenib)			9,300	9,300	9,300						27,900
		Flood conveyance canal (Gheris)						900	900				1,800
		Flood diversion weir (Sifa)						1,600	1,600				3,200
		Recharge dam (Fezzou, Alnif)*1						16,000	16,000				32,000
		Recharge dam (Ahassia, Alnif)*2								39,000	39,000	39,000	117,000
		Recharge dam (Tanguerfa)*3								2,280	2,280	2,280	6,840
		Flood dispersion dike (Gheris)*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.	Administration cost (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 canal rehabilitation (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%)	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%)		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%)		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
		Water saving irrigation system (Subvention) *6	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	6,000	60,000

*1: Cost allocation 50% is applied to the construction cost
*2: Cost allocation 10% is applied to the construction cost
*3: Cost allocation 5% is applied to the construction cost
*4: Cost is for 1 square km recharge per annum
*5: DH11,250/ha×15ha/year
*6: DH100,000/ha×150ha×40% subsidy =DH6,000,000/year

Figures



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

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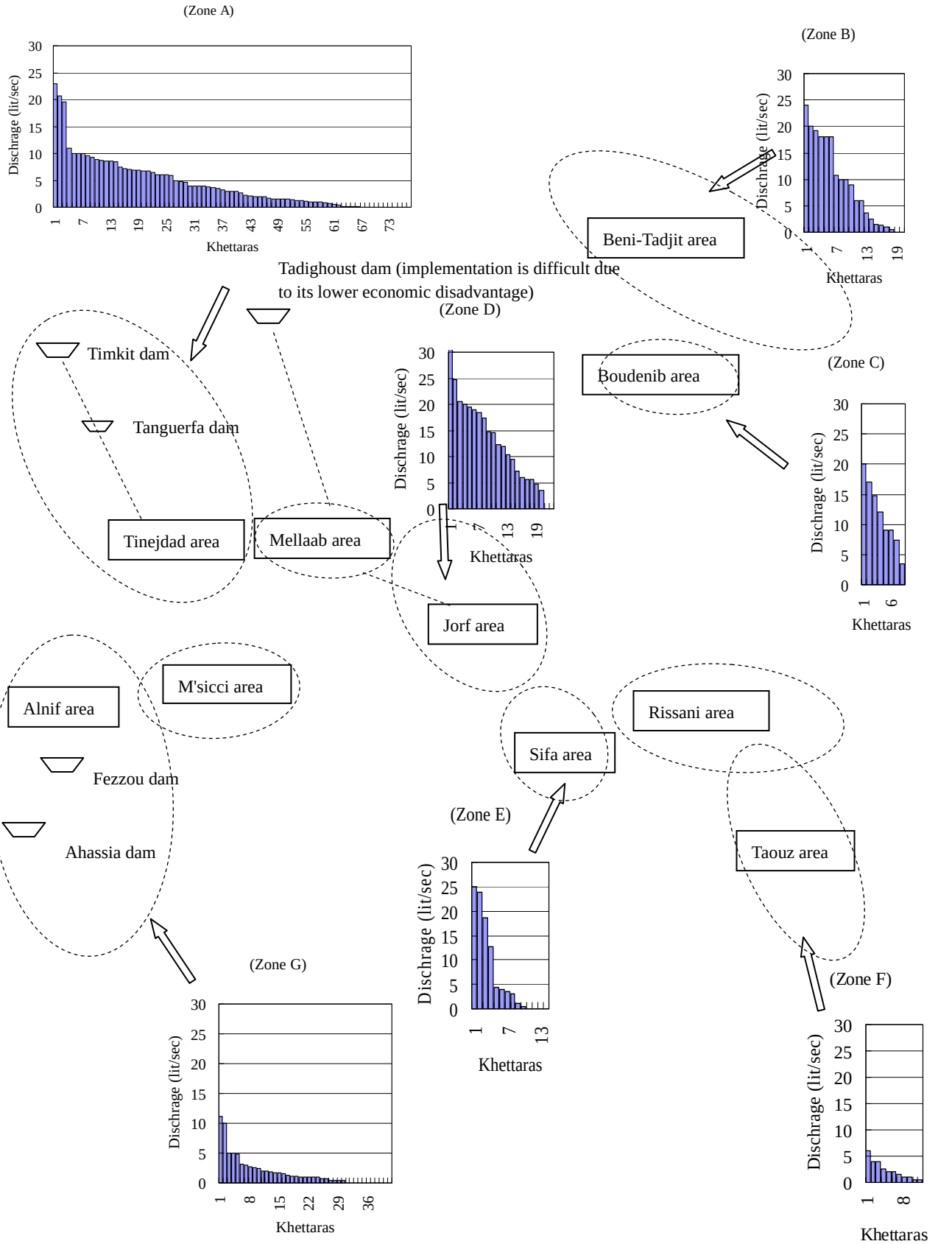
Figure H.2.1
Khettara Location and Water Source Potential



The Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation in the Kingdom of Morocco	Figure H.2.2 Khettara Number and Discharge by Zone
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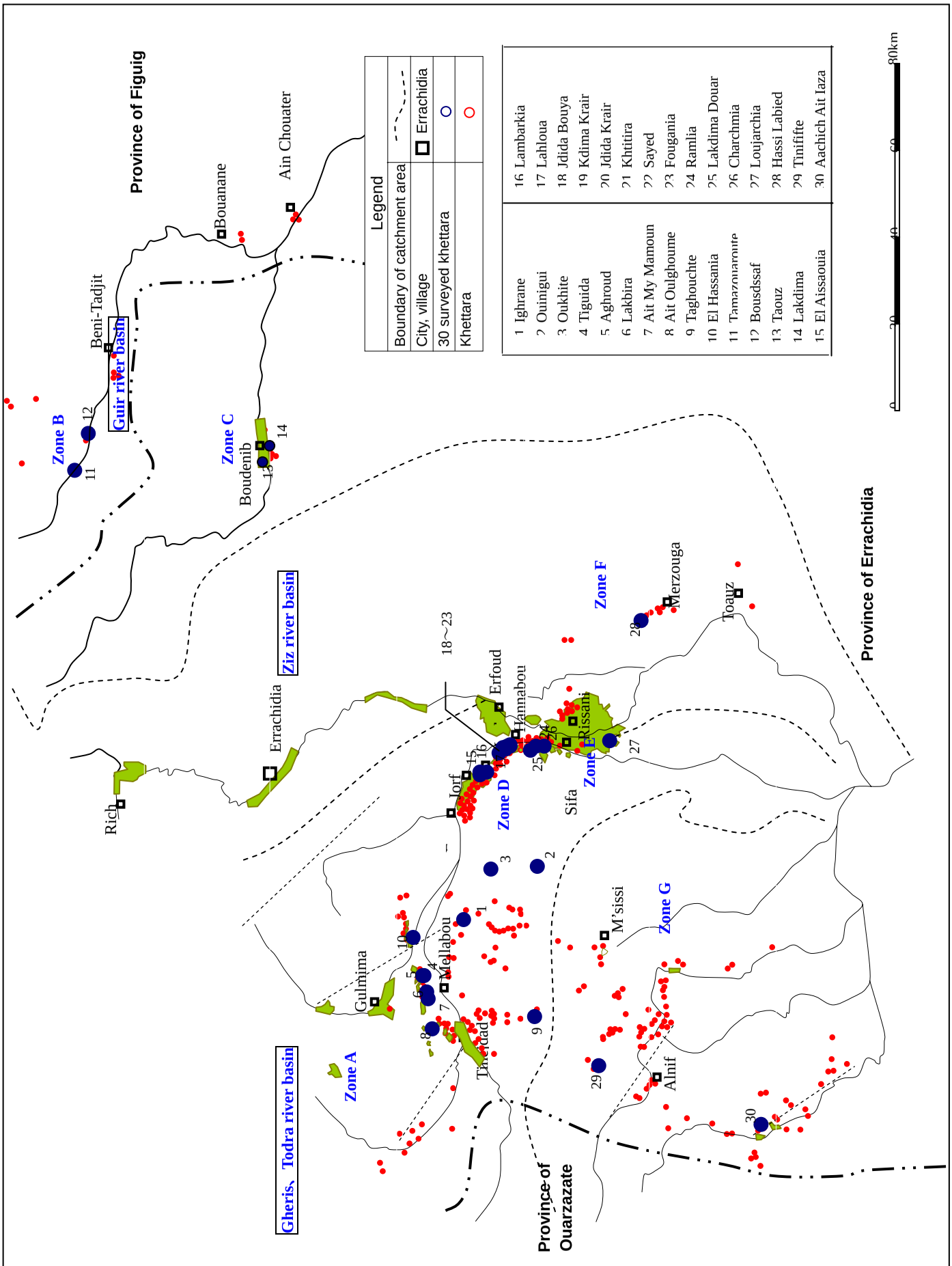
Figure H.4.1 Implementation Schedule

No.	Rehabilitation Works	Term / Year	Short Term (5 years) 1	2	3	4	5	Intermediate Term (5 years) 6	7	8	9	10
1.	Khettara rehabilitation											
	130 khettaras (Discharge >2 lit/sec)		(maximum 600 m rehabilitation is conducted when proposed khettara rehabilitation length is more than 600 m.)					(Rehabilitation of remaining section for the khettaras they are more than 600 m long.)				
	61 khettaras (Discharge < 2 lit/sec)											
2.	Irrigation canal rehabilitation											
3.	Recharge facility construction											
	Recharge pond (Hannabou)		Investigation/design	Construction								
	Flood diversion weir (Boudenib)			Investigation/design		Construction						
	Flood conveyance canal (Gheris)						Investigation/design	Construction				
	Flood diversion weir (Sifa)											
	Recharge dam (Fezzou, Alnif)											
	Recharge dam (Ahassia, Alnif)							Investigation/design		Construction		
	Recharge dam (Tanguerfa, Alnif)											
	Flood dispersion dike (Gheris)											
4.	Afforestation		150 ha afforestation in 10 years									
5.	Facilitation of water saving irrigation system (Drip irigation)		ORMVA/TF is responsible for technical assistance and administrative assistance for subsidy on drip irrigation									



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

Japan International Cooperation Agency

Figure H.4.2
Location Map of Selected 30 Khettaras

Annexe I Project Justification

Annexe I Project Justification

Contents

Tables

I.1 Introduction

This part is devoted to the Project justification by the economic and financial analysis of the Master Plan. The implementation plan proposed for 10 first years concentrates on the rehabilitation of the 191 khettaras with confirmed water discharge. During those 10 years the discharge of the 219 khettaras which are dry at the moment might be restored, and their rehabilitation will be undertaken. The analysis excludes those 219 khettaras since at present it is impossible to establish the relationship cost - benefit. The recharge dam facilities are also excluded since the study of their impact on the groundwater must be undertaken during 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 ground and masonry canals as well as outlets).

I.2 Economic Analysis

I.2.1 Main assumptions

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

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 1 USD = 9.20 DH, and 1 USD= 110 JPY

(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 I.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; the opportunity cost of labor was taken into consideration

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

I.2.2 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:

	Benefits	Assumptions
(i)	Increase in cultivated area:	Additional cultivated area (622 ha) bringing estimated benefit of DH 12 560 by hectar (1-6 year) and of DH 14 980 (7-30 year) (economic values) The cultivations include (i) 50% vegetables, (ii) 50% alfa-alfa (1-6 year) and dates (7-30 year)
	By rehabilitation of khettaras	Rehabilitation of 1km of khettara brings 2.5l/s (if initial discharge >=10l/s), 2l/s (if initial discharge >=5l/s), 1.5l/s (if initial discharge <5l/s)
	By rehabilitation of canals	Increase of 10% of initial water discharge after canals rehabilitation. Discharge of 0.4l/s 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)

I.2.3 Economic costs

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

Assumptions for Calculations

	Costs	Assumptions
(i)	Investment costs :	
	Rehabilitation of khettaras	Financial cost of rehabilitation of 1m of khettara : DH 1 200
	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.

Table: Estimated Total Project Costs

('000 DH)

Project Costs by Component	Total Economic	Total Financial
I. Rehabilitation works		
1. Khettara rehabilitation	144,900	166,552
2. Canals rehabilitation	29,900	34,370
Total cost (I)	174,800	200,922
II. Technical assistance (5%)	8,700	10,000
III. Administrative costs (3%)	5,200	6,000
Total baseline costs (I+II+III)	188,700	216,922
IV. Physical contingency (10%)	18,870	21,690
V. Price contingency (1.3 %)	0	16,050
Total Amount of Project (I+II+III+IV	**207,570**	**254,662**

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

I.2.4 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 I.2 and the ranking of khettaras according to their EIRR is presented in the Table I.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%

I.3 Financial Analysis

I.3.1 Farm economy analysis

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

Analysis of Farm Economy (financial values)

	Wheat	Vegetables	Beans	Alfa-alfa	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

We can see that the implementation of the Project brings the additional revenue of 15 400 DH for one farm irrigated by khettara, which will bring the household average income to 10 000 DH.

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

I.3.2 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 255 millions DH over the 10 years, which corresponds to about 28 million DH per year during the 5 first years and 23 million DH per year during the next 5 years. The operation and maintenance charges have to be covered by the beneficiaries.

The ORMVA/TF dedicates the annual budget of 5 million DH for the development of khettaras. We can suppose 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[3] 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 big scale rehabilitation of khettaras or seguias (beneficiaries should cover the 100% costs of the traditional systems and 80% of khettaras and sequias). Consequently, the financial charge for the operation and maintenance will not be significant for the State. It 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[4]. 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.

I.4 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 since the EIRR of the economic development for poverty reduction in this region of Morocco is of 12%.

(2) The realization of works is likely to also contribute to solving important social problems of the

[3] 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.
[4] 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.

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. 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.

<table>
<tr><th>Evaluation criterion</th><th>Contents</th></tr>
<tr><td>Efficiency</td><td>

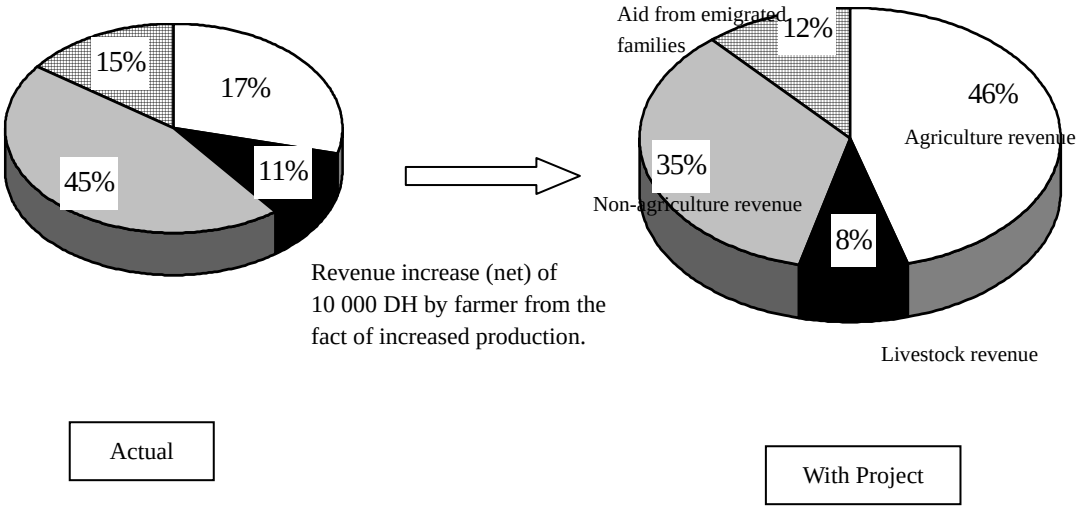
The economic costs are of 117 million DH, and economic benefits of 140 million DH, which gives the benefit/ cost ratio of 1.2; that should give sufficient economic benefits if we apply the EIRR of 12.2%.

B/C=1.2
EIRR (Economic Internal Rate of Return) =12 %
Reference: EIRR based on the result of verification Study= 14%

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 has planned the budget, and there is a high possibility that the expected results will be achieved.

</td></tr>
<tr><td>Effectiveness</td><td>

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 5 400 DH to 15 400 DH, which is the increase of 10 000 DH (indicated in % in the graphs below). Table I.4 presents data on farm economy.



</td></tr>
</table>

Evaluation Criterion	Contents
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 “rural exodus” 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 ✓ Improvement of the implementation capacity of the ORMVA/ TF
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 subdivisions, 22 DMV or CE, 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 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 equilibrium. ● The Master Plan includes the income generating activities in the form visible for the farmers, so that the enthusiasm of the farmers should be lasting. ● The EIRR of 12.2% should translate into the durable economic benefits.

Tables

Table I.1 Standard Conversion Factor

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 I.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			Increase in yield		
No	Year	Khettaras rehabilitation	Canals rehabilitation	O&M canal	O&M khettara	Total cost [DH]	From khettaras	From canals	From rehabilitation		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 I.3(1/5) Khettara Ranking by EIRR

Rank	Zone	No	Name of Khettara	Ksar	Discharge l/S	Irrgation 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 I.3(2/5) Khettara Ranking by EIRR

Rank	Zone	No	Name of Khettara	Ksar	Discharge l/S	Irrgation 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 I.3(3/5) Khettara Ranking by EIRR

Rank	Zone	No	Name of Khettara	Ksar	Discharge l/S	Irrgation 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 I.3(4/5) Khettara Ranking by EIRR

Rank	Zone	No	Name of Khettara	Ksar	Discharge l/S	Irrgation 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 I.3(5/5) Khettara Ranking by EIRR

Rank	Zone	No	Name of Khettara	Ksar	Discharge l/S	Irrgation 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 I.4 (1/3) Farm Economy - Without Project Condition -

Cultures		Produits							Charges		Valeur Nette
		Importance		Rendement		Prix unitaire		Valeur	Prix unitaire	Valeur	[DH]
		ha	%	Qt.	[kg/ha]	[DH/kg]		[DH]	[DH/ha]	[DH]	
Céréales	Blé	0.50	62%	1,620	[kg/ha]	4.00	[DH/kg]	3,809	4,888	2,424	1,385
Maraichage		0.05	6%					1,591		480	1,112
Maraichage 1	Carrote			12,600	[kg/ha]	1.50	[DH/kg]	18,900	6,720		
Maraichage 2	Onion			16,380	[kg/ha]	3.00	[DH/kg]	49,140	7,980		
Maraichage 3	Tomate			18,900	[kg/ha]	1.75	[DH/kg]	33,075	13,990		
Maraichage 4	Poivron			12,600	[kg/ha]	2.50	[DH/kg]	31,500	11,270		
Maraichage 5	Fève	0.02	3%	1,890	[kg/ha]	6.00	[DH/kg]	272	7,700	185	87
Fourrage	Luzerne	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	Palmier Dattier	0.08	70%	1,575	[kg/ha]	14.00	[DH/kg]	22,050	2,710		
Arb. 2	Olivier	0.04	30%	2,313	[kg/ha]	4.00	[DH/kg]	9,252	240		
		0.8	103%								**5,370**

Table I.4 (2/3) Farm Economy - With Project Condition
financial prices (1-6 year)

Cultures		Produits							Charges		Valeur Nette
		Importance		Rendement		Prix unitaire		Valeur	Prix unitaire	Valeur	[DH]
		ha	%	Qt.	[kg/ha]	[DH/kg]		[DH]	[DH/ha]	[DH]	
Céréales	Blé	0.49	51%	2,700	[kg/ha]	4.00	[DH/kg]	5,875	7,860	3,848	2,027
Maraichage		0.13	14%					7,639		2,913	4,726
Maraichage 1	Carrote			18,000	[kg/ha]	1.80	[DH/kg]	32,400	9,240		
Maraichage 2	Onion			23,400	[kg/ha]	3.60	[DH/kg]	84,240	20,480		
Maraichage 3	Tomate			27,000	[kg/ha]	2.10	[DH/kg]	56,700	33,360		
Maraichage 4	Poivron			18,000	[kg/ha]	3.00	[DH/kg]	54,000	23,620		
Maraichage 5	Fève	0.07	7%	2,700	[kg/ha]	6.00	[DH/kg]	1,089	9,000	605	484
Fourrage	Luzerne	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	Palmier Dattier	0.08	70%	2,736	[kg/ha]	16.00	[DH/kg]	43,776	6,720		
Arb. 2	Olivier	0.03	30%	4,617	[kg/ha]	4.80	[DH/kg]	22,162	3,760		
		0.96	107%								**12,910**

Table I.4 (3/3) Farm Economy - With Project Condition -
financial prices (7-30 année)

Cultures		Produits							Charges		Valeur Nette
		Importance		Rendement		Prix unitaire		Valeur	Prix unitaire	Valeur	[DH]
		ha	%	Qt.	[kg/ha]	[DH/kg]		[DH]	[DH/ha]	[DH]	
Céréales	Blé	0.49	51%	2,700	[kg/ha]	4.00	[DH/kg]	5,875	7,860	3,848	2,027
Maraichage		0.13	14%					7,639		2,913	4,726
Maraichage 1	Carrote			18,000	[kg/ha]	1.80	[DH/kg]	32,400	9,240		
Maraichage 2	Onion			23,400	[kg/ha]	3.60	[DH/kg]	84,240	20,480		
Maraichage 3	Tomate			27,000	[kg/ha]	2.10	[DH/kg]	56,700	33,360		
Maraichage 4	Poivron			18,000	[kg/ha]	3.00	[DH/kg]	54,000	23,620		
Maraichage 5	Fève	0.07	7%	2,700	[kg/ha]	6.00	[DH/kg]	1,089	9,000	605	484
Fourrage	Luzerne	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	Palmier Dattier	0.14	70%	2,736	[kg/ha]	16.00	[DH/kg]	43,776	6,720		
Arb. 2	Olivier	0.06	30%	4,617	[kg/ha]	4.80	[DH/kg]	22,162	3,760		
		0.96	107%					0			**15,400**

Annexe J Khettaras Rehabilitation Plan

Annexe J Khettaras Rehabilitation Plan

Contents

Tables

Figures

J.1 Purpose of Khettaras Rehabilitation Plan

The purpose of the khettaras rehabilitation plan is to study effectiveness and validity on the scale and components of rehabilitation in detail, for the whole khettara community covered by the Master plan, through selecting appropriate sites as a rehabilitation model. Concrete 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. Better living and income generation activities are excluded as study items, because they are not directly related to the khettara rehabilitation plan, being developed in phases, but classified as general development indicators in the whole region. Therefore they are not counted as direct benefit of khettara rehabilitation.

Details of each item are explained as below.

(1) Khettara Rehabilitation

The Master plan sets khettara rehabilitation level at 40 %, including 10 % rehabilitated portion, based on the effects of khettara rehabilitation for discharge increase, O&M work load decrease and cost benefit analysis. The most appropriate plan should be formulated, surveying discharge condition and O&M cost of selected khettara on the study. The rehabilitation method and location is designed considering with workability of construction work and economical efficiency.

(2) Irrigation Canal Rehabilitation

Irrigation canal rehabilitation and modification of division works 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 modification of division works as noted in (2). 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 steady irrigation water supply and 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 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 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 *Ksar* is carefully reviewed. An appropriate organizational structure for the future maintenance and rehabilitation works will be devised with paying due consideration to these issues.

J.2 Site Selection

The table below shows selected sites for khettara rehabilitation plan. The sites are selected as models from 191 khettaras plus 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

J.3 Study Items

(1) Khettara Rehabilitation

Formulation of rehabilitation plan and cost estimate for construction works are carried out through

surveying the following details on the study.

1) Number of discharge observation points is increased to scrutinize length, location and volume of groundwater exuding and leaking portion. Through these activities, the most effective portions are confirmed to achieve the target of discharge increase.

2) Geographical condition around the khettara's mother well and upstream recharge area are surveyed and increased volume of discharge by mother well extension is estimated.

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

4) Discharge increase due to leakage loss prevention and O&M cost saving are expected as effects of rehabilitation works. Related to 3), the most appropriate 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 target for rehabilitation works and improvement of irrigation efficiency is planned by lining of earth canal. Rehabilitation span and method are designed through field survey and construction cost is estimated. Prevention of division loss and seepage loss at division works are planned by modification of division works at existing main canal of concrete. Number of modified division works is surveyed through the field survey, and construction cost is estimated.

2) The fair water requirement is proposed based on the degree of improvement on irrigation efficiency due to main canal rehabilitation. Since the Master plan is targeting 10 % improvement of irrigation efficiency, the effect should be resurveyed at each khettara.

(3) Water Use and Agricultural Technology and Extension

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

2) Effectiveness and validity for introduction of vegetables and high value crops are verified

through surveys for present cropping pattern and land use.

(4) Operation, Maintenance and Farmer's Organizations

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

1) Operation and maintenance activities on Khettara and irrigation canals are carefully examined together with capability of concerned farmer's organizations in the study area

2) Present situation and activities carried out by farmer's organizations concerned on Khettara maintenance works, namely traditional Khettara water user's organization and association, are confirmed through field survey. This information will be the base on preparation of organization strengthening plan and future evaluation activity.

3) On preparation of operation and maintenance plan on Khettara and irrigation canal, division of responsibility among farmer's organizations, including traditional Khettara organization and association, is clearly defined.

(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 second field survey. Survey items are basically same as the ones used for the IEE screening and scoping.

2) As some items are not clear in terms of influences to environment, those items should be defined in selected sites as much as possible. The results are utilized for finalization of the Master plan, and necessity of additional survey is explained through the Verification study.

(6) Project Evaluation

1) The purpose of the project evaluation on selected sites is to reflect the results of evaluation as models to the project evaluation for the whole study area (including conditions used for calculation of cost and benefit) as indicated in the Master plan. Criteria for the project evaluation on selected sites follow the criteria explained in the Master plan.

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

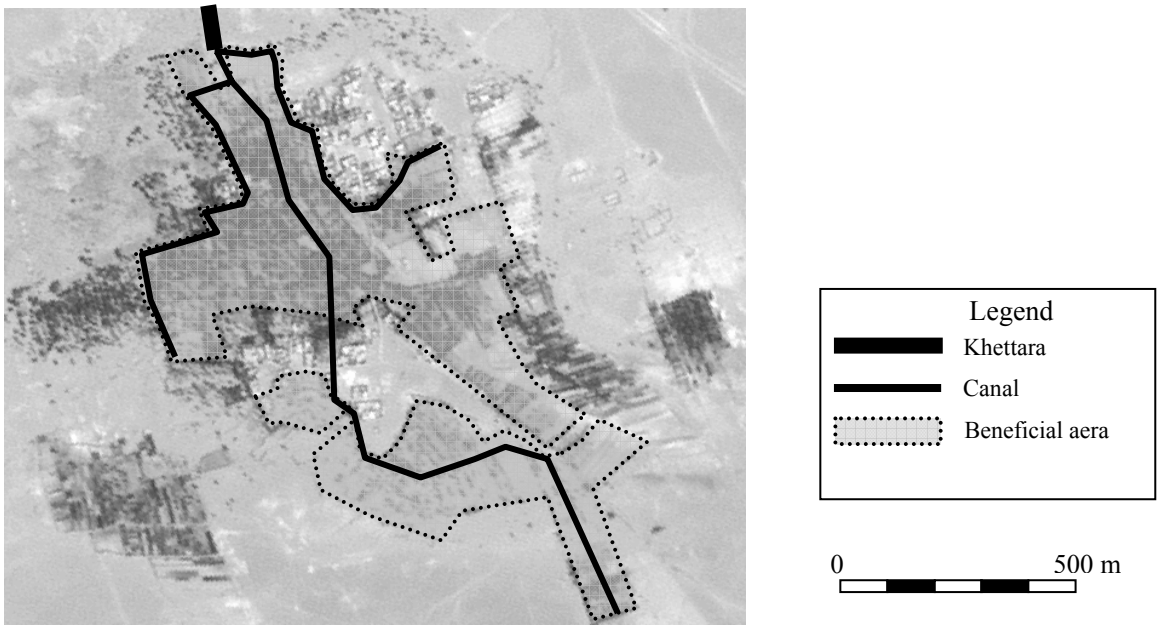
Details of survey results are explained in Annex J.

J.4 Feasibility Study Results by Khettara Area

J.4.1 Ait Ben Omar

(1) General Data of the Feasibility Study and Khettaras Priority Areas

1) Ksar and Khettara rural commune	Ait Ben Omar / Ferkla Soufla
2) Location	5 km north-west of Tinejdad and 18.5 km south-west of Goulmima
3) General data	・ Population : 1 200 inhabitants ・ Households : 110 ・ Roads : 7 km to Tinejdad (of which 4 km are paved and 3 km non paped) ・ Drinding water: 1 standpipe installed by l'ONEP in 2001, no connextion with private users. ・ Electrical power: Supply to all homes by ONE (since August 2000) ・ Telecom : 8 permanent telephone stations. Area covered by the network. Cellular phones are numerous. ・ Schools : One primary school (7 classes, 110 pupils of which 50 to 60 girls). Nearly all the pupils complete the curriculum. Junior high scchools and Senior high schools are located in Tinejda. (about 20 students of which 8 to 9 girls attend Senior high school). ・ Health centers : none（It is necessary to go to Tinejdad）。 ・ Number of khettaras in the ksar : 2
4) Project Khettara	・ Name : Ait Ben Omar ・ Discharge : 9.6 lit/s (October 2003 an january 2004 mean value) ・ Farms area : 34 ha ・ Area irrigated by khettara : 18.6 ha



hydrogéologie et nappes	Topography and Geology	Site locates in the left bank side of Tanguerfa River and few kilometers northwestern side from the confluence of Ferkla and Tanguerfa rivers. High Atlas Mountains consist mainly of Jurassic Series (Limestone, Sandstone and Mudstone), and the surroundings form some terraces continueing to Cretaceous Basin (mainly Limestone). In the valley, gorge or lowland, gravelly splashed flood deposits distribute widely on those rock basements. Elongated hills orienting ENE-WSW situating just upstream of La'ksiba & Ait Ben Omar area consist mainly of Visean sedimentary rocks of Carboniferous so called Ras Sdaf Sandstone and Limestone, and partly of Breccia. Between these rock basements around the study sites, the above-mentioned flood deposits distribute continuously. While in the side of Tanguerfa River, Devonian Limestones gently dipping to High Atlas Mountain side get into under the Carboniferous. Sedimentaries in the area are lacustrine marl just on bedrock, lacustrine travertine-like limestone, and subrecent to recent gravelly splashed flood deposits.
	Result of In Situ Investigation	**Drilling** : location; upstream of La'ksiba & AitBenOmar khettara area (N31o34'07'', W005o03'10''), EL 1012.29m. 0～4m Conglomerate 4～9 beige gravel bearing silt (k = 0.9～1.8×10^{-3} cm/sec) 9～16 silt ~ sandy pebble (k = 3～8×10^{-3} cm/sec) 16～23 marly soil : lacustrine marl (k = 2～4×10^{-3} cm/sec) 23～70 pelitic schist (k = lower than 1×10^{-4} cm/sec) **Borehole Logging**: At the depth 23 ~ 25m where is around the border of bedrock and sedimentaries, aquifer can be found. It can also be found at the depth 15 ~ 17m where is the border of lacustrine marl and the upper sedimentaries. **Geoelectrical Prospecting** : two resistivity layers in Sedimentaries (ρ=60～200, 30～40Ωm). The resistivity of bedrock is such values lower than 50Ωm.
	Hydrogeology	Even in bedrock portion, there is some possibilty that much water content portions exist because they are composed of Carboniferous and Devonian Limestones. But basically, the formation supplying groundwater to khettara is Plio-Quaternary. Lacustrine Marl is basically aquitard, and main aquifer in the area exists in the upper sedimentaries just on Lacustrine Marl. Further, the case existing conglomerate between bedrock and lacustrine marl are reported many though it is not found out in this study. This layer may form aquifer. According to borehole logging, this portion may show aquifer where permeability test result k in the order of 10^{-3} cm/sec.
	Model and hydrology parameters along the khettara	Mother Well ~ 350m from outlet: Seepage formation of the upstream k = 1×10^{-2}cm/sec, Storage coefficient 0.041. Piezometric gradient along khettara 3～4/1000 (considering the 3 ~ 4km downstream point = elevation 1006m as discharging point). Bottom and Side wall until height 18cm of the downstream k = 2×10^{-5}cm/sec, Side Wall higher than 18cm k = 3.3×10^{-3}cm/sec. 350m from outlet ~ outlet: Bottom and Side wall k = 3.3×10^{-3}cm/sec.
Khettara	Discharge	At the far end of the khettara downstream are 8~10 lit/sec discharge is secured throughout the whole year. Catchement zone：a 300 m section downstream of the mother well Leakage area ：300 m upstream of the concrete canal (see Figure J.4.1 (1)
	Khettata extension	Total length ： 1 050m（excluding a 100 branch) Existing canal lining ： 150m（e = 0,6m × H = 1,2m） Existing concrete raising ： 100 m Non protected section ： 800 m

<table>
<tr><td rowspan="4">Water use</td><td>Water use</td><td>Khettara water in Ait Ben Omar has been use for multi purposes such as drinking and domestic water, livestock water, and irrigation water. Public faucet for drinking and domestic water is furnished by ONEP; however, Khettera water is commonly used as drinking water as well as ONEP water. Three laundry places are constructed along the main canal (Seguia Jadida) passing by the residential area, and one drinking place for the livestock is installed at the beggining point of the main canal (Seguia Harch).

Irrigation water is distributed to the benefit area with 18.6 ha through the open canal network.</td></tr>
<tr><td></td><td>Irrigation canal network consists of three main canals and a large number of secondary and on-farm canals. In the main canal (Seguia Jadidi) located in center of the irrigation area, the most part is the concere canal (B=0.4m×H=0.4m) and the remainig at down stream is the earthen canal. Almost half section of right side main canal (Seguia Dhar) is the culvert type canal to prevend the soil accumulation owning to desertification. On the oter hand, left side main canal (Seguia Harsh) is the earthen canal in all section.

Steel gate is installed at the turning points of the main canals. No gate is inatalled at the other inlet points; therefore, water divertion is managed with stacking up the soil by manpower.

According to the common law, the installation of well pump is prohibited near the Khettara. The installation of well pump is not prohibited in the irrigation area; however, no pumping station is installed at present.

(see Figure J.4.2.(1):Canal network)
<table>
<tr><th>Regulating basin</th><th>Irrigation canal</th><th>Concrete canal</th><th>Earthen canal</th><th>Total</th></tr>
<tr><td>—</td><td>Main canal</td><td>0.68 km</td><td>0.83 km</td><td>1.51 km</td></tr>
<tr><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td></tr>
</table></td></tr>
<tr><td>Irrigation method and water management</td><td>Irrigation method is the basin irrigation which fills the farmland divided into small plots with water by gravity in turn. Water distribution is managed in rotation by the water use hour for 24 hours whole day and night based on water right.
<table>
<tr><th>Water right holders</th><th>Water right interval</th><th>Water use hours</th></tr>
<tr><td>95 households</td><td>13 days</td><td>12 hrs～30 minutes</td></tr>
</table></td></tr>
<tr><td>Operation and Management</td><td>The soil accumulation is widely observed at the downstream of the main canal, Seguia Dhar and Seguia Jadid due to the disertification. Maintenance activitise such as eliminating the acumulated soil in the irrigation canal have been conducted once two to three months. The operatin requires 12 man-days per one time.</td></tr>
<tr><td rowspan="4">Farming and extension</td><td rowspan="4">Soil and farm land utilization</td><td>Soil The alluvium deposit useful layer is deep, of medium grading
Fertility Relatively fertile. However, it will be worthwile to increase the water storage capacity
Utilization Khettara irrigation potential is of 34,0 ha, of which 38,8 % are abandonned due to lack of irrigation water and desertification</td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
<tr><td></td></tr>
</table>

Crops (irrigated)	Fallow (non irrigated)	Abandoned land	Total
18,6 ha	2,2 ha	13,2 ha	34,0 ha
(54,7%)	(6,5%)	(38,8%)	(100%)

<table>
<tr><td rowspan="4"></td><td>Morphology and cropping rate</td><td>Cropping system : See table above and Figure J.4.3 (1/7)
Cropping rate 104 % (Only of irrigated land excluding fallow and abandoned land)

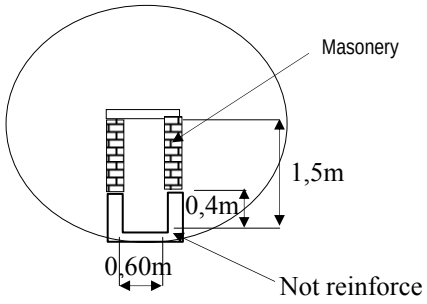
Tree farming
<table>
<tr><td>Date trees</td><td>Olive trees</td><td>Others</td><td>Total</td><td></td></tr>
<tr><td>2,94 ha</td><td>1,50 ha</td><td>1,0 ha</td><td>5,4 ha</td><td></td></tr>
<tr><td>(15,8%)</td><td>(8,%)</td><td>(5,%)</td><td>(29,%)</td><td></td></tr>
</table>
Crops
<table>
<tr><td>Wheat</td><td>Alfa Alfa</td><td>Vegetables</td><td>Others</td><td>Total</td></tr>
<tr><td>9,8 ha</td><td>1,5 ha</td><td>0,7 ha</td><td>1,9 ha</td><td>13,09 ha</td></tr>
<tr><td>(51,4%)</td><td>(10.5%)</td><td>(2,%)</td><td>(6,4%)</td><td>(70,3%)</td></tr>
</table>
( )indicate the percentage of cultuvated land</td></tr>
<tr><td>Farming</td><td>1. Olive and fruit (figs) cropping is more prosperous than in the other areas
2. Vegetables seeds are purchased in the market, Wheat ones are supplied by ORMVA; Dates are of the traditional type and are scarecely of the improved species.
3. Wheat and vegetables are improved by urea input. On the other hand, fruit trees are simplu manured. No phytosanitary products are used.
4. For cropping wheat and vegetables, tractors are brought from other areas.
5. Vegetables, fruits, dates and olives are sold in Tinijdad market. Other products are wholly self consummed localy.</td></tr>
<tr><td>Extension organization</td><td>Tinijdad CMVs of ORMVA are in charge of agricultural extension services. Each CMV covers 40 ksars employing 11 persons, of which :
<table>
<tr><td>Extension agent</td><td>Stock breeder</td><td>Driver</td><td>Miscellaneous</td><td>Remarks</td></tr>
<tr><td>2</td><td>2</td><td>2</td><td>4</td><td>2 vehicles</td></tr>
</table></td></tr>
<tr><td>Agricultural organizations</td><td>Water owner s traditional organizations</td><td>1) Number of owners : 95 households (total population of farmers’families owners of water rights: 982 persons）
2) Maintenance activities
Sand removal requires 12 persons in average during 7 days 3 to 4 times a year.
3) Responsible for the necessary maintenance labor
The required labor for sand removal and simple repair is supplied by the traditional organization.
4) Collecting maintenance expenses
In order to cover equipment supplies necessary to the maintenance works a financial contribution is levied two times a year from the water rights ownerss according to actual needs.
The amount is fixed each time according to the alloted number of hours to the water right, and the head of the organization who collects the funds. The rate of one hour water right is about 20~100 DH. All water rights owners pay the required amount;
The total collected contribution amounts to DH37 440, which is allocated for maintenance expenses.
There is no water rights lease system that may allow funds collection.</td></tr>
</table>

	Association on whome the traditional organization depends	1) Name : Association El Amal (AUEA) 2) Creation year: 2002 3) Organization : constitude of the traditional organizations representatives of 26 khettaras of Ferkla Soufla rural commune. 4) Activities : Assistance for the maintenance and repair works of khettaras. 5) Financial contributions : 100 DH par khettara during its institution (all the 26 khettara paid up). A yearly 960 DH contribution paid by each khettara has instituted but so far only 6 khettaras have paid it.
Agro-economy & Marketing		Additional irrigated land will be cultivated in vegetables and palm trees (of medium quality) ; The additional production exceed self consumption needs and may be sold in the market. Farmer have access to Goulmima local market (Tinejdad, less than one paved km). Market prices are slightly lower than prices in Jorf and Errachidia, but are higher in Alnif. The market is experiencing a high demand, specially for vegetables (At prensent time, 70 % come from outside the province, for example, Agadir). Low income and production impedes the farmers to enter markets that offer higher prices, the appreciation of dates prices may lead to a possible income improvement.

(2) Hindrances'causes

1) Khettara	1) 2 lit/sec leakage 300m upstream of the concrete lined section. 2) 1～0,70km from the mother well collapses are significant because the soil is sandy and non compacted silt. Soil piles up in the khettara flume and water flow is impeded. 3) Collected water volume is low et will not increase through extension of the khettara tunnel since the mother well's surroudings are formed of clayey loam. 4) When the soil layer above the khettara is thin, the well walls would collapse.
2) Water use	1) Much water amount filtrates into the underground from the earthen canal, which obstructs the efficient water use. 2) Seepage loss and operation loss at the inlet points obstructs the efficient water use. 3) Big water loss is created due to basin irrigation with low irrigation efficiency.
3) Farming and extension	1) Land intensive desertion because of water volume reduction and desertification 2) Lack of water saving and crop varieties knowledge.
4) Agricultural organizations	1) Traditional organizations supply man power for khettara cleaning and simple operations thereto but they have no financial means de implement major works such as khettara rehabilitation, tunel be lowering and gellery extension which will solve discharge reduction problems. 2) The association has just been created and so it has no experience and knowledge in the field of management. Neither it has ever undertaken any works in cooperation with traditional organizations, and so, the latter do not take it as a meeting and documents exchange point with other outer ogranisations.

(3) Development Plan

<table>
<tr><td colspan="2">Khettara rehabilitation</td><td colspan="4">1) Concrete canal between the mother well 1~0.70 km downstream (300 m leakage section) (works in the tunnel)
 

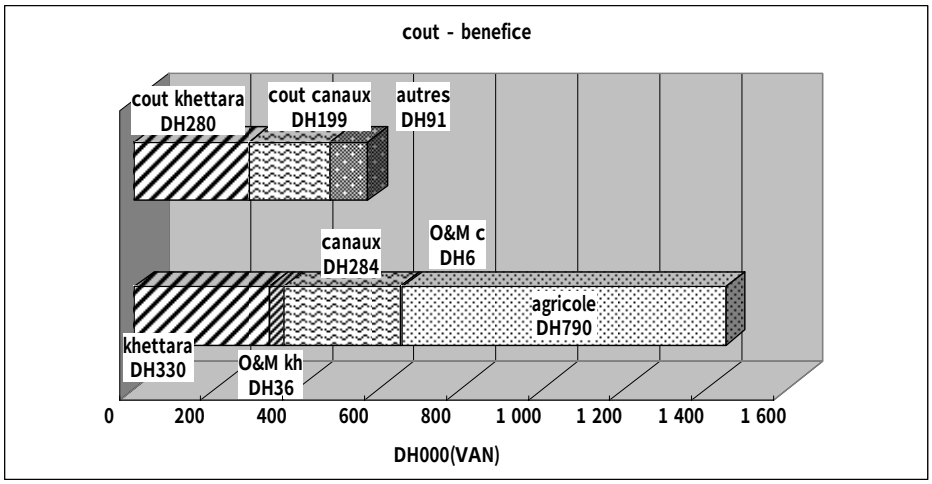
(see Figure J.4.4 (1))</td></tr>
<tr><td colspan="2">2) Water use plan</td><td colspan="4">Rehabilitation of the main canal
1)Concrete lining of earthen canal
Open canal B=0.4m×H=0.4m、L=576m
Culvert canal B=0.4m×H=0.4m、L=250m
2)Improvement of inlets
Inlets N=50 sites
Application of water saving irrigation techniques
Irrigation area A=2.4 ha</td></tr>
<tr><td rowspan="8">Farming and Extension Plan</td><td>Argicultural potential</td><td colspan="4">Since no there are no existing soil problems it would be possible to increase crop land by 15.4 ha through irrigation. But that ought to be done taking into account desertification control.
Tinijdad town, which is overpopulated, is a prospective market.</td></tr>
<tr><td rowspan="7">Crop system and rate of planed crops.</td><td colspan="4">Planned crops See table below and Figure J.4.5 (1/7)
Planed rate 105 % (irrigated land only, excluding fallow and abandoned land)</td></tr>
<tr><td rowspan="2">Crops</td><td rowspan="2">Present</td><td colspan="2">After implementation</td></tr>
<tr><td>1 to 6 years</td><td>7 to 30 years</td></tr>
<tr><td>Wheat and cereals</td><td>51,4%</td><td>40,0%</td><td>40,0%</td></tr>
<tr><td>Vegetables (August to december)</td><td>8,4%</td><td>18,0%</td><td>18,0%</td></tr>
<tr><td>Vegetables and legumes(March to July)</td><td>4,2%</td><td>4,0%</td><td>4,0%</td></tr>
<tr><td>Alfa-Alfa and other fodder corps</td><td>10,5%</td><td>20,0%</td><td>8,0%</td></tr>
<tr><td>Dates and other fruits</td><td>29,7%</td><td>23,0%</td><td>54,0%</td></tr>
<tr><td>Total</td><td>104%</td><td>105%</td><td>105%</td></tr>
</table>

		AlfaAlfa and dates combined after the works (1 to 6 years) but crops rate calculation does not include AlfaAlfa.
	Cropping practices and miscellaneous activities	1. It is necessary to emphasize vegetables cropping intended for Tinijdad market. This crop is in high demand. 2. It is necessary to increase manure application in order to maintain good soil fertility and stop desertification. 3. It is necessary to maintain olive and dates crops which existed in the area for a long time. 4. It is necessary to introduce date crop farms new species with high market value (Majhol, Faggouss, Khalt).However, since farmers are reluctant to the introduction of new species, it is necessary to plan demontration activities and technicial supervision. 5. Tree crops is highly in demand, but farmers have little experience. In addition, fruit trees do not resist well to draught, so that it is recommanded to cultivate on a small scale.
Reinforcement plan for maintenance organizations		1. After khettara rehabilitation the maintenance cost and manpower supply will remain the responsability of the traditional organizations. 2. Training (courses, study tours) shall be initiated to supply the association with the administration knowledge in order to set up the administrative structures. 3 The monitoring that will be carried out together by the associations and the traditional organizations will allow to strengthen the ties between them, and will constitute the common ground for the works joint implementation.

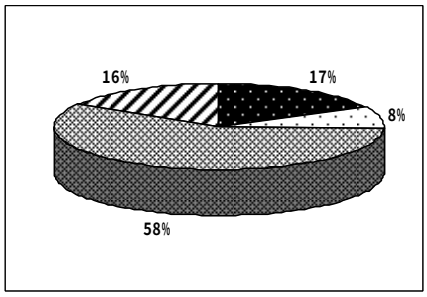
(4) Works cost

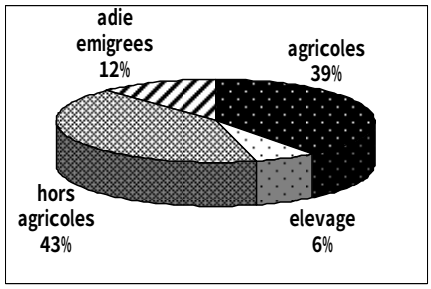
Khettara	Concrete canal (combined to masonery 300 m DH 354 600（see Table J.4.1）
2) Water use plan	Lining of the earthen canal：264,385DH Improvement of the inlets：4,800D （see Table J.4.1）
Reinforcement Plan for maintenance organizations	1) Maintenance charges : 44 600 DH/an (Water rights charges and their collecting like it was done in the past) 2) Organizations reinforcement cost : ・Year of works startup : 47 500 DH (Trainning and monitoring cost). ・Second year and following year : 4 000/year (Monitoring cost)

(5) Porject Evaluation

<table>
<tr><td rowspan="2">Economic evaluation</td><td><u>Without project</u>: irrigated area by khettara will decrease from 22,3ha (present; from khettara discharge) to 17,5ha(2014), causing drop in revenue from agriculture.</td><td><u>With project:</u> increase of irrigated area by 1,5ha (to total of 23,8ha) through khettara and canals rehabilitation. Improved agriculture practices (extension and water management) will increase the net income by DH13,500/ha (economic terms).</td></tr>
<tr><td colspan="2"> 

B=DH968,000 C=528,000 B/C=1.8 (NPV; discount rate of 10%); EIRR= 18.9%

Balanced benefits come from khettara and canals rehabilitation; big part of benefits comes from agriculture (improved practices and water management). That important agriculture potential to be mobilized is hindered by small land holdings (additionally scattered), lack of land certificates (hampers access to credit), heritage of land. Farms keep diversified agro-production – and would not specialize to increase the revenue. Relatively high EIRR – thanks to big initial discharge and efficient use of rehabilitation costs.</td></tr>
<tr><td>Financial Evaluation</td><td><u>Present:</u>
 

Present income from agriculture: DH5,870, for standard farm of 0,8ha. Farm budget is shown in TableJ.4.2
The low share of income from agriculture might enforce rural exodus (156HH/970 people in 2000 decreased to 95HH/610 people in 2004).</td><td><u>With project:</u>
 

Income from agriculture: increase to DH18,660, for standard farm of 1,03ha;
The additional income (DH12,790) and decrease in O&M works gives possibility to develop agriculture practices/other activities. The project increases the share of income from agriculture to 39% of average family budget.</td></tr>
</table>

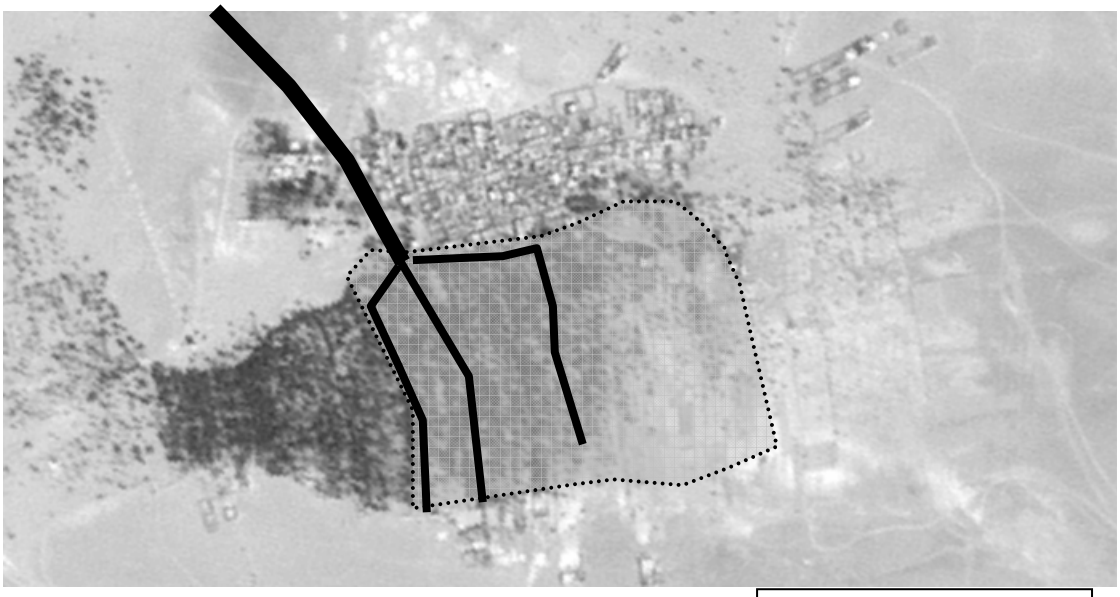
(6) Environment

Natural environment	Water quality	Salt density: satisfactory for irrigation
		Bacillus : oui
	Soil salinity	No
	Desertification control	Yes
Social environment	Khettara water use as drinking water	Yes
	Laundry water treatment	Yes
Environment evaluation results	Components having a strong impact on environment	No

J.4.2 Diba

(1) General Data of the Feasibility Study and Khettaras Priority Areas

1) Ksar and Khettara rural commune	Ksar Ksiba / Ferkla Soufla
2) Location	6,5 km north of Tinijdad and 16,5 km south-west of Goulmima
3) General data	• Population : 1 500 inhabitants • Number of households : 120 • Roads : 7 km up to Tinejidad of which 4 are paved and 3 unpaved. • Drinking water : 2 standpipes intalled by ONEP and operated since 2000. No connections to private houses. • Electrical power: Electrification of all houses by ONE since the year 2000. • Télécom : 36 fixed telephone stations. Cellular phones are largely used. • Schools : 1 primry school. All the pupils achieve their curriculum. Junior high school and senior high school are located in Tinejdad (agout 50 students attend school but few girls do). • Health centers : none (Must go to Tinejdad) • Number of khettaras in the Ksar : 2
4) Project Khettara	• Name : Diba • Discharge : 3.6 lit/s (mean value of October 2003 and January 2004) • Farm area : 25 ha • Area irrigated by khettara: 14 ha



Hyddrology and ground water	Topography and Geology	Site locates in the left bank side of Tanguerfa River and few kilometers northwestern side from the confluence of Ferkla and Tanguerfa rivers. High Atlas Mountains consist mainly of Jurassic Series (Limestone, Sandstone and Mudstone), and the surroundings form some terraces continueing to Cretaceous Basin (mainly Limestone). In the valley, gorge or lowland, gravelly splashed flood deposits distribute widely on those rock basements. Elongated hills orienting ENE-WSW situating just upstream of La'ksiba & Ait Ben Omar area consist mainly of Visean sedimentary rocks of Carboniferous so called Ras Sdaf Sandstone and Limestone, and partly of Breccia. Between these rock basements around the study sites, the above-mentioned flood deposits distribute continuously. While in the side of Tanguerfa River, Devonian Limestones gently dipping to High Atlas Mountain side get into under the Carboniferous. Sedimentaries in the area are lacustrine marl just on bedrock, lacustrine travertine-like limestone, and subrecent to recent gravelly splashed flood deposits.
	Results of In Situ Investigation	**Drilling** : location; upstream of La'ksiba & AitBenOmar khettara area (N31o34'07'', W005o03'10''), EL 1012.29m. 0～4m Conglomerate 4～9 beige gravel bearing silt (k = 0.9～1.8×10^{-3} cm/sec) 9～16 silt ~ sandy pebble (k = 3～8×10^{-3} cm/sec) 16～23 marly soil : lacustrine marl (k = 2～4×10^{-3} cm/sec) 23～70 pelitic schist (k = lower than 1×10^{-4} cm/sec) **Borehole Logging**: At the depth 23 ~ 25m where is around the border of bedrock and sedimentaries, aquifer can be found. It can also be found at the depth 15 ~ 17m where is the border of lacustrine marl and the upper sedimentaries. **Geoelectrical Prospecting** : two resistivity layers in Sedimentaries (ρ=60～200, 30～40Ωm). The resistivity of bedrock is such values lower than 50Ωm.
	Hydrogeology	Even in bedrock portion, there is some possibilty that much water content portions exist because they are composed of Carboniferous and Devonian Limestones. But basically, the formation supplying groundwater to khettara is Plio-Quaternary. Lacustrine Marl is basically aquitard, and main aquifer in the area exists in the upper sedimentaries just on Lacustrine Marl. Further, the case existing conglomerate between bedrock and lacustrine marl are reported many though it is not found out in this study. This layer may form aquifer. According to borehole logging, this portion may show aquifer where permeability test result k in the order of 10^{-3} cm/sec.
	Model and hydrology parameters along the khettara	Seepage formation of the upstream k = 1×10^{-2}cm/sec, Storage coefficient 0.041. Piezometric gradient along khettara is around 4/1000 (considering the 4km downstream point = elevation 1006m as discharging point). Bottom and Side wall until height 10cm of the downstream k = 1×10^{-5}cm/sec, Side Wall higher than 10cm k = 2×10^{-1}cm/sec
Khettara	Discharge	At the far end of the khettara the discharge is 3 ～4 lit/sec and is maintained throughout the year Water collecting section：observed along 600m downstream of the mother well and at the mother well. Leakage area ：observed along 500m upstream of the existing concrete canal (See Figure J.4.1 (2))
	Khettara extension	Total length ： 1 700 m Existing concrete lining ： 450 m（e = 0,6m × H = 1,2m） Existing masonery raising ： 250m (e = 0,6 m × H 0,4 m) Non protected section ： 1 000m (See Figure 3.9. 2 (2))

<table>
<tr><td rowspan="4">Water use</td><td>Water use</td><td>Khettara water in Diba has been use for multi purposes such as drinking and domestic water, livestock water, and irrigation water. Public faucet for drinking and domestic water is installed by ONEP; however, Khettera water is commonly used as drinking water as well as ONEP water. There is no specified laundry place along the main canal. People wash the clothes by keeping the distance from the irrigation canal not to contaminate Khettara water. Drinking place for livestock as well as laundry place is not specified.
Irrigation water is distributed to the benefit area with 14.0 ha through the open canal network</td></tr>
<tr><td>Irrigation facilities</td><td>As a countermeasure for decreasing Khettara water discharge, the regulating basin was constructed at the exit of Khettara around 10 years ago. To reduce water loss and convey water as much as possible to the farmland, the water stored during half hours of water use time zone is distributed by the remaining half water use hours.

Irrigation canal network consists of three main canals and a large number of secondary and on-farm canals. Three main canals are classified into right side canal, Seuia Ait Ami Aiyachi, center canal, Seguia Oudstania, and left side canal, Seguia Abdelkadelia. All main canals are still esrthen canal excepting the beginning section in 15 m length. Water divertion is managed with stacking up the soil by manpower.

According to the common law, the installation of well pump is prohibited near the Khettara. The installation of well pump is not prohibited in the irrigation area; therefore, two pumping stations are installed at present.
(see Figure J.4.2 (2):Canal network)
<table>
<tr><td>Regulating basin</td><td>Irrigation canal</td><td>Concrete canal</td><td>Earthen canal</td><td>Total</td></tr>
<tr><td>17m×15m×0.8m</td><td>Main canal</td><td>0.04km</td><td>0.71km</td><td>0.75km</td></tr>
<tr><td>204m^3</td><td>—</td><td>—</td><td>—</td><td>—</td></tr>
</table></td></tr>
<tr><td>Irrigation method andwater management</td><td>Irrigation method is the basin irrigation which fills the farmland divided into small plots with water by gravity in turn. Water distribution is managed in rotation by the water use hour for 24 hours whole day and night based on water right.
<table>
<tr><td>Water right holders</td><td>Water use intervak</td><td>Water right sours</td></tr>
<tr><td>186 householgs</td><td>12days</td><td>12hours～20minutes</td></tr>
</table></td></tr>
<tr><td>Operation and Management</td><td>The negative impact of the deserticication is not observed in the irrigation area. Joint maintenance activities for the irrigation canal are not formulated; therefore, individual farmer elminates on his initiative in need.</td></tr>
<tr><td rowspan="2">Farming and Extension</td><td>Soil and farmland utilization</td><td>Soil the rhizosphere is of medium thikness and the soil is formed of medium grading river deposits.
Fertility The soil does not have a high nutrients content. It is necessary to add fertilizers to increase fertility and water holding capacity.
Utilization Khettara irrigation capaciy is 25,0 ha, of which 19,5 % are abandonned because of lack of irrigation water
<table>
<tr><td>Crops (irrigated)</td><td>Fallow (non irrigated)</td><td>Abandoned land</td><td>Total</td></tr>
<tr><td>14,0 ha</td><td>6,1 ha</td><td>4,9 ha</td><td>25,0 ha</td></tr>
<tr><td>(56,1%)</td><td>(24,4%)</td><td>(19,5%)</td><td>(100%)</td></tr>
</table></td></tr>
</table>

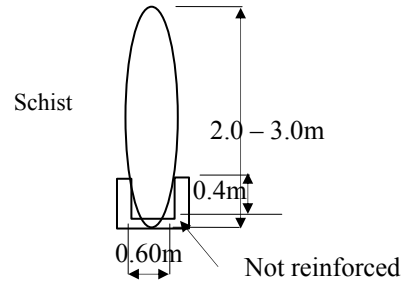
<table>
<tr><td rowspan="5"></td><td>Morphology and cropping rate</td><td>Cropping system See above table and Figure J.4.3 (2/7)
Cropping rate 102 % (irrigated land only, not including fallow and abandoned land)
Tree Crops
<table>
<tr><td>Date trees</td><td>Olive trees</td><td>Others</td><td>Total</td><td></td></tr>
<tr><td>3,81 ha</td><td>0,34 ha</td><td>0,58 ha</td><td>4,73 ha</td><td></td></tr>
<tr><td>(27,2%)</td><td>(2,4%)</td><td>(4,1%)</td><td>(33,7%)</td><td></td></tr>
</table>
Crops
<table>
<tr><td>Wheat</td><td>Alfa Alfa</td><td>Vegetables</td><td>Others</td><td>Total</td></tr>
<tr><td>8,06 ha</td><td>0,76 ha</td><td>0,16 ha</td><td>0,31 ha</td><td>9,29 ha</td></tr>
<tr><td>(57,5%)</td><td>(5,4%)</td><td>(1,1%)</td><td>(2,2%)</td><td>(66,3%)</td></tr>
</table>
( ) indicates cultivated areas percentage</td></tr>
<tr><td>Farming</td><td>1. Vegetables seed are bought in the market, wheat seeds are bought in ORMVA. Dates are often of traditional type and rarely improved ones.
2. Wheat and vegetables are improved using urea. Moreover, manure is often applied on fruit trees. No use is made of phytosanitary products.
3. Wheat and vegetables fields are ploughed with tractors obtained outside area.
4. Dates are sold in Tinijdad market. Other products are simply self consummed localy.</td></tr>
<tr><td>Extension organization</td><td>Tinijdad CMVs of ORMVA are in charge of agricultural extension services. Each CMV covers 40 ksars employing 11 persons, of which :
<table>
<tr><td>Extension agents</td><td>Livestock Breeders</td><td>Drivers</td><td>Miscellaneous</td><td>Remarks</td></tr>
<tr><td>2</td><td>2</td><td>2</td><td>4</td><td>2 vehicles</td></tr>
</table></td></tr>
<tr><td>Agricultural organizations</td><td>Water owners traditional organizations</td><td>5) Number of owners : 95 households (total population of farmers'families owner of water rights: 982 persons）
6) Maintenance activities
Sand removal requires 12 persons in average during 7 days 3 to 4 times a year.
7) Responsible for the necessary maintenance labor
The required labor for sand removal and simple repair is supplied by the traditional organization.
8) Collecting maintenance expenses
In order to cover equipment supplies necessary to the maintenance works a financial contribution is levied two times a year from the water rights owners according to actual needs.
The amount is fixed each time according to the alloted number of hours to the water right, and the head of the organization who collects the funds. The rate of one hour water right is about 20~170 DH. All water rights owners pay the required amount;
The total collected contribution amounts to DH43 200, which is allocated for maintenance expenses.
On the other hand, there exists a common water right rental system intended for collecting maintenance funds. This system is implemented ones every three months only. The charge for one hour water right is 15 DH and this way 1400DH/year is collected in average. This money is intended for maintenance wroks.</td></tr>
</table>

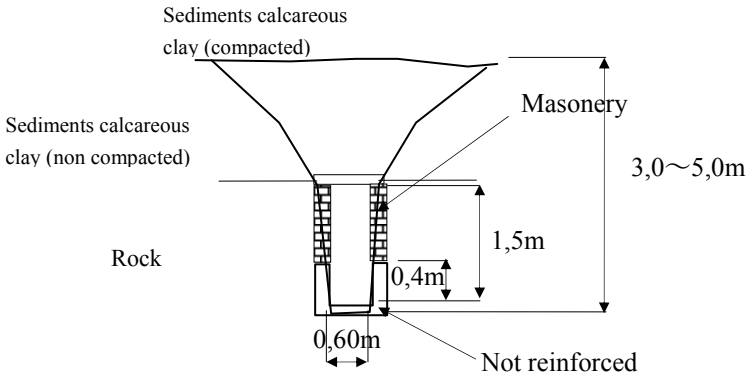
	Association on whome tranditional organization depends	6) Name : Association El Amal (AUEA) 7) Creation year: 2002 8) Organization : constitude of the traditional organizations representatives of 26 khettaras of Ferkla Soufla rural commune. 9) Activities : Assistance for the maintenance and repair works of khettaras. Financial contributions : 100 DH par khettara during its institution (all the 26 khettara paid up). A yearly 960 DH contribution paid by each khettara has instituted but so far only 6 khettaras have paid it.
Agro-economy & Marketing		Additional irrigated land will be cultivated in vegetables and palm trees (of medium quality) ; The additional production exceed self consumption needs and may be sold in the market. Farmer have access to Goulmima local market (Tinejdad, less than one paved km). Market prices are slightly lower than prices in Jorf and Errachidia, but are higher in Alnif. The market is experiencing a high demand, specially for vegetables (At prensent time, 70 % come from outside the province, for example, Agadir). Low income and production impedes the farmers to enter markets that offer higher prices, the appreciation of dates prices may lead to a possible income improvement

(2) Hindrances' causes

1) Khettara	1) 2 lit/sec leakage about 500m upstream of the concrete canal 2) 720-770 m from mother well, collapses are significant because of loamy sand soil. Soil piles up in the canal and impedes water flow. 3) Collected water volume is low and should not increase much after khettara extension because the mothewells environment is constituted by calcareous clay. 4) 80 % of the khettara extension length is constituted of hard rock (schist or clayey rock) so it is difficult to enlarge.
2) Water use	1) Much water amount filtrates into the underground from the earthen canal, which obstructs the efficient water use. 2) Seepage loss and operation loss at the inlet points obstructs the efficient water use. 3) Big water loss is created due to basin irrigation with low irrigation efficiency.
3) Farming and extension	・ The number of abandoned land increases because of lack of water resources. ・ Vegetables cropping is not pursued because the soile's fertility is low. ・ Farmers have a low knowledge of water saving irrigation methods and new crops species.
4) Agricultural organizations	3) Traditional organizations supply man power for khettara cleaning and simple operations thereto but they have no financial means de implement major works such as khettara rehabilitation, tunel be lowering and gellery extension which will solve discharge reduction problems. 1) The association has just been created and so it has no experience and knowledge in the field of management. Neither it has ever undertaken any works in cooperation with traditional organizations, and so, the latter do not take it as a meeting and documents exchange point with other outer ogranisations.

(3) Development plan

<table>
<tr><td>Khettara rehabilitation</td><td colspan="2">1) Concrete lining 500m upstream of the concrete section (Works within the galery)
 

Concrete lining+masonery : 50 m
 

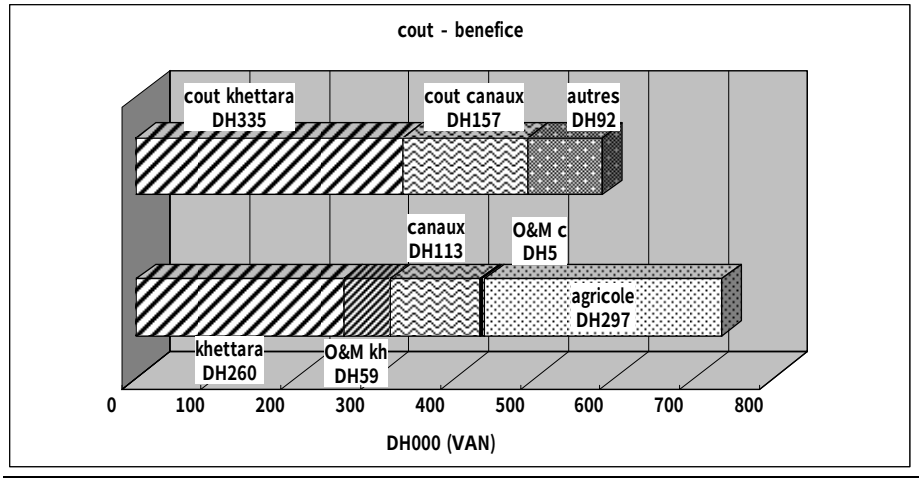
Concrete lining : 450 m
See Figure J.4.4 (2)</td></tr>
<tr><td>2) Water use plan</td><td colspan="2">Rehabilitation of the main canal
1)Concrete lining of earthen canal
Open canal B=0.4m×H=0.4m、L=709m
2)Improvement of inlets
Inlets N=24 sites
Application of water saving irrigation techniques
Irrigation area A=0.9ha</td></tr>
<tr><td rowspan="2">Farming and extension plan</td><td>Agricultural potential</td><td>Since no there are no existing soil problems it would be possible to increase crop land by 11.0 ha through irrigation. But that ought to be done taking into account desertification control.
Tinijdad town, which is overpopulated, is a prospective market.</td></tr>
<tr><td>Cropping system and rate of planed crops</td><td>Planned crops See table below and Figure J.4.5 (2/7)
Planed rate 108 % (irrigated land only, excluding fallow and abandoned land)</td></tr>
</table>

		Crops	Present	After implementation	
				1 to 6 years	7 to 30 years
		Wheat and cereals	57,5%	44,0%	44,0%
		Vegetables (August to december)	3,3%	14,0%	14,0%
		Vegetables and legumes(March to July)	1,7%	4,0%	4,0%
		Alfa-Alfa and other fodder corps	5,4%	16,0%	4,0%
		Dates and other fruits	33,7%	26,0%	37,0%
		Total	102%	104%	104%
		Culture combinée de luzerne et de dattes après les travaux (1 to 6 years) mais le calcul du taux de culture ne concerne que la luzerne.			
	Cropping practices and miscellaneous activities	1. It is necessary to emphasize vegetables cropping intended for Tinijdad market. This crop is in high demand. 2. It is necessary to increase manure application in order to maintain good soil fertility and stop desertification. 3. It is necessary to maintain olive and dates crops which existed in the area for a long time. 4. It is necessary to introduce date crop farms new species with high market value (Majhol, Faggouss, Khalt).However, since farmers are reluctant to the introduction of new species, it is necessary to plan demontration activities and technicial supervision. 5. Tree crops is highly in demand, but farmers have little experience. In addition, fruit trees do not resist well to draught, so that it is recommanded to cultivate on a small scale.			
Reinforcement plan of maintenance organizations		1) After khettaras rehabilitation maitenance and labour cos twill be supported by traditional organizations. 2) Training (courses, study tours) will be started to improve associations management skills set up administrative human resources. 3. The monitoring that will be carried out together by the associations and the traditional organizations will allow to strengthen the ties between them, and will constitute the common ground for the works joint implementation.			

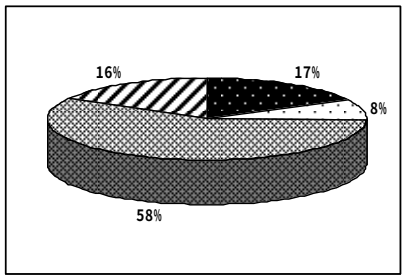
(4) Works' cost

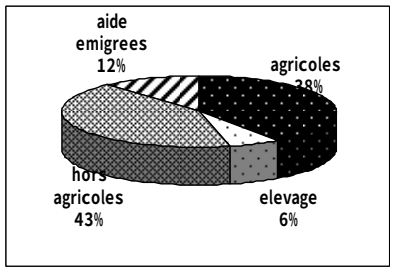
Khettara rehabitation	Concrete lining + masonery DH 423 800（see Table J.4.1）
2) Water use plan	Lining of the earthen canal：209,985DH Improvement of the inlets：5,783DH （see Table J.4.1）
Reinforcing Plan for maintenance organizations	1) Maintenance charges : 44 600 DH/an (Water rights charges and their collecting like it was done in the past) 2) Organizations reinforcement cost : ・Year of works startup : 47 500 DH (Trainning and monitoring cost). ・Second year and following year : 4 000/year (Monitoring cost)

(5) Project Evaluation

<table>
<tr><td rowspan="3">Economic evaluation</td><td><u>Without project</u>: irrigated area by khettara will decrease from 6,8ha (present, from khettara discharge) to 4,7ha(2014), causing drop in revenue from agriculture.</td><td><u>With project:</u> increase of irrigated area by 1,7ha (to total of 8,5ha) through khettara and canals rehabilitation. Improved agriculture practices (extension and water management) will increase the net income by DH14,800/ha (economic terms).</td></tr>
<tr><td colspan="2"> 

B= DH 361,000 C= DH 519,000 B/C= 0.7 (NPV, discount rate 10%); EIRR=6.8%

Relatively important share of benefit from khettara and canals rehabilitation in total benefit. The additional irrigated area will be cultivated mostly by vegetables, bringing quick return; small land holdings, and lack of land certificates hamper access to credit and further investments (planting new trees, introduction of machines, etc.)</td></tr>
<tr><td><u>Present:</u>
 

Present income from agriculture: DH6,740, for standard farm of 0,8ha. Farm budget is shown in Table J.4.2. The low share of income from agriculture might enforce rural exodus (274HH/1,280 people in 2000; 109HH/935 people in 2003).</td><td><u>With project:</u>
 

Income from agriculture: increase to DH17,910, for standard farm of 1,05ha.
The additional income (DH11,170) and decrease in O&M works gives possibility to develop agriculture practices/other activities. The project increases the share of income from agriculture to 38% of average family budget.</td></tr>
</table>

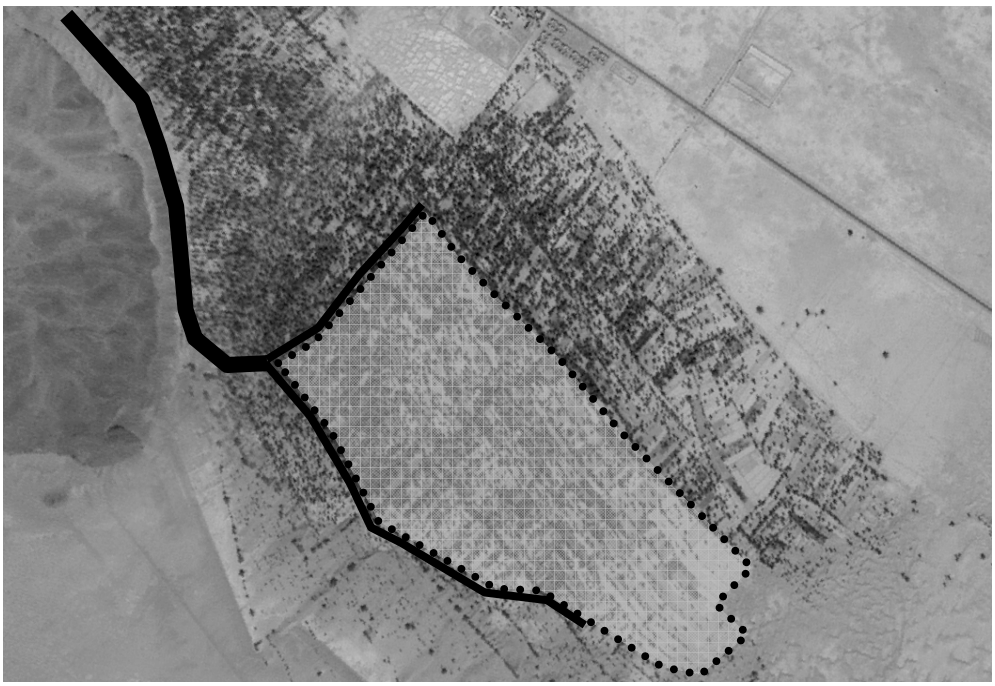
(6) Environment

Natural environment	Water quality	Salt density: satisfactory for irrigation
		Bacillus : oui
	Soil salinity	No
	Desertification control	No
Social environment	Khettara water use as drinking water	Yes
	Laundry water treatment	Yes
Environment evaluation results	Components having a strong impact on environment	No

J.4.3 Lambarkia

(1) General data on khettaras and feasibility study prirority areas

1)	Ksar and khettara rural commune	Mounkara / Jorf
2)	Location	A 2 km au sud de Jorf et 17 km à l'Ouest de Erfoud
3)	General data	• Population : 1 824 inhabitants • Number of households: 304 • Roads : 2 km paved road up to Jorf • Drinking water : Supply by ONEP completed for 98 % of households (started in 1986) • Power: Electrification of all households by ONE started in 1996 • Télécom : 15 permanent telephone stations. The area is covered by the network, many cellular phones. • Schools : 1 primary school (5 years). Almost al the pupils have finished the curriculum. One high scholl has been constructed in the area, but it has no students. • Health centers : none (one has to go to Jorf) • Number of khettaras in the ksar : 4
4)	Project khettara	• Nom : Lambarkia • Discharge : 23.5 lit/s (January 2004) • Farm area : 45.3 ha • Irrigated area : 18.9 ha



hydrogéologie et nappes	Topography and Geology	Site locates in the right bank side of the mid- and downstream area of Gheris basin, where Anti Atlas Mountains situate to the western, and also in some kilometer width's plain composed of the clastic sediments from the mountain to Erfoud–Jorf–Tinejdad (or Goulmima) Road. Mounkara Hill existes around khettara outlet. Mother well locates around few kilometers from mountain foot. Lithological condition around the study site is as follows: Anti Atlas Mountains: Ordovician Bani Sandstone (Limestones and Phosphate at the base) and Cambrian Sandstone (partly Exclusive Rocks, Sandy Argillite and Basaltic Rocks). Hill between Mounkara ~ Gheris: Devonian Marl ~ Limestone and Red Sandstone ~ Sandy Limestone. Plio-Quaternary: from lower to upper; Conglomerate (Tensiftien), Silty to Clayey layer and Silty gravel (both are Soltanien).
	Results of In Situ Investigation	**Drilling** : location; Mounkara, upstream of khettara (N31º28'56'', W004º28'41''), EL840.54m. 0～10m Granule bearing marly soil ($k = 2～4\times10^{-3}$ cm/sec) 10～22 Beige clay ($k = 1\times10^{-4}$ cm/sec) 22～26 Sand, gravel and boulder ($k = 1\times10^{-1}$ cm/sec) 26～29 Gray pelitic schist (weathered) 29～50 Pelitic schist **Borehole Logging**: Main aquifer 21～27m, Upper aquifer 9～11m. Water content portion in bed –rock is around depth 40m and 46m. **Geoelectrical Prospecting** : two resistivity layers (ρ=2～30, 150～200Ωm) in Sedimentaries, and few layers in bedrock. Layers are horizontal.
	Hydrogeology	Sedimentaries in the area are divided from upper to lower into three such as Silty Gravel, Silt～Clay and Sand to Boulder. Second layer is aquitard (k = around 1×10^{-4}cm/sec), and its upper and lower layers are aquifers. Lower aquifer ($k = 1\times10^{-1}$cm/sec) is very permeable, but khettaras take groundwater from upper aquifers ($k = 2～4\times10^{-3}$cm/sec) due to eleveation condition. This aquifer supplying to khettaras is considered distributing from the mountain foot of Anti Atalas to around Jorf area. Then, groundwater recharge may depends on the condition of the area Anti Atlas and the upstream basin of Gheris river.
	Model and hydrogeology parameters along the khettaras	Seepage formation of the upstream $k = 3.2\times10^{-3}$cm/sec, Storage coefficient 0.019. Piezometric gradient along khettara 1/200. Bottom and Side wall until height 35cm of the downstream $k = 1\times10^{-5}$cm/sec, Side Wall higher than 35cm $k = 1.6\times10^{-3}$cm/sec.
Khettara	Discharge	All the year at the furthest downstream area of the khettara has 15~20 lit/sec Catchement area：Noticible on a 600m downstream section and arround the mother welld. Leakage area ：Leakage is relatively low because of the loamy clay formation almost all along the khettaras (See Figure J.4.1(3))
	Khettatra extension	Total length ： 6 200 m（including a 100 m branch） Existing concrete lining ： 300 m（e = 0,6m × H = 1,2m） Existing concrete canal ： 1 900 m (e = 0,6 m x H = 0,4 m) Non protected section ： 3 715 m (see Figure J.4.1 (3))

Water use

Water use

Khettara water in Lambarkia has been use for multi purposes such as drinking and domestic water, livestock water, and irrigation water. Since Khettara water shows high Electric Conductivity with 3,290μs/cm, ONEP water being supplied to individual house is widely used as drinking water. Laundry places are constructed at the exit of Khettara. Drinking place for the livestock is not specified.

Irrigation water is distributed to the benefit area with 18.9 ha through the open canal network.

Irrigation facilities

Irrigation canal between the exit of Khettara and the beginning point of the irrigation area is rehabilitated as the trapezoid concrete canal with 0.45 to 0.55m width and 0.50m height. In the irrigation area, the irrigation canal is divided into two main canals, right side canal and left side canal.

Irrigation network consists of this two main canals and a large number of secondary and on-farm canals. All irrigation canals in the irrigation area are the earthen canal.

Left side main canal is connected to another Khettara Lahloua at the end point in order to make it possible to use irrigation water mutually. Right side main canal was forced to sift the alighment due to the desertification at the down stream.

At the inlet points, water divertion is managed with stacking up the soil by manpower.

According to the common law, the installation of well pump is prohibited near the Khettara. The installation of well pump is not prohibited in the irrigation are; however, no pumping station is installed at present. (see Figure J.4.2 (3):Canal network)

Regulating basin	Irrigation canal	Concrete canal	Earthen canal	Total
—	Main canal	—	1.04km	1.04km
—	—	—	—	—

Irrigation method and water management

Irrigation method is the basin irrigation which fills the farmland divided into small plots with water by gravity in turn. Water distribution is managed in rotation by the water use hour for 24 hours whole day and night based on water right.

Water right holders	Water use intervak	Water right sours
128 households	15 days	13 hours～45 minutes

Operation and Management

The soil accumulation is widely observed at the downstream of the main canal, Seguia Dhar and Seguia Jadid owning to the disertification. Maintenance activitise such as eliminating the acumulated soil in the irrigation canal have been conducted once two to three months. The operatin requires 12 man-days per one time.

Farming and extension

Soil and farmland utilization

Soil — The rhizosphere is deep and the soil is constituted of river deposits having fine to medium grading, with accumulated salt.

Fertility — Care must be given to drainage because of accumulated salt. Wind erosion is severe in some areas.

Utilization — Khettara irrigation potential is 45,3 ha of which 44,9 % are abandonned due to lack of irrigation water and desertification.

Crops (irriguated)	Fallow (non irrigated)	Abandoned land	Total
18.9 ha	6.1 ha	20.3 ha	45.3 ha
(41.7%)	(13.4%)	(44.9%)	(100%)

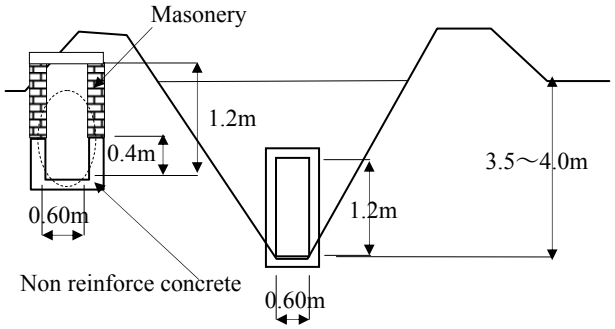
<table>
<tr><td rowspan="5"></td><td>Morphology and cropping rate</td><td>
Cropping system See above table and Figure J.4.3 (3/7)
Cropping rate 108 % (irrigated land only, not including fallow and abandoned land)
Tree Crops
<table>
<tr><td>Date treess</td><td>Olive trees</td><td>Others</td><td>Total</td><td></td></tr>
<tr><td>6.34 ha</td><td>0.31 ha</td><td>0.58 ha</td><td>7.23 ha</td><td></td></tr>
<tr><td>(33,6%)</td><td>(1,6%)</td><td>(3,1%)</td><td>(38,3%)</td><td></td></tr>
</table>
Crops
<table>
<tr><td>Wheat</td><td>Alfa Alfa</td><td>Vegetables</td><td>Others</td><td>Total</td></tr>
<tr><td>5.50 ha</td><td>3.15 ha</td><td>1.02 ha</td><td>1.99 ha</td><td>11.66 ha</td></tr>
<tr><td>(29.1%)</td><td>(16.7%)</td><td>(5.4%)</td><td>(10.5%)</td><td>(61.7%)</td></tr>
</table>
( ) indicates cultivated areas percentage
</td></tr>
<tr><td>Farming</td><td>
1. Dates crop is relatively more implemented than in the other areas. Qulity species (Majhol, Faggous) are cultivated, but bayoud disease is dissiminating the palm treesd.
2. Vegetable and AlfaAlfa seeds are purchased in the market, Wheat ones are purchased at ORMVA;
3. Wheat, vegetables and AlfaAlfa are improved with ferilizers and urea input. Some farmers buy chimical fertilizers at ORMVA. Moreover, for dates palm trees, the majority of farmers use manure. Phytosanitary products are commonly used.
4. To grow wheat and vegetables, tractors are brought from other areas.
5. Dates are sold to an midllemen or a market in Jorf. Other products are pratically all intended to self consumption.
</td></tr>
<tr><td>Extension organisation</td><td>
Tinijdad CMVs of ORMVA is in charge of agriultural extrension services. Each CMV covers 22 ksars and employes 11 persons of which:
<table>
<tr><td>Extension agents</td><td>Livestock breeders</td><td>Drivers</td><td>Miscellaneous</td><td>Remarks</td></tr>
<tr><td>1</td><td>2</td><td>2</td><td>5</td><td>2 vehicules</td></tr>
</table>
</td></tr>
<tr><td rowspan="2">Agricultural organizations</td><td>Traditional organizations of water rights owners</td><td>
1. Number of owners : 128 households (total population of farmers’families owners of water rights: 897 persons）
2. Maintenance activities
Sand removal requires 30 persons in average during 30 days 5 times a year in average.
3. Responsible for the necessary maintenance labor
The required labor for sand removal and simple repair is supplied by the traditional organization.
4. Collecting maintenance expenses
In order to cover equipment supplies necessary to the maintenance works a financial contribution is levied two times a year from the water rights owners according to actual needs.
The amounts are fixed each time in accordance of the number of hours alloted by a water right an it is the head of the organization who collects the funds. The rate for 12 hours is 200DH. All the water rights owners pay the requested amount.
The collected total contributions amount to 24 000DH which intended for maintenance expenses.
A system of joint lease of water rights is carried out in order to collect the necessary funds for maitenance. This system est open two days a year only. One hour water right costs 40 DH which allowed to collect 2000DH a year in average serving to cover the maintenance expenses.
</td></tr>
</table>

	Association on whome tranditional organization depends	1) Name : Association Monkara (AUEA) 2) Creation year: 2001 3) Organization : constituted of the traditional organizations representatives of 4 khettaras of Ferkla Soufla rural commune 4) Activities : Assistance for the khettara repair works, pump stations and dikes constructin, discussion of problems and solutions of khettaras, extensions services on farming pratice. 5) Does not apply
Agroéconomie & Marketing		Additional irrigated land will mainly culitvated in dates palm trees. Additional production will exceed self consumption and may be sold in the market (specially dates). Dates are sold in the nearby market of Jorf and Errachidia or sold to middlemen. Rich farmers may hire trucs and sell their dates harvest in Fez, getting a better benefit than those obtrained localy. Farmers do not institute cooperatives to sell their dates production.

(2) Hindrances' causes

1) Khettara	1) The 130m section upstream of khettara outlet is opencast and and sand piles are significant. 2) Along 200m upstream of this section the covring thickness does not exceed 1M. 3) More than 30 % of the gallery is 1.2 to 1.4 m high, making the maintenance difficult.
2) Water use	1) Much water amount filtrates into the underground from the earthen canal, which obstructs the efficient water use. 2) Seepage loss and operation loss at the inlet points obstructs the efficient water use. 3) Big water loss is created due to basin irrigation with low irrigation efficiency.
3) Farming and extension	1) Land intensive desertion due to water volume deficit and desertification. 2) Vegetables crops is not pursued due to soil salinity and because farmers would rather grow dates. 3) Lack of skill in water saving practices, in vegetables crops and struggle against bayoud disease.
4) Agricultural organizations	1) Traditional organizations supply man Electrical power for khettara cleaning and simple operations thereto but they have no financial means de implement major works such as khettara rehabilitation, tunel be lowering and gellery extension which will solve discharge reduction problems. 2) The association has just been created and so it has no experience and knowledge in the field of management. Neither it has ever undertaken any works in cooperation with traditional organizations, and so, the latter do not take it as a meeting and documents exchange point with other outer ogranisations.

(3) Development plan

<table>
<tr><td>Khettara rehabilitation</td><td colspan="4">1) 500m concrete lining upstream of the khettara outlet (opencast works)
 

2) Enlarging and covering works of 1000m section upstream of 1)

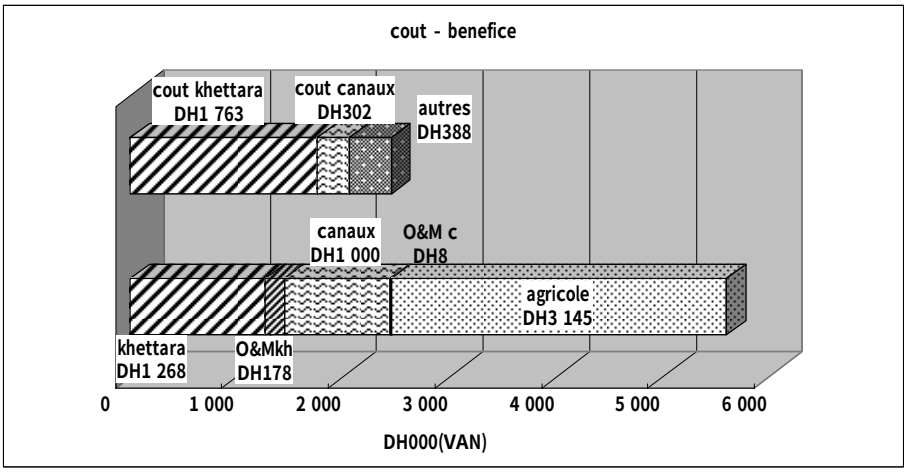
See Figure J.4.4 (3)</td></tr>
<tr><td colspan="2">2) Water use plan</td><td colspan="3">Rehabilitation of the main canal
1)Concrete lining of earthen canal
Open canal B=0.5m×H=0.5m、L=586m
Culvert canal B=0.5m×H=0.5m、L=450m
2)Improvement of inlets
Inlets N=35 sites
Application of water saving irrigation techniques
Irrigation area A=5.0 ha</td></tr>
<tr><td rowspan="8">Farming and extension plan</td><td>Agricultural potential</td><td colspan="3">It is possible to increase the culitvated areas by 2.6 ha if drainage is harnessed in order to avoid salt accumulation and if irrigation is carried out. However, it is necessary to take into account checking desertification effects.
Jorf town, which has a large population, is a promising market.</td></tr>
<tr><td rowspan="7">Cropping system and rate of planed crops</td><td colspan="3">Planed system See table above and Figure J.4.5 (3/7).
Planed rate 108 % (irirgated land only, excluding fallow and abandoned land)</td></tr>
<tr><td rowspan="2">Crops</td><td rowspan="2">Present</td><td colspan="2">After implementation</td></tr>
<tr><td>1 to 6 years</td><td>7 to 30 years</td></tr>
<tr><td>Wheat and cerials</td><td>37.6%</td><td>30.0%</td><td>30.0%</td></tr>
<tr><td>Vegetables (August to December)</td><td>7.5%</td><td>17.0%</td><td>17.0%</td></tr>
<tr><td>Vegetables and legumes (March to July)</td><td>3.8%</td><td>4.0%</td><td>4.0%</td></tr>
<tr><td>Alfa Alfa and other fodder crops</td><td>16.7%</td><td>24.0%</td><td>13.0%</td></tr>
<tr><td>Dates and other ruits</td><td>38.3%</td><td>29.0%</td><td>41.0%</td></tr>
<tr><td>Total</td><td>108%</td><td>108%</td><td>108%</td></tr>
<tr><td colspan="4">Combined AlfaAlfa and dates crops after the works (1 to 6 years) but the crops rate calculation does not include Alfa Alfa.</td></tr>
</table>

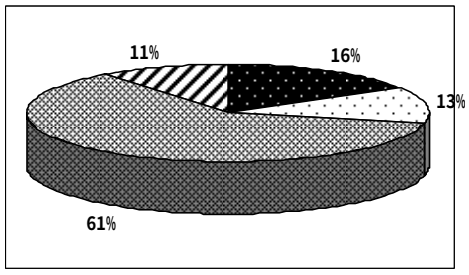
	Cropping practices and miscellaneous activities	1. It is necessary to continue the introduction of dates species with high market value (Majhol, Faffouss, Khalt), but much care must be taken to use resistant plants to bayoud disease. 2. It is necessary to emphasize vegetables cropping and target Jorf market, after having set up a good soil drainage system. 3. From the point of view of resistance to salinity, it is possible to enhance cereals cropping such as barley which are cultivated in parallel with wheat. 4. It is necessary to increase fertilizing in order to stop desertification. 5. Tree crops are strongly pursued but farmers have little experience in of draught and salinity resistant so it is recommandable to apply such crops on a small scale.
Reinforcement plan for maintenance organizations		1) After khettaras rehabilitation maitenance and labour cos twill be supported by traditional organizations. 2) Training (courses, study tours) will be started to improve associations management skills set up administrative human resources. 4. The monitoring that will be carried out together by the associations and the traditional organizations will allow to strengthen the ties between them, and will constitute the common ground for the works joint implementation.

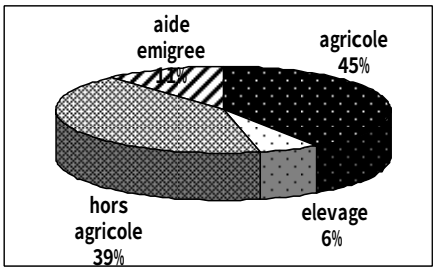
(4) Works' cost

Khettara rehabilitation	Concrete lining 500 m Concrete lining or masonery 1000 m DH 2 228 500 （see Table J.4.1）
2) Water use plan	Lining of the earthen canal：408,547DH Improvement of the inlets：5,250DH （see Table J.4.1）
Reinforcement plan for maintenance organizations	1) Maintenance expenses : 26 000 DH/year (Water rights expenses and financial contributions collecting as in the past) 2) Cost of organizations reinforcement : ・Year of works startup : 47 500 DH (Training and monitoring cost). ・ 2nd year and follwing years : 4 000/year (monitoring cost)

(5) Project Evaluation

<table>
<tr><td>Economic evaluation</td><td><u>Without project</u>: irrigated area by khettara will decrease from 38,5ha (present, from khettara discharge) to 30,5ha(2014), causing drop in revenue from agriculture.</td><td><u>With project:</u> increase of irrigated area by 11,1ha (to total of 49,7ha) through khettara and canals rehabilitation. Improved agriculture practices (extension and water management) will increase the net income by DH18,800/ha (economic terms).</td></tr>
<tr><td></td><td colspan="2"> 

B= DH 3,802,000 C= 2,267,000 B/C= 1.68 (NPV, discount rate 10%), EIRR=16.0%
Good variety of cultivated dates and big initial water discharge (20,6l/s) gives big potential for agriculture. Stabilized/increased water discharge through rehabilitation, further improvement of agriculture practices and water management, enforcement of farmers organizations (associations, cooperatives for dates commercialization) is expected to mobilize this potential.</td></tr>
<tr><td>Financial Evaluation</td><td><u>Present:</u>
 

Present income from agriculture: DH8,400, for standard farm of 0,8ha. Farm budget is shown in TableJ.4.2.</td><td><u>With project:</u>
 

Income from agriculture: DH20,960, for standard farm of 1,03ha. The additional income (DH12,560) and decrease in O&M works gives possibility to develop agriculture practices/other activities. The project increases the share of income from agriculture to 45% of average family budget.</td></tr>
</table>

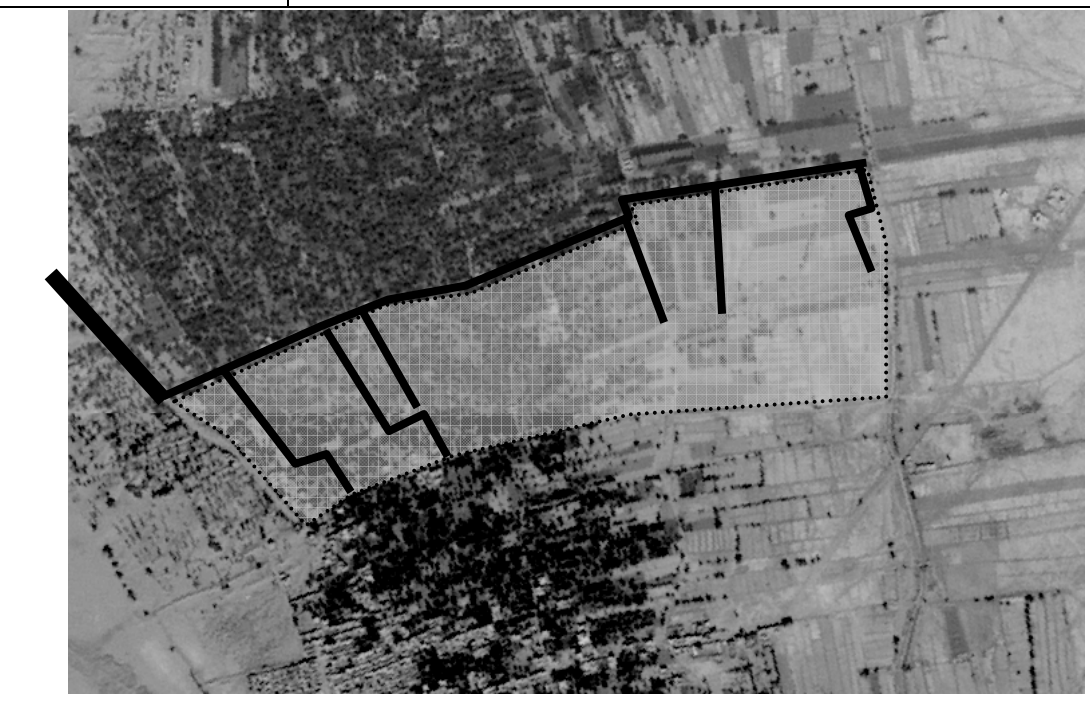
(6) Environment

Natural environment	Water quality	Salt density: high
		Bacillus : oui
	Soil salinity	Some
	Desertification control	Yes
Social environment	Khettara water use as drinking water	No
	Laundry water treatment	Yes
Environment evaluation results	Components having a strong impact on environment	No

J.4.4 Oustania

(1) General data on khettaras and feasibility study prirority areas

1) Ksar and khettara rural commune	Hannabou / Arab Sbah Ghris
2) Location	9 km south-east of Jorf and at 10,5 km west of Erfoud.
3) General data	• Population : 5 130 inhabitants • Number of households: 560 • Roads : 11 km paved road up to Jorf • Drinking water : 6 standpipes installed between 1999 and 2000. • Electrical power : Electrification of 98 % of households by ONE, started in the fifties. • Télécom : 32 permanent telephone stations. Even though not all the area is covered, the cellular phones are in common use. • Schools : 1 primary school (11 classes, 110 pupils of which 50 to 60 are girls). Nearly all the pupils finished the curriculum. Junior and senior high schools are located in Jorf but few girls attend. • Health centers : 1 dispensary (one doctor and one nurse) The hopital is located in Erfoud). • Number of khettaras in the Ksar : 10
	• Name : Oustania • Discharge : 8.3 lit/s (mean value for October 2003 and January 2004) • Farm area : 31.3 ha • Area irrigated by khettara : 27.9 ha



hydrogéologie et nappes	Topography and Geology	Site locates in the right bank side of the mid- and downstream area of Gheris basin, where Anti Atlas Mountains situate to the western, and also in some kilometer width's plain composed of the clastic sediments from the mountain to Erfoud–Jorf–Tinejdad (or Goulmima) Road where some mountains or hills seriating from Anti Atlas Mountains lie sporadically and rocky table hills locate until Gheris river. Mother well of khettara in Hannabou area locates at the foot of these mountains. Lithological condition around the study site is as follows: Anti Atlas Mountains: Ordovician Bani Sandstone (Limestones and Phosphate at the base) and Cambrian Sandstone (partly Exclusive Rocks, Sandy Argillite and Basaltic Rocks). Hills upto Gheris: Devonian Marl ~ Limestone and Red Sandstone ~ Sandy Limestone. Plio-Quaternary: from lower to upper; Conglomerate (Tensiftien), Silty to Clayey layer and Silty gravel (both are Soltanien). Further, Aeolian sand deposits on ground surface; thickness 2 ~ 3m.
	Result of In Situ Investigation	**Drilling** : location; upstream of khettaras in Hannabou area (N31º27'43'', W004º25'49''), EL826.08m. 0～2m Dune sand (silty sand) 2～6 beige clay (k = 3×10^{-4} cm/sec) 6～16 plastic clay (k = $3\sim4\times10^{-4}$ cm/sec) 16～21 gravel bearing clay (k = 1×10^{-4} cm/sec) 21～30 sand and gravel (k = $4\sim5\times10^{-2}$ cm/sec) 30～38 sandstone (k = $3\sim4\times10^{-2}$ cm/sec) 38～70 argillaceous schist **Borehole Logging**: between the depth 22～28m, aquifer can be found as typical one. Water content portion can not be found in bedrock. **Geoelectrical Prospecting** : two resistivity layers in Sedimentaries (ρ=2～30、150～200Ωm), and few layers in bedrock. All layers are horizontal.
	Hydrogeology	Upper portion of Sedimentaries in the area is composed of clay forming aquitard with thickness around 20m (lowest around 5m is gravel-bearing) (k = $2\sim3\times10^{-4}$cm/sec), except the uppermost dune sand. Typical aquifer composed of sand and gravel with thickness around 10m lies between the upper aquitard and bedrock (k = $4\sim5\times10^{-2}$cm/sec). Piezometric level is higher than this layer , then this is confined. Permeability test shows its coefficient of sandstones in upper bedrock in the order of 10^{-2}cm/sec, however according to the result of borehole logging, any sign as this is aquifer cannot be found. High permeability may be only partial. The aquifer supplying groundwater to khettaras in the area is different from that in Mounkara~Jorf. Probably, this aquifer may not connect to surface water or shallow subsurface water in the area, and may be recharged in the upstream area. That is to say, recharge area is Todrha – Ferkla and Ichim rivers etc in the upstream basin and the upper Gheris river basin.
	Parameters for discharge analysis	Mother Well ~ 1km from outlet: Seepage formation of the upstream k = 5×10^{-2}cm/sec, Storage coefficient 0.092. Piezometric gradient along khettara 1.6/1000. Bottom and Side wall until height 18cm of the downstream k = 1×10^{-5}cm/sec. Side Wall higher than 18cm k = 3.6×10^{-3}cm/sec. 1km from outlet ~ outlet: Bottom and Side wall until height 10cm k = 2.5×10^{-4}cm/sec, Side Wall higher than 10cm k = 3.6×10^{-3}cm/sec.
Khettara	Discharge	At the furthest downstream area of the khettara the discharge fluctuates greatly arround the year with records of 3 lit/sec in the summer and 12 lit/sec in winter time. Water collecting section：noticeable along a 300m section downstream and arround the mother well. Leakage zone ：noticeable at 300 to 800m upstream of the mother well. Before this section, leakage is low due to the fact that the soil is made of loam silt (see Figure J.4.1 (4))
	Khettara estension	Khettara length ： 7,700 m Existing concrete lining ： 500 m（e = 0.5m×H1.2m） 700 m（e = 0.5m×H0.5m） Non protected section ： 6 500 m (see Figure J.4.1(4))

Water use

Water use

Khettara water in Oustania has been use for multi purposes such as drinking and domestic water, livestock water, and irrigation water. Public faucet for drinking and domestic water is installed by foreign donor; however, Khettera water is commonly used as drinking water as well as public faucet. Laundry places are constructed at the exit of Khettara, but drinking place for the livestock is not specified. Khettara water is also used as washing water of the vegetable harvested in Khettara irrigation area.

Irrigation water is distributed to the benefit area with 27.9 ha through the open canal network.

Irrigation facilities

Irrigation network consists of seven main canals and a large number of secondary and on-farm canals connected with the main canals. One main canal (Canal Principal) runs through the left end of the benefit area from the exit of Khettara. Other six main canals branch off from Canal Principal to distribute water to the whole benefit area. Canal Principal is paved by concrete (B=0.60m×H=0.40m) in all section because it is the most important canal in this irrigation area.

The main canal of other Khettara Fougania, of which benefit area is located at the left side of the Khettara Oustania benefit area, joints Canal Principal at several points to exchage irrigation water each other. Besides, flood water is also intaken from the point crossing with another canal (Seguia La Hmida) at the end of Canal Principal.

At the other inlet points, water divertion is managed with stacking up the soil by manpower.

According to the common law, the installation of well pump is prohibited near the Khettara. The installation of well pump is not prohibited in the irrigation are; however, no pumping station is installed at present. (see **Figure J.4.2 (4):Canal network**)

Regulating basin	Irrigation canal	Concrete canal	Earthen canal	Total
—	Main canal	1.44 km	—	1.44 km
—	—	—	—	—

Irrigation method and water management

Irrigation method is the basin irrigation which fills the farmland divided into small plots with water by gravity in turn. Water distribution is managed in rotation by the water use hour for 24 hours whole day and night based on water right.

Water right holders	Water use intervak	Water right sours
75 households	13 days	12 hours～10 minutes

Operation and maintenance

Desertification gives negative impact in Khettra iteself, but no influence is observed in the irrigation canal. Maintenance activitise such as eliminating the acumulated soil in the main canals have been conducted once a month or two months. The operatin requires 6 workers per one time. Individual farmer is responsible for the maintenance of secondary and on farm canals.

Farming and extension

Soil and farmland utilization

Soil — The rhizosphere is deep and made of alluvium deposits with fine grading. The soil contains salt, even though in small quantities.

Fertility — Care must be given to drainage because of salt accumulated salt.

Utilization — Khettara irrigation potential is 31,3 ha of which 1 % only is abandoned.

Crops (irrigated)	Fallow (non irrigated)	Abandoned land	Total
27.87 ha	3.1 ha	0.3 ha	31.3 ha
(89.0%)	(10.0%)	(1.0%)	(100%)

Morphology and cropping rate

Cropping system — See table above and Figure J.4.3 (4/7)

Taux de culture — 108 % (irrigated land only without fallow or abandoned land)

Date palm trees	Olive trees	Others	Total	
3.22 ha	0.37 ha	0.60 ha	4.19 ha	
(11.6%)	(1.3%)	(2.2%)	(15.0%)	

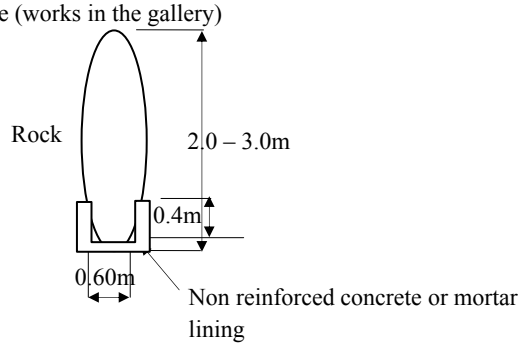
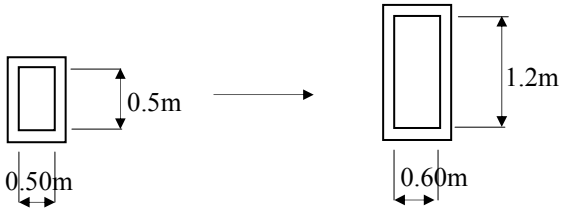
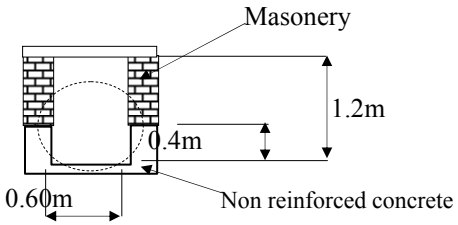
<table>
<tr><td rowspan="5"></td><td></td><td colspan="5">Crops</td></tr>
<tr><td></td><td>Wheat</td><td>Alfa Alfa</td><td>légumes</td><td>Others</td><td>Total</td></tr>
<tr><td></td><td>13.82 ha</td><td>5.19 ha</td><td>3.62 ha</td><td>1.05 ha</td><td>23.68 ha</td></tr>
<tr><td></td><td>(49.6%)</td><td>(18.6%)</td><td>(13.0%)</td><td>(3.8%)</td><td>(85.0%)</td></tr>
<tr><td></td><td colspan="5">( ) indicates cultivated areas percentage</td></tr>
<tr><td></td><td>Farming</td><td colspan="5">1. More prosperous vegetable crops than in the other areas.
2. Vegetables and AlfaAlfa seeds are purchased in the market, wheat seeds are purchased from ORMVA;
3. Wheat, vegetables and Alfa Alfa are improved using manure and urea. Chimical fertilizers are purchased from private firms. However, the majority of farmers do not use manure on the palm trees. Photosaniyaru products are hardly used.
4. To grow wheat and vegetables, tractors are brought from other areas.
5. Dates, vegetables and alfa alfa are sold to a middleman or in Jorf and markets. Other crops are intended for self consumption.</td></tr>
<tr><td rowspan="3"></td><td rowspan="3">Extension organisation</td><td colspan="5">Jorf CMVs of ORMVA is in charge of agriultural extrension services. Each CMV covers 22 ksars and employes 11 persons of which:</td></tr>
<tr><td>Extension agents</td><td>Livestock breeders</td><td>Drivers</td><td>Miscellaneous</td><td>Remarks</td></tr>
<tr><td>1</td><td>2</td><td>2</td><td>5</td><td>2 vehicles</td></tr>
<tr><td>Agricultural organizations</td><td>Traditional organizations of water rights owners</td><td colspan="5">1. Number of owners : 75 households (total population of farmers’families owners of water rights: 814 persons）
2. Maintenance activities
Sand removal requires 26 persons in average during 4 days 12 times a year in average.
3. Responsible for the necessary maintenance labor
The required labor for sand removal and simple repair is supplied by the traditional organization.
4. Collecting maintenance expenses
In order to cover equipment supplies necessary to the maintenance works a financial contribution is levied two times a year from the water rights owners according to actual needs.
The amounts are fixed each time in accordance of the number of hours alloted by a water right an it is the head of the organization who collects the funds. The rate for 1 hour is 50DH. All the water rights owners pay the requested amount.
The collected total contributions amount to 14 000DH which intended for maintenance expenses.
A system of joint lease of water rights is carried out in order to collect the necessary funds for maitenance. This system est open two days a year only. One hour water right costs 50 DH which allowed to collect 2400DH a year in average serving to cover the maintenance expenses.</td></tr>
</table>

	Association on whome tranditional organization depends	1) Name: Association Ghriss (Khettara Association) 2) Year of creation : 2001 3) Organization : Constituted of the representants of 8 traditional organizations among 10 Hannabou khettaras. The other 2 organizations created an independant association. 4) Activities : Sharing and finding solutions to khettara problems, fostering awarness of for the necessity of khettara rehabilitation, getting assistance and improving production. 5) Financial contributions : not applied.
Agro-economy & Marketing		Additional irrigated land will mainly culitvated in dates palm trees. Additional production will exceed self consumption and may be sold in the market (specially dates). Dates are sold in the nearby market of Jorf and Errachidia or sold to middlemen. Rich farmers may hire trucs and sell their dates harvest in Fez, getting a better benefit than those obtrained localy. Farmers do not institute cooperatives to sell their dates production

(2) Hindrances' causes

1) Khettara	1) Leakage is noticeable on a 300~800m section downstream of the mother well because the soil is mixed with pebbles. To find a remedy, the khettara gallery bed has been covered with clay（width e= 0.5m、sides e = 0.1m）. 2) Concrete lining along 700m of a de 0.5m×0.5m section and so it is impossible to do any maintenance in this part. (In fact there is no silting problems) The khettara is 2,5～3,0m high but it is narrow (about 0.4～0.6m) which hampers maintenance works. 4) The bed rock overcrops in the khettara 4 km through, which impedes digging to lower the khettara foundation. 5) Along the khettara 1 500 m downstream section it is low in height (H = 0.8～1.2m) which hampers maintenance works. 6) Due to desertification the shafts are clogged along 1.5～2.0 km which impedes maintenace works (maintenance is carried out about 3 times a year but only where no problems exist) 7) Practically not a single shaft opening is protected. They surrounded by 1m sand ridge and to enter the khettara is uneasy.
2) Water use	1) Much water amount filtrates into the underground from the earthen canal, which obstructs the efficient water use. 2) Seepage loss and operation loss at the inlet points obstructs the efficient water use. 3) Big water loss is created due to basin irrigation with low irrigation efficiency.
3) Farming and extension	1) Farmers complain of water deficit downstream. 2) Lack of knowledge agout water saving technics and vegetable farming. 3) It is necessary to be carefull agout drainage situation because of salinity and the dammagers it may entail.
4) Agricultural organizations	1) Traditional organizations supply man power for khettara cleaning and simple operations thereto but they have no financial means de implement major works such as khettara rehabilitation, tunel be lowering and gellery extension which will solve discharge reduction problems. 2) The association has just been created and so it has no experience and knowledge in the field of management. Neither it has ever undertaken any works in cooperation with traditional organizations, and so, the latter do not take it as a meeting and documents exchange point with other outer ogranisations.

(3) Development plan

Khettara rehabilitation	1) Concrete lining of the canal along 300~800m section downstream of the mother well in order to control leakage (works in the gallery)  2) Rehabilitation of the covered part with concrete thourgh a section of 0,5m×0,5m（700m）  3) Enlarging works and cover installation  See Figure J.4.4 (4)
2) Water use plan	**Rehabilitation of the main canal** 1)Concrete lining of earthen canal - 2)Improvement of inlets Inlets N=48 sites **Application of water saving irrigation techniques** Irrigation area A=2.2 ha

<table>
<tr><td rowspan="3">Farming and extension plan</td><td>Agricultural potential</td><td colspan="4">There is a possibility of increasing the cultivated area by 3,4 ha if irrigation is applied. In addition, more water may be conveyed from khettara Fougania. However, care must be taken to remedy the drainage situation.

Jorf and Erfoud towns, with large populations, are promising markets.</td></tr>
<tr><td>Cropping system and rate of planed crops</td><td colspan="4">Planned crops See table below and Figure J.4.5 (4/7)

Planed rate 108 % (irrigated land only, excluding fallow and abandoned land)

<table><tr><td rowspan="2">Crops</td><td rowspan="2">Prensent</td><td colspan="2">After implementation</td></tr><tr><td>1 to 6 years</td><td>7 to 30 years</td></tr><tr><td>Wheat and cereals</td><td>49.6%</td><td>38.0%</td><td>38.0%</td></tr><tr><td>Vegetables (August to december)</td><td>16.8%</td><td>24.0%</td><td>24.0%</td></tr><tr><td>Vegetables and legumes(March to July)</td><td>8.4%</td><td>9.0%</td><td>9.0%</td></tr><tr><td>Alfa-Alfa and other fodder corps</td><td>18.6%</td><td>25.0%</td><td>14.0%</td></tr><tr><td>Dates and other fruits</td><td>15.0%</td><td>12.0%</td><td>23.0%</td></tr><tr><td><u>Total</u></td><td><u>108%</u></td><td><u>108%</u></td><td><u>108%</u></td></tr></table>
Combination of AlfaAlfa and dates after the works (1 to 6 years) but crops rate calculation does not include AlfaAlfa.</td></tr>
<tr><td>Cropping practices and miscellaneous activities</td><td colspan="4">6. It is necessary to emphasize vegetables cropping intended for Tinijdad market. This crop is in high demand.

7. It is necessary to increase manure application in order to maintain good soil fertility and stop desertification.

8. It is necessary to maintain olive and dates crops which existed in the area since long.

9. It is necessary to introduce date crop farms new species with high market value (Majhol, Faggouss, Khalt).However, since farmers are reluctant to the introduction of new species, it is necessary to plan demontration activities and technicial supervision.

10. Tree crops is highly in demand, but farmers have little experience. In addition, fruit trees do not resist well to draught, so that it is recommanded to cultivate on a small scale.</td></tr>
<tr><td colspan="2">Reinforcement plan for maintenance organizations</td><td colspan="4">1) After khettara rehabilitation the maintenance cost and manpower supply will remain the responsability of the traditional organizations.

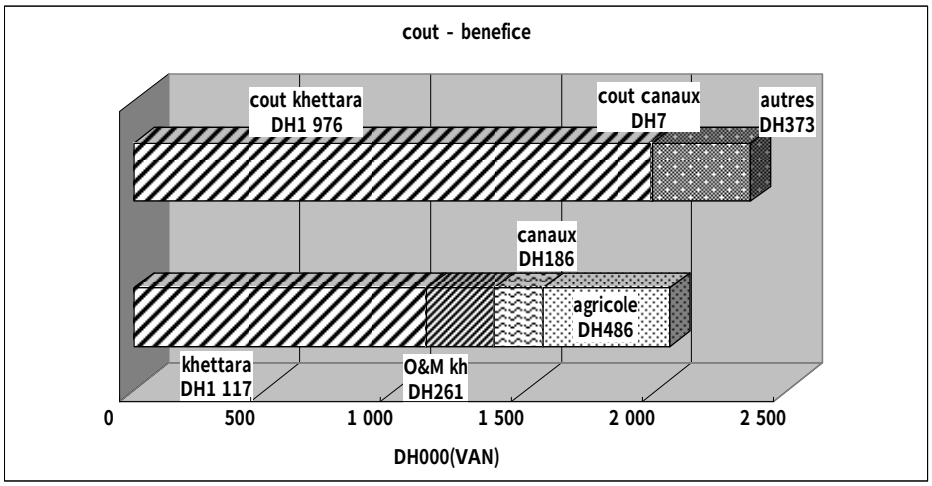
2) Training (courses, study tours) shall be initiated to supply the association with the administration knowledge in order to set up the administrative structures.

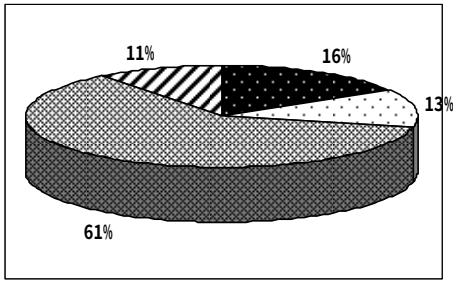
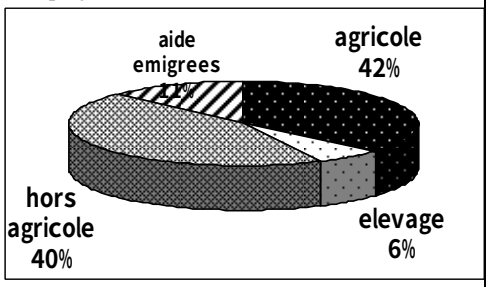
3) The monitoring that will be carried out together by the associations and the traditional organizations will allow to strengthen the ties between them, and will constitute the common ground for the works joint implementation.</td></tr>
</table>

(4) Works cost

Khettara	Concrete canal (500 m), installation of a concrete cover on top of the canal (700 m), installation of a concrete cover + a masonery cover (1 000 m) DH 2 498 900 （see Table J.4.1）
2) Water use plan	Lining of the earthen canal：－ Improvement of the inlets：6,912 DH （see Table J.4.1）
Reinforcement plan for maintenance organizations	1) Maintenance charges : 16 000 DH/an (Water rights charges and their collecting like it was done in the past) 2) Organizations reinforcement cost : ・Year of works startup : 47 500 DH (Trainning and monitoring cost). ・Second year and following year : 4 000/year (Monitoring cost)

(5) Project Evaluation

Economic evaluation	Without project: irrigated area by khettara will decrease from 12,3ha (present, from khettara discharge) to 9,6ha(2014), causing drop in revenue from agriculture.	With project: increase of irrigated area by 9,0ha (to total of 21,3ha) through khettara and canals rehabilitation. Improved agriculture practices (extension and water management) will increase the net income by DH18,800/ha (economic terms).
	 B= 1,164,000 C= 2,095,000 B/C=0,8 (NPV, discount rate 10%); **EIRR= 7.7%** Relatively important share of benefits from khettara rehabilitation in total benefits. Due to big khattara rehabilitation length (2,200m) khettara rehabilitation constitutes big share of costs. Canals rehabilitation is limited to improvement of distribution work, with relatively small cost and important benefit. The EIRR is relatively low due to intensive rehabilitation works, which is still considered acceptable for rural development project, in the specific situation of Hannabou ksar.	

Financial Evaluation	Present:  Present income from agriculture: DH6,290, for standard farm of 0,8ha. Farm budget is shown in Table J.4.2. Decrease in income from agriculture might cause rural exodus (80-90HH/640-720 people in 2000; 75HH/417 people in 2002).	With project:  Income from agriculture: DH16,820, for standard farm of 1,03ha. The additional income (DH10,530) and decrease in O&M works gives possibility to develop agriculture practices/other activities. The project increases the share of income from agriculture to 45% of average family budget.

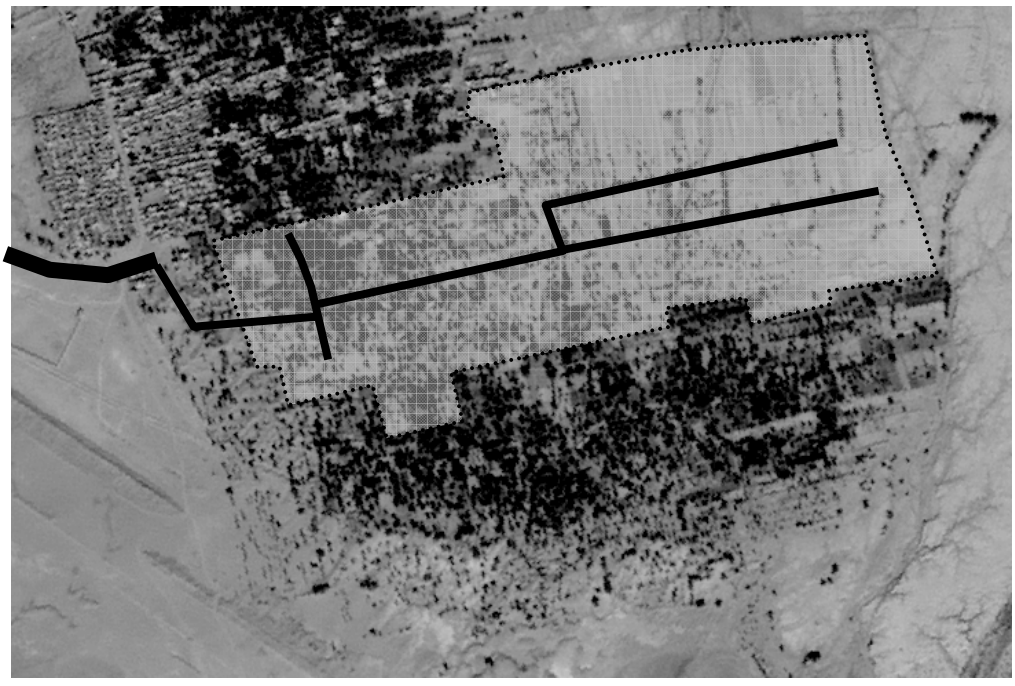
(6) Environment

Natural environment	Water quality	Salt density: slightly high
		Bacillus : oui
	Soil salinity	some
	Desertification control	Yes
Social environment	Khettara water use as drinking water	Yes
	Laundry water treatment	Yes
Environment evaluation results	Components having a strong impact on environment	No

J.4.5 Lagrinia

(1) General data on khettaras and feasibility study prirority areas

1)	Ksar and khettara rural commune	Hannabou / Arab Sbah Ghris
2)	Location	9 km south-east of Jorj and at 10,5 km west of Erfoud
3)	General data	・ Population : 5 130 inhabitants ・ Number of households : 560 ・ Roads : 11 km paved road up to Jorf ・ Drinking water : 6 standpipes installed in 1999 and 2000. ・ Electrical power : Electrification of 98 % of households by ONE, started in the fifties. ・ Télécom : 32 permanent telephone stations. Cellular phone is commonly used. ・ Schools : 1 primary school (11 classes, 110 pupils of which 50 to 60 girls). Almost all the pupils finish the curriculum. Junior and Senior high school are located in Jorf but few girls attend. ・ Health centers : 1 dispensary (one doctor and one nurse). The hospital is in Erfourd. ・ Number of khettaras in ksar : 10
4)	Khettara du projet	・Name : Lagrinia ・ Discharge : 4.9 lit/s（average of Octobre 2003 and Janvier 2004） ・ Farm area : 28.8 ha ・ Khettara irrigated area: 20.1 ha



hydrogéologie et nappes	Topography and Geology	Site locates in the right bank side of the mid- and downstream area of Gheris basin, where Anti Atlas Mountains situate to the western, and also in some kilometer width's plain composed of the clastic sediments from the mountain to Erfoud–Jorf–Tinejdad (or Goulmima) Road where some mountains or hills seriating from Anti Atlas Mountains lie sporadically and rocky table hills locate until Gheris river. Mother well of khettara in Hannabou area locates at the foot of these mountains. Lithological condition around the study site is as follows: Anti Atlas Mountains: Ordovician Bani Sandstone (Limestones and Phosphate at the base) and Cambrian Sandstone (partly Exclusive Rocks, Sandy Argillite and Basaltic Rocks). Hills upto Gheris: Devonian Marl ~ Limestone and Red Sandstone ~ Sandy Limestone. Plio-Quaternary: from lower to upper; Conglomerate (Tensiftien), Silty to Clayey layer and Silty gravel (both are Soltanien). Further, Aeolian sand deposits on ground surface; thickness 2 ~ 3m.
	Result of In Situ Investigation	**Drilling** : location; upstream of khettaras in Hannabou area (N31o27'43'', W004o25'49''), EL826.08m. 0～2m Dune sand (silty sand) 2～6 beige clay (k = 3×10^{-4} cm/sec) 6～16 plastic clay (k = $3\sim4\times10^{-4}$ cm/sec) 16～21 gravel bearing clay (k = 1×10^{-4} cm/sec) 21～30 sand and gravel (k = $4\sim5\times10^{-2}$ cm/sec) 30～38 sandstone (k = $3\sim4\times10^{-2}$ cm/sec) 38～70 argillaceous schist **Borehole Logging**: between the depth 22～28m, aquifer can be found as typical one. Water content portion can not be found in bedrock. **Geoelectrical Prospecting** : two resistivity layers in Sedimentaries (ρ =2～30、150～200Ωm), and few layers in bedrock. All layers are horizontal.
	Hydrogeology	Upper portion of Sedimentaries in the area is composed of clay forming aquitard with thickness around 20m (lowest around 5m is gravel-bearing) (k = $2\sim3\times10^{-4}$cm/sec), except the uppermost dune sand. Typical aquifer composed of sand and gravel with thickness around 10m lies between the upper aquitard and bedrock (k = $4\sim5\times10^{-2}$cm/sec). Piezometric level is higher than this layer , then this is confined. Permeability test shows its coefficient of sandstones in upper bedrock in the order of 10^{-2}cm/sec, however according to the result of borehole logging, any sign as this is aquifer cannot be found. High permeability may be only partial. The aquifer supplying groundwater to khettaras in the area is different from that in Mounkara~Jorf. Probably, this aquifer may not connect to surface water or shallow subsurface water in the area, and may be recharged in the upstream area. That is to say, recharge area is Todrha – Ferkla and Ichim rivers etc in the upstream basin and the upper Gheris river basin.
	Parameters for discharge analysis	Mother Well ~ 1km from outlet: Seepage formation of the upstream k = 5×10^{-2}cm/sec, Storage coefficient 0.092. Piezometric gradient along khettara 1.6/1000. Bottom and Side wall until height 18cm of the downstream k = 1×10^{-5}cm/sec. Side Wall higher than 18cm k = 3.6×10^{-3}cm/sec. 1km from outlet ~ outlet: Bottom and Side wall until height 10cm k = 2.5×10^{-4}cm/sec, Side Wall higher than 10cm k = 3.6×10^{-3}cm/sec.
Khettara	Discharge	Secured discharge 4 lit/sec ～ 6 lit/sec downstream of the khettara Water collecting section： 200 m downstream of the mother well. It increases from 1～2 lit/sec to 1.5～4.0km downstream of the mother well. Leakage zone：Some leakage is observed, even though it is small, downstream of the mother well between 200 and 1300 m due to the mixed soil layer with pebbles. Leakage is relatively low along all the downstream section since the soil is formed of loamy silt :2-3 lit/sec at the far downstream end (see Figure J.4.1(5))
	Khettara extension	Total length ： 6 500 m Existing concrete lining ： 70 m（e0.6m×H1.2m） 405 m（e0.3～0,7m×H0.9m） Existing concrete canals ： 1 900 m（e0.3～0,7m×H0.7m） Non protected section ： 5 400 m (voir Figure J.4.1 (5))

<table>
<tr><td rowspan="4">Water use</td><td>Water use</td><td>Khettara water in Lagriniaia has been use for multi purposes such as drinking and domestic water, livestock water, and irrigation water. Public faucet for drinking and domestic water is installed by foreign donor; however, Khettera water is commonly used as drinking water as well as public faucet. Laundry place is not specified; therefore, laundry is done at the exit of Khettara or somewhere along the irrigation canal. Drinking place for the livestock is not specified as well.

Irrigation water is distributed to the benefit area with 20.1 ha through the open canal network.</td></tr>
<tr><td>Irrigation facilities</td><td>Irrigation network consists of four main canals and a large number of secondary and on-farm canals. One main canal (Canal Principal-1) runs through the center of the benefit area from the exit of Khettara. Other three main canals branch off from Canal Principal-1 to distribute water to the whole benefit area. Canal Principal-1 is the concrete canal with covers for the protection against the desertification at the beginning point, and it is paved with concrete (B=0.50m× H=0.40m) to the point crossing the flood irrigation canal (Seguia La Hmida). Canal Principal-2 is also paved with concrete (B=0.45m×H=0.30m) at the section of 200 m down steram from the crossing point of Seguia LaHmida. The remaining of above mentioned main canals is earthen canal.

Flood water is diverted from Seguia La Hmida to the main canal (Canal Principal-1) during flood.

At the other inlet points, water divertion is managed with stacking up the soil by manpower.

According to the common law, the installation of well pump is prohibited not only near the Khettara but also irrigation area. (see Figure J.4.2 (5):Canal network)
<table>
<tr><th>Regulating basin</th><th>Irrigation canal</th><th>Concrete canal</th><th>Earthen canal</th><th>Total</th></tr>
<tr><td>—</td><td>Main canal</td><td>0.86 km</td><td>0.47 km</td><td>1.33 km</td></tr>
<tr><td>—</td><td>—</td><td>—</td><td>—</td><td>—</td></tr>
</table></td></tr>
<tr><td>Irrigation method and water management</td><td>Irrigation method is the basin irrigation which fills the farmland divided into small plots with water by gravity in turn. Water distribution is managed in rotation by the water use hour for 24 hours whole day and night based on water right.
<table>
<tr><th>Water right holders</th><th>Water use intervak</th><th>Water right sours</th></tr>
<tr><td>92 households</td><td>15 days</td><td>12 hours～30 minutes</td></tr>
</table></td></tr>
<tr><td>Operation and maintenance</td><td>The soil accumulation is observed at the farmlands and the main canals, especially in July to September. Some secondary canals are also affected by the soil accumulation. Maintenance activitise such as eliminating the acumulated soil in the irrigation canal have been conducted once three months. The operatin requires 7 workers per one time.
Individual farmer is responsible for the maintenance of secondary and on farm canals.</td></tr>
<tr><td rowspan="2">Farming and extension</td><td>Soil and farmland utilization</td><td>Soil The rhizosphere is deep and constituted of fine grading river deposits having low salt accumulation.

Fertility It is necessary to watch over the drainage because of salt accumulation. Wind erosion is severe in places.

Utilization Khettara irrigation potential is 28,8 ha of which 44,9 % are abandoned due water deficit and desertification
<table>
<tr><th>Crops (irriguated)</th><th>Fallow (non irrigated)</th><th>Abandoned land</th><th>Total</th></tr>
<tr><td>20.1 ha</td><td>5.2 ha</td><td>3.5 ha</td><td>28.8 ha</td></tr>
<tr><td>(69,9%)</td><td>(18,1%)</td><td>(12,0%)</td><td>(100%)</td></tr>
</table></td></tr>
</table>

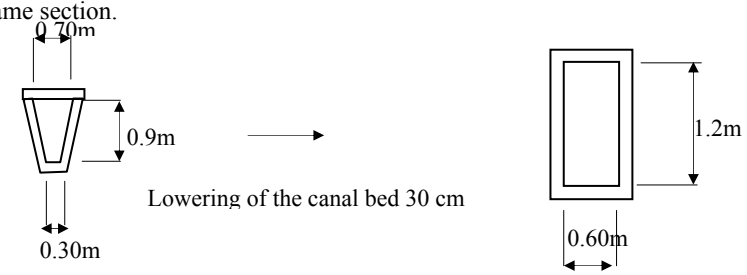
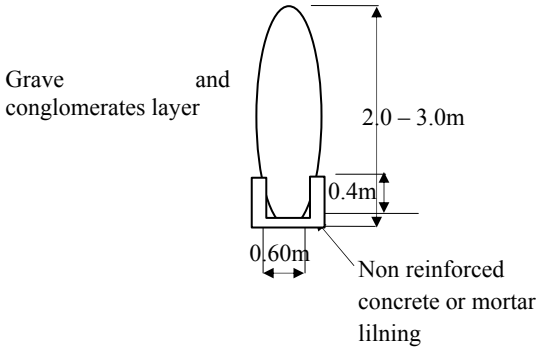
<table>
<tr><td></td><td>Morphology and cropping rate</td><td>
Cropping system See table above and Figure J.4.3 (5/7)
Taux de culture 108 % (irrigated land only without fallow or abandoned land))
Fruit trees
<table>
<tr><td>Date treess</td><td>Olive trees</td><td>Others</td><td>Total</td><td></td></tr>
<tr><td>2.52 ha</td><td>0.14 ha</td><td>0.14 ha</td><td>2.80 ha</td><td></td></tr>
<tr><td>(12.5%)</td><td>(0.7%)</td><td>(0.7%)</td><td>(13.9%)</td><td></td></tr>
<tr><td colspan="5">Crops</td></tr>
<tr><td>Wheat</td><td>Alfa Alfa</td><td>Vegetables</td><td>Others</td><td>Total</td></tr>
<tr><td>11.86 ha</td><td>2.19 ha</td><td>2.61 ha</td><td>0.66 ha</td><td>17.32 ha</td></tr>
<tr><td>(58.9%)</td><td>(10.9%)</td><td>(13.0%)</td><td>(3.3%)</td><td>(86.1%)</td></tr>
</table>
( ) indicates cultivated areas percentage
</td></tr>
<tr><td></td><td>Farming</td><td>
1. More prosperous vegetable crops than in the other areas.
2. Vegetables and AlfaAlfa seeds are purchased in the market, wheat seeds are purchased from ORMVA;
3. Wheat, vegetables and Alfa Alfa are improved using manure and urea. Chimical fertilizers are purchased from private firms. However, the majority of farmers do not use manure on the palm trees. Photosaniyaru products are hardly used.
4. To grow wheat and vegetables, tractors are brought from other areas.
5. Dates, vegetables and alfa alfa are sold to a middleman or in Jorf and markets. Other crops are intended for self consumption.
</td></tr>
<tr><td></td><td>Extension organization</td><td>
Jorf CMVs of ORMVA is in charge of agriultural extrension services. Each CMV covers 22 ksars and employes 11 persons of which:
<table>
<tr><td>Extension agents</td><td>Livestock breeders</td><td>Drivers</td><td>Miscellaneous</td><td>Remarks</td></tr>
<tr><td>1</td><td>2</td><td>2</td><td>5</td><td>2 vehicles</td></tr>
</table>
</td></tr>
<tr><td>Agricultural organizations</td><td>Traditional organizations of water rights owners</td><td>
1. Number of owners : 92 households (total population of farmers’families owners of water rights: 1186 persons）
2. Maintenance activities
Sand removal requires 12 persons in average during 8 days 10 times a year in average.
3. Responsible for the necessary maintenance labor
The required labor for sand removal and simple repair is supplied by the traditional organization.
4. Collecting maintenance expenses
In order to cover equipment supplies necessary to the maintenance works a financial contribution is levied 4 times a year from the water rights owners according to actual needs.
The amounts are fixed each time in accordance of the number of hours alloted by a water right an it is the head of the organization who collects the funds. The rate for 12 hours is 200~300DH. All the water rights owners pay the requested amount.
The collected total contributions amounts to 30 000DH which is intended for maintenance expenses.
A system of joint lease of water rights is carried out in order to collect the necessary funds for maitenance. This system est open two days a year only. One hour water right costs 20 DH which allowed to collect 2000DH a year in average serving to cover the maintenance expenses.
</td></tr>
</table>

	Association on whome tranditional organization depends	1) Name : Association Ghriss (Khettara association) 2) Year of creation : 2001 3) Constituted of traditionnal organizations representants of 8 among the 10 khettaras of Ksar Hannabou. The two others constituted an independant khettara association. 4) Activities : Sharing and finding solutions to khettara problems, fostering awarness of for the necessity of khettara rehabilitation, getting assistance and improving production. 5) Financial contributions : not applied
Agro-economy & Marketing		Additional irrigated land will mainly culitvated in dates palm trees. Additional production will exceed self consumption and may be sold in the market (specially dates). Dates are sold in the nearby market of Jorf and Errachidia or sold to middlemen. Rich farmers may hire trucs and sell their dates harvest in Fez, getting a better benefit than those obtrained localy. Farmers do not institute cooperatives to sell their dates production.

(2) Hindrances' causes

1) Khettara	1) There is a concrete lined section downstream measuring e=0.3 à 0.7 m X H = 0.9 m along 405 m so that the mainteanance is quite impossible to be carried out therein. (in fact silting in observed) 2) The concrete canal is raised of about 0.3 m in comparison with the upstream section,and the khettara foundation bed that existed before concrete lining is used a derivation chanel. 3) Khettara's height i slow along 1000m downstream (0.6～1.0m) and impedes maintenance works. 4) Shafts are clogged along 1.5 km due to desertification which hampers maintenance works. (maintenance is carried out about 3 times a year wherever there is a probem). 6) Shafts opening are not protected. They are surrounded by 1.0~1.5 m circular sand mounds. To enter the khettara request a huge effort.
2) Water use	1) Much water amount filtrates into the underground from the earthen canal, which obstructs the efficient water use. 2) Seepage loss and operation loss at the inlet points obstructs the efficient water use. 3) Big water loss is created due to basin irrigation with low irrigation efficiency.
3) Farming and extension	1) Abandoned land is increasing due water deficit. 2) Lack of knowledge agout water saving technics and vegetable farming. 3) It is necessary to be carefull agout drainage situation because of salinity and the dammagers it may entail
4) Agricultural organizations	1) Traditional organizations supply man power for khettara cleaning and simple operations thereto but they have no financial means de implement major works such as khettara rehabilitation, tunel be lowering and gellery extension which will solve discharge reduction problems. 2) The association has just been created and so it has no experience and knowledge in the field of management. Neither it has ever undertaken any works in cooperation with traditional organizations, and so, the latter do not take it as a meeting and documents exchange point with other outer ogranisations.

(3) Development plan

Khettara rehabilitation	1) Rehabilitation of the 630m downstream concrete canal section (demolition of the canal and a new construction if necessary) and rehabilitation of 1000m along and upstream of the same section.  2) Canal concrete lining between 200 and 1300m downstream of the mother well (1100M section) in order to control leakage of the latyer formed by a soil conglomerates mixture (works done inside tunnel)  See Figure J.4.4 (5)
2) Water use plan	**Rehabilitation of the main canal** 1)Concrete lining of earthen canal Open canal B=0.5m×H=0.4m、L=473m 2)Improvement of inlets Inlets N=45 sites **Application of water saving irrigation techniques** Irrigation area A=2.1 ha

<table>
<tr><td rowspan="5">Farming and extension plan</td><td>Agricultural potential</td><td colspan="4">There is a possibility of increasing the cultivated area by 8.7 ha if irrigation is applied. In addition, more water may be conveyed from khettara Fougania. However, care must be taken to remedy the drainage situation.
Jorf and Erfoud towns, with large populations, are promising markets.</td></tr>
<tr><td>Cropping system and rate of planed crops</td><td colspan="4">Planned crops: See table below and Figure J.4.5 (5/7)
Planed rate: 108 % (irrigated land only, excluding fallow and abandoned land)</td></tr>
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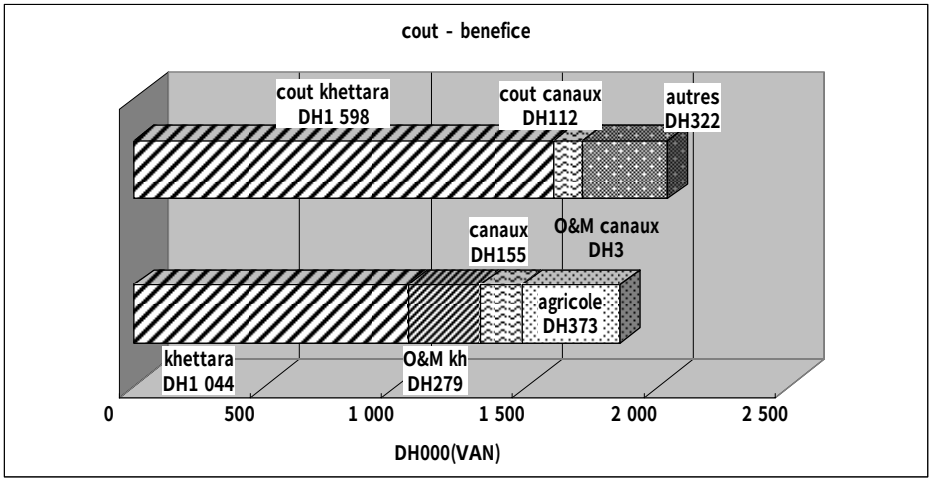
<tr><td>Wheat and cerials</td><td>58.9%</td><td>45.0%</td><td>45.0%</td></tr>
<tr><td>Vegetables (mainly between August and december)</td><td>16.3%</td><td>24.0%</td><td>24.0%</td></tr>
<tr><td>Vegetables et légumineuses (mainly between March and July)</td><td>8.2%</td><td>9.0%</td><td>9.0%</td></tr>
<tr><td>Alfa Alfa and other fodder crops</td><td>10.9%</td><td>20.0%</td><td>8.0%</td></tr>
<tr><td>Dates and other fruits</td><td>13.9%</td><td>11.0%</td><td>22.0%</td></tr>
<tr><td>Total</td><td>108%</td><td>108%</td><td>108%</td></tr>
</table></td></tr>
<tr><td></td><td colspan="4">Combined AlfaAlfa and dates crops after the works (1 to 6 years) but the crops rate calculation does not include Alfa Alfa.</td></tr>
<tr><td>Cropping practices and miscellaneous activities</td><td colspan="4">1. It is desirable to promote a better water utilization through the introduction of water saving irrigation. However, it is necessary to provide for the proper technical supervision through extension services.
2. It is possible to increase vegetables crops intended for Jorf and Erfoud markets using water saving irrigation.
3. It is necessary to introduce date crop farms new species with high market value (Majhol, Faggouss, Khalt).However, since farmers are reluctant to the introduction of new species, it is necessary to plan demontration activities and technicial supervision.
4. Tree crops is highly in demand, but farmers have little experience. In addition, fruit trees do not resist well to draught, so that it is recommanded to cultivate on a small scale</td></tr>
<tr><td colspan="2">Reinforcement plan for maintenance organizations</td><td colspan="4">1) After khettara rehabilitation the maintenance cost and manpower supply will remain the responsability of the traditional organizations.
2) Training (courses, study tours) shall be initiated to supply the association with the administration knowledge in order to set up the administrative structures.
3) The monitoring that will be carried out together by the associations and the traditional organizations will allow to strengthen the ties between them, and will constitute the common ground for the works joint implementation.</td></tr>
</table>

(4) Works cost

Khettara rehabilitation	Concrete canal (1 100 m), installation of a concrete cover (1 250 m) DH 2 020 600 （see Table J.4.1）
2) Water use plan	Lining of the earthen canal：145,580DH Improvement of the inlets：5,400DH （see Table J.4.1）
Reinforcement plan for maintenance organizations	1) Maintenance charges : 32 600 DH/an (Water rights charges and their collecting like it was done in the past) 2) Organizations reinforcement cost : ・Year of works startup : 47 500 DH (Trainning and monitoring cost). ・Second year and following year : 4 000/year (Monitoring cost)

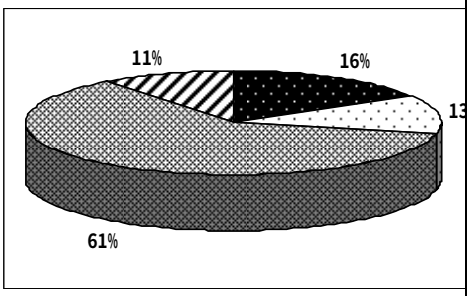
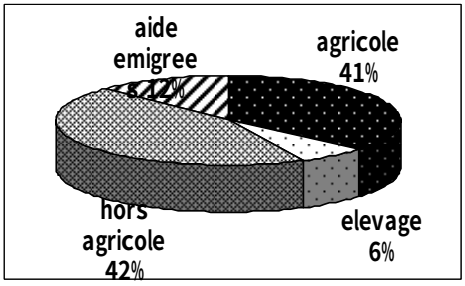
(5) Project Evaluation

Economic evaluation	Without project: irrigated area by khettara will decrease from 10.9ha (present, from khettara discharge) to8,5ha(2014), causing drop in revenue from agriculture.	With project: increase of irrigated area by 8.9ha (to total of 19.8ha) through khettara and canals rehabilitation. Improved agriculture practices (extension and water management) will increase the net income by DH18,800/ha (economic terms).



B= DH 1,164,000 C= DH 1,749,000 B/C= 0,7 (NPV, discount rate 10%); **EIRR=6.5%**

Due to big khattara rehabilitation length (2,350m) contributes to the big share in the benefit. The EIRR is relatively low due to those intensive rehabilitation works. Farmers show considerable entrepreneurship – and would be eager to further rehabilitate/maintain khettara by own efforts, provided availability of equipment (compressor).

Financial Evaluation	Present:  Present income from agriculture: DH6,230, for standard farm of 0,8ha. Farm budget is shown in Table J.4.2	With project:  Income from agriculture: DH16,680, for standard farm of 1,03ha. The additional income (DH10,450) and decrease in O&M works gives possibility to develop agriculture practices/other activities. The project increases the share of income from agriculture to 41% of average family budget.

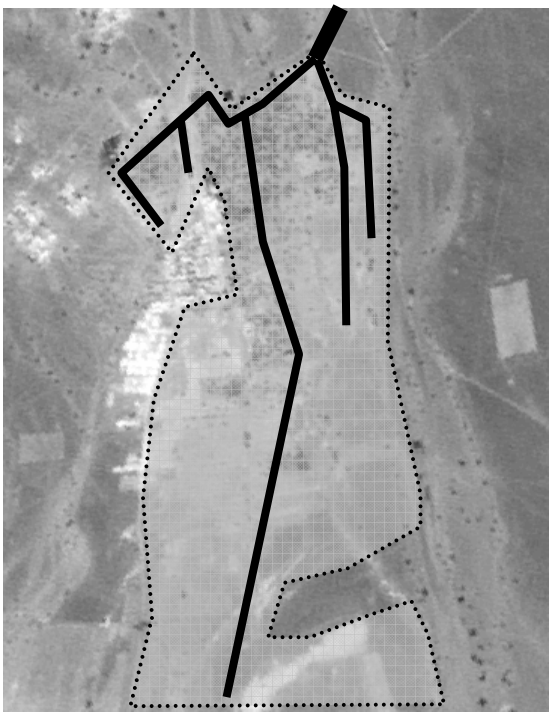
(6) Environment

Natural environment	Water quality	Salt density: Slightly high
		Bacillus : oui
	Soil salinity	Some
	Desertification control	Yes
Social environment	Khettara water use as drinking water	Yes
	Laundry water treatment	No
Environment evaluation results	Components having a strong impact on environment	No

J.4.6 Timarzite

(1) General data on khettaras and feasibility study prirority areas

1) Ksar and khettara rural commune	Timarzit / Alnif
2) Location	20,5 km north east of Alnif
3) General data	・ Population : 782 inhabitants ・ Number of households : 52 ・ Roads : 23 km up to Alnif of which 21,5 paved road and 1,5 km unpaved road. ・ Drinking water : Water conveyance to all households implemented through Luxemburg cooperation program started in 2000. ・ Power : 1 generator supplies all the homes during 5 hours after dark. 6 families have solar panels. ・ Télécom : There no permanent telephone stations. Though there is no network, cellular phones are numerous. ・ Schools : 1 primary school having 3 classes and 160 pupils of which 60 are girls. Nearly all the pupils finish their curriculum. High school is in Alnif. At the present time, 15 boys attend high scholl and no girls do. ・ Health centers : none (the nearest is in Alnif) ・ Number of khettaras in the ksar : 1
4) Project Khettara	・ Name : Timarzit ・ Discharge : 2.2 lit/s （moyenne d'octobre 2003 et janvier 2004） ・ Farm area : 82.1 ha ・ Irrigated area: 13.9 ha



hydrogéologie et nappes	Topography and Geology	Khettara Timarzit locates few kilometers west of Taomart area, and basement rock distribution is same. Jbel Ougnate mass is in northern side and two small mountain ranges seriating from Jbel Gaiz is in southern side orienting E-W or ENE-WSW. Ksar Timarzit locates in between of these two small mountain ranges on Asif n'Timarzit which flows from Jbel Ougnate through the one gorge of northern small mountain range. Khettara Timarzite is in line from Ksar toward Jbel Ougnate through the gorge. Bedding of rock basement composing two small mountain ranges, which is Ordovician Quartzite, Sandstone and Mudstone but partly Devonian Limestone etc., is striking E-W or ENE-WSW and dipping to north. In the gorge and valleys, gravelly alluviums burying on bedrock deposit relatively thickly with ten and several meters at some parts. Upper few meters of this deposit consist of recent sand and gravel, and lower portion is semi-consolidated subrecent sand and gravel.
	Hydrogeology	Khettara Timarzit is in line basically on Asif n'Timarzit and dug through river deposits. Topographically, this river catches all surface and subsoil water on the area between Jbel Ougnate and northern small mountain range, and main aquifer is in river deposits or valley deposits. Recent alluviums in upper portion of this deposits collect recharged water just after rainfall, while in subrecent alluviums in lower portion exists groundwater recharged with a little longer elapsed time so that groundwater may supply from this portion even during no rainfall. The upstream of khettara Timarzit is dug through these subrecent deposits. Further in fissures of bedrock that is the same Argillaceous Schist (Partly Psammytic Schist) as Taomart area, some artesian groundwater exists and recharge to aquifers in Sedimentaries. At present, Mother Well is on extended to upstream side to collect the water existing in these fissures of bedrock.
Khettara	Discharge	2 lit/sec to 3 lit/sec secured discharge at the far downstream section of the khettara. Water collecting section ： Near the mother well Leakage zone ：Leakage is observed in the soil-pebbles layer throughout a section downstream of the mother well between 200 and 1300m but it does exceed 1 lit/sec. Downstream this section, practically all the khettara contains silt deposits making leakage very low. (see Figure J.4.1(6))
	Khettara extension	Total length ： 2 100 m Existing concrete lining ： 290 m（e0.6m×H1.5m） Non protected section ： 1,810 m (see Figure J.4.1(6))

<table>
<tr><td rowspan="4">Water use</td><td>Water use</td><td>Khettara water in Timarzite has been use for livestock water and irrigation water. For drinking and domestic water use, people in the village use water being supplied to the individual households with the system which were provided in 2000 by foreign donor. Drinking place for the livestock is not specified in the canal network of Khettra Taoumart.

Irrigation water is distributed to the benefit area with 13.9 ha through the open canal network.</td></tr>
<tr><td>Irrigation facilities</td><td>As a countermeasure for decreasing Khettara water discharge, the regulating basin was constructed at the exit of Khettara. To reduce water loss and convey water as much as possible to the farmland, the water stored during half hours of water use time zone is distributed by the remaining half water use hours. The time for storing water at the regulating basin in winter is longer than one in summer.

Irrigation canal network consists of four main canals branching off just ater the downstream of the regulating basin and a large number of secondary and on-farm canals. The main canals were so far rehabilitated to the concrete canal (B=0.40 m×H=0.20 to 0.35 m) by ORMVA.

The longest main canal running through the center of the benefit area, receives supplimental water which is supplied with the pump equipped in well at the down stream; namely, the end point of the Khettara irrigation area is recognized to be this pumping station

Water divertion is managed with stacking up the soil by manpower.

According to the common law, the installation of well pump is prohibited near the Khettara. The installation of well pump is not prohibited in the irrigation area; therefore, 18 private pumping stations are installed at present.

(see Figure J.4.2 (6):Canal network)
<table>
<tr><th>Regulating basin</th><th>Irrigation canal</th><th>Concrete canal</th><th>Earthen canal</th><th>Total</th></tr>
<tr><td>16 m×16 m×0.9 m</td><td>Main canal</td><td>0.70 km</td><td>—</td><td>0.70 km</td></tr>
<tr><td>230 m^3</td><td>—</td><td>—</td><td>—</td><td>—</td></tr>
</table></td></tr>
<tr><td>Irrigation method and water management</td><td>Irrigation method is the basin irrigation which fills the farmland divided into small plots with water by gravity in turn. Water distribution is managed in rotation by the water use hour for 24 hours whole day and night based on water right.
<table>
<tr><th>Water right holders</th><th>Water use intervak</th><th>Water right sours</th></tr>
<tr><td>64 households</td><td>7 days (May to October)
12 days (November to April)</td><td>24 hours to 5 hours</td></tr>
</table></td></tr>
<tr><td>Operation and maintenance</td><td>Maintenance activitise have been conducted to eliminating the acumulated soil in the main and secondary canals at the rate of four times a year. 12 paticipants a day joint in joint operation. For two days.

Water right holder has the obligation to provide one worker per 6 water right hours.</td></tr>
<tr><td>Farming and extension</td><td>Soi and farm land utilization</td><td>Soil — the rhizosphere is deep and constituted of alluvium deposits of fine grading and mixed with gravel.

Fertility — It is necessary to remove the gravel. Water holding capacity i slow and soil improved usign manure should be provided for.

Utilization — Khettara irrigation capacity is 82,1 ha of which 42,19 % are abandoned due irrigation water deficit.</td></tr>
</table>

		Crops (irrigated)	Fallow (non irrigated)	Abandoned land	Total	
		13.9 ha	33.6 ha	34.6 ha	82.1 ha	
		(16.9%)	(41.1%)	(42.1%)	(100%)	
	Morphology and cropping rate	Cropping system : See table above and Figure J.4.3 (6/7) Cropping rate 107 % (Only of irrigated land excluding fallow and abandoned land) Tree farming				
		Date treess	Olive trees	Others	Total	
		1.61 ha	0.07 ha	0.36 ha	2.04 ha	
		(11,6%)	(0,5%)	(2,6%)	(14,7%)	
		Crops				
		Wheat	Alfa Alfa	Vegetables	Others	Total
		9.10 ha	0.82 ha	1.60 ha	0.34 ha	11.86 ha
		(65.5%)	(5.9%)	(11.5%)	(2.4%)	(85.3%)
		( ) indicates cultivated areas percentage				
	Farming	1. Pumping irrigation and prosperous vegetables farming. Cumin and henna are cultivated under contract agreement. 2. Vegetables and Alfa Alfa seeds are purchased in the market and wheat one are purchased at the ORMVA; 3. Wheat, vegetables, Alfa Alfa, cumin and henna are improved using manure and urea. Also, phytosanitary products anre applied to cumin and henna crops. 4. Cultivation of wheat and vegetables requires the use of tractors hired outside the area. 5. Cumin and henna cultivated under contract agreements are purchased by middlemen (the latter supply the seeds and the fertilizers out of charge). Dates, vegetables and Alfa Alfa are sold to middlemen or in Alnif market. Other products are fully intended for self consumption.				
	Extension organization	Jorf CMVs of ORMVA are in charge of agricultural extension services. Each CMV covers 22 ksars employing 4 persons, of which :				
		Extension agents	Livestock breeders	Drivers	Miscellaneous	Remarks
		1	1	1	1	1 vehicle

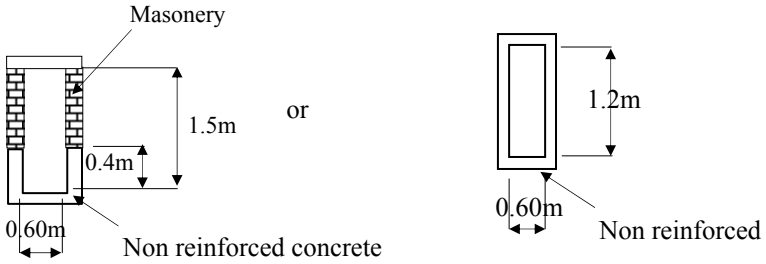
Agricultural organizations	Traditional organizations of water rights owners	5. 1) Number of owners : 64 households (total population of farmers'families owners of water rights: 818 persons） 6. Maintenance activities Sand removal requires 12 persons in average during 24days 2 times a year in average. 7. Responsible for the necessary maintenance labor The required labor for sand removal and simple repair is supplied by the traditional organization. 8. Collecting maintenance expenses In order to cover equipment supplies necessary to the maintenance works a financial contribution is levied 4 times a year from the water rights owners according to actual needs. The amounts are fixed each time in accordance of the number of hours alloted by a water right an it is the head of the organization who collects the funds. The rate for 6 hours is 100~500DH. All the water rights owners pay the requested amount. The collected total contributions amounts to 14 400DH which is intended for maintenance expenses. A system of joint lease of water rights is carried out in order to collect the necessary funds for maitenance. This system is operated one day a year and during 12 hours only. One hour water right costs 250 DH which allowed to collect 3000DH a year in average serving to cover the maintenance expenses.
	Association on whome tranditional organization depends	1) Name : Association Timarzite (Agricultural development association) 2) Year of creation : 2003 3) Organization : created in order to speed up Timarzite ksar agricultural development, it also undertakes the maintenance of the ksar khettara. 4) Activities : Helps in khettara maintenance and repair works, trainning, environment activities, rural developmen plan (as a spokesperson of the ksar to the outer organizations) 5) Financial contributions : do not apply
Agro-economy & Marketing		Additional irrigated areas are cultivated with vegetables (for self consumption and sale), henna and cumin are sold. The products are sold in the nearest market (Alnif) or to middlemen. Access to Alnif market is difficult (unpaved roads).

(2) Hindrances' causes

1) Khettara	1) Downstream of the mother well the section is narrow because the khettara crosses the river, (e0.9～1.1m×H1.2～1.4m） which impeded maintenance works. 2) The khettara is submerged by floods once every ten years or less. 3) Upstream of the khettara, there a schist layer so that khettara extension may not increase water volume.
2) Water use	1) Seepage loss and operation loss at the inlet points obstructs the efficient water use. 2) Big water loss is created due to basin irrigation with low irrigation efficiency.

3) Farming and extension	1) Land intensive desertion because of water volume reduction and desertification 2) Lack of water saving and crop varieties knowledge 3) CMV staff in charge of extension activities are few in comparison with other ksars.
4) Agricultural organizations	1) Traditional organizations supply man power for khettara cleaning and simple operations thereto but they have no financial means de implement major works such as khettara rehabilitation, tunel be lowering and gellery extension which will solve discharge reduction problems. 2) The association has just been created and so it has no experience and knowledge in the field of management. 3) Created to support traditional organizations, trust is actually is strongly established. However, due to lack of information, it is not able to find the proper solutions to the ksar inner problems.

(3) Development plan

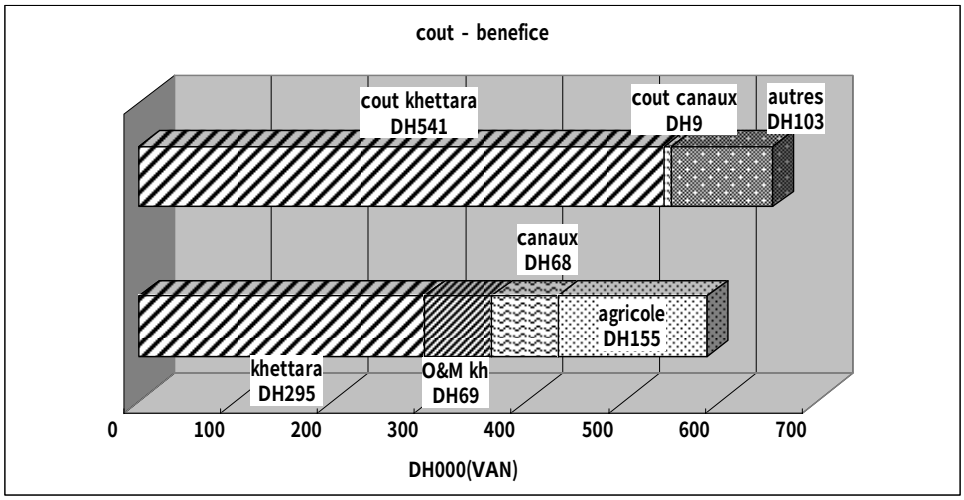
Khettara rehabilitation	1) Rehabilitation intended to reduce flood damages (opencast excavation)  See Figure J.4.4 (6)
2) Water use plan	**Rehabilitation of the main canal** 1)Concrete lining of earthen canal - 2)Improvement of inlets Inlets N=70 sites **Application of water saving irrigation techniques** Irrigation area A=0.9 ha

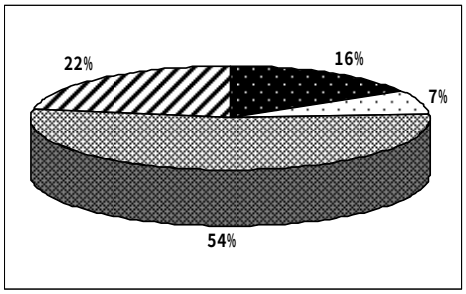
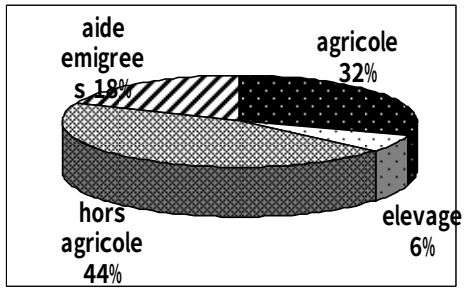
<table>
<tr><td rowspan="4">Farming and extension plan</td><td>Agricultural potential</td><td colspan="4">It is possible to increase the cultivate area by 68.2 ha if irrigation is implemented. Henna and cumin crops, which are prosperous, become the region speciality.</td></tr>
<tr><td>Cropping system and rate of planed crops</td><td colspan="4">Planned crops: See table below and Figure J.4.5 (6/7)
Planed rate: 107 % (irrigated land only, excluding fallow and abandoned land)</td></tr>
<tr><td colspan="4"><table>
<tr><td rowspan="2">Crops</td><td rowspan="2">Present</td><td colspan="2">After implementation</td></tr>
<tr><td>1 to 6 years</td><td>7 to 30 years</td></tr>
<tr><td>Wheat and cereals</td><td>65.5%</td><td>51.0%</td><td>51.0%</td></tr>
<tr><td>Vegetables (August to september)</td><td>13.9%</td><td>22.0%</td><td>22.0%</td></tr>
<tr><td>Vegetables and legumes (March to July)</td><td>7.0%</td><td>7.0%</td><td>7.0%</td></tr>
<tr><td>Alfa Alfa and other fodder crops</td><td>5.9%</td><td>16.0%</td><td>5.0%</td></tr>
<tr><td>Dates and other fruit trees</td><td>14.7%</td><td>11.0%</td><td>23.0%</td></tr>
<tr><td>Total</td><td>107%</td><td>107%</td><td>107%</td></tr>
</table></td></tr>
<tr><td colspan="4">Combined AlfaAlfa and dates crops after the works (1 to 6 years) but the crops rate calculation does not include Alfa Alfa.</td></tr>
<tr><td>Cropping practices and miscellaneous activities</td><td colspan="4">1. Water saving irrigation will be efficient for a better water resources utilization. This will require the proper technical supervision through extension services.
2. Water saving irrigation will allow to expand vegetables, cumin and henna cultivation.
3. It is important to check manure and fertilizers and remove the stones from the farm land.
4. Tree crops are much in demand, but the farmers have little experience and trees resist badly to draught, to the point that it is recommended to cultivate them on a small scale.</td></tr>
<tr><td colspan="2">4) Reinforcement plan for maintenance organizations</td><td colspan="4">1. After khettara rehabilitation the maintenance cost and manpower supply will remain the responsability of the traditional organizations.
2. Training (courses, study tours) shall be initiated to supply the association with the administration knowledge in order to set up the administrative structures.
3. The monitoring that will be carried out together by the associations and the traditional organizations will allow to strengthen the ties between them, and will constitute the common ground for the works' joint implementation.</td></tr>
</table>

(4) Works' cost

Khettara rehabilitation	Installation of a concrete cover (580 m) DH 684 400 (see Table J.4.1)
2) Water use plan	Lining of the earthen canal：- Improvement of the inlets：11,903DH (see Table J.4.1)
Reinforcement plan for maintenance organizations	1) Managaement expenses : 17 400 DH/year (Water rights expenses and funds collecting as in the past) 2) Organizations reinforcement cost : ・Year of works startup: 47 500 DH (Training and monitoring cost). ・ 2nd and following years : 4 000/year (monitoring cost)

(5) Project Evaluation

Economic evaluation	Without project: irrigated area by khettara will decrease from 6,0ha (present, from khettara discharge) to 4,6ha (2014), causing drop in revenue from agriculture.	With project: increase of irrigated area by 2,7ha (to total of 8,7ha) through khettara and canals rehabilitation. Improved agriculture practices (extension and water management) will increase the net income by DH15,200/ha (economic terms).
	 B= DH 323,000 C= DH 584,000 B/C=0.6 (NPV, discount rate 10%); **EIRR= 5.1%** Khettara rehabilitation brings considerable costs – (concrete culvert relatively costly; comparing to Jdida, the same benefit – similar rehabilitation length and initial discharge – but double cost). The big value added plantations (cumin and henna) give good prospects for the use of additional irrigated area. Some of the aspects hampering further development are access to markets and lack of land certificates (no access to credit/subsidy).	

Financial Evaluation	Present:  Present income from agriculture: DH4,450, for standard farm of 0.8ha. Farm budget is shown in Table J.4.2	With project:  Income from agriculture: DH15,010, for standard farm of 1.03ha. The additional income (DH10,560) and decrease in O&M works gives possibility to develop agriculture practices/other activities. The project increases the share of income from agriculture to 32% of average family budget.

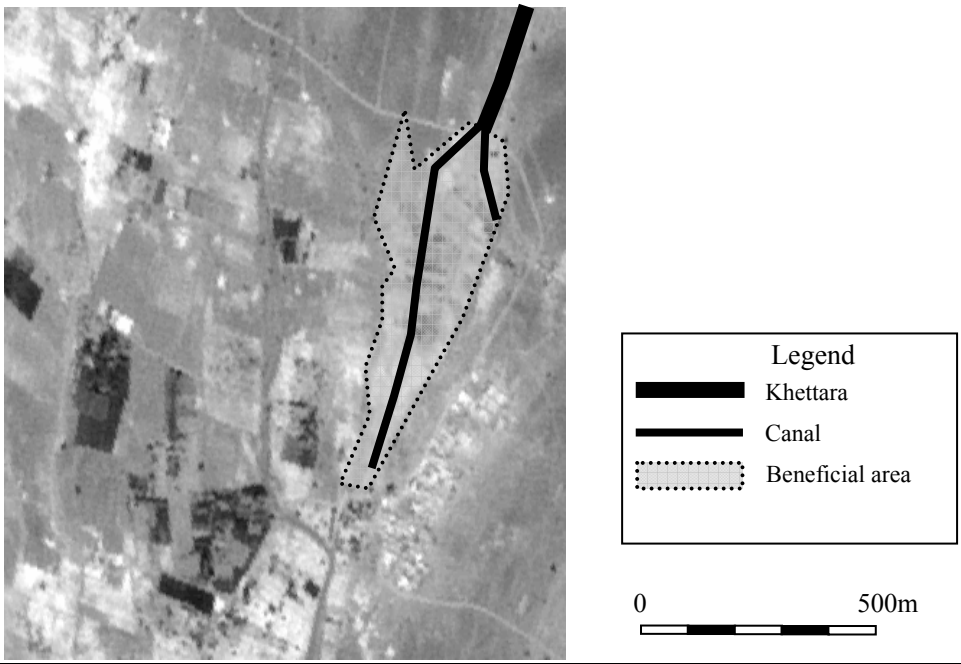
(6) Environment

Natural environment	Water quality	Salt density: meets irrigation requirements
		Bacillus : oui
	Soil salinity	No
	Desertification control	No
Social environment	Khettara water use as drinking water	Some
	Laundry water treatment	Yes
Environment evaluation results	Components having a strong impact on environment	No

J.4.7 Taoumart

(1) General data on khettaras and feasibility study prirority areas

1) Ksar and khettara rural commune	Taoumart / Alnif
2) Location	14,5 km north-east of Alnif
3) General data	• Population : 800 inhabitants • Number of houholds : 75 • Roads : About 19 km from Alnif of which 12 are paved and 17 km are not. • Drinking water : Supply made with the cooperation of Luxemburg and finilized in January 2004. • Power : 1 generator supplies all the households. Power is supplied 3 hours after sun set (the generator is managed by tranditional organization). 6 households have solar panels. • Télécom : There is no permanent telephone stations. Cellular phones are of common use. • School : 1 primary school (4 classes, about 150 pupils of which 50 girls). All the pupils finish the curriculum. High schools are located in Alnif and Tinghir (At the present time 16 children attend of which one girl). • Health centers : none (one ought to go to Alnif) • Number of khettaras in the ksar : 2
4) Project Khettara	• Name : Jadida Taoumart • Discharge : 3.1 lit/s （janvier 2004） • Farm land area : 11.2 ha • Irrigated area : 4.3 ha



hydrogéologie et nappes	Topography and Geology	Khettara Taomart locates between Jbel Ougnate to northeast and Jbel Gaiz to southwest in Anti Atlas Mountains. Asif Tinifiifit flows on the valley between these mountains poured by Asif Bou as tributary from the side of Jbel Ougnate. The khettara is in line on Asif Bou. Jbel Ougnate is the main portion of eastern side of Anti Atlas and composed mainly of such Igneous rocks as Rhyolite (partly Granite), Gabbro, Andesite of Precambrian and so on. And, Taomart side of the mountain is mainly of NW-SE orienting bedded Red Sandstone or Conglomerate, Green Psammytic Schist of Cambrian. While, Jbel Gaiz is of Quartzite, Sandstone and Mudstone of Ordovician. Asif Tinifiifit forming straight lineament is tectonic (faults) valley between Jbel Ougnate Precambrian to Cambrian massif and Jbel Gaiz Ordovician massif. This tectonic valley curves gradually and orients NE-SW in eastern side. Gravelly alluviums bury these valleys but their thickness is relatively thin. The basement rocks forming valleys is generally such weak rock mass as Mudstone or Argillaceous Schistes or Sheared zones.
	Hydrogeology	There are two khettaras as Khettaras Taomart, that is the new and the old. One is basically in Sedimentaries and the other is in bedrock (Argillaceous Schistes, partly Alternation with Psammytic Schistes). Sheared zone exists along the foot of upstream mountainside in this bedrock. Along the sheared zone, bedrocks are graphitized and fissured. Groundwater exists in these fissures. This groundwater is in more artesian condition, if existing deeper position. When drilled into this sheared zone, some small volume of groundwater springs out as the artesian. Groundwater in Sedimentaries exists only after rainfall, while groundwater in fissures of bedrock exists perennially but its volume is not much.
Khettara	Discharge	The secured discharge at the far downstream area is 2 lit sec to 3 lit sec. Water collecting section： Section at 300 m down stream of mother well. Leakage area ： at the cracks along 300 ~600m section donwstreamof the mother well 1to 2lit/sec leakage is observed. See Figure J.4.1 (7)
	Khettara extension	Total length ： 600 m Protected section ： 600 m (open cast excavation throughout the whole length) See Figure J.4.1 (7)

<table>
<tr><td rowspan="4">Water use</td><td>Water use</td><td>Khettara water in Taoumart has been use for multi purposes such as laundry water, livestock water, and irrigation water. For drinking and domestic water use, people in the village use water being supplied to the individual households with the system which were provided in January 2004 by foreign donor. No facility is installed at the irrigation canal for the laundry. Laundry has been done near the exsit of the regulating basin. Drinking place for the livestock is not specified in the canal network of Khettra Taoumart.

Irrigation water is distributed to the benefit area with 4.3 ha through the open canal network.</td></tr>
<tr><td>Irrigation facilities</td><td>As a countermeasure for decreasing Khettara water discharge, the regulating basin was constructed at the exit of Khettara. To reduce water loss and convey water as much as possible to the farmland, the water stored during half hours of water use time zone is distributed by the remaining half water use hours.

Irrigation canal network consists of three main canals and a large number of secondary and on-farm canals. The main canals were so far rehabilitated to the concrete canal (B=0.35m×H=0.20 m) by ORMVA.

The longest main canal running through the center of the benefit area, connectes to the regulating basin of another Khettara Kadima Taoumart at the end. When Khettara Jdida Taoumart has sufficient water, water of Khettara Jdida Taoumart is poured into the the regulating basin of Khettara Kadima Taoumart to enhance mutual water use among one village.

Water divertion is managed with stacking up the soil by manpower.

According to the common law, the installation of well pump is prohibited near the Khettara. The installation of well pump is not prohibited in the irrigation area; however, no private pumping station is installed at present.

(see Figure J.4.2 (7):Canal network)
<table>
<tr><th>Regulating basin</th><th>Irrigation canal</th><th>Concrete canal</th><th>Earthen canal</th><th>Total</th></tr>
<tr><td>8m×15m×0.5m</td><td>Main canal</td><td>0.50km</td><td>－</td><td>0.50km</td></tr>
<tr><td>60m^3</td><td>－</td><td>－</td><td>－</td><td>－</td></tr>
</table></td></tr>
<tr><td>Irrigation method and water management</td><td>Irrigation method is the basin irrigation which fills the farmland divided into small plots with water by gravity in turn. Water distribution is managed in rotation by the water use hour for 24 hours whole day and night based on water right.
<table>
<tr><th>Water right holders</th><th>Water use intervak</th><th>Water right sours</th></tr>
<tr><td>52 households</td><td>9 days</td><td>24 hours～2.5 hours</td></tr>
</table></td></tr>
<tr><td>Operation and maintenance</td><td>Maintenance activitise have been conducted to eliminating the acumulated soil in the main and secondary canals at the rate of two to four times a year. 18 workers a day paticipates the joint operation for one day or two days.

Water right holder has the obligation to provide one worker per 12 water right hours.</td></tr>
<tr><td>Farming and extension</td><td>Soil and farm land utilization</td><td>Soil　the rhizosphere in not thick an dis constituted of medium grading river alluvium mixed with gravel.

Fertility　It is necessary ot remove the gravel that is mixed with soil.

Utilization　Khettara irrigation possibilities are 11.2 ha of which 27.9 are abandoned for lack of irrigation water.
<table>
<tr><th>Crops (irrigated)</th><th>Fallow (non irrigated)</th><th>Abandoned land</th><th>Total</th></tr>
<tr><td>4.3 ha</td><td>3.8 ha</td><td>3.1 ha</td><td>11.2 ha</td></tr>
<tr><td>(38,0%)</td><td>(34,1%)</td><td>(27,9%)</td><td>(100%)</td></tr>
</table></td></tr>
</table>

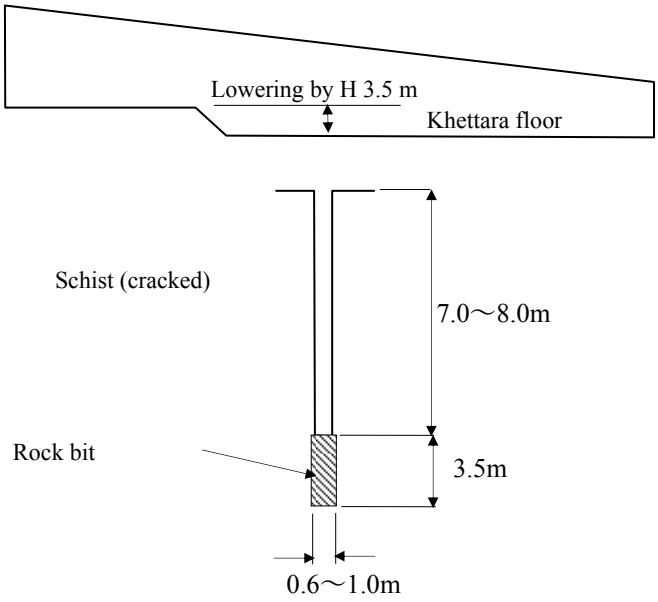
<table>
<tr><td rowspan="11"></td><td>Morphology and cropping rate</td><td colspan="5">Cropping system : See table above and Figure J.4.3 (7/7)
Cropping rate 105 % (Only of irrigated land excluding fallow and abandoned land)
Tree farming</td></tr>
<tr><td></td><td>Date treess</td><td>Olive trees</td><td>Others</td><td>Total</td><td></td></tr>
<tr><td></td><td>0.45 ha</td><td>0.01 ha</td><td>0.09 ha</td><td>0.55 ha</td><td></td></tr>
<tr><td></td><td>(10.5%)</td><td>(0.2%)</td><td>(2.1%)</td><td>(12.9%)</td><td></td></tr>
<tr><td></td><td colspan="5">Crops</td></tr>
<tr><td></td><td>Wheat</td><td>Alfa Alfa</td><td>Vegetables</td><td>Others</td><td>Total</td></tr>
<tr><td></td><td>3,27 ha</td><td>0,07 ha</td><td>0,15 ha</td><td>0.23 ha</td><td>3.72 ha</td></tr>
<tr><td></td><td>(76.6%)</td><td>(1.6%)</td><td>(3.5%)</td><td>(5.4%)</td><td>(87.1%)</td></tr>
<tr><td></td><td colspan="5">( ) indicates cultivated areas percentage</td></tr>
<tr><td>Farming</td><td colspan="5">1. Pumping irrigation and prosperous vegetables farming. Cumin and henna are cultivated under contract agreement.
2. Vegetables and Alfa Alfa seeds are purchased in the market and wheat one are purchased at the ORMVA;
3. Wheat, vegetables, Alfa Alfa, cumin and henna are improved using manure and urea. Also, phytosanitary products anre applied to cumin and henna crops.
4. Cultivation of wheat and vegetables requires the use of tractors hired outside the area.
5. Cumin and henna cultivated under contract agreements are purchased by middlemen (the latter supply the seeds and the fertilizers out of charge). Dates, vegetables and Alfa Alfa are sold to middlemen or in Alnif market. Other products are fully intended for self consumption.</td></tr>
<tr><td>Extention organization</td><td colspan="5">Jorf CMVs of ORMVA are in charge of agricultural extension services. Each CMV covers 22 ksars employing 4 persons, of which :</td></tr>
<tr><td></td><td>Extension agents</td><td>Livestock breeders</td><td>Drivers</td><td>Miscellaneous</td><td>Remarks</td></tr>
<tr><td></td><td>1</td><td>1</td><td>1</td><td>1</td><td>1 vehicle</td></tr>
<tr><td rowspan="2">Agricultural organizations</td><td>Traditional organizations of water rights owners</td><td colspan="5">1. Number of owners : 52 households (total population of farmers’families owner of water rights: 830 persons）
2. Maintenance activities
Sand removal requires 18 persons in average during 3 days 3 times a year.
3. Responsible for the necessary maintenance labor
The required labor for sand removal and simple repair is supplied by the traditional organization.
4. Collecting maintenance expenses
In order to cover equipment supplies necessary to the maintenance works a financial contribution is levied two times a year from the water rights owners according to actual needs.
The amount is fixed each time according to the alloted number of hours to the water right, and the head of the organization who collects the funds. The rate of 6 hours water right is about 50~500 DH. All water rights owners pay the required amount;
The total collected contribution amounts to DH19 800, which is allocated for maintenance expenses.
There is no water rights lease system that may allow funds collection.</td></tr>
</table>

	Association on whome tranditional organizations depend	1) Name : Association Agdal Taoumart (Agricultural development association agricole) 2) Creation year: 2003 3) Organization : constituted to speed up the ksar Agdal Taoumart agricultural development, also, it undertakes the maintenance of the 2 ksar khettaras. 4) Activities : development action organization (khettaras repair, roads, environment). 5) Financial contributions : do not apply
Agro-economy & Marketing		Additional irrigated areas will be cultivated with vegetables (for self consumption while now supplies come from the market), henna and cumin for sale. The ksar is supplied by 4 middlmen who sell as well inputs for henna and cumin et undertake the products sale. Otherwise, access to the nearest market (Alnif) is difficult (unpaved road, 19 km). Farmers rely more on their own inputs and labor and resort to a lesser extent to the market.

(2) Hindrances' causes

1) Khettara	1) Water catchment is low due to the fact that the khettara is located in cracked schist zone. 2) The khettara upstream section is elevated by 3.5m above the khettara foundation so that water collecting is slow.
2) Water use	1) Seepage loss and operation loss at the inlet points obstructs the efficient water use. 2) Big water loss is created due to basin irrigation with low irrigation efficiency.
3) Farming and extension	1) Land intensive desertion because of water volume reduction and desertification 2) Lack of water saving knowledge 3) CMV staff in charge of extension activities are few in comparison with other ksars.
4) Agricultural organizations	1) Traditional organizations supply man power for khettara cleaning and simple operations thereto but they have no financial means de implement major works such as khettara rehabilitation, tunel be lowering and gellery extension which will solve discharge reduction problems. 2) The association has just been created and so it has no experience and knowledge in the field of management. Neither it has ever undertaken any works in cooperation with traditional organizations, and so, the latter do not take it as a meeting and documents exchange point with other outer ogranisations.

(3) Development plan

<table>
<tr><td>Khettara</td><td colspan="4">1)Excavation of the khettara foundation to fetch the water from the bedrock cracks (opencast excavation)
It is possible to excavate the schist layer that forms the bedrock (pneumatic drill or concrete braker)
 

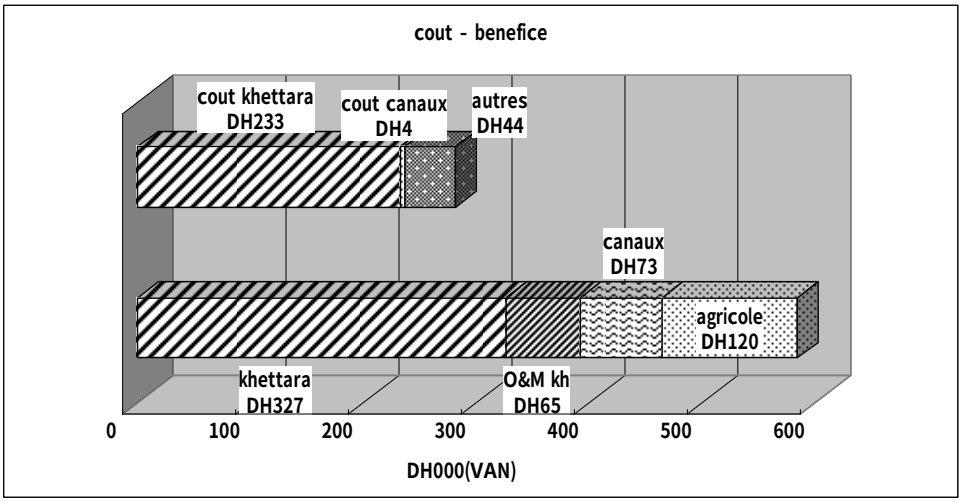
See Figure J.4.4 (7)</td></tr>
<tr><td>2) Water use plan</td><td colspan="4">Rehabilitation of the main canal
1)Concrete lining of earthen canal
-
2)Improvement of inlets
Inlets N=32 sites
Application of water saving irrigation techniques
Irrigation area A=1.2 ha</td></tr>
<tr><td rowspan="3">Farming and extension plan</td><td>Agricultural potential</td><td colspan="4">There a possibility of increasing the cultivated by 6,9 ha if irrigation is used. Henna and cumin crops will become the region’s speciality.</td></tr>
<tr><td>Cropping system and rate of planed crops</td><td colspan="4">Planned crops See table below and Figure J.4.5 (7/7)
Planed rate 105 % (irrigated land only, excluding fallow and abandoned land)</td></tr>
<tr><td colspan="2"><table>
<tr><td rowspan="2">Crops</td><td rowspan="2">Present</td><td colspan="2">After implementation</td></tr>
<tr><td>1 to 6 years</td><td>7to 30 years</td></tr>
<tr><td>Wheat and cereals</td><td>76.6%</td><td>59.0%</td><td>59.0%</td></tr>
<tr><td>Vegetables (August to september)</td><td>8.9%</td><td>18.0%</td><td>18.0%</td></tr>
<tr><td>Vegetables and legumes (March to July)</td><td>4.5%</td><td>5.0%</td><td>5.0%</td></tr>
<tr><td>Alfa Alfa and other fodder crops</td><td>1.6%</td><td>13.0%</td><td>1.0%</td></tr>
<tr><td>Dates and other fruit trees</td><td>12.9%</td><td>10.0%</td><td>21.0%</td></tr>
<tr><td><u>Total</u></td><td><u>105%</u></td><td><u>105%</u></td><td><u>105%</u></td></tr>
</table></td></tr>
<tr><td colspan="2">Combined AlfaAlfa and dates crops after the works (1 to 6 years) but the crops rate calculation does not include Alfa Alfa.</td></tr>
</table>

	Cropping practices and miscellaneous activities	1. Water saving irrigation will be efficient for a better water resources utilization. This will require the proper technical supervision through extension services. 2. Water saving irrigation will allow to expand vegetables, cumin and henna cultivation. 3. Tree crops are much in demand, but the farmers have little experience and trees resist badly to draught, to the point that it is recommended to cultivate them on a small scale.
4) Reinforcement plan for maintenance organizations		4. After khettara rehabilitation the maintenance cost and manpower supply will remain the responsability of the traditional organizations. 5. Training (courses, study tours) shall be initiated to supply the association with the administration knowledge in order to set up the administrative structures. 6. The monitoring that will be carried out together by the associations and the traditional organizations will allow to strengthen the ties between them, and will constitute the common ground for the works joint implementation.

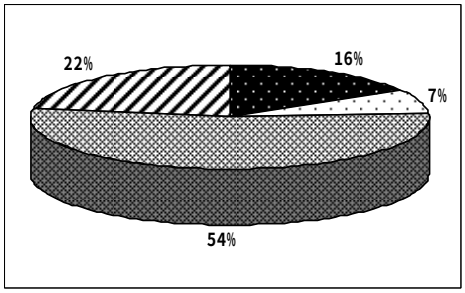
(4) Works cost

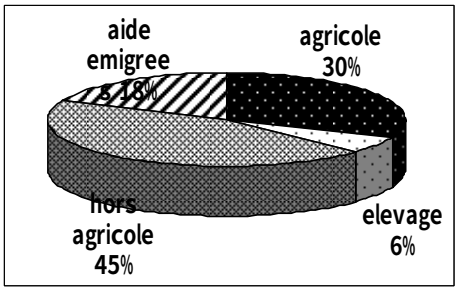
Khettara rehabilitation	Khettara floor excavation DH 294 250 (see Table J.4.1)
Water use	Lining of the earthen canal：- Improvement of the inlets：5,373DH (see Table J.4.1)
Reinforcement plan for maintenance organizations	1) Maintenance charges : 19 800 DH/year (Water rights charges and their collecting like it was done in the past) 2) Organizations reinforcement cost : ・Year of works startup : 47 500 DH (Trainning and monitoring cost). ・Second year and following year : 4 000/year (Monitoring cost)

(5) Project Evaluation

<table>
<tr><td>Economic evaluation</td><td><u>Without project</u>: irrigated area by khettara will decrease from 8.8ha (present, from khettara discharge) to 6.8ha(2014), causing drop in revenue from agriculture.</td><td><u>With project:</u> increase of irrigated area by 2.8ha (to total of 11.6ha) through khettara and canals rehabilitation. Improved agriculture practices (extension and water management) will increase the net income by DH15,200/ha (economic terms).</td></tr>
<tr><td></td><td colspan="2"> 

B= DH 444,000 C= DH 215,000 B/C= 2.1 (NPV, discount rate 10%); EIRR= 18,0%

Khettara rehabilitation contributes most to generation of benefit (excavation of khettara base – relatively less costly) – in terms of increase in irrigated area and decrease of O&M works. The big value added plantations (cumin and henna) give good prospects for the use of additional irrigated area. The aspects hampering further development are paved roads (access to market, school), telephone connections, lack of land certificates (no access to credit/subsidy).</td></tr>
<tr><td>Financial Evaluation</td><td><u>Present:</u>
 

Present income from agriculture: DH6,090, for standard farm of 0,8ha. Farm budget Table 3.8.3.
Decrease in income from agriculture might cause rural exodus (76HH/800 people in 2004; outflow of 60 people, including 30 abroad, since 2000).</td><td><u>With project:</u>
 

Income from agriculture: DH16,390, for standard farm of 1.03ha. The additional income (DH10,300) and decrease in O&M works gives possibility to develop agriculture practices/other activities. The project increases the share of income from agriculture to 30% of average family budget.</td></tr>
</table>