Annexe C Irrigation and Water Use

Annexe C Irrigation and Water Use

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C.1 Khettara Irrigation System

C.1.1 Water Use

Groundwater gathered through Khettara is conveyed with open canals by gravity to residential and irrigation area, and then utilized for various purposes such as drinking, washing, domestic water, livestock water, and irrigation water. It is common way that Khettara water is first consumed as drinking water, secondly washing or domestic water, and finally irrigation water. In some Khettaras, however, washing places are equipped inside a network of irrigation canals.

For drinking, washing, or domestic water use, local population relies upon deferent water resources such as Khettara water, water supplied by ONEP, local communities, or others, depending on the villages.

ONEP has rapidly extended water supply service to rural area in recent years, so that present service area rises to 82% of potential service area in 2003 from 12% in 1982. Furthermore, ONEP launched a five years extension program aiming to cover 97% of potential service area by 2007.

Water charge of public fountains equipped by ONEP is 0.05DH more and less per one plastic pot with the capacity of 5 liter. Some people utilize Khettara water for drinking because it is free of charge, even though water quality does not satisfy with the guideline of drinking water.

Besides, washing of clothes in the canal leads to the quality deterioration of irrigation water which is utilized at the downstream of washing place.

Continuous decrease of water discharge does not satisfy water demand required for present Khettara irrigation area. Constant water flow is observed throughout year, but discharge of that fluctuates by season. Cultivable acreage shows a tendency to decrease in summer season and increase in winter season because water discharge in summer season is smaller than in winter and evapotranspiration in summer season is bigger than in winter. As a countermeasure against structural water shortage of Khettara, some farmers have exploited groundwater with drilling well by their own expense.

C.1.2 Irrigation Facilities

C.1.2.1 Irrigation Canal Network

Water is distributed from Khettara exit to individual farmlands with small scale open canals (width and height; 0.3-0.5m with gentle gradient).

Irrigation canal network set up over the Khettara irrigation area is classified into three categories, principal canal, secondary canal, and on-farm canal as shown in the following schematic diagram.

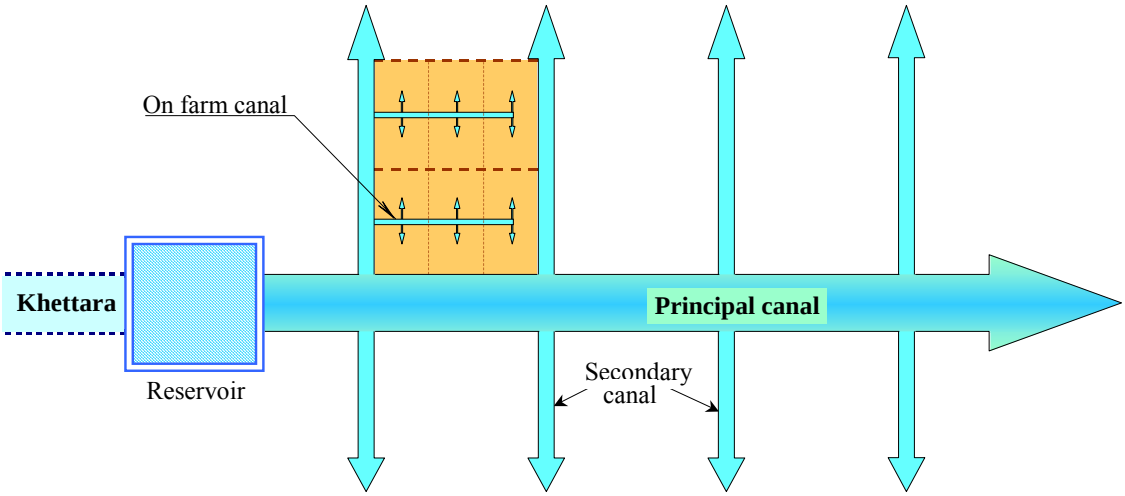
- Principal canal is defined as main canal which conveys irrigation water from Khettara exit to the secondary canal. The ratio of lining and earthen canal is approximately half.
- Secondary canal is defined as the canal branched off from principal canal in order to distribute water to individual farmlands. The majority of the secondary canal is earthen canal.
- On-farm canal is defined as the terminal canal which distributes water to the irrigation plots divided

in the farmlands. Every on-farm canal is left to be earthen.

According to the result of Khettara inventory survey, the length of principal canal and secondary canal is classified into two structure types, earthen canal and concrete canal as shown in below table. Earthen canal accounts for 47% of total length on principal canal, 89% on secondary canal, and 100% on on-farm canal. It seems reasonable to say that infiltration loss caused by the earthen canal is one of constrains hindering rational use of Khettara water.

Classification of irrigation canal（Source: Khettara inventory survey）

Classification	Earthen canal	Concrete canal	Total
Principal Canal	116 km (47%)	127 km (53%)	243 km (100%)
Secondary Canal	389km (89%)	46 km (11%)	435 km (100%)
Total	505 km (73%)	173 km (27%)	678 km (100%)



Schematic Diagram of Irrigation Canal Network

C.1.2.2 Inlet

No gate is equipped at the points diverting irrigation water from canal to farmland, and it is common practice for the diversion that farmers switch a stack of soil by manpower. Leakage of the inlet is inevitable, so that it leads to a big amount of water loss in total because of enormous number of the inlets.

1.2.3 Regulating basin

Regulating basins are observed especially in the Khettera with small water discharge, which is installed at the beginning point of the irrigation canal with 12 to 19m in length, 0.5 to 1.2m in depth.

The basin made of concrete has only notch at the inlet; therefore, water inflow from Khettara is not controlled. On the other side, a circle hole is equipped at the outlet of the basin, which is stuffed with rags for storage and opened with removing the rags.

Individual water users, not a specified operator go to the basin for the operation at the beginning of their

water use hours. After Khettara water is stored in the basin for certain hours, it is blown off and then conveyed through the irrigation canal to their farmland with.

Above mentioned water management reflects severe situation that farmers are facing difficulty in distributing irrigation water due to the limited discharge. We can recognize strong will of farmers who try to gain more water amount in the way of minimizing water conveyance loss as much as possible.

Khettara water discharge is decreasing under the situation of continuous drought; therefore, the construction for enlarging the basin capacity was implemented at Khettara Taboumiat in Merzouga.

The regulating basin itself does not have enough capacity to regulate water supply from Khettara and water demand of irrigation area on daily or monthly basis.

C.1.3 Irrigation Method

Multi cropping is widely applied in the oasis, date trees shading the farmlands from direct sunray are planted as top layer, olive trees as middle layer, and wheat, fodder crops, beans, vegetables, etc as low layer.

Traditional basin irrigation method is applied to all of Khettara irrigation area, which fills the farmland divided into small plots with water by gravity. Date trees and olive trees planned here and there are irrigated at the same time when the crops planted at low layer are irrigated in turn.

Basin irrigation method has following disadvantages from the viewpoint of rational water use.

- Wetting zone spreading to the whole farm plot causes big evaporation from soil surface.
- Big infiltration loss is observed due to unequal irrigation hours and water depth in the farm plot.

Farmers have been tried water several saving measures such as small farm plot to minimize infiltration loss and partial irrigation for date trees; however, these are not recognized to be a drastic measure for rising water use effectiveness.

C.1.4 Water Right and Irrigation Schedule

Water right owners hold Khettara water right in proportion with the amount of work done by the former workers during the construction of Khettaras, which is defined as rigid water rotation, water use hours with a certain interval days. (Hereinafter referred to as “water right interval days”)

Since water right has been taken over as the patrimony, it is shared to many owners and water use hours vary in the range of 10 minutes and 24 hours at present time.

Water right interval days are decided in the range of 4 to 26 days according to Khettara inventory survey. In some case, an extra day squeezed by increasing water right interval days (for example; 8days→9days) is provided to the applicants and/or allotted to maintenance cost. Besides, watering schedule is practically adjusted based on water demand with buying and selling of water right or exchanging of water use hours.

One Khettara formulates one rotation block which is performed based on the order regulated by water right

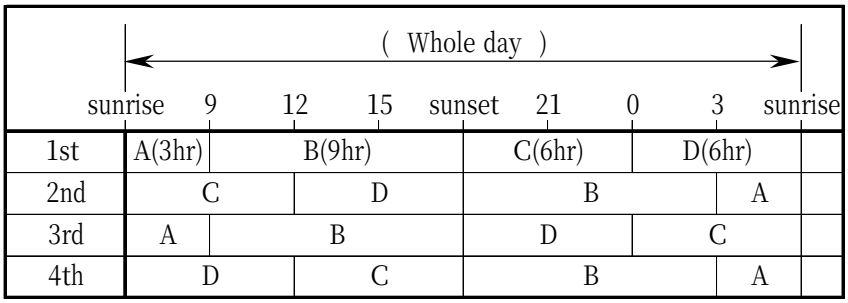
all day and all night in order to avoid the waste of water.

Farmland as well as water right has been taken over as the patrimony; therefore, the farmlands have been divided into tiny lots. This hereditary system causes the negative impacts of increasing water management loss in the irrigation canal.

Water use time schedule of each water right holder is not always same. It is regulated in consideration of fairness on operation labor force and water amount distribution. Each Khettara has an individual rule of the water distribution order. The figure below gives an example of Khettara Talaabast that water distribution order is set up by sunrise and sunset.

Water right holders A, B, C and D who own water use hours in a same day change their order each others in water right interval days (8 days). Let us examine the case of water right holder C who owns water right hours of 6 hours. Time zone for the first turn is shared from sunset to 0 o'clock of midnight, for the second turn from sunrise to 12 o'clock of daytime, for the third turn from 0 o'clock of midnight to sunrise, and for the fourth turn from 12 o'clock of daytime to sunset. Finally it returns to the first time zone for the fifth turn, and then it is repeated in same order of the following.

Water use time schedule（Example; Khettara Talaabast）



C.2 Irrigation Water Requirement

C.2.1 Meteorological Conditions

Tafilalet plain is located at the east of High Atlas mountain and the north western area of the Sahara desert. The climate of this area is arid with its annual rainfall of 50 to 250mm, annual evaporation of 2,000 to 3,000mm. **Figure C.2.1** shows the meteorological data of Errachidia which is located in the center of Tafilalet plain. Annual rainfall is only 100 mm on average. Seasonal distribution of rainfall is not equal, much in summer (from October to February), less in winter (from June to August). In general, rainfall is very scarce, but localized heavy rainfall sometime causes the flood.

Meanwhile, mean evaporation measured with A-pan shows 2,194mm on yearly basis, highest 336mm in June, and lowest 53mm in December. Mean temperature shows the highest 29.4℃ in July, the lowest 6.7℃ in January, and average humidity shows 41 % on yearly basis, less than 30% in summer season, over 50% in winter season. Both sunshine hours and velocity shows bigger value in summer season than winter season, and the former is 9.1 hours per day and the later is 0.9 m/s on the yearly average.

Above mentioned climate condition results in water shortage throughout years, especially difficulty for vegetable cultivation in summer season.

C.2.2 Evapotranspiration

Various methods are proposed for the estimation of evapotranspiration (ETo).

Blaney-Criddle method is commonly applied in Morocco because evapotranspiration (ETo) can be estimated with temperature data, and Penman-Monteith equation is used in case that four sorts of data temperature, wind speed, humidity, and sun shine hours are available.

C.2.2.1 Blaney-Criddle method

Reference evapotranspiration(ETo) is obtained with the following formula.

$$ET_0 = c \cdot f = c \cdot p \cdot (0.457 \cdot T + 8.128)$$

ET_0 ; Reference evapotranspiration〔mm/day〕

T ; Mean daily temperature over the month〔℃〕

p ; Mean monthly percentage of total annual daytime hours

c ; Adjustment factor

For appling this method to various meteorological conditions, evapotranspiration (f) should be adjusted with an adjustment factor (c) consisting of minimum relative humidity (Rh_{min}), sunshine hours (n/N), and daytime wind speed (U_{day}).

Figure C.2.2 is the chart prepared with above three factors and **Figure C.2.3** gives the calculation process and result in case of using the meteorological data of Errachidia.

p-value：Mean monthly percentage of total annual daytime hours

North latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
South latitude	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
60	.15	.20	.26	.32	.38	.41	.40	.34	.28	.22	.17	.13
58	.16	.21	.26	.32	.37	.40	.39	.34	.28	.23	.18	.15
56	.17	.21	.26	.32	.36	.39	.38	.33	.28	.23	.18	.16
54	.18	.22	.26	.31	.36	.38	.37	.33	.28	.23	.19	.17
52	.19	.22	.27	.31	.35	.37	.36	.33	.28	.24	.20	.17
50	.19	.23	.27	.31	.34	.36	.35	.32	.28	.24	.20	.18
48	.20	.23	.27	.31	.34	.36	.35	.32	.28	.24	.21	.19
46	.20	.23	.27	.30	.34	.35	.34	.32	.28	.24	.21	.20
44	.21	.24	.27	.30	.33	.35	.34	.31	.28	.25	.22	.20
42	.21	.24	.27	.30	.33	.34	.33	.31	.28	.25	.22	.21
40	.22	.24	.27	.30	.32	.34	.33	.31	.28	.25	.22	.21
35	.23	.25	.27	.29	.31	.32	.32	.30	.28	.25	.23	.22
30	.24	.25	.27	.29	.31	.32	.31	.30	.28	.26	.24	.23
25	.24	.26	.27	.29	.30	.31	.31	.29	.28	.26	.25	.24
20	.25	.26	.27	.28	.29	.30	.30	.29	.28	.26	.25	.25
15	.26	.26	.27	.28	.29	.29	.29	.28	.28	.27	.26	.25
10	.26	.27	.27	.28	.28	.29	.29	.28	.28	.27	.26	.26
5	.27	.27	.27	.28	.28	.28	.28	.28	.28	.27	.27	.27
0	.27	.27	.27	.27	.27	.27	.27	.27	.27	.27	.27	.27

C.2.2.2 FAO Penman-Monteith Equation

FAO Penman-Monteith equation defines the reference crop evapotranspiration (ET_o) as the rate of evapotranspiration from the extensive field surface covered by 8 to 15 cm tall green grass with uniform height, actively growing, completely shading the ground and not short of water.

Calculation procedure is referred to "Crop evapotranspiration - Guideline for computing crop water requirements - FAO Irrigation and drainage paper, 5 FAO (1998)". **Figure C.2.4** gives the calculation process and result in case of using the meteorological data of Errachidia.

FAO Penman-Monteith equation can be split into a radiation term ET_{rad} and an aerodynamic term Et_{aero}.

$$ET_o = ET_{rad} + ET_{aero}$$

ET_{rad} ; Radiation term〔mm/day〕

ET_{aero} ; Aerodynamic term〔mm/day〕

(1) Radiation term ET_{rad}

$$ET_{rad} = \frac{\Delta}{\Delta + r^*} \cdot \frac{Rn}{\lambda}$$

Δ ; Slope vapour pressure curve〔KPa/℃〕

r* ; Modified psychometric constant〔KPa/℃〕

Rn ; Net radiation at crop surface〔MJ/m^2,day〕

λ ; Latent heat of vaporization〔MJ/kg〕

Net radiation (R_n) is defined as the difference between all incoming and outgoing radiation. It can also be calculated from solar radiation or sunshine hours or degree of cloudiness, temperature and humidity data.

$$R_n = R_{ns} + R_{nl}$$

R_n ; Net radiation 〔MJ/m^2,day〕 / 〔mm/day〕

R_{ns} ; Net incoming shortwave radiation 〔MJ/m^2,day〕 / 〔mm/day〕

R_{nl} ; Net outgoing longwave radiation 〔MJ/m^2,day〕 / 〔mm/day〕

The net shortwave radiation (R_{ns}) means the radiation received effectively by the crop canopy taking into account losses due to reflection.

$$R_{ns} = (1-\alpha)R_s$$

$$R_s = (a_s + b_s \cdot \frac{n}{N}) \cdot R_a$$

$$N = \frac{24}{\pi}\varpi_s$$

$$R_a = 37.586 \cdot d_r(\varpi_s \cdot \sin\phi \cdot \sin\delta + \cos\phi \cdot \cos\delta \cdot \sin\varpi_s)$$

$$d_r = 1 + 0.033 \cdot \cos(\frac{2\pi}{365} \cdot J)$$

$$J = Integer(30.42 \cdot M - 15.23)$$

$$\delta = 0.4093 \cdot \sin(\frac{2\pi}{365} \cdot J - 1.405)$$

$$\omega_s = \cos^{-1}(-\tan\phi \cdot \tan\delta)$$

Rs ; Incoming short wave radiation 〔MJ/m^2,day〕 / 〔mm/day〕

α ; albedo =0.23 (for reference crop: grass)

R_a ; Extra terrestrial radiation 〔MJ/m^2,day〕 / 〔mm/day〕

n ; Actual sunshine hours per day 〔hr〕

N ; Maximum possible sunshine hours 〔hr〕

a_s= 0.25 (for average climate) b_s= 0.50 (for average climate)

d_r ; Relative distance between Earth and Sun

ω_s ; Sunset hour angle 〔rad〕

ϕ ; Latitude 〔rad〕

δ ; Solar declination 〔rad〕

J ; Julian day number: 1 to 365

M ; Month number: 1 to12

Net long wave radiation can be determined from available temperature (T), actual vapor pressure (e_d), and the actual sunshine hours (n).

$$R_{nl} = f(\frac{n}{N}) \cdot f(e_d) \cdot f(T) = -(a\frac{n}{N} + b) \cdot (c - d\sqrt{e_d}) \cdot \sigma \cdot (T_{k,\max}{}^4 + T_{k,\min}{}^4)/2$$

$$\therefore R_{nl} = -(0.9 \cdot \frac{n}{N} + 0.1) \cdot (0.34 - 0.14\sqrt{e_d}) \cdot \sigma \cdot (T_{k,\max}{}^4 + T_{k,\min}{}^4)/2$$

σ ; Boltzman constant= 4.903×10^{-9} 〔$MJ/m^2, {}^0K^4$,day〕

T_k ; Air temperature 〔^{0}K〕 Fahrenheit Tk 〔^{0}K〕 =Centigrade T 〔℃〕 ＋273.2

e_d ; Actual vapor pressure 〔kPa〕

a=0.9 b=0.1 c=0.34 d=0.14

(2) Aerodynamic term E_{aero}

$$ET_{aero} = \frac{\gamma}{\Delta + \gamma^*} \cdot \frac{900}{(T+275)} \cdot U_2 \cdot (e_a - e_d)$$

$$e_a = 0.6108 \times e^{(\frac{17.27 \cdot T}{T+237.3})}$$

$$e_d = e_a \times \frac{RH}{100}$$

$$\Delta = \frac{4098 \cdot e_a}{(T+237.3)^2}$$

$$P = 101.3 \cdot (\frac{293 - 0.0065 \cdot z}{293})^{5.256}$$

$$\gamma = 0.0016286 \frac{P}{\lambda}$$

$$\lambda = 2.501 - (2.361 \times 10^{-3})T$$

$$\gamma^* = \gamma(1 + 0.33U_2)$$

T ; Air temperature 〔℃〕

U_2 ; Wind speed measured at 2 m height 〔m/sec〕

e_a ; Saturation vapor pressure of the air 〔kPa〕

e_d ; Actual vapor pressure of the air 〔kPa〕

Δ ; Slope vapor pressure curve 〔kPa/℃〕

γ ; Psychometric constant 〔kPa/℃〕

γ^* ; Modified psychometric constant 〔kPa/℃〕

λ ; Latent heat of vaporization 〔MJ/kg〕 $\lambda = 2.45$

RH ; Relative humidity 〔%〕

Z ; Altitude (m)

P ; Atmospheric pressure 〔kPa〕

C.2.2.3 Evapotranspiration (ETo)

Evapotranspiration (ETo) was estimated by Blaney Criddle method and FAO Penman-Monteith equation based on the meteorological data of Errachidia from 1980 to 2002. There is no remarkable difference between both methods, but the result of Blaney Criddle method shows slightly bigger than that of FAO Penman Monteith equation.

Montly evapotranspiration (ETo) (mm/day)

	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug
Blaney-Criddle method	**4.9**	**3.4**	**2.3**	**1.5**	**1.5**	**2.0**	**3.0**	**4.0**	**5.0**	**6.3**	**6.7**	**6.3**
FAO Penman-Monteith equation	4.1	2.5	1.4	1.0	1.1	1.7	2.9	4.1	5.1	5.6	6.1	5.1

C.2.3 Water Requirement

The water amount required for the village relied upon Khettara is defined as a total amount of various water demands such as irrigation water, drinking water including domestic use and livestock water.

C.2.3.1 Irrigation Water

Water discharge is a critical factor in Khettara irrigation area. Irrigable acreage is directly affected by the water discharge; therefore, increase of water discharge leads to expansion of cultivable acreage and introduction of cash crops and decrease of water discharge leads to the opposite result.

Following equation gives the irrigation water requirement which is defined as a sum of water amount required for the crops according to the growth stage.

Irrigation water requirement $Q = (\sum Qi) \div Ef$ (a)

Net water requirement of each crop $Qi = ETo \times Kc \times A \times 10$ (b)

Q ; Irrigation water requirement＝Gross water requirement [m^3/month/ha].

Qi ; Net water requirement of each crop [m^3/month/ha]

ETo ; Reference evapotranspiration [mm/day].

Kc ; Crop coefficient of each growth stage

Table C.2.1 gives Kc value for the crops (fodder, date, olive, wheat, and vegetable) applied by Ministry of Agriculture, Rural Development and Fisheries.

A ; Cultivation area [ha]

Ef ; Irrigation efficiency

Ef value is referred to ”Applications of Climatic Data for Effective Irrigation Planning” FAO（refer to **Table C.2.2**）

Present Ef=canal efficiency 75%×field application efficiency 70%=53%

Proposed Ef=canal efficiency 80%×field application efficiency 73%=58%

Irrigation water requirement per one (1) ha is calculated in accordance with following procedure.

1) Net water requirement of each crop (m^3/month/ha) is given by equation (a) which consists of reference evapotranspiration ETo estimated with Blaney-Criddle method, crop coefficient Kc of each growth stage according to the cropping pattern, and cultivation area of each crop A.

2) Monthly gross water requirement (m^3/month/ha) is obtained dividing total net water requirement Qi by irrigation efficiency Ef as shown in equation (b).

3) Finally, monthly gross water requirement (m^3/month/ha) is converted to gross water requirement expressed in unit of lit/sec/ha.

Figure C.2.5 and **Figure C.2.6** show present monthly gross water requirements (m^3/month/ha) and proposed one respectively, which were obtained based on the classified four (4) types of cropping patterns (ZoneA, ZoneB, ZoneC, ZoneD,E,F,G). According to monthly gross water requirement (lit/sec/ha) of each cropping pattern listed in table below, maximum values of monthly gross water requirement range from 0.29 to 0.59lit/sec/ha and 0.4lit/sec/ha on average.

Monthly gross irrigation water requirement（lit/sec/ha）

	Classification	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Zone A	Present	0.32	0.24	0.21	0.17	0.18	0.25	0.35	0.40	0.37	0.41	0.42	0.39
	Proposed	0.34	0.27	0.23	0.15	0.14	0.20	0.29	0.35	0.34	0.38	0.37	0.37
Zone.B	Present	0.25	0.20	0.19	0.16	0.17	0.24	0.33	0.37	0.31	0.32	0.32	0.30
	Proposed	0.30	0.25	0.21	0.15	0.14	0.19	0.28	0.32	0.29	0.32	0.30	0.30
Zone.C	Present	0.47	0.35	0.28	0.19	0.19	0.26	0.38	0.48	0.51	0.59	0.59	0.56
	Proposed	0.45	0.36	0.27	0.17	0.15	0.20	0.31	0.39	0.42	0.50	0.49	0.49
Zone D,E,F,G	Present	0.14	0.11	0.11	0.12	0.15	0.22	0.32	0.37	0.29	0.19	0.17	0.16
	Proposed	0.22	0.19	0.16	0.12	0.12	0.18	0.28	0.36	0.34	0.30	0.25	0.21

C.2.3.2 Drinking Water (Including Domestic Water)

Water requirement for drinking and domestic use is estimated based on actual daily water consumption rate of 10 lit per person, which is survey result conducted by ONEP.

Drinking water(m^3/day)＝population(persons)×water consumption rate(10 lit/ day/person)÷1,000

C.2.3.3 Livestock Water

Socio economic survey was conducted to collect various data on social and economic aspects including the number of livestock per capita in the Khettara area. Water requirement for livestock is estimated based on

this survey result showing an average livestock number of one farmer's household, three head of cattle, eight head of sheep, and ten head of goat.

Livestock water (m^3/day)＝number of household× ｛number of livestock×unit water requirement （lit/head/day）｝

Unit water requirement; cattle: 50 lit /head/day, sheep and goat: 10 lit /head/day

A quantitative ratio of irrigation, drinking, and livestock water requirement varies depending on the Khettara. On the whole, irrigation water requirement accounts of 93% and others account of 7% only.

C.2.4 Khettara Water Discharge

Khetarra water discharge ranges between 0lit/sec and 44lit/sec according to Khettara inventory survey. **Figure C.2.7 (left)** shows the distribution of water discharge of Khettaras where water flow was confirmed at the site. Khettras with less than 5 lit/sec accounts for 60% and Khettaras with less than 20lit/sec accounts for 95% according to

Meanwhile, **Figure C.2.7 (right)** reveals the situation that Khettara water discharge is not sufficient for the irrigation water demand, on the whole. Only 55% of Khettaras satisfies with 0.4lit/sec/ha theoretically estimated as irrigation water requirement in the preceding section. This survey result reflects actual situation that farmers try to control water demand through adjusting farming plan such as the reduction of the cultivation area and/or limit of vegetable cultivation.

There is no doubt that water discharge is a critical factor in oasis agriculture. As a countermeasure against decreasing water discharge, it is important to increase Khettara water discharge itself through the rehabilitation works in Khettara. In addition, rational water use system must be established through improving traditional irrigation method and facilities.

C.3 Water Saving Measures in Khettara Irrigation Area

C.3.1 Water Balance of Khettara Irrigation System

The concept of water balance in Khettara irrigation area can be illustrated as below figure.

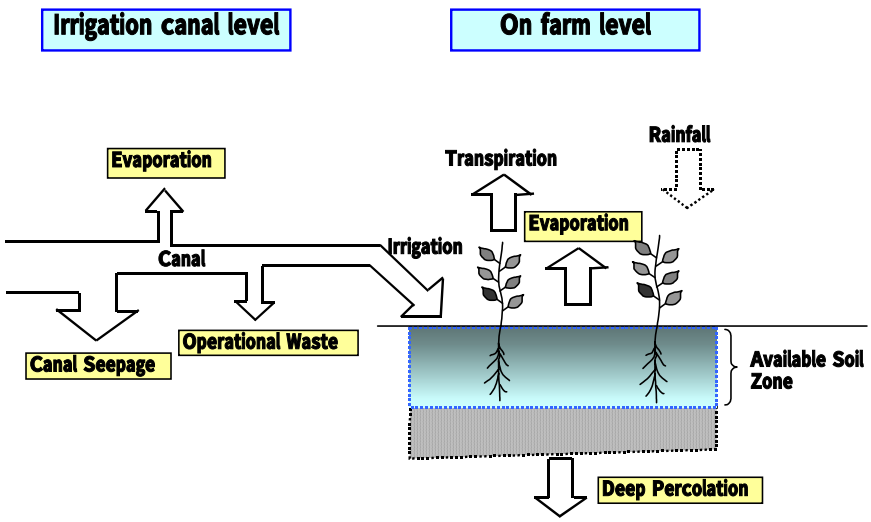
After some amount of Khettara water is lost as conveyance loss, water management loss, and water surface evaporation while it flows in the irrigation canal, the remains of Khettara water reaches the farmlands. However, all amount of which is not available for crop growth.

On farm, some amount of irrigation water is lost as soil surface evaporation and soil deep percolation as well. Soil water amount only stored between pF2.0 (Field capacity) and pF4.2 (Permanent wilting point) in available soil layer can be consumed for the crop growth.

Reducing the waste of water is therefore a main target in order to supply irrigation water to available soil layer as much as possible. It is the way to achieve effective use of scarce Khettara water.

The constrains and water saving approach both on irrigation canal level and on-farm level will be discussed fully in the following paragraph.

Schematic Diagram of Water Balance in Khettra Irrigation Area



C.3.2 Water Saving Measure

C.3.2.1 Selection of Water Saving Measure

Water users have created a cooperative water management system and farming techniques in order to utilize Khettara water effectively under sever climate condition. Following concrete water saving efforts were made in Khettara irrigation area so far.

- Extermination of waste of water by keeping the rigid water management for continuous 24 hours.
- Restrain of evaporation by shading the field from the direct sunray with the planted date and olive trees.

- Decrease of conveyance loss by lining main canals with concrete.
- Decrease of infiltration loss by splitting the field into small lots.
- Minimization of irrigation water amount by concentrating the watering on the root zone of date and olive trees.

More drastic water saving measures must be applied to Khettara irrigation area in addition to above prevailing ones. Prior to formulate the drastic water saving measures, we need to confirm basic approahes for water saving 1) restrain of evaporation, 2) restrain of infiltration loss, and 3) decrease of water management loss. Various water saving measures can be listed as follows dividing into irrigation canal level and on farm level.

Water saving measures

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

(1) Canal rehabilitation

Most part of irrigation canals is made with earth, 48% of principal canal and 89% of secondary canal; therefore, infiltration loss is observed here and there along the canals. Lining earthen canal with concrete reliably improve water use efficiency by decreasing sharply the filtration loss.

It is generally accepted that placing covers on open canal has an effect of decreasing evaporation from water surface; however, it bring about difficulty on maintenance activity because of small canal width (0.4 to o.5m). This measure is proposed to be applied to the section of the open canal where much dispersions of sand is coming into.

(2) Inlet improvement

It is common that water user stack the inlet point of the canal with soil to divert water flow. Leakage and operation loss can not be neglected because number of the inlets is too numerous; Therefore, inlet improvement is essential from both viewpoints of water management and water saving.

(3) Restrain of evaporation

Crop consumption consists of evaporation from soil surface and transpiration from leaf surface. The later can not be restricted because it is a dispensable element for crop growth, but the former can be controlled with various water saving measures. Shelter-belt has an effect of restraining soil surface evaporation by blocking wind; therefore, we can see the earthen fences here and there constructed at the boundary of farmlands. Khettara inventory survey reveals the fact that more than half number of Khettara irrigation areas has been suffered from desertification. Therefore, the shelter-belt made of trees or soil is effective not only as water saving measure but also as an environmental measure for farmland conservation.

Multi layer cropping is widely applied in this area, two layer cropping (olive+cereal, feed crops, etc.) in the mountain area, three layer cropping (date+olive+cereal, fodder crops, beans, vegetables, etc.) in middle, and three layer cropping (date+cereal, fodder crops, vegetables, etc.) in Tafilalet plain.

Considering that mulching contributes to not only restraining evaporation from soil surface but also retaining soil moisture, this measure is proposed to apply using natural materials available in this area.

(4) Water saving irrigation techniques

Sprinkler irrigation technique requires high water pressure (standard pressure: 20 to 30 bar) for operating sprinkler itself with allowable regularity. Adaptability of this method is low in arid area because some part of water amount irrigated by sprinklers is lost by evaporation of water-drops entrapped into the leaves of crops.

Furrow irrigation is recognized to be more water saving technique than traditional basin irrigation because only partial wet zone is formulated by furrow irrigation.

Drip irrigation is defined as slow watering with discrete or continuous drops. Since water is applied directly to the root zoon through emitters placed on the soil surface, drip irrigation is the most water saving

techniques.

(5) Farming techniques

The varieties of crops should be carefully selected in order to minimize water consumption. The crops such as date or alfalfa, which have been cultivated in this area, are characterized by small water consumption and high durability against draught.

Double sack method is one of effective reforestation methods, which has excellent experiences in the Republic of Djibouti. This method aiming at preserving soil moisture in root zone should be examined the adaptability for this area.

(6) Soil characteristic improvement

Although various admixtures for improving soil characteristics have been developed, it is notified that there is difficulty on applying them to wide irrigation area due to some problems over disposal of wasted materials and high cost.

(7) On farm water management

If farmers keep irrigation interval 7 to 14 days based on traditional water right; therefore, it is impossible to conduct optimum watering according to the crop growth. To give the flexibility of watering, it is proposed to install on farm small reservoir for storing Khettara water.

C.3.2.2 Water Saving on Irrigation Canal Level

Two main approaches can be proposed as water saving measures, one is canal rehabilitation and the other is inlet improvement.

(1) Canal rehabilitation (refer to **Figure C.3.1**)

In order to grasp the actual situation of infiltration loss on earthen irrigation canal, water discharge was measured at the beginning point and ending point of three principal canals, Seguia Harch of Khettaea Ait Ben Omar, Seguia Gauahe and Seguia Droitein of Khettara Lambarkia in the verification study. The infiltration loss of 18 to 22% (average 19%) was confirmed from the deference of water discharge between two points. After concrete lining of above principal canals in the study, the infiltration loss decreased to 5 to 10% (average 7%). It is concluded that irrigation canal rehabilitation leads to the reduction of water loss (average 12%).

Besides, the result of the study clearly proved that principal canal rehabilitation itself contributes to not only expansion of cultivable farmland through increasing available water discharge, but also recovery of the devastated farmlands through regaining water flow at the downstream as follows.

Rehabilitation works was implemented with PVC pipe at the downstream of principal canal “Seguia Jdida” of Khettara Ait Ben Omar where irrigation water has not reached for several years due to the damage caused by desertification. Revival of water flow ensured the cultivation for 40 farmers owning water rights there. Similar experience was observed at right main canal in Lambarkia. Concrete lining of the existing

earthen canal being suffered from desertification brought the recovery of water supply at the downstream of the canal and 10 farmers restarted the cultivation as well as Ait Ben Omar.

There is no doubt that lining of every irrigation canals including secondary and on farm canals leads to drastically minimize infiltration loss. However, in Master Plan, the priority was given to principal canals taking economic aspect into consideration because the lining of the principal canals largely contribute betterment of water use efficiency over whole benefit area,

(2) Inlet improvement (refer to **Figure C.3.2**)

In order to grasp the actual situation of infiltration loss and operation loss caused by the structural defects on existing inlet, water discharge was measured at the beginning point and ending point of two principal canals paved with concrete, Seguia Jdida of Khettaea Ait Ben Omar, Principal-1 of Khettara Taoumart in the verification study. The water loss of 11 to 14% (average 13%) was confirmed from the deference of water discharge between two points. After improving the existing inlet to the new type of simple steel gate or PVC pipe in the study, the water loss decreased to 6%. It is concluded that inlet improvement leads to the reduction of water loss (average 7%).

In regard to the inlet improvement, it was verified that PVC pipe type applied to the irrigation canal in Taoumart has a reliable effect for water saving due to high waterproof, easy handling, and low cost. The outcome of the verification study gives a possibility of extending to other Khettara irrigation canals with less than 10 lit/sec of water discharge.

C.3.2.3 Water Saving On Farm Level

Two approaches can be proposed as water saving measures, one is the introduction of water saving techniques and the installation of on farm reservoir.

(1) Introduction of water saving irrigation techniques (Furrow irrigation, Drip irrigation)

Traditional basin irrigation method with low irrigation coefficient has been applied over a long period. In order to improve the efficiency of water use, modern water saving irrigation techniques must be extended to Khettara irrigation area. Furrow irrigation and drip irrigation are proposed as water saving irrigation techniques, the former leads to the restrain of soil surface evaporation due to the formulated partial wet zone, the latter leads to minimize soil surface evaporation and deep percolation due to the direct watering at root zoon.

Meanwhile, national government established the supporting system which subsidizes 40% of investment cost for the drip irrigation facilities in order to conserve the scarce water resource and encourage effective water use.

(2) Installation of on farm reservoir

Irrigation interval days and water use hours on farm level are regulated based on traditional water right. Supply initiate system in terms of hydraulic aspect is established from water resource to terminal farmland as well. Since irrigation time schedule is basically fixed, it is difficult to control watering timing and

irrigation water amount taking the growth stage of crops into consideration. Excessive or less irrigation is inevitable in Khettara irrigation area. Therefore, installation of small reservoir on farm is essential to achieve appropriate irrigation timing.

Four (4) cases of combining water saving irrigation techniques and on farm reservoir were compared through actual vegetable farming in three demonstration farms.

Case1; Drip irrigation (with reservoir)
Case2; Furrow irrigation (with reservoir)
Case3; Furrow irrigation (without reservoir)
Case4; Basin irrigation (without reservoir)

Following table gives the total volume of irrigation water consumed in the actual vegetable farming of two seasons.

Water consumption for each case (m^3/ha)

Stage / Khettara name		Drip irrigation (with reservoir)	Furrow irrigation (with reservoir)	Furrow irrigation (without reservoir)	Basin irrigation (without reservoir)
1st Stage (October -January)	Ait Ben Omar	3,300(30)	7,037(65)	7,171(66)	10,881(100)
	Lambarkia	2,078(17)	9,902(80)	8,455(68)	12,374(100)
	Taoumart	-	6,274(172)	4,199(115)	3,645(100)
	*Average	2,689(23)	8,470(73)	7,813(67)	11,628(100)
2nd Stage (April -June)	Ait Ben Omar	3,697(41)	6,108(67)	6,333(69)	9,118(100)
	Lambarkia	5,372(64)	6,860(81)	5,556(66)	8,444(100)
	Taoumart	-	7,118(233)	4,000(131)	3,059(100)
	*Average	4,535(52)	6,484(74)	5,945(68)	8,781(100)
*Average		3,612(38)	7,477(73)	6,879(67)	10,204(100)

Note) Figures in the parentheses indicate the water consumption ratio of each case assuming that total water consumption of basin irrigation is 100.

*Figures indicate the average of Ait Ben Omar and Lambarkia.

Drip irrigation

Irrigation water amount consumed at drip irrigation plot was only 38% of that at basin irrigation plot and the richest harvest was also recorded in drip irrigation. It can be said that drip irrigation technique is drastic water saving approach in Khettara irrigation area as well as other irrigation area.

Some farmers in the study area applied drip irrigation using wells as a water resource, but drip irrigation in the demonstration farms was the first experience using Khettara water. From technical aspect, it was proved that drip irrigation technique can be adopted for Khettara irrigation area with on farm reservoir. Besides, this practice revealed that drip irrigation has several advantages not only on water saving but also on increase of yield, quality control of products, and mitigation of labor force. Farmers in Khettara

irrigation area have raised their concerns in drip irrigation through the seminars for the extension of water saving techniques or study tours of the demonstration farms.

Furrow irrigation

Furrow irrigation formulates partial wet zone because only furrow is impounded by irrigation water. The verification study, therefore, gave the result that irrigation water amount consumed at furrow irrigation plot was 73% and 67% of that at basin irrigation plot, respectively in case of with reservoir and without reservoir. As a result, it shows reliable evidence that furrow irrigation is recognized as one of water saving irrigation techniques. Furrow irrigation itself was a newly applied technique in Khettara irrigation area; however, farmers of demonstration farm understood water saving effectiveness through their vegetable farming. Actually, a farmer of demonstration farm in Khettara Lambarkia started beams cultivation with furrow irrigation on their own initiative, and farmers of demonstration farm in Taoumart are scheduled to adopt furrow irrigation technique as well.

On the other hand, it was proved that irrigation time schedule has some flexibility, but the range of water right adjustment has also limit. The effectiveness of on farm reservoir was verified by the outcome of vegetable farming especially in summer season that crop yield in furrow irrigation plot with reservoir was better than that in furrow irrigation plot without reservoir by means of shortening watering interval days. In addition to this, furrow irrigation technique combined with on farm reservoir is recommendable because this combination is more economical approach than drip irrigation technique.

C.4 Water Saving Irrigation Plan

C.4.1 Irrigation Water Requirement

C.4.1.1 Readily Available Soil Moisture (RFU)

Readily available moisture (RFU) called "TRAM" in Japanese is defined as moisture content in the effective soil layer readily consumable under the conditions that crops is expected to grow normally. It expresses the characteristics on holding soil moisture and means the upper limit of water amount for irrigation of one time. Readily available moisture (RFU) was estimated based on Moroccan irrigation planning standard same procedure as "*Applications of Climatic Data for Effective Irrigation Planning and Management* "published in 1991 by FAO.

Available soil moisture (RU) is obtained with the following equation by using Field capacity (SFC) and Permanent wilting point (SWP). Field capacity (SFC) expresses soil moisture content being held by soil matrix against the gravitational forces. It is defined as soil moisture content which is kept with the tension of around pF2.0 for sandy soil, pF2.5 for clay or loamy from soil physical aspects. Permanent wilting point (SWP) expresses soil moisture content that crops had permanently wilted, which is equivalent to soil moisture content being kept with the tension of pF4.2. Beyond permanent wilting point, watering is no longer available to the crops. However, it is said that the growth of the crops begins to decline before soil moisture content reaches permanent wilting point (SWP).

Readily available soil moisture (RFU) is obtained multiplying total available soil moisture (RU) by the fraction coefficient (P).

$$RFU = RU \times P$$

$$RU = SA \times D/10 = (SFC - SWP) \times D/10$$

RFU ; Readily available soil moisture (mm)
RU ; Total available soil moisture (mm)
P ; Fraction coefficient, P=2/3 (Moroccan standard)
SA ; Available moisture (vol%)
D ; Root depth (cm), D=45cm (vegetable)
SFC ; Field capacity (vol%)
SWL ; Permanent wilting point (vol%)

The table below shows the magnitude of RFU which was estimated based on pF analysis result (summarized in **Figure C.4.1**) of the sampling soil at three demonstration farms. RFU ranges from 20 mm to 29 mm and it suggests that the capacity of holding soil moisture is slightly low.

Readily available soil moisture (RFU) of demonstration farms

Demonstration farm	Soil type	Field capacity PF2.5 SFC(vol%)	Permanent wilting point PF4.2 SWP(vol%)	Available soil moisture SA=SFC-SWP (vol%)	Total available soil moisture RU (mm)	Readily available soil moisture RFU (mm)
Ait Ben Omar	Sandy clay loam	24.2	14.7	9.5	43	29
Lambarkia	clay loam	28.3	21.8	6.5	29	20
Taoumart	Sandy clay loam	21.9	13.5	8.4	38	25

C.4.1.2 Water Consumption

Two kinds of vegetable, carrot and turnip were cultivated at the 1st stage from September to January and four kinds of vegetable such as tomato, gumbo, watermelon, and melon were cultivated at the 2nd stage from March to July. Water consumption (WC) can be obtained with evapotranspiration (ETo) and crop coefficient (Kc) as follows. **Table C.4.1** gives the example of demonstration farms.

$$WC = ETo \times Kc$$

WC ; Water consumption (mm/day)
ETo ; Evapotranspiration (mm/day)
Kc ; Crop coefficient

C.4.1.3 Irrigation Interval Days

Irrigation interval days are calculated with readily available soil moisture (RFU) and water consumption (WC).

$$\text{Irrigation interval days} = RFU \times WC \text{ (omit decimates)}$$

RFU ; readily available soil moisture (mm)
WC ; water consumption (mm/day)

On the other hand, water use interval is fixed at 13days in Ait Ben Omar, 15 days in Lambarkia, and 9 days in Taoumart in accordance with traditional water right. Judging from the table below, water use interval days exceed above mentioned irrigation interval days from September to December at 1st stage and from April to July at 2nd stage in Ait Ben Omar, from May to July at 2nd stage in Taoumart, and all periods in Lambarkia. During this period, soil moisture might fall to the level below the permanent wilting point and the crops might dry up due to a lack of soil moisture. For the reason explained above, the necessity of on farm reservoir is theoretically endorsed from the viewpoint of shortening the water use days.

Interval days (Maximum)

Cultivation stage			1st stage					2nd stage				
			Sept	Oct	Nov	Dec	Jan	Mar	Apr	May	Jun	July
Water consumption WC (mm/day)			2.5	2.4	2.3	1.5	1.4	1.5	2.7	4.4	5.7	5.2
Ait Ben Omar	Water use interval 13day	RFU 29mm	**11**	**12**	**12**	19	20	19	**10**	**6**	**5**	**5**
Lambarkia	Water use interval 15day	RFU 20mm	**8**	**8**	**8**	**13**	**14**	**13**	**7**	**4**	**3**	**3**
Taoumart	Water use interval 9day	RFU 25mm	10	10	10	16	17	16	9	**5**	**4**	**4**

C.4.2 Furrow Irrigation Plan

(1) Furrow length

It is recommended to make furrow length as longer as possible for minimizing labor force on water distribution; however, it should be carefully decided to raise an application coefficient taking soil intake rate and flow speed into consideration. Soil types of the demonstration farms are classified into loam and clay based on the soil physical analysis. Furrow length must be settled shorter than the reference length listed in below table because most of farmlands are close to flat in Khettara irrigation area.

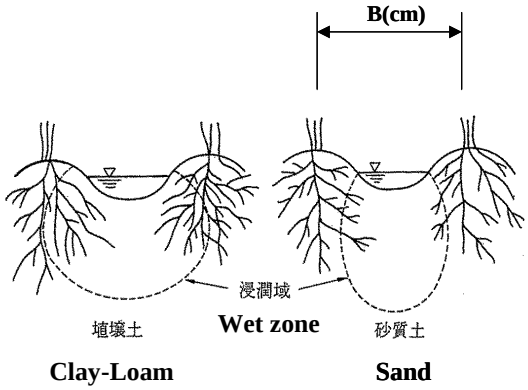
Reference furrow length by soil type

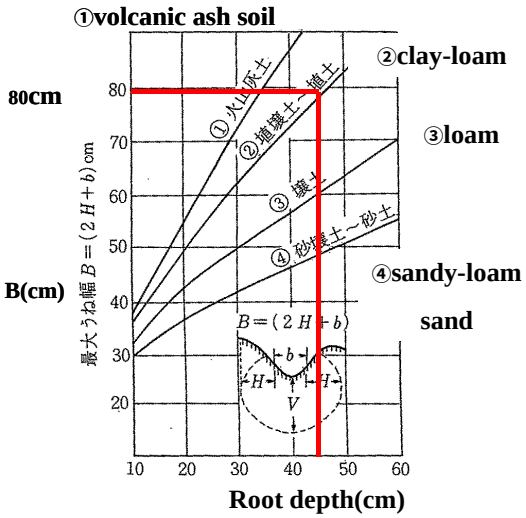
Soil type	Root zone depth (cm)	Irrigation amount (mm)	Maximum furrow length(m)	Remarks
Sand	40	16	4	Gradient of furrow: 10%
Volcanic ash soil	40	44	29	
Sandy-loam	40	34	36	
Loam	40	38	99	
Clay	40	44	121	

Source) *Engineering Manual for Irrigation & Drainage, Upland irrigation, 1990, The Japanese Institute of Irrigation and Drainage*

(2) Furrow width

Furrow width should be determined for irrigation wet zone to cover the root zone fully. Figure below (left) illustrates sectional diffusion of wet zone formulated by irrigation that horizontal diffusion is predominant in case of clay-loam soil type and vertical diffusion is predominant in case of sand soil type. Furrow width is recommended to keep 80 cm in distance on the assumption that root depth of vegetable is 45cm and soil type is loam - clay.



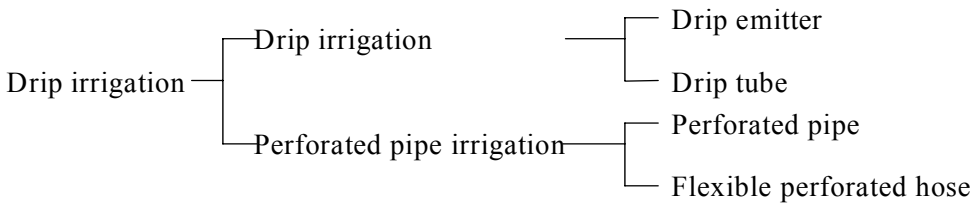


C.4.3 Drip Irrigation Plan

C.4.3.1 Classification Of Drip Irrigation

Drip irrigation type should be selected considering the following conditions specified in this area.

- Heat-resistant material must be applied because temperature is extremely high during daytime in summer season.
- Sunshine-resistant material is required because sunshine hours are fairly long through the year.
- Easy maintenance for clogging is required because some irrigation water shows high salinity.



Type	Pressure (bar)	Discharge (lit/hr/m)	Wet zone width (m)
Drip irrigation	～1.0	～10	0.3～1.0
Perforated pipe irrigation	0.05～0.4	6～50	0.3～5.0

(1) Drip emitter

Several types of water pressure control device are developed as drip emitter such as orifice type and spiral type. Orifice type emitter can be placed exclusively at the circumference of date, olive, and other fruit trees.

(2) Drip tube

Irrigation water drips through drip holes after reducing water pressure in dual-chamber tube. Since wetting circles being formulated around drip holes overlap each other, drip tube can be applied to the vegetables planted in line or densely.

(3) Perforated pipe

Perforated pipe is the hard pipe made of PVC, polyethylene, or aluminum with many holes on upper section, which sprays irrigation water to both sides of the pipes. The perforated pipe is detachable, lightweight, and portable; therefore it is easily connected with joints to expand the irrigation area.

(4) Flexible perforated tube

Perforated tube made of high molecular materials has the advantages in the handling, easy expansion, and low cost. Irrigation water is sprayed to both sides from small holes placed on the perforated tubes.

C.4.3.2 Irrigation Dimension

Irrigation dimension should be determined based on the meteorological and soil physical data collected at proposed project site. Hereby, the procedure for determining irrigation dimension is described using the data on the demonstration farms as reference.

(1) Crop: Vegetable

(2) Water consumption

Cultivation stage	1st stage (Winter season)					2nd stage (Summer season)				
Month	Sept	Oct	Nov	Dec	Jan	Mar	Apr	May	Jun	July
Water consumption (mm/day)	2.5	2.4	2.3	1.5	1.4	1.5	2.7	4.4	5.7	5.2

Maximum water consumption= 5.7mm/day (June)

(3) Readily available soil moisture (RFU)

Readily available moisture (RFU) is assumed to be 25mm as an average of three demonstration farms.

(4) Irrigation interval days

$$\text{Irrigation interval days} = \frac{\text{Readily available soil moisture(RFU)}}{\text{Maximum water consumption}} = \frac{25}{5.7} = 4.4 days \rightarrow 4 days$$

(5) Gross irrigation amount

$$\text{Gross irrigation amount} = \frac{\text{Water consumption} \times \text{Irrigation interval days}}{\text{Application efficiency}} = \frac{5.7 mm/day \times 4 days}{0.95} = 24 mm$$

(6) Irrigation intensive rate (P)

Discharge Q=2-4lit/hr/drip hole, Interval of drip holes=0.4m

→ Average q = 7.5 lit /hr/m (0.125lit /min/m)

Tube diameter 13×16mm

Water pressure 1.0bar (10m)

Wet zone width 0.65m

Irrigation intensive rate $P = \frac{0.125\ \ell/\min/m \times 60\ \min/hr}{0.65 m} = 11.5 m/hr$

(7) Irrigation hour

$$\text{Irrigation hour (Maximum)} = \frac{\text{Gross irrigation amount}}{\text{Irrigation intensive rate}} = \frac{24mm}{11.5mm/hr} = 2.1hr$$

Cultivation stage	1st stage					2nd stage				
Month	Sept	Oct	Nov	Dec	Jan	Mar	Apr	May	Jun	July
Water consumption (mm/day)	2.5	2.4	2.3	1.5	1.4	1.5	2.7	4.4	5.7	5.2
Irrigation hours(hr)	0.9	0.9	0.8	0.6	0.5	0.6	1.0	1.6	2.1	1.9

(8) Irrigation times per day

$$\text{Irrigation times per day} = \frac{\text{Irrigation hours per day}}{\text{Each irrigation hours}} = \frac{12\,hr}{2.1hr} = 5.7 \rightarrow 5times$$

(9) Rotation Block

Standard one (1) drip block=0.15ha（50m×30m）

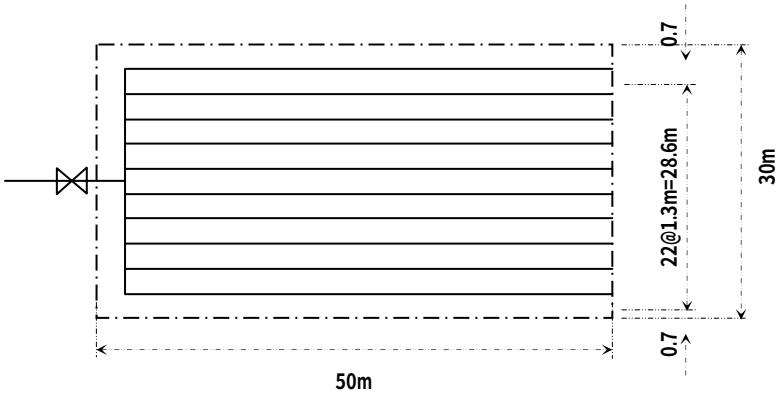
One (1) rotation block＝One (1) drip block×irrigation times per day×irrigation interval days

＝0.15ha×5times×4days＝3.0ha

Area of one rotation block is estimated to be 3.0ha as shown in **Figure C.4.2** on the assumption that area of one drip block is 0.15ha and maximum irrigation hours is 12 hours.

C.4.3.3 Hydraulic Calculation

(1) Design discharge



$$Q = 7.5\ell/hr/m \times 50\,m \times 23\text{本} = 8{,}625\ \ell/hr = 143.8\ell/\min = 2.4\ell/\sec$$

(2) Water head loss

Required water pressure for drip tube h1=10m (1.0kgf/cm$^{2)}$

Water head loss of filters, valves, and others h2 =5.0m

Pipeline head loss

$$h3 = 3.97\times10^{-1}\times\{6.287\times10^{6}\times(\frac{71.9}{140})^{1.85}\times\frac{15}{50^{4.87}}\} = 0.06m$$

$$h4 = 6.287\times10^{6}\times(\frac{Q}{C})^{1.85}\times\frac{L}{D^{4.87}} = 6.287\times10^{6}\times(\frac{143.8}{140})^{1.85}\times\frac{5}{75^{4.87}} = 0.02m$$

$$h5 = 6.287\times10^{6}\times(\frac{Q}{C})^{1.85}\times\frac{L}{D^{4.87}} = 6.287\times10^{6}\times(\frac{143.8}{140})^{1.85}\times\frac{300}{75^{4.87}} = 1.46m$$

∴Required head=h1+ h2+1.1×(h3+h4+h5)

=10+5+1.1×(0.06+0.02+1.46)＝16.7m

C.4.3.4 Specification of Pump

Discharge Q=2.4lit/sec→0.144m3/min(8.6m3/hr)

Total pump head H=20m（required head16.7m＋suction head3.3m）

$$P = 0.163\times\frac{Q\times H}{\eta}\times(1+R) = 0.163\times\frac{0.144\times20}{0.5}\times(1+0.15) = 1.0\,kw$$

C.4.4 On Farm Reservoir Capacity

Water balance on farm level is expressed by supply from Khettara and demand in farmland. Water supply is subject to the traditional water right and water demand is subject to the irrigation in farmland. In case of basin irrigation, farmers irrigate to their farmlands when water use turn come to them, therefore there is no need to regulate between supply and demand on farm level.

Although water use schedule is settled based on the traditional water right, farmers sometimes adjust to meet crop water demand through exchanging and/or dividing their irrigation hours. However, it is actually impossible to reduce the irrigation interval days not to exceed the lower limit of soil moisture (permanent wilting point) and adopt drip irrigation technique with one to two days of irrigation interval. In this regard, the construction of on-farm reservoir is indispensable to realize optimum water management and apply drip irrigation in Khettara irrigation area.

Following equation gives on-farm reservoir capacity which corresponds to the total water volume consumed by next water supply.

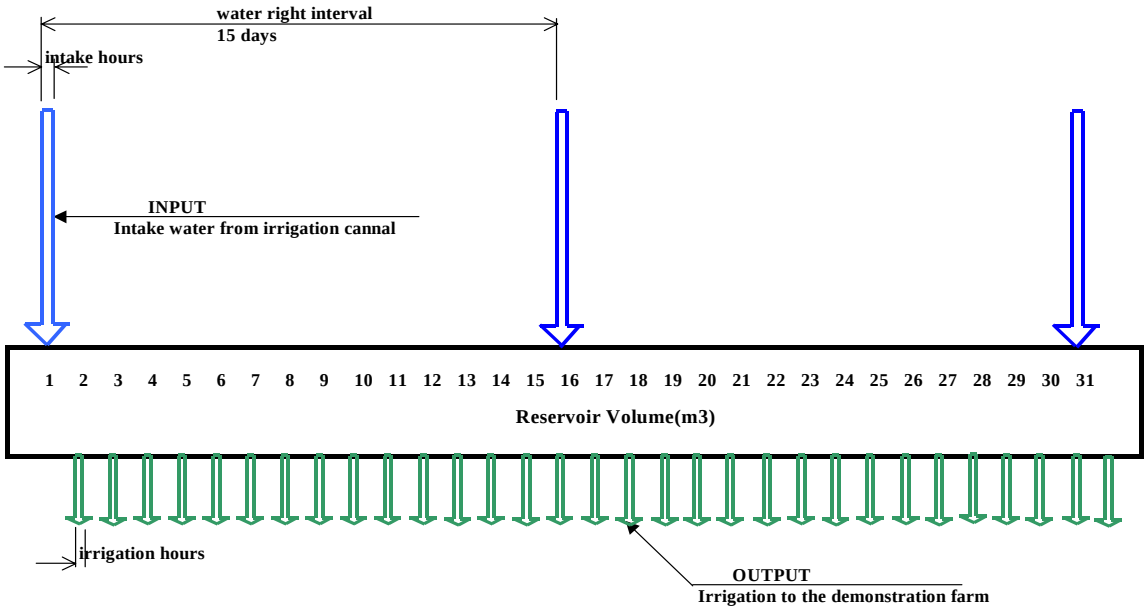
V=WD×DAY

V ; Capacity of on-farm reservoir (m^3)
WD ; Water demand (m^3/day)
DAY ; Supply interval day (days)

Required capacity of on farm reservoir for drip irrigation and furrow irrigation are estimated as follows, respectively in case of June showing highest water consumption 5.7mm/day. **Figure C.4.3** gives the graph of the required capacity of on farm reservoir.

Required capacity of on farm reservoir (m^3)

	A(ha)/days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Drip	1.00	30	60	90	120	150	180	210	240	270	300	330	360	390	420	450
Irrigation	2.00	60	120	180	240	300	360	420	480	540	600	660	720	780	840	900
	3.00	90	180	270	360	450	540	630	720	810	900	990	1,080	1,170	1,260	1,350
Furrow	1.00	45	89	134	179	224	268	313	358	402	447	492	536	581	626	671
Irigation	2.00	89	179	268	358	447	536	626	715	805	894	984	1,073	1,162	1,252	1,341
	3.00	134	268	402	536	671	805	939	1,073	1,207	1,341	1,475	1,609	1,744	1,878	2,012



Tables

Table C.2.1 Crop Coefficient Kc

Krop coeffidient Kc-value compiled by MARD(Ministry of Agriculture, Rural Development and Fisheries)

Kind of crops	Percentage of crop growth period (%)									
	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
Cereals	0.45	0.60	0.80	0.95	1.00	1.00	1.00	0.80	0.70	0.50
Beet	0.45	0.50	0.70	0.90	1.00	1.00	1.00	1.00	1.00	0.90
Cotton	0.45	0.45	0.45	0.60	0.90	1.00	1.00	0.90	0.70	0.60
Maize(Grain)	0.45	0.55	0.65	0.80	1.00	1.00	1.00	1.00	0.90	0.80
Maize(Fodder)	0.45	0.55	0.65	0.70	0.90	1.00	1.00	1.00	1.00	0.90
Sunflower	0.45	0.50	0.55	0.80	0.80	1.00	1.00	1.00	0.80	0.60
Green bean, Soybean	0.50	0.65	0.80	1.00	1.00	1.00	1.00	0.95	0.80	0.70
Broad bean	0.50	0.60	0.70	0.80	0.90	0.95	1.00	1.00	0.90	0.70
Vegetable	0.45	0.50	0.60	0.70	0.90	1.00	1.00	1.00	0.90	0.80
Tomato	0.45	0.45	0.50	0.65	0.85	1.00	1.00	0.95	0.85	0.75
Potato	0.45	0.45	0.60	0.85	1.00	1.00	1.00	1.00	1.00	0.90
Melon, Water melon	0.45	0.50	0.60	0.70	0.80	0.80	0.80	0.80	0.75	0.70

Kind of crops	Month												Average
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	
Alfalfa(First year)	0.70	0.75	0.90	1.00	1.05	1.10	1.15	1.15	0.45	0.55	0.60	0.65	
Alfalfa(Next year)	0.60	0.75	0.85	1.00	1.10	1.15	1.10	1.05	1.00	0.90	0.80	0.65	0.91
	1.00	1.00	1.00	1.00	1.00				0.45	0.80	1.00	1.00	
Sugar cane (planted at Avril)				0.45	0.50	0.70	0.90	0.95	0.90	0.70	0.60	0.45	
(First year)	0.45	0.45	0.55	0.70	0.90	1.00	1.15	1.15	1.15	0.75	0.60	0.45	
(Second year)	0.45	0.50	0.60										
Sugar cane (planted at Mayl)					0.45	0.50	0.70	0.90	0.95	0.70	0.60	0.45	
(First year)	0.45	0.50	0.60	0.70	0.90	1.00	1.15	1.15	1.15	0.75	0.60	0.45	
(Second year)	0.45	0.50	0.60	0.70									
Sugar cane (planted at June)						0.45	0.50	0.70	0.85	0.70	0.60	0.45	
(First year)	0.45	0.50	0.60	0.70	0.90	1.00	1.15	1.15	1.15	0.75	0.60	0.45	
(Second year)	0.45	0.50	0.60	0.75	0.95								
Ratoon(transplanted at Avril)	0.45	0.50	0.60	0.45	0.55	0.80	1.00	1.05	1.05	0.75	0.60	0.45	
Ratoon(transplanted at May)	0.45	0.50	0.60	0.70	0.45	0.60	0.85	1.05	1.05	0.70	0.60	0.45	
Ratoon(transplanted at June)	0.45	0.50	0.60	0.75	0.95	0.45	0.60	0.90	1.05	0.80	0.60	0.45	
Grape	0.20	0.25	0.30	0.50	0.70	0.80	0.80	0.75	0.65	0.50	0.35	0.20	
Orange	0.64	0.66	0.68	0.70	0.71	0.72	0.72	0.70	0.68	0.67	0.66	0.65	
Date tree, Olive tree(withered leaf)	0.17	0.25	0.40	0.65	0.85	0.95	0.90	0.80	0.50	0.30	0.20	0.15	0.51
Date tree, Olive tree(grass)	0.65	0.75	0.85	0.95	1.10	1.15	1.10	1.05	0.95	0.90	0.80	0.60	

Conveyance efficiency (E_c)		ICID/ILRI
Continuous supply with no substantial change in flow		0.9
Rotational supply in projects of 3000 to 7000ha and rotational areas of 70～300ha with effective management		0.8
Rotational supply in large schemes (>10000ha) and small schemes (<1000ha) with respective problematic communication and less effective management :		
	- based on predetermined schedule	0.7
	- based on advance request	0.65

Field canal efficiency (E_b)		
Blocks larger than 20ha	- unlined	0.8
	- lined or piped	0.9
Blocks below or up to 20ha	- unlined	0.7
	- lined or piped	0.8

Distribution efficiency ($E_d = E_c \cdot E_b$)		
Average for rotational supply with management and communication		
	- adequate	0.65
	- sufficient	0.55
	- insufficient	0.40
	- poor	0.30

Field application efficiency (E_d)		USDA	US(SCS)	ICID/ILRI
Surface methods :				
- soil type	- light soils	0.55		
	- medium soils	0.70		
	- heavy soils	0.60		
- irrigation method	- graded border		0.60～0.75	0.53
	- basin and level border		0.60～0.80	0.58
	- contour ditch		0.50～0.55	
	- furrow		0.55～0.70	0.57
	- corrugation		0.50～0.70	
Subsurface			up to 0.80	
Sprinkler	- hot, dry climate		0.60	
	- moderate climate		0.70	
	- humid, cool climate		0.80	0.67
Rice				0.32

Table 6.2 Conveyance, field canal, distribution, field application efficiencies
"Applications of Climatic Data for Effective Irrigation Planning and Management"(FAO)

The Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation	Table C.2.2 Irrigation Efficiency
Japan International Cooperation Agency	

Table C. 4.1 Water Consumption（Demonstration Farm)

Water consumption(WC) =ET0×Kc (mm/day)

ET0:Evapotransipiration (mm/day)

Kc:Crop coefficiency

1st stage

Month		Sep		Oct		Nov		Dec		Jan	
ET0(mm/day)		4.9		3.4		2.3		1.5		1.5	
	%	Kc	WC	Kc	WC	Kc	WC	Kc	WC	Kc	WC
Carrots	50	0.5	2.5	0.7	2.4	1.0	2.3	1.0	1.5	0.9	1.4
Turnip	50	0.5	2.5	0.7	2.4	1.0	2.3	1.0	1.5	0.9	1.4
Average			2.5		2.4		2.3		1.5		1.4

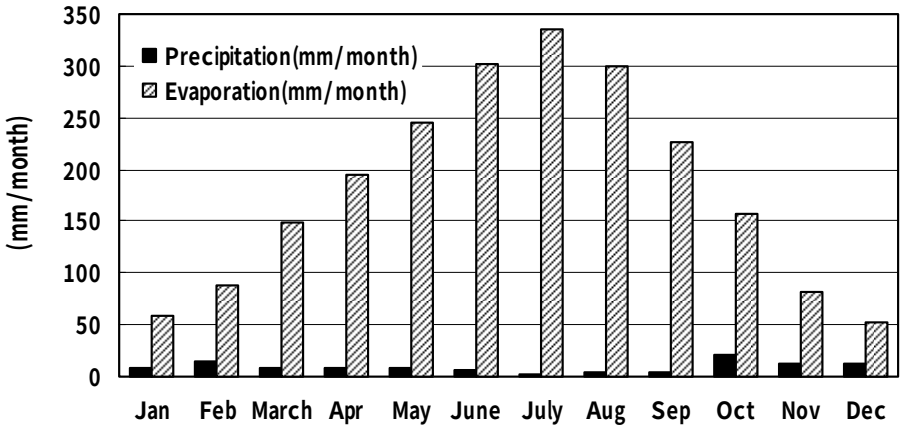
2nd stage

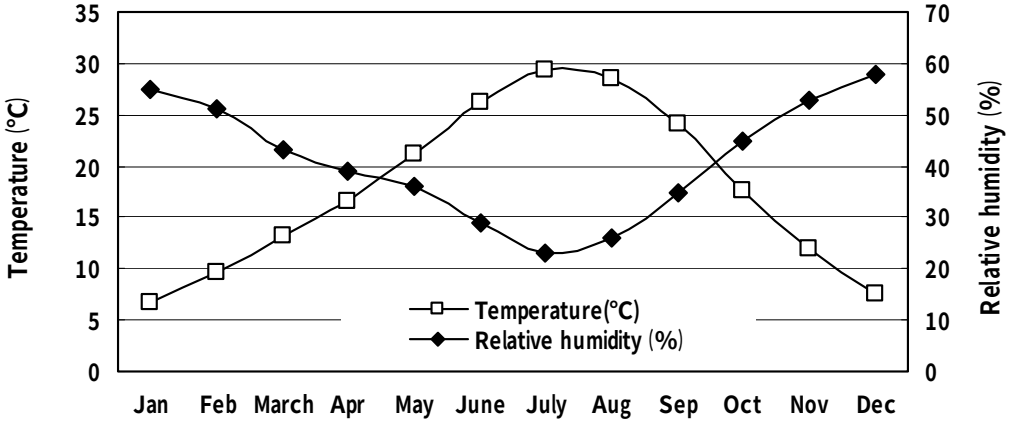
Month		Mar		Apr		May		Jun		July	
ET0(mm/day)		3.0		4.0		5.0		6.3		6.7	
	%	Kc	WC	Kc	WC	Kc	WC	Kc	WC	Kc	WC
Melon	25	0.5	1.5	0.7	2.8	0.8	4.0	0.8	5.0	0.7	4.7
Gumbo	25	0.5	1.5	0.7	2.8	1.0	5.0	1.0	6.3	0.9	6.0
Water melon	25	0.5	1.5	0.7	2.8	0.8	4.0	0.8	5.0	0.7	4.7
Tomato	25	0.5	1.5	0.6	2.4	0.9	4.5	1.0	6.3	0.8	5.4
Average			1.5		2.7		4.4		5.7		5.2

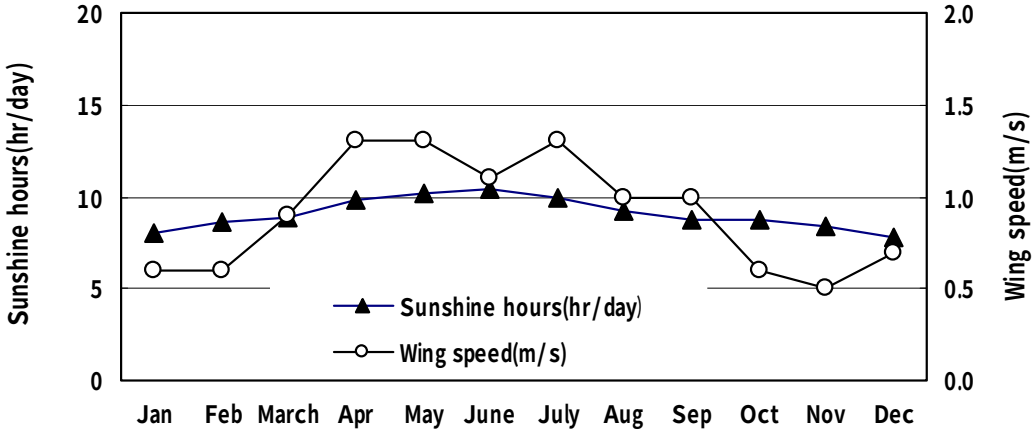
Kc value (M.A.R.D)

	Persentage of Crop Stage									
Vegetable	0-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
Wheat	0.45	0.60	0.80	0.95	1.00	1.00	1.00	0.80	0.70	0.50
Suger beet	0.45	0.50	0.70	0.90	1.00	1.00	1.00	1.00	1.00	0.90
Cotton	0.45	0.45	0.45	0.60	0.90	1.00	1.00	0.90	0.70	0.60
Maize(Edible)	0.45	0.55	0.65	0.80	1.00	1.00	1.00	1.00	0.90	0.80
Maize(for Animal)	0.45	0.55	0.65	0.70	0.90	1.00	1.00	1.00	1.00	0.90
Sunflower	0.45	0.50	0.55	0.80	0.80	1.00	1.00	1.00	0.80	0.60
Soybeans	0.50	0.65	0.80	1.00	1.00	1.00	1.00	0.95	0.80	0.70
Broad Beans	0.50	0.60	0.70	0.80	0.90	0.95	1.00	1.00	0.90	0.70
Vegetable	0.45	0.50	0.60	0.70	0.90	1.00	1.00	1.00	0.90	0.80
Tomato	0.45	0.45	0.50	0.65	0.85	1.00	1.00	0.95	0.85	0.75
Potato	0.45	0.45	0.60	0.85	1.00	1.00	1.00	1.00	1.00	0.90
Melon, Water melon	0.45	0.50	0.60	0.70	0.80	0.80	0.80	0.80	0.75	0.70

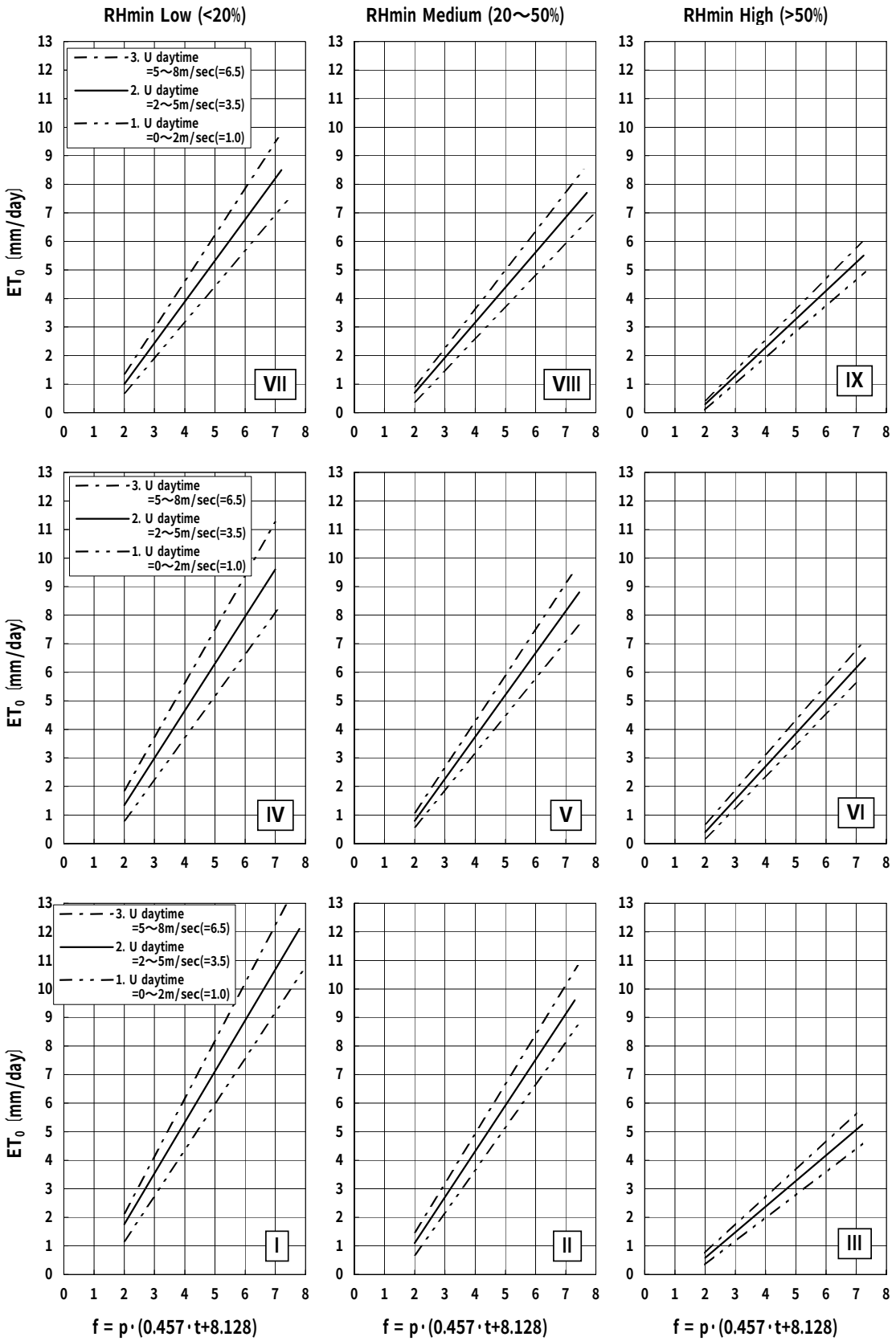
Figures







The Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation	Figure C.2.1 Meteorological Data
Japan International Cooperation Agency	



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

Figure C.2.2

Blaney Criddle Method
Prediction of ETo from f-factor

Japan International Cooperation Agency

ORMVA / TAFILALET
SEMVA / ERRACHIDIA
Year: 1982/83 - 2002/03

Zone V

Sunshine n/N: Midium(=0.7)
Rhmin: Midium(20～50%)
Udaytime: 0～2m/s

Mean Temperature (℃)

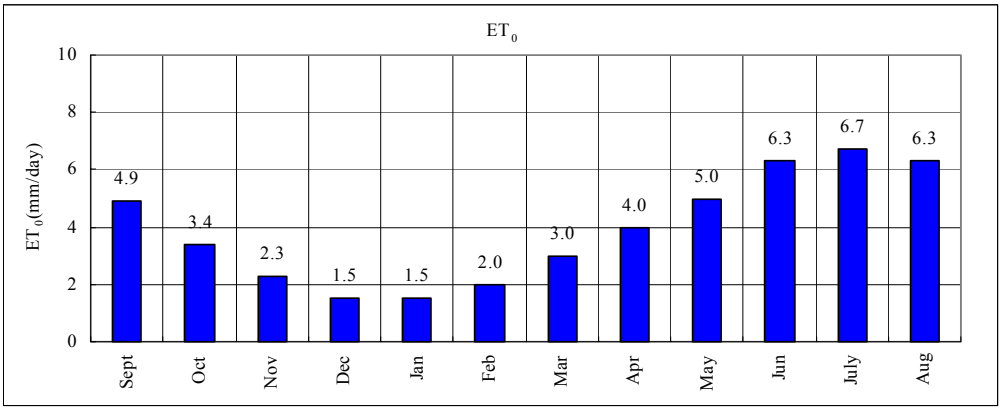
Month / Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug
1982/83	23.8	18.5	10.0	5.5	5.8	9.5	14.6	14.9	20.6	26.0	28.2	28.3
1983/84	24.0	17.8	13.8	7.8	5.6	8.3	10.4	16.2	18.3	26.1	27.7	27.4
1984/85	24.5	16.7	11.6	7.1	6.3	11.9	12.9	15.5	19.9	27.8	30.1	29.6
1985/86	24.2	18.3	13.2	7.2	8.1	10.7	12.5	15.5	23.8	25.8	29.9	29.4
1986/87	25.1	17.3	11.4	6.8	8.1	9.2	14.6	19.1	21.9	26.8	28.1	29.7
1987/88	25.7	18.6	11.8	6.7	8.5	10.7	13.7	18.2	22.5	25.5	30.0	29.6
1988/89	23.7	17.8	12.0	5.4	4.5	8.6	13.2	16.4	21.6	25.4	29.5	28.1
1989/90	24.3	18.3	12.4	5.7	6.6	11.0	14.1	15.5	21.3	26.6	29.5	28.3
1990/91	24.8	18.3	12.3	7.4	5.9	7.5	12.2	16.0	19.1	25.6	28.9	28.5
1991/92	23.5	15.7	10.9	8.8	5.0	9.3	12.0	16.2	20.1	23.0	27.9	28.0
1992/93	24.9	17.3	11.2	7.9	5.2	8.0	12.0	16.0	20.9	27.1	30.7	28.3
1993/94	22.1	17.0	11.2	8.3	7.3	9.1	13.5	16.0	21.8	26.9	28.9	28.8
1994/95	23.2	17.2	12.2	8.7	7.3	10.8	11.8	14.9	23.2	24.8	28.2	28.5
1995/96	21.6	17.6	13.0	8.3	9.1	9.3	12.6	17.4	20.1	24.3	28.0	27.6
1996/97	23.7	17.0	11.5	8.3	8.3	10.4	13.1	16.3	21.1	25.3	28.7	26.2
1997/98	23.7	18.8	12.8	8.5	7.7	10.2	13.1	17.9	19.8	25.4	29.9	28.7
1998/99	24.9	17.1	12.6	5.6	6.7	7.6	12.7	18.4	22.9	28.1	30.7	30.2
1999/00	25.1	19.2	10.6	7.9	4.8	10.1	13.8	16.3	20.4	25.1	30.6	28.1
2000/01	23.9	15.8	12.3	8.8	6.4	9.5	16.3	18.5	21.6	29.0	31.6	30.1
2001/02	25.6	20.5	12.7	9.3	7.4	10.1	12.9	16.1	22.0	27.4	30.0	28.0
2002/03	24.1	18.7	12.7	9.4	7.0	8.9	14.2	18.5	22.4	-	-	-
Average	24.1	17.8	12.0	7.6	6.7	9.6	13.2	16.7	21.2	26.1	29.4	28.6

p (30 degree of latitude North)

Month	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug
p	0.28	0.26	0.24	0.23	0.24	0.25	0.27	0.29	0.31	0.32	0.31	0.3
days	30	31	31	31	31	28	31	30	31	30	31	31

ET_0 (mm)

Month / Year	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	July	Aug
1982/83	160	134	94	76	80	87	124	130	169	192	202	196
1983/84	160	131	107	83	80	83	108	135	158	193	200	192
1984/85	162	127	100	81	82	95	117	132	166	200	210	201
1985/86	161	133	105	81	88	91	116	132	183	191	209	201
1986/87	165	129	99	80	88	86	124	147	174	196	202	202
1987/88	167	134	101	80	89	91	120	143	177	190	210	201
1988/89	159	131	101	76	76	84	119	136	173	189	208	195
1989/90	162	133	103	77	83	92	122	132	172	195	208	196
1990/91	163	133	102	82	81	81	115	134	162	190	205	197
1991/92	158	123	98	87	77	87	114	135	166	179	201	195
1992/93	164	129	99	84	78	82	114	134	170	197	213	196
1993/94	153	128	99	85	85	86	120	134	174	196	205	198
1994/95	157	129	102	86	85	91	113	130	180	187	202	197
1995/96	151	130	105	85	91	87	116	140	166	185	201	193
1996/97	159	128	100	85	89	90	118	136	171	189	204	187
1997/98	159	135	104	86	87	90	118	142	165	189	209	198
1998/99	164	128	103	76	83	81	117	144	179	201	213	204
1999/00	165	136	97	84	77	89	121	136	168	188	212	195
2000/01	160	124	102	87	82	87	130	144	173	205	217	204
2001/02	167	141	104	88	86	89	117	135	175	198	210	195
2002/03	161	134	104	89	84	85	122	144	176	-	-	-
Average(mm/month)	161	131	101	83	83	87	118	137	171	193	207	197
f(mm/day)	5.4	4.2	3.3	2.7	2.7	3.1	3.8	4.6	5.5	6.4	6.7	6.4
ET0(mm/day)	4.9	3.4	2.3	1.5	1.5	2.0	3.0	4.0	5.0	6.3	6.7	6.3



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

Japan International Cooperation Agency

FigureC.2.3

Blaney Criddle Method
Calculation process and result

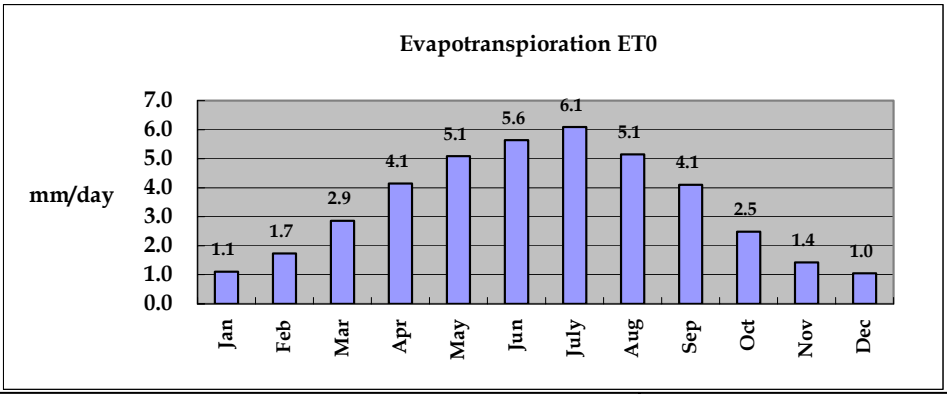
Calculation of ET0 with the combination method (Penman Monteith approach)

Country:	**Morocco**
Place:	**Errachidia**
Latitude(φ)	**32.9333** (deg) → 0.5748 (rad)
Altitude(Z)	**1037.2** (m)

P= 89.6 (Kpa)
λ= 2.45 (MJ/kg)
γ= 0.060 (Kpa/°C)

Tmean: ORMVA-SEMVA(1982-2003)
Rhmean,n: SMN-Errachidia(1980-1999)
U2: ORMVA-Errachidia(1999-2000)

Item	Unit	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
Month		1	2	3	4	5	6	7	8	9	10	11	12
J		15	45	76	106	136	167	197	228	258	288	319	349
Tmean	**°C**	**6.7**	**9.6**	**13.2**	**16.7**	**21.2**	**26.1**	**29.4**	**28.6**	**24.1**	**17.8**	**12.0**	**7.6**
u2	**m/s**	**0.6**	**0.6**	**0.9**	**1.3**	**1.3**	**1.1**	**1.3**	**1.0**	**1.0**	**0.6**	**0.5**	**0.7**
RHmean	**%**	**55**	**51**	**43**	**39**	**36**	**29**	**23**	**26**	**35**	**45**	**53**	**58**
n	**hr**	**8.0**	**8.6**	**8.9**	**9.8**	**10.2**	**10.4**	**10.0**	**9.2**	**8.8**	**8.7**	**8.4**	**7.8**
ea	Kpa	0.98	1.20	1.52	1.90	2.52	3.38	4.10	3.91	3.00	2.04	1.40	1.04
ed	Kpa	0.54	0.61	0.65	0.74	0.91	0.98	0.94	1.02	1.05	0.92	0.74	0.61
Δ	Kpa/°C	0.07	0.08	0.10	0.12	0.15	0.20	0.24	0.23	0.18	0.13	0.09	0.07
γ*	Kpa/°C	0.071	0.071	0.077	0.085	0.085	0.081	0.085	0.079	0.079	0.071	0.069	0.073
γ/(Δ+γ*)		0.43	0.39	0.34	0.29	0.25	0.21	0.19	0.19	0.23	0.30	0.37	0.41
900/(T+275)		3.19	3.16	3.12	3.09	3.04	2.99	2.96	2.96	3.01	3.07	3.14	3.18
ea-ed	Kpa	0.44	0.59	0.86	1.16	1.61	2.40	3.16	2.90	1.95	1.12	0.66	0.44
ETaero	**mm/day**	**0.4**	**0.4**	**0.8**	**1.3**	**1.6**	**1.7**	**2.2**	**1.7**	**1.3**	**0.6**	**0.4**	**0.4**
δ	rad	-0.37	-0.24	-0.04	0.17	0.33	0.41	0.37	0.24	0.04	-0.16	-0.33	-0.41
ωs	rad	1.31	1.41	1.55	1.68	1.79	1.85	1.83	1.73	1.60	1.46	1.35	1.29
dr		1.03	1.02	1.01	0.99	0.98	0.97	0.97	0.98	0.99	1.01	1.02	1.03
Ra	MJ/m2/day	19.2	23.9	30.5	36.3	40.0	41.5	40.7	37.7	32.6	26.3	20.6	18.0
N	hr	10.0	10.8	11.8	12.8	13.7	14.2	14.0	13.2	12.2	11.2	10.3	9.8
n/N		0.80	0.80	0.75	0.76	0.74	0.73	0.72	0.70	0.72	0.78	0.82	0.79
Rns	MJ/m2/day	9.6	11.9	14.7	17.7	19.2	19.7	19.1	17.4	15.3	12.9	10.4	8.9
f(n/N)		0.82	0.82	0.78	0.79	0.77	0.76	0.74	0.73	0.75	0.80	0.84	0.81
f(ed)		0.24	0.23	0.23	0.22	0.21	0.20	0.20	0.20	0.20	0.21	0.22	0.23
f(T)		30.09	31.36	32.99	34.63	36.83	39.34	41.11	40.68	38.30	35.16	32.44	30.48
Rnl	MJ/m2/day	-5.8	-5.9	-5.8	-6.0	-5.9	-6.0	-6.2	-5.9	-5.6	-5.8	-5.9	-5.7
Rn=Rns+Rnl	MJ/m2/day	3.8	6.0	8.9	11.7	13.3	13.7	12.8	11.5	9.7	7.1	4.5	3.2
Δ/(Δ+γ*)		0.49	0.53	0.56	0.59	0.64	0.71	0.74	0.74	0.69	0.64	0.57	0.49
ETrad	**mm/day**	**0.7**	**1.3**	**2.0**	**2.8**	**3.5**	**4.0**	**3.8**	**3.5**	**2.7**	**1.9**	**1.0**	**0.6**
ET0	**mm/day**	**1.1**	**1.7**	**2.9**	**4.1**	**5.1**	**5.6**	**6.1**	**5.1**	**4.1**	**2.5**	**1.4**	**1.0**

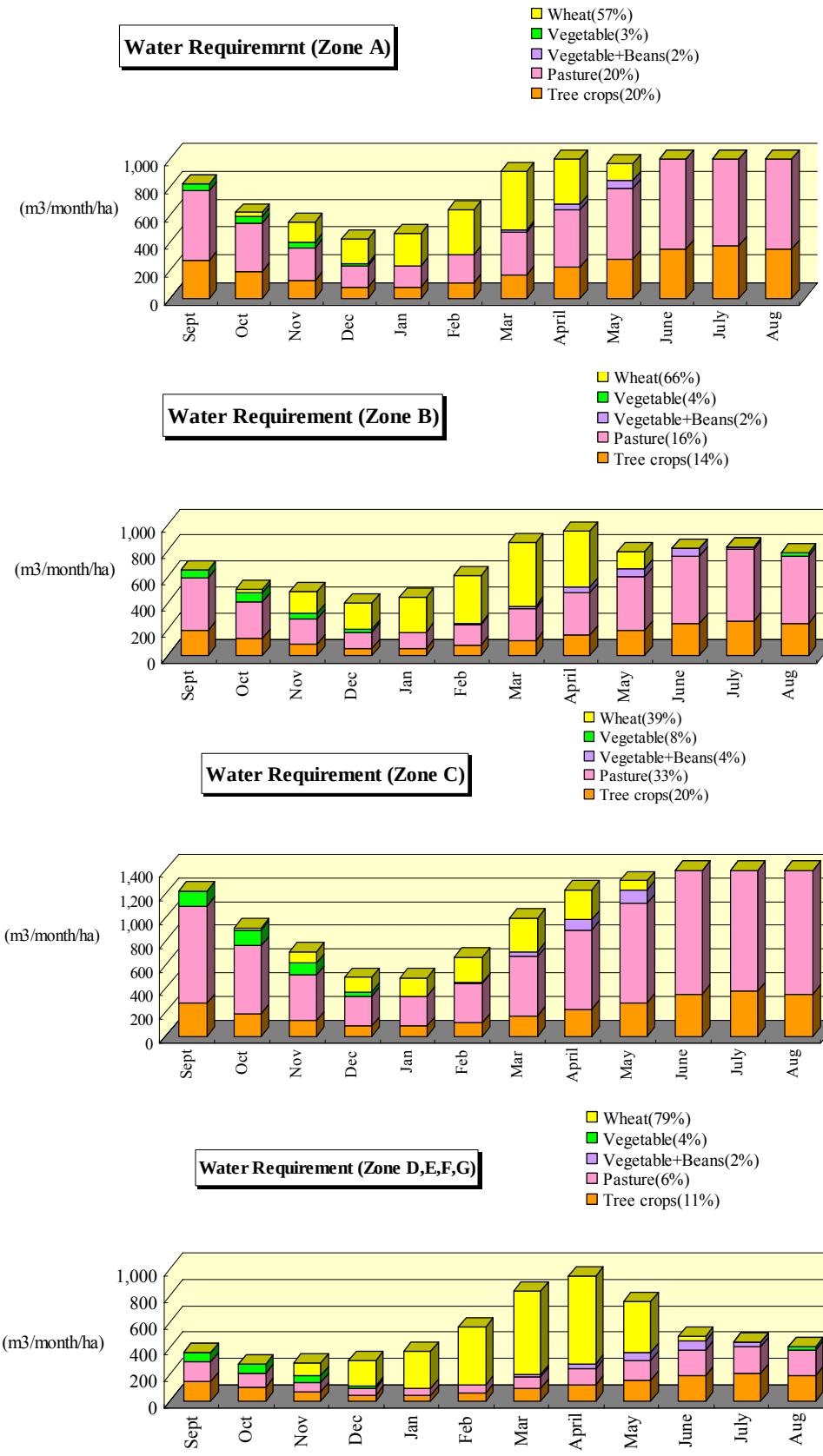


The Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation

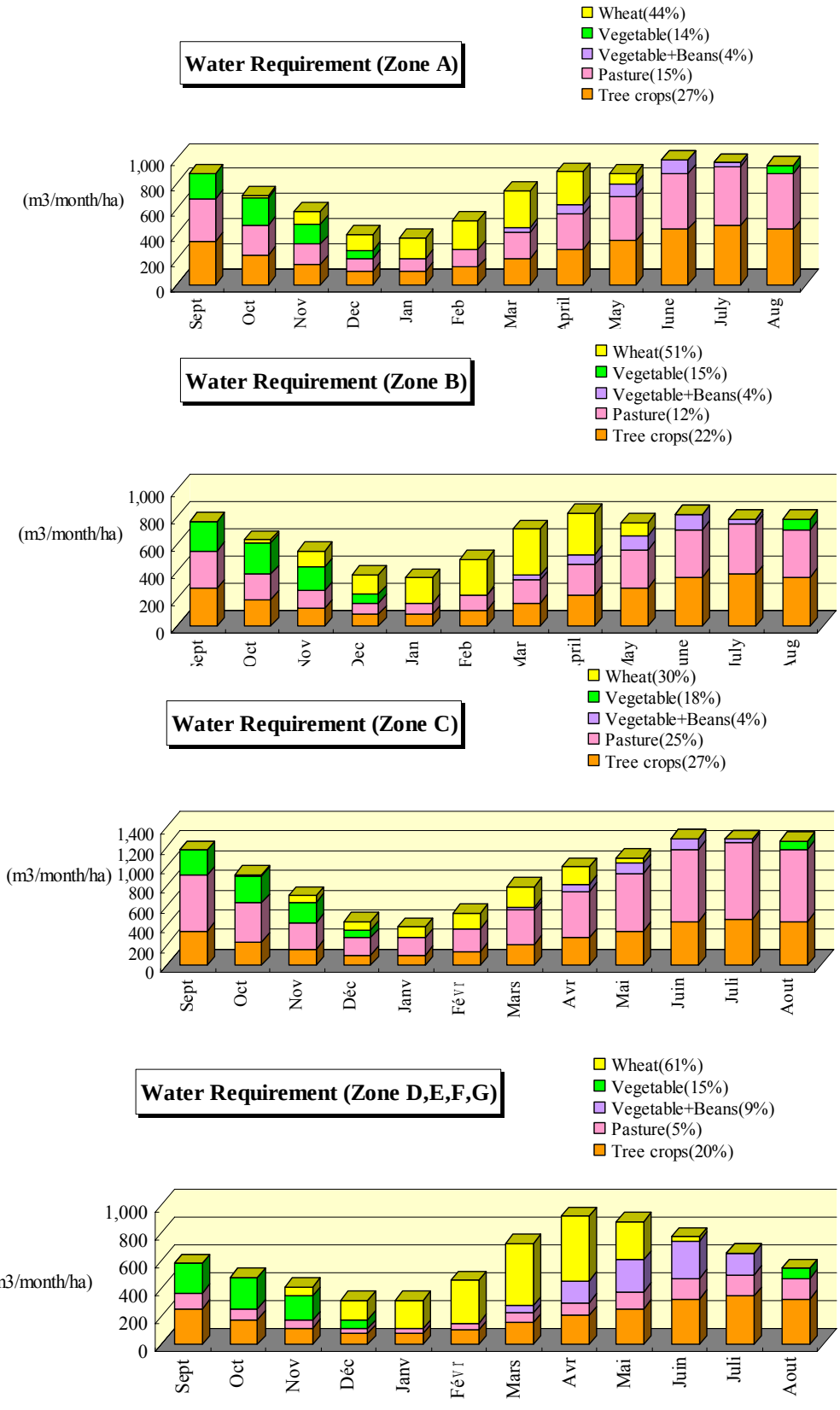
Japan International Cooperation Agency

Figure C.2.4

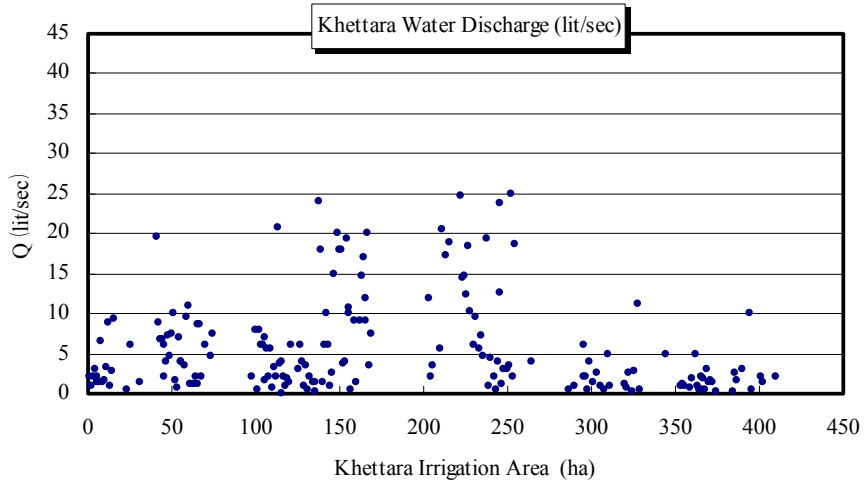
FAO Penman-Monteith Equation Calculation process and result

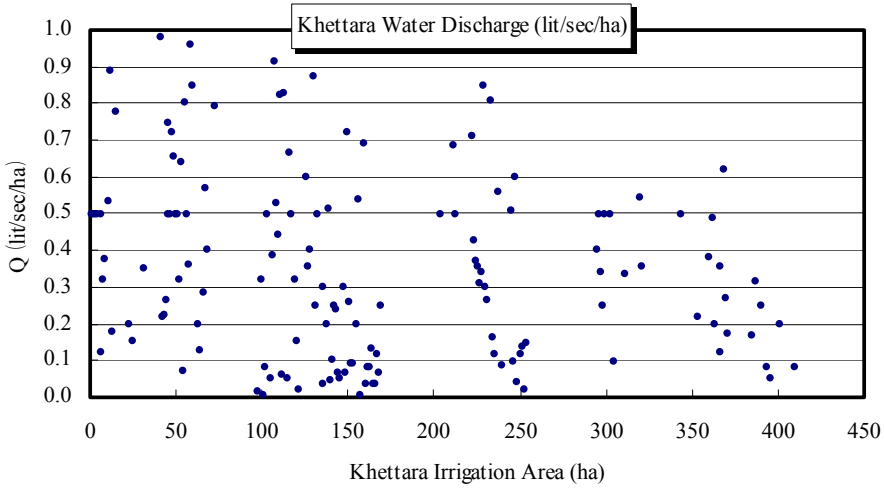


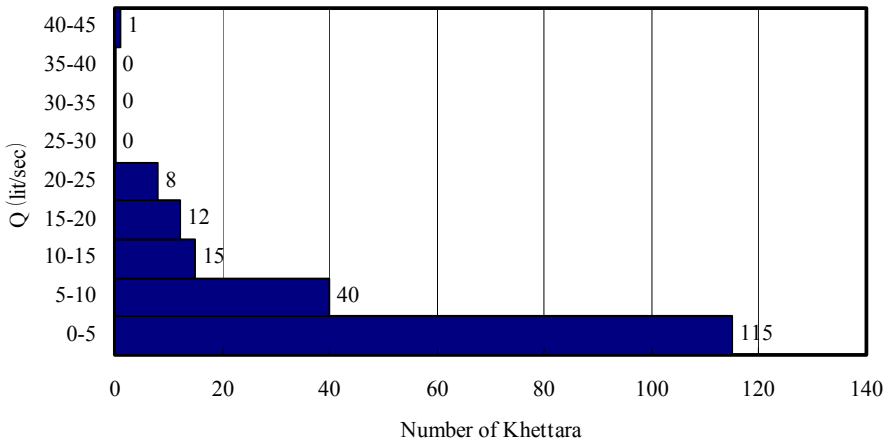
The Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation	Figure C.2.5 Irrigation Water Requirement (Present)
Japan International Cooperation Agency	

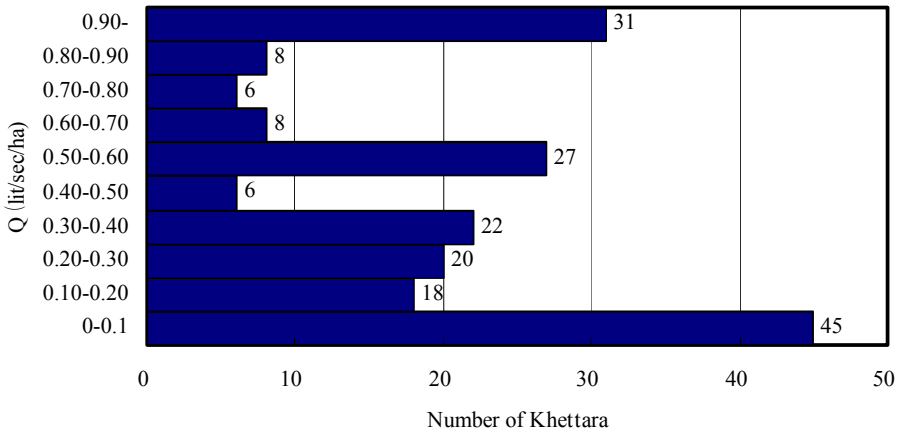


The Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation	Figure C.2.6 Irrigation Water Requirement (Proposed)
Japan International Cooperation Agency	



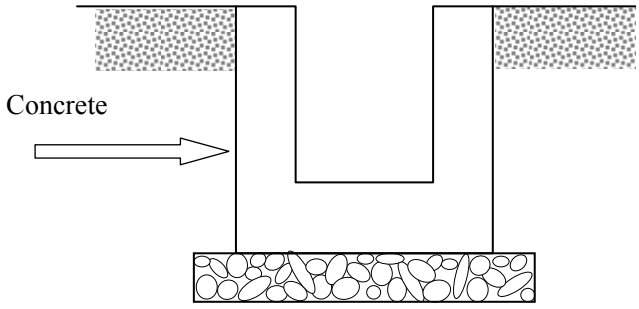


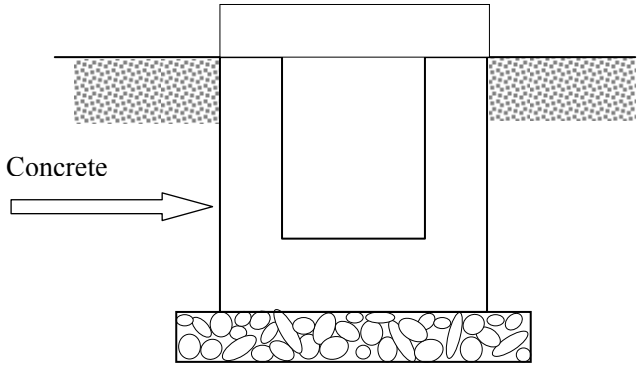


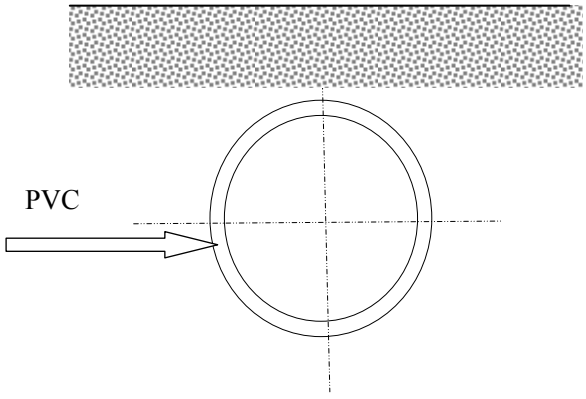


The Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation	Figure C.2.7 Khettara Water Discharge
Japan International Cooperation Agency	

Rehabilitation of Irrigation Canal



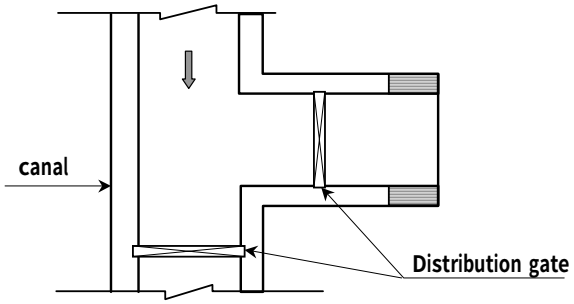


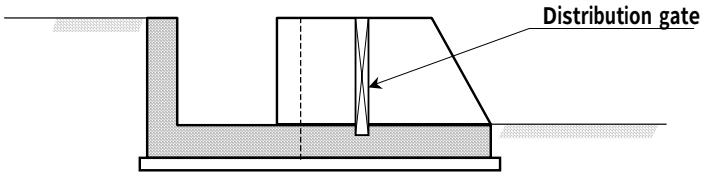


The Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation	FigureC.3.1 Rehabilitation of Irrigation Canal
Japan International Cooperation Agency	

Improvement of Distribution Outlet

Q≧5lit/sec





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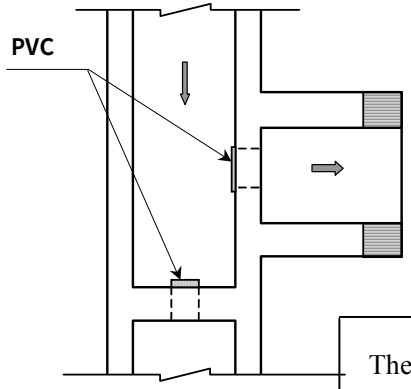
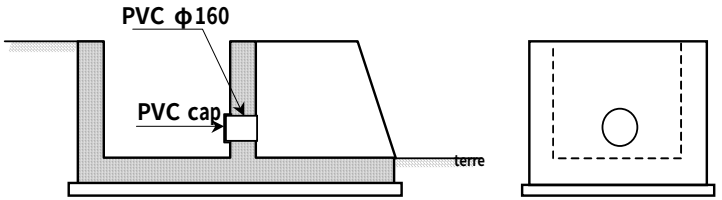
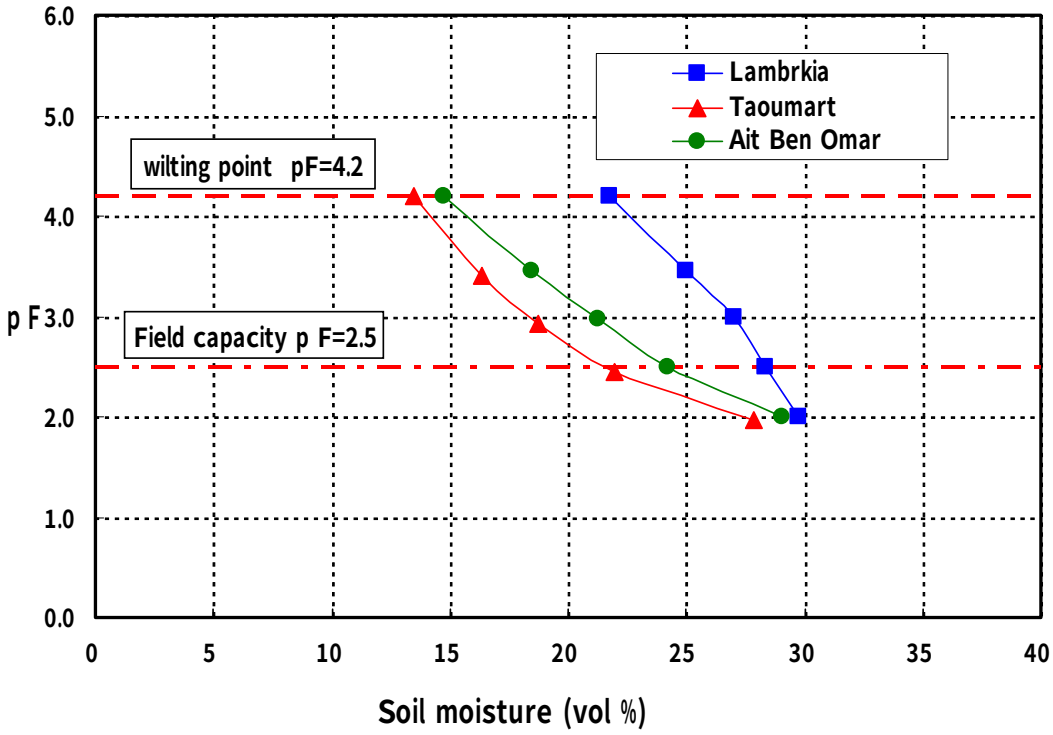




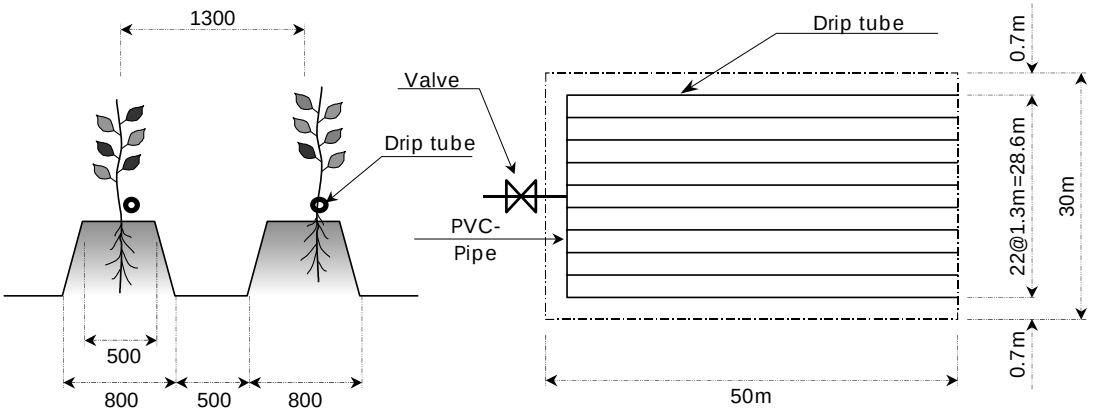
The Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation	Figure C.3.2 Improvement of Distribution Outlet
Japan International Cooperation Agency	

p F Analysis Result

Sampling Site	Sampling method	Dry density ρ d (g/cm³)		1	2	3	4	5
Lambrkia	Disturbed Soil	1.469	pF	2.0	2.5	3.0	3.5	4.2
			W	20.3	19.3	18.4	17.0	14.8
			θ	29.8	28.3	27.0	25.0	21.8
Taoumart	Disturbed Soil	1.240	pF	2.0	2.5	2.9	3.4	4.2
			W	22.5	17.7	15.1	13.2	10.9
			θ	27.9	21.9	18.7	16.3	13.5
Ait Ben Omar	Disturbed Soil	1.638	pF	2.0	2.5	3.0	3.5	4.2
			W	17.7	14.8	13.0	11.3	9.0
			θ	29.1	24.2	21.2	18.5	14.7

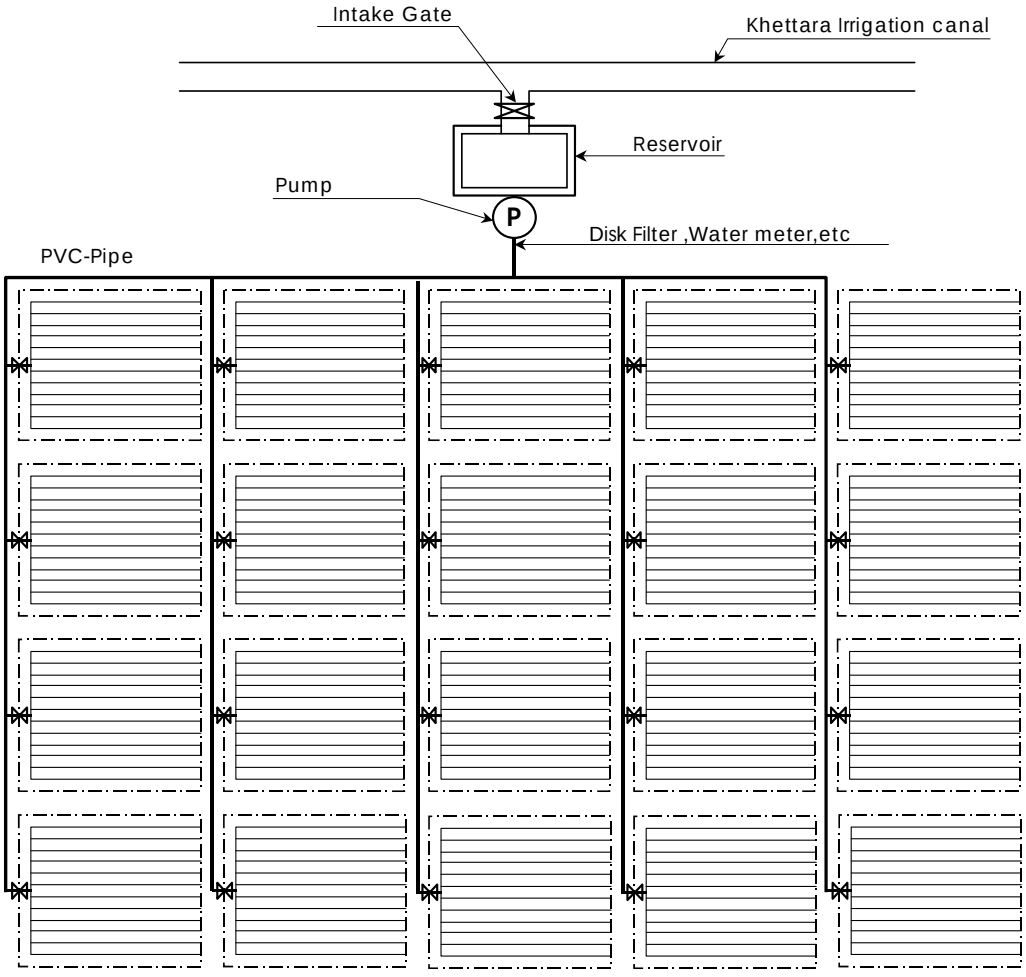


The Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation	Figure C.4.1 pF Analysis Result
Japan International Cooperation Agency	



Section

Plan of Drip Block

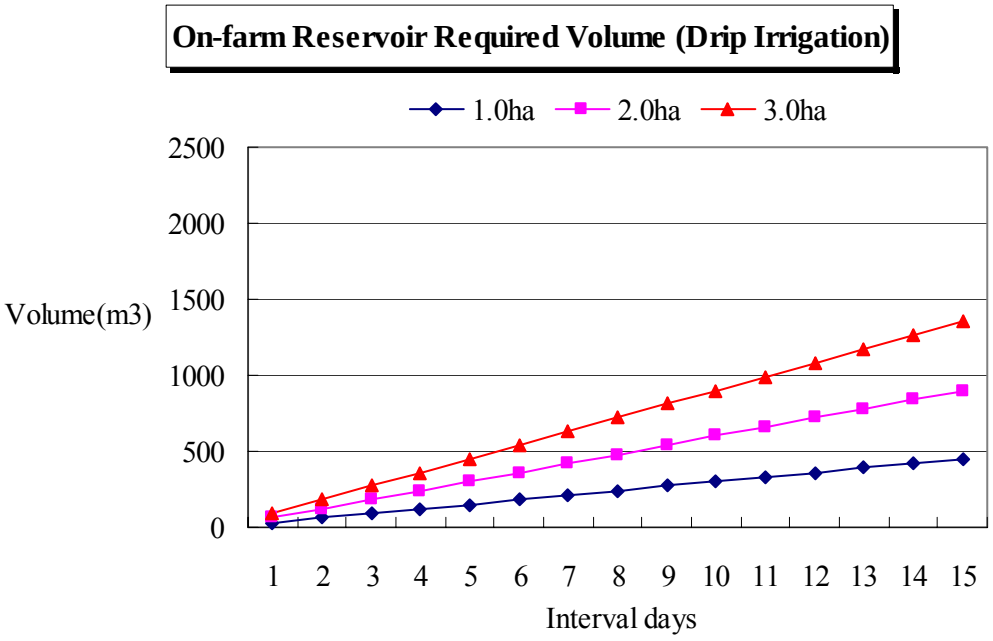


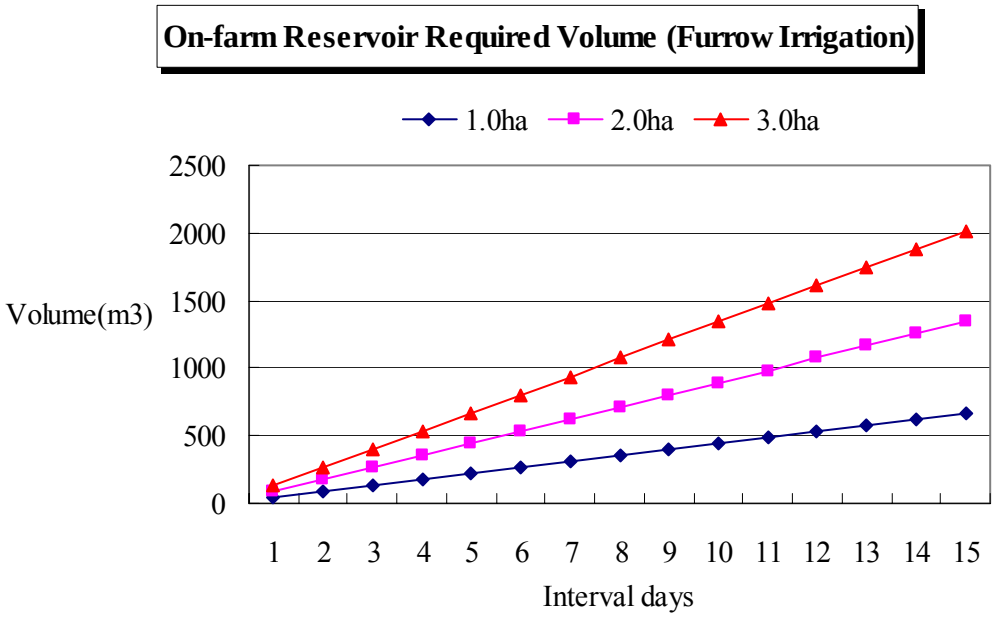
Drip Irrigation Area = 0.15ha×20block = 3.0ha

Plan of Drip Irrigation

The Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation	FigureC.4.2 Drip Irrigation Plan
Japan International Cooperation Agency	

Water Consumption=5.7mm/day(Max)





The Development Study on Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation	FigureC.4.3 On farm Reservoir Capacity
Japan International Cooperation Agency	

Annexe D Agriculture and Extension

Annexe D Agriculture and Extension

Contents

Tables

Figures

D.1 General

This is Annex D repot for agriculture and extension service. This report mentions: i) the outlook of agriculture sector in Morrocco, ii) present condition of agriculture in the study area, iii) progress and result of verification study related to the agariculture, and iv) agriculture development plan.

D.2 Outlook of Agriculture Sector

D.2.1 Agriculture Sector

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

Evolution of GDP in Morocco (Unit: DH million)

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

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

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

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

1 World Bank, Evaluation Document of the rural development projects, May 2003.

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

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

Source: World Bank, Evaluation Document of the rural development projects, May 2003.

As can be seen above, the agriculture sector benefits from the considerable public investments, after the transport and communication sector. However, more than 70% of public investment in the agriculture sector is dedicated for the installation of big scale irrigation facilities, and the investments for the poor communities are not sufficient.[2]

D.2.2 Agriculture Development Policy and Rural Communities

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

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

- Increase of the agriculture production to respond the future internal and external demand for food products;

- Increase of the employment and revenues in the agriculture;

- Creation and diversification of the employment in the para-agriculture activities and outside of the agriculture sector in order to respond to the demand for employment of the active rural population which cannot be absorbed by the agriculture production;

- Stop the process of human-made environmental degradation;

[2] World Bank, Country Assistance Strategy of World Bank, May 2001

- Upgrading and improvement of the education and professional training of rural men and women;

- Improvement of services related to the quality of life and well-being;

- Correcting of regional and sub-regional imbalances in the field of infrastructure, commerce and land management;

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

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

The principle of "decentralization" consists of transferring the authorities of the Ministry of Agriculture, Rural Development and Fishery to provinces and local offices. The principle of "integration" consists of reinforcing the cooperation between the governmental organizations, private enterprises, NGOs, farmers, etc. to jointly respond to problems. The principle of "participation" aims at: - stimulating the initiative of farmers in the development programs' activities, - improving the accessibility to the agriculture credit system, and – training farmers to enable them to evaluate and monitor their activities.

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

D.2.3 Farmers Organizations and Associations

The Ministry of Agriculture, Rural Development and Fishery has the complete authority of the Moroccan Government for elaborating and executing of the agriculture development policy. Figure D.2.1 presents organization chart of the Ministry. The Ministry includes a number of directorates. Those which are mainly in charge of the agriculture techniques development and extension as well as the farmers' organizations are the Directorate of Planification of Economic Affairs (DPAE), the Directorate of Teaching, Research and Development (DERD), the Directorate of Plant Production, Control Techniques, and Repression of Fraud (DPVCTRE), the Directorate of Plant Protection (DPV), the Directorate of Animal Husbandry (DE), and the Directorate of Public Agriculture Enterprises and Professional Associations (DEPAP).

At the regional level, there are 40 provincial agriculture directorates (DPA) and 9 regional offices of agriculture development. They are in charge of the agriculture development at the regional level. The DPAs are mainly in charge of the small and medium irrigation systems and of sectors of rain-fed agriculture (Bour).

The ORMVAs are in charge of the big-scale irrigation (and small and medium irrigation). Consequently, the areas of activities of DPA and ORMVA do not overlap.

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

D.3 Present Codtion of Agriculture in Study Area

D.3.1 Soils

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

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

Pedological Distributions of Study Zones

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

In addition to the above existing data, the soil suvery for the study area was carried out in 2003. Table D.3.1

presents a synthesis of soil unites, land capability classes and the proposed land managements for the studied perimeters. Results are grouped by zone as specified in this study. The main soil type present in the study area is a typical slightly developed soil according to the French classification used in Morocco. It corresponds to the xerochrept group of the soil Taxonomy. The second most frequent soil type is made of aerial sand deposits. It is classified as mineral soil in the French classification. The corresponding soil group in the soil Taxonomy is Psamment. Some perimeters contain other soil types such as the Isohumic soils (haploxerolls) or red Mediterranean soils (haploxaralfd or calcixerolls). These are relict soils from previous wetter climatic conditions.

The main constraints affecting the soils are: wind erosion, salinisation and texture. In some perimeters located in the low terraces near the rivers, flooding risk is a major constraint. Secondary constraints are: soil depth and alkalinity. Wind erosion control and manure application are the major land management proposed. The installation of wind breaks before any soil management around the perimeters is a requirement for a sustainable agricultural management. A minimum of live stock should be associated to farming in order to provide manure.

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

D.3.2 Agriculture

D.3.2.1 Agriculture Land Use

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

Agriculture Land Use in Tafilalet Region

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

Source : ORMVA/TF

As shown in the above table, over 52% of the lands are not appropriate for the agriculture use and the irrigated lands represent mere 0.8%. According to the ORMVA/TF the effective mobilization of the water

resources would allow enlarging the irrigated lands to 75,000ha.

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

D.3.2.2 Agriculture Production

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

Agriculture Production and yeild in Tafilalet region in 2001/02

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

Source: ORMVA/TF

Note: n.d. signifies not determined

The number of fruit trees includes the young trees which do not yet yield the fruits.

The detailed data of cultivation area, production, and yield of agricultural crops in 2004 by sub-dividsion is shown in Table D.3.2.

Dates

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

Olives

45% of olive trees are old (more than 50 years) and producing weak yield. The only type cultivated is the "Picholine Marocaine". Other than oil manufacturers of Rich, Errachidia and Goulmina, the production of oil of olives is mostly done by small business or applying traditional methods.

Wheat

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

Other agriculture products

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

D.3.2.3 Animal Husbandry

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

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

Number of Livestock in Tafilalet Region

Livestock	Number	Comment
Cattle	36 000	9 % of pure race, 27% of mixed race and 64% of hybrid race
Sheep	400 000	Including 100.000 of D'man race
Goats	350 000	
Camels	7 500	

Source: ORMVA/TF

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

D.3.3 Support Service for Agriculture and Rural Communities

D.3.3.1 System of Support Service for Agriculture and Rural Communities

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

Services of ORMVA/TF and Their Main Activities

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

Source : ORMVA/TF

The ORMVA/TF is divided into 5 subdivisions (Errachidia, Rich, Erfoud, Goulmima et Beni-Tadjit). In each subdivision, there is one agent in charge of coordination of the equipment works, maintenance of the network, agriculture, animal husbandry and material. Under the guardianship of the subdivision there are 22 centers: the development centers (CMV) in charge of the extension and support services, and the animal husbandry centers (CE) in charge of the animal health (vaccination, etc.)

The services of the agriculture support of the ORMVA/TF are ensured in the sense of "extension service and animal husbandry service → Subdivisions → CMV and CE → farmers ".

D.3.3.2 Agriculture Extension

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

Those activities are reviewed in the monthly meetings in the level of SV, the quarterly meetings in Errachidia

and annual meeting held in July in Errachidia. For the annual meetings, they summarize and evaluate the annual results. Also, the program for extension services for the next year is In the course of annual meetings, the program of extension for the next year is elaborated.

D.3.3.3 Agriculture Research and Experimental Study

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

D.3.3.4 Support for Rural Women

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

D.3.3.5 Agriculture Cooperatives

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

Cooperatives by Sector and Number of Members

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

Source: ORMVA/TF

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

D.3.3.6 System of Agriculture Credit

The National Agricultural Credit Bank (CNCA) opened the regional office (CRCA) in Errachidia and 4 branches (CLCA) in Errachidia, Rich, Erfoud and in Beni-Tadjit. There are two forms of credit, namely short-term credit and long-term credit. Those who fulfilled the process of the short-term credit can apply for the long-term credit. The interest rate of the short-term credit is of 8 to 10% annually for the maximum period of one year. The interest rate of the long-term credit is of 10 to 12.5% annually with the duration of

one year to 15 years. The total amount of the short-term loans is of DH1,621 million, equivalent of 3% of the total loans amount of DH48 million. The following table shows the results of loans in 2000 - 2004.

Loan Record of Agricultural Bank (2000 - 2004)

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

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

In addition to the system of national credit mentioned above, there is a system of micro-credit recently established for the benefit of the poor population. In fact, the Foundation of Agriculture Credit for Micro-credit started its activities in Errachidia in January 2002, with the intention of creating the regional platform. 111 persons have already benefited from micro-credit (half of whom are women). They obtained the total amount of 158 000 DH to finance the activities such as animal husbandry, purchase of fodders, or purchase of sewing machines.

D.3.4 Constraints Identified in the Agriculture

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

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

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

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

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

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

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

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

D.4 Progress and Result of Verification Study

D.4.1 General

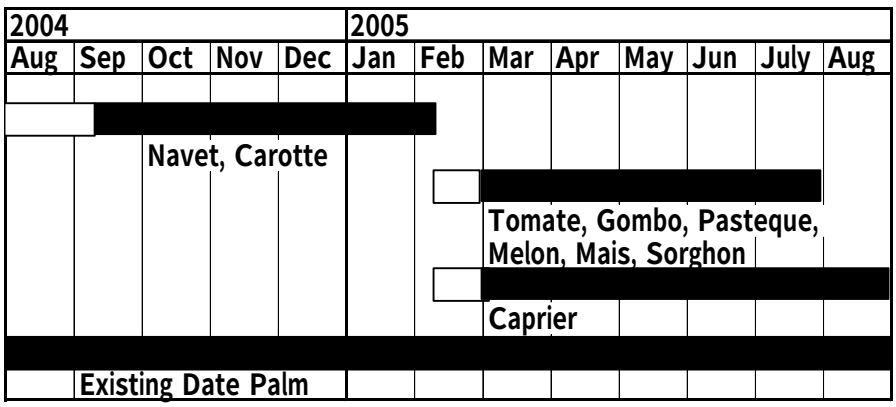
For foumulation of the master plan as shown in chapter 5, the verification study was peoposed. As the verification study for farming and extension, it was proposed to implemt i) demonstration and adaptability test for vegetable cultivation in the existing condition of KhettaraKsar using waster saving irrigation, ii) demonstration on agro-processing, iii) demonstration on income generation activities, iv) hygiene control of khettara, and v) environmental improvement of Khettara Ksar.

D.4.2 Adaptability Test and Demonstration for Water Saving Irrigation

(1) Contents and progress

In the Study Area, crop production has decreased to 50% during past 10 years due to decrease of rainfall. Therefore, efficient use of irrigation water is needed. Three khettara sites as demonstration for vegitable cultivation with effcient water use has been selected, namely: Ait Ben Omar、Lambarkia、and Jdida Taoumant. Through discussion between ORMVA/TF and JICA Study Team, the selection criteria for demonstration were finalized. The criteria includes: i) the demonstration plot will be used during August 2004 - September 2005 and owner of land should be fully participated into demonstration activities, ii) owner or family members of owners have strong willingness to participate into the demonstration, and iii) it is desirable that the participant(s) has experience of vegetable cultivation. Based on the criteria, ORMVA/TF explained the purpose of demonstration and selection criteria of demonstration plot to local people of Ait Ben Omar、Lambarkia、and Jdida Taoumant. As a result of effort of ORMVA/TF, it is expected that the demonstration could get farmers who has strong willingness as well as full cooperation of local association.

In succession to the selection of demonstration plots made by local people, ORMVA/TF in cooperation with JICA Study Team implemented surveys such as topographic condition, land use and water right to selected plots. Based on the survey result, the following cropping pattern were finalized through discussion between RMVA/TF and JICA Study Team.



The following risks and actions have been identified in the initial stage.

Risk and Action

Khettara Name	Resent Condition	Risk	Action to be Taken
Ait Ben Omar (Tinjdad)	Association shows high concerns to the demonstration. It is also confirmed that association will provide full cooperation to the demonstration.	Only one farmer will participate into demonstration. Therefore, demonstration may face shortage of water due to his limited water right.	CMV and water management expert of JICA should guide proper irrigation management and monitor activities of irrigation.
Lambarkia (Jorf)	Farmer shows strong willingness to participate into the demonstration.	Association complained shortage of explanation of the demonstration to JICA Study Team.	The explanation to association was made. The future explanation will be made fro time to time.
Taomart (Alnif)	Association shows high concerns to the demonstraion.	The demonstration plots will be operated by 7 farmers. They will create some conflicts.	CMV is requested that careful monitoring will be made.

The actual progress of demonstrations was shown in Table D.4.1 and D.4.2 and summrized below.

Summry of Cultivation Record

Tunip

Location		Drip irrigation	Fallow irrigation with reservoir	Fallow irrigation without reservoir	Traditional irrigation
Ait Ben Omar	Period	16/09-14/12	26/09-07/12	26/09-11/12	23/09-14/12
	Growth Date	89	41	45	82
Lambarkia	Period	14/09-20/12	11/09-28/12	15/09-25/01	13/09-30/12
	Growth Date	96	107	130	107
Taoumart	Period		12/09-31/12	09/09-11/01	10/09-17/11
	Growth Date		102	122	67

Carrot

Location		Drip irrigation	Fallow irrigation with reservoir	Fallow irrigation without reservoir	Traditional irrigation
Ait Ben Omar	Period	16/09-06/02	26/09-05/02	26/09-05/02	23/9-16/02
	Growth Date	141	122	122	143
Lambarkia	Period	14/09-18/02	11/09-18/02	15/09-18/02	13/09-18/02
	Growth Date	154	157	153	155
Taoumart	Period		12/09-18/02	09/09-18/02	10/09-18/02
	Growth Date		151	160	159

Tomate

Location		Drip irrigation	Fallow irrigation with reservoir	Fallow irrigation without reservoir	Traditional irrigation
Ait Ben Omar	Period	2005/3/28 - 2005/8/15	2005/3/28 - 2005/8/15	2005/3/28 - 2005/8/15	2005/3/11 - 2005/8/15
	Growth Date	141	141	141	158
Lambarkia	Period	2005/3/28 - 2005/9/10	2005/3/28 - 2005/9/10	2005/3/28 - 2005/9/10	2005/4/11 - 2005/9/10
	Growth Date	167	167	167	153
Taoumart	Period		2005/3/9 - 2005/8/15	2005/3/9 - 2005/8/15	2005/3/15 - 2005/8/15
	Growth Date		160	160	154

Gumbo

Location		Drip irrigation	Fallow irrigation with reservoir	Fallow irrigation without reservoir	Traditional irrigation
Lambarkia	Period	2005/3/4 - 2005/7/22	2005/3/2 - 2005/7/22	2005/3/4 - 2005/7/22	2005/3/4 - 2005/7/22
	Growth Date	141	143	141	141
Taoumart	Period		2005/3/10 - 2005/8/14	2005/3/4 - 2005/8/14	2005/3/10 - 2005/8/14
	Growth Date		158	164	158

Melon

Location		Drip irrigation	Fallow irrigation with reservoir	Fallow irrigation without reservoir	Traditional irrigation
Ait Ben Omar	Period	2005/3/11 - 2005/7/20	2005/3/11 - 2005/7/20	2005/3/11 - 2005/7/20	2005/3/11 - 2005/7/20
	Growth Date	132	132	132	132
Lambarkia	Period	2005/3/3 - 2005/7/12	2005/3/3 - 2005/7/12	2005/3/3 - 2005/7/12	2005/3/29 - 2005/7/12
	Growth Date	132	132	132	106
Taoumart	Period		2005/3/9 - 2005/7/18	2005/3/9 - 2005/7/18	2005/3/12 - 2005/7/18
	Growth Date		132	132	129

Water Melon

Location		Drip irrigation	Fallow irrigation with reservoir	Fallow irrigation without reservoir	Traditional irrigation
Lambarkia	Period	2005/3/3 - 2005/7/5	2005/3/3 - 2005/7/5	2005/3/3 - 2005/7/5	2005/3/26 - 2005/7/5
	Growth Date	125	125	125	102
Taoumart	Period		2005/3/9 - 2005/7/12	2005/3/9 - 2005/7/12	2005/3/12 - 2005/7/12
	Growth Date		126	126	123

Farmers in charge of demonstration plots measured harvest volume of cultivated crops. Based on the measurement results, the unit yield of each plot is estimated as shown below (Details are shown in Table D.4.3 and D.4.4).

The Unit Yields by Crops and Irrigation methods (First Crop)

Name of Khettara	Irrigation Method	Unit Yield (ton/ha)			
		Turnip		Carrot	
National Average*		15.0	-	20.0	-
Ait Ben Omar (Tinjdad)	Drip irrigation	17.3	(91%)	10.3	(98%)
	Fallow irrigation with reservoir	7.1	(37%)	3.0	(29%)
	Fallow irrigation without reservoir	5.8	(30%)	2.5	(24%)
	Traditional irrigation	19.1	(100%)	10.5	(100%)
Lambarkia (Jorf)	Drip irrigation	27.9	(125%)	38.5	(170%)
	Fallow irrigation with reservoir	23.8	(106%)	39.7	(175%)
	Fallow irrigation without reservoir	24.7	(110%)	17.3	(76%)
	Traditional irrigation	22.4	(100%)	22.7	(100%)
Taoumart (Alnif)	Fallow irrigation with reservoir	38.8	(162%)	60.7	(110%)
	Fallow irrigation without reservoir	52.3	(219%)	42.0	(76%)
	Traditional irrigation	23.9	(100%)	55.4	(100%)

Note: Source of national average is refering to the data of Ministry of Agriculture.

The Unit Yields by Crops and Irrigation methods (Second Crop-1)

Name of Khettara	Irrigation Method	Unit Yield (ton/ha)			
		Tomato		Gumbo	
National Average*		24.0	-	15.0	-
Ait Ben Omar (Tinjdad)	Drip irrigation	50.3	(729%)		
	Fallow irrigation with reservoir	40.9	(593%)		
	Fallow irrigation without reservoir	15.1	(219%)		
	Traditional irrigation	6.9	(100%)		
Lambarkia (Jorf)	Drip irrigation	58.7	(618%)	46.1	(475%)
	Fallow irrigation with reservoir	28.9	(304%)	24.8	(256%)
	Fallow irrigation without reservoir	27.6	(291%)	30	(309%)
	Traditional irrigation	9.5	(100%)	9.7	(100%)
Taoumart (Alnif)	Fallow irrigation with reservoir	69.2	(276%)	42.5	(720%)
	Fallow irrigation without reservoir	71.0	(283%)	11.0	(186%)
	Traditional irrigation	25.1	(100%)	5.9	(100%)

Note: Source of national average is refering to the data of Ministry of Agriculture.

The Unit Yields by Crops and Irrigation methods (Second Crop-2)

Name of Khettara	Irrigation Method	Unit Yield (ton/ha)			
		Melon		Water Melon	
National Average*		18.0	-	20.0	-
Ait Ben Omar (Tinjdad)	Drip irrigation	10.4	(212%)		
	Fallow irrigation with reservoir	9.1	(186%)		
	Fallow irrigation without reservoir	5.8	(118%)		
	Traditional irrigation	4.9	(100%)		
Lambarkia (Jorf)	Drip irrigation	15	(133%)	19.3	(117%)
	Fallow irrigation with reservoir	13.7	(121%)	19.0	(115%)
	Fallow irrigation without reservoir	8.7	(77%)	18.9	(115%)
	Traditional irrigation	11.3	(100%)	16.5	(100%)
Taoumart (Alnif)	Fallow irrigation with reservoir	55.0	(585%)	22.9	(107%)
	Fallow irrigation without reservoir	9.7	(103%)	14.0	(65%)
	Traditional irrigation	9.4	(100%)	21.5	(100%)

Note: Source of national average is refering to the data of Ministry of Agriculture.

The above table shows the following fact-findings..

- ✓ In the plots for fallow irrigation with and without reservoir in Ait Ben Omar in the first cropping, yields of both turnips and carrot were extremely low. In addition, yields of melon in the second crop were extremely low.

- ✓ The yield in drip irrigation plots are high in both first and second cropping compared with traditional basin irrigation plots.

- ✓ Excluding the plots for fallow irrigation with and without reservoir in Ait Ben Omar, fallow irrigation plots with reservoir indicate yield increase in the first cropping. On the other hand, fallow irrigation plot without reservoir indicates yield increase in turnip cultivation, while fallow irrigation plot without reservoir indicates yield decrease in carrot cultivation.

- ✓ The fallow irrigation plots with reservoir indicate yield increase in the second cropping. On the other hand, fallow irrigation plot without reservoir indicates yield increase in tomato and gumbo cultivation, while fallow irrigation plot without reservoir indicates yield decrease in melon and water melon cultivation in some cases.

The selling price and products were recorded. Based on the sales records on products, unit gross income is estimated as shown below (Details are shown in Table D.4.3 and D.4.4).

Unit Gross Income by Crops and Irrigation Method (First Crop)

Name of Khettara	Irrigation Method	Unit Gross Income (DH/ha)			
		Turnip		Carrot	
Ait Ben Omar (Tinjdad)	Drip irrigation	17,700	(89%)	15,900	(126%)
	Fallow irrigation with reservoir	7,120	(36%)	-	-
	Fallow irrigation without reservoir	5,760	(29%)	-	-
	Traditional irrigation	19,900	(100%)	12,600	(100%)
Lambarkia (Jorf)	Drip irrigation	17,500	(44%)	20,300	(46%)
	Fallow irrigation with reservoir	12,200	(31%)	22,000	(50%)
	Fallow irrigation without reservoir	11,600	(29%)	12,700	(29%)
	Traditional irrigation	39,500	(100%)	43,700	(100%)
Taoumart (Alnif)	Fallow irrigation with reservoir	37,300	(285%)	59,860	(103%)
	Fallow irrigation without reservoir	45,400	(347%)	37,900	(65%)
	Traditional irrigation	13,100	(100%)	58,400	(100%)

Unit Gross Income by Crops and Irrigation Method (Second Crop-1)

Name of Khettara	Irrigation Method	Unit Gross Income (DH/ha)			
		Tomato		Gumbo	
Ait Ben Omar (Tinjdad)	Drip irrigation	67,960	(531%)		
	Fallow irrigation with reservoir	64,170	(502%)		
	Fallow irrigation without reservoir	28,040	(219%)		
	Traditional irrigation	12,790	(100%)		
Lambarkia (Jorf)	Drip irrigation	105,910	(657%)	209,600	(495%)
	Fallow irrigation with reservoir	53,330	(331%)	132,510	(313%)
	Fallow irrigation without reservoir	40,000	(248%)	162,610	(384%)
	Traditional irrigation	16,130	(100%)	42,370	(100%)
Taoumart (Alnif)	Fallow irrigation with reservoir	80,830	(226%)	154,490	(322%)
	Fallow irrigation without reservoir	39,540	(111%)	53,230	(111%)
	Traditional irrigation	35,710	(100%)	48,000	(100%)

Unit Gross Income by Crops and Irrigation Method (Second Crop-2)

Name of Khettara	Irrigation Method	Unit Gross Income (DH/ha)			
		Melon		Water Melon	
Ait Ben Omar (Tinjdad)	Drip irrigation	25,100	(560%)		
	Fallow irrigation with reservoir	6,150	(137%)		
	Fallow irrigation without reservoir	7,530	(168%)		
	Traditional irrigation	4,480	(100%)		
Lambarkia (Jorf)	Drip irrigation	40,950	(142%)	32,850	(105%)
	Fallow irrigation with reservoir	35,810	(124%)	31,730	(102%)
	Fallow irrigation without reservoir	19,420	(67%)	35,170	(113%)
	Traditional irrigation	28,840	(100%)	31,170	(100%)
Taoumart (Alnif)	Fallow irrigation with reservoir	78,290	(356%)	66,570	(198%)
	Fallow irrigation without reservoir	20,290	(92%)	25,940	(77%)
	Traditional irrigation	21,980	(100%)	33,670	(100%)

The above table shows the following fact-findings.

- ✓ In the plots for fallow irrigation with and without reservoir in Ait Ben Omar in the first cropping, quantity and quality of both turnips and carrot production were extremely low. As results, those products were not sold. In the plots for fallow irrigation with and without reservoir in Ait Ben Omar in the second cropping, quantity and quality of melon production were also extremely low.

- ✓ The unit gross income made from traditional basin irrigation in Lambarkia site was extremely high in the first cropping, since the farmer in change of this plot management directly sold products in the local market without intervention of middle man. In the second cropping, the farmer in Lambarkia site sold most of the products to middle man.

- ✓ In Taumart, the unit gross income was relatively high, since yields and farm gate prices of products were higher than other demonstration sites.

Based on the purchasing record of farm inputs, daily cultivation records made by farmers, depreciation cost of irrigation facilities, and irrigation cots, the total cultivation cost is estimated. The costs are summarized below (Details are shown in Table D.4.5 and D.4.6).:

Unit Cultivation Cost Based on Actual Expenditures for First Cropping

（Unit: DH/ha）

Irrigation Method	Farming Cost	Irrigation Cost	Total Cultivation Cost
Drip irrigation	6,820	10,580	17,400
Fallow irrigation with reservoir	6,820	3,450	10,270
Fallow irrigation without reservoir	6,820	940	7,760
Traditional irrigation	6,820	1,400	8,220

Unit Cultivation Cost Based on Actual Expenditures for Second Cropping

（Unit: DH/ha）

Irrigation Method	Farming Cost	Irrigation Cost	Total Cultivation Cost
Drip irrigation	19,420	11,200	30,620
Fallow irrigation with reservoir	19,420	2,760	22,180
Fallow irrigation without reservoir	19,420	970	20,390
Traditional irrigation	19,420	1,590	21,010

The above table shows the following fact-findings..

- ✓ The cultivation cost using drip irrigation is much higher than other irrigation methods due to high facility cost.

- ✓ The cultivation cost using fallow irrigation without reservoir is cheapest amongst irrigation methods compared, since water saving effect caused minimum irrigation cost.

In the middle of December 2004 and June 2005, SVOP with cooperation of JICA Strudy carried out the study tours for extension staff and famers to the demonstration plots. The outline of the study tour is suumrized below:

Outline of Study Tour to Demonstration Plots Made ~~in December 2004~~

Target	Date	Zone Covered	Demonstration Plot	Content
Extension staff of ORMVA （55 persons in total）	Dec 09, 2004 (Participants: 25 persons) June 09, 2005 (Participants: 30 persons)	All	Ait Ben Omar, Lambarkia	1. Explanation of JICA Study Team on cultivation techniques introduced 2. Presentation of farmers on waster saving effects
Farmers （207 persons in total）	Dec 13, 2004 (Participants: 30 persons) June 10, 2005 (Participants: 24 persons)	Goulmima Tinjedad	Ait Ben Omar, Lambarkia	1. Explanation of SVOP on outline of demonstration plots 2. Explanation of JICA Study Team on cultivation techniques introduced 3. Presentation of farmers on waster saving effects
	Dec 14, 2004 (Participants: 30 persons) June 15, 2005 (Participants: 24 persons)	Alnif	Ait Ben Omar, Lambarkia	
	June 14, 2005 (Participants: 15 persons)	Beni Tadjit, Rcih, Boudenib	Ait Ben Omar, Lambarkia	
	Dec 15, 2004 (Participants: 30 persons) June 13, 2005 (Participants: 24 persons)	Erfoud, Jorf, Rissani	Ait Ben Omar, Lambarkia	
	Dec 16, 2004 (Participants: 30 persons)	Alnif	Taoumart	

In the study tour, SVOP and JICA Study Team carried out questinnire survey. The responses to quesinnire are summlized below:

Summary of Responses to Questionnaire Survey in Study Tour Made in December 2004

Date	Demonstration Plot	Cultivation Method	Reason	Irrigation Method to be Interested	Remarks
Dec 13, 2004 (Participants: 30 persons) June 10, 2005 (Participants: 24 persons)	Ait Ben Omar, Lambarkia	Good	High productivity Small irrigation water requirement	Drip Irrigation	More study tor should be made.
Dec 14, 2004 (Participants: 30 persons) June 15, 2005 (Participants: 24 persons)	Ait Ben Omar, Lambarkia	Good	High quality of products	Drip Irrigation	Cooperative for drip irrigation will be required.
Dec 14, 2004 (Participants: 15 persons)	Ait Ben Omar, Lambarkia	Very Good	High productivity	Drip Irrigation	Cooperative for drip irrigation will be required.
Dec 15, 2004 (Participants: 30 persons) June 13, 2005 (Participants: 24 persons)	Ait Ben Omar, Lambarkia	Very Good	High productivity	Drip Irrigation	High cost for introduction of drip irrigation will be problem. Khettara also should be rehabilitated.
Dec 16, 2004 (Participants: 30 persons)	Taoumart	Very Good	Easy techniques introduced High productivity	Fallow irrigation with reservoir	-

Source: Result of questinnire survey in the study tour to demonstration plots.

The above table shows the following fact-findings.

- ✓ The most of participants showed their interesting in most modernized irrigation method in each demonstration plot such as drip irrigation in Ait Ben Omar and Lambarkia as well as fallow irrigation with reservoir in Taoumart, since farmers appreciated effeteness of irrigation water saving and high quality and quantity of products using modernized irrigation method.

- ✓ On the other hand, participants pointed out that the high introduction cots of drip irrigation would be problem.

In the verification study, adaptability test for caper crop was made in Ait Ben Omar and Lambarkia sites, since caper crop is well know as medical crop. The main activities for the adaptability test of caper crop are as follows:。

The Main Activities for the Adaptability Test of Caper

Target	Date	Location	Content
Workshop for famers	March 22, 2005 (Participants: 50 persons)	Ait Ben Omar, Lambarkia	1. Explanation on advantage of caper crop 2. Explanation on caper cultivation method
Site training for farmers	April 15, 2005 (Participants: 20 persons)	Ait Ben Omar, Lambarkia	1. Practice of plantation of caper crop at sites 2. Explanation on caper cultivation method
Lecture for ORMVA staff	May 19, 2005 (Participants: 39 persons)	All area of ORMVA-TF	3. Explanation on technical and economical advantages of caper crop 1. Explanation on caper cultivation method(density, soil, fertilization and irrigation method)

As of July 2005, the survival rations of caper crop are 60% in Ait Ben Omar and 80% in Lambarkia, respectively. It is judged that the growth condition of the caper crop in the plots is fair or slightly good, since survival rations of caper crop are normally around 70%. In addition, it has been confirmed that i) no application of fertilizer is not required, ii) the irrigation interval is around 10 days and no irrigation will be required in the second year, and iii) the harvest will be expected in the second year.

(2) Monitoring

For the demonstration of vegetable cultivation under water saving irrigation, the following indicators and targets as “Outputs” are set up.

Indicators and Targets for Outputs of Demonstration for Water Saving Irrigation

Indicators		Target
Vegetation and Caper Crop		
Technical aspect:	Yield of vegetable production	More than 70% of target yield
	Possibility of Caper crop cultivation	Confirmation of caper crop cultivation
Financial aspect:	Benefit/cost ratio (excluding caper crop)	More than 1.1 of Benefit/cost ratio
Other aspects:	Interests of farmers	More than 50% of participants of study tour indicate their interesting in vegetable cultivation under water saving irrigation

Achievements to targets by irrigation method and by crops are as follows:

Achievements to Targets of Indicators

1) First Crops (Turnip and Carrot)

Name of Khettara	Irrigation Method	Achievement		
		Yield	B/C	Interests of farmer
Target			＞1.1	50%
Ait Ben Omar (Tinjdad)	Drip irrigation	Not Achieved	Not Achieved	Achieved
	Fallow irrigation with reservoir	Not Achieved	Not Achieved	-
	Fallow irrigation without reservoir	Not Achieved	Not Achieved	-
	Traditional irrigation	Not Achieved	Achieved	Not Achieved
Lambarkia (Jorf)	Drip irrigation	Achieved	Not Achieved	Achieved
	Fallow irrigation with reservoir	Achieved	Achieved	Not Achieved
	Fallow irrigation without reservoir	Achieved	Achieved	Not Achieved
	Traditional irrigation	Achieved	Achieved	Not Achieved
Taoumart (Alnif)	Fallow irrigation with reservoir	Achieved	Achieved	Achieved
	Fallow irrigation without reservoir	Achieved	Achieved	Not Achieved
	Traditional irrigation	Achieved	Achieved	Not Achieved

2) Second Crop (Tomato, Gumbo, Melon and Water Melon)

Name of Khettara	Irrigation Method	Achievement		
		Yield		
Target			＞1.1	50%
Ait Ben Omar (Tinjdad)	Drip irrigation	Partially Not Achieved	Partially Not Achieved	Achieved
	Fallow irrigation with reservoir	Partially Not Achieved	Partially Not Achieved	-
	Fallow irrigation without reservoir	Not Achieved	Not Achieved	-
	Traditional irrigation	Not Achieved	Not Achieved	Not Achieved
Lambarkia (Jorf)	Drip irrigation	Achieved	Achieved	Achieved
	Fallow irrigation with reservoir	Achieved	Achieved	Achieved
	Fallow irrigation without reservoir	Partially Not Achieved	Almost Achieved	Not Achieved
	Traditional irrigation	Not Achieved	Almost Achieved	Not Achieved
Taoumart (Alnif)	Fallow irrigation with reservoir	Achieved	Achieved	Achieved
	Fallow irrigation without reservoir	Not Achieved	Almost Achieved	Not Achieved
	Traditional irrigation	Not Achieved	Almost Achieved	Not Achieved

(3) Observation

Based on the monitoring results for the demonstration of vegetable cultivation under water saving irrigation, the following issues and countermeasure will be identified in terms of technical, financial and farmers' participatory aspects.

Issues and Countermeasures Identified through the Demonstration of Water Saving Irrigation

	Issue	Coarse Analysis	Countermeasures
Technical Aspect	- Poor growth of both carrot and turnip in fallow irrigation with and without reservoir in Ait Ben Omar (Tinjdad) - No achievement of target yield of carrot and melon cultivation in Ait Ben Omar (Tinjdad)。	- Pump trouble and rehabilitation work of khettara caused delay of cultivation period. - Technical level of farmer in Ait Ben Omar is lower than other demonstration sites. - Soil fertility of farmer in Ait Ben Omar is lower than other demonstration sites.	- CMV and JICA Study Team should more guide proper irrigation management and farming practice. - Number of crops will be reduced from 4 to 2 for second cropping. - Beneficiary for demonstration plot should be selected more carefully in terms of technical skill and flexibility. - The sand will be added to the farm land, so that soil will be improved.
Financial Aspect	- Low profit from drop irrigation in the first cropping, while profit from drop irrigation is not bad in the second cropping since the yield is very high.	- High facility cost causes low profit.	- Co-use of drip irrigation facility should be considered. - Cultivation area per one drip irrigation facility should be examined from a financial viewpoint. - Subsidy to drip irrigation facility should examined form a institutional viewpoint.
Farmers' participatory aspect	- Less interesting in fallow irrigation system than drip irrigation system in the first cropping. On the other hand, many farmers showed high interest to fallow irrigation with reservoir in the second cropping since the yield is very high.	- It is not enough to explain farmers about financial advantage in fallow irrigation, since the financial analysis was not completed in the study tour made in December 2004.	- Financial analysis result will be explained in the next study tour.

(4) Feedback to Master Plan

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

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

Otherwise, the verification proved that 1) farmers must be carefully selected because the results will be difficult to achieve in case of farmers who apply the inefficient and traditional cultivation techniques (case of Ait ben Omar), 2) it is necessary to study possibility of reducing the costs and re-dividing the lands because the investment costs for the installation of drip irrigation are high and it will be very difficult to achieve the appropriate benefits, 3) in the middle term, it is necessary to consider the extension of the fallow irrigation, which is profitable from the financial point of view, and until now it has not been utilized in the zone. The ORMVA/TF must study all those issues in the future.

D.4.3 Demonstration on Agro-processing

In the Study Area, most of agricultural products are used as home consumption. Only a part of the products are soled in the local markets without any added value through agro-processing activity. In order to increase market value of agriculture products, demonstrations of agro-processing for date palm, henna and gumbo were proposed. Based on the demonstration and post-demonstration results, the feasibility of proposed agro-processing activity will be examined from technical and financial view points. The detailed specifications of agro-processing and necessary attachments were finalized through discussion between ORMVA/TF and JICA Study Team considering technical advice made by experimental station of ORMVA. The specifications of processing machine and attachments are shown in Table D.4.7. The remarks for specifications are summarized below:

Table Remarks for Specification of Agro-Processing Machine and Attachments

Agro-Processing Machine	Remarks	Necessity Attachment
Datte processing machine	Supplier advised that smaller date processing machine is recommendable. However, experimental station of ORMV pointed out that small processing machines are frequently blocked by processed date and, accordingly, are low productivity. As a result, the basic spec machine is selected.	Mold for datte pasting is required to lap the processed datte paste.
Henna mill	It was confirmed that the basic specification is not required any modifications.	ORMVA/TF proposed to add packing machine. However, this proposals is not accepted due to shortage of budget.
Gumbo processing machine	It was confirmed that the basic specification is not required any modifications.	Drying rack will be required to dry processed gumbo.

The following sites were selected through discussion between ORMVA/TF and JICA Study Team considering that: i) capacity of associations/cooperative is confirmed, ii) production of target crops is

sufficient, and iii) the target Hsar should be Khettara Ksar. In addition, willingness of people to participations were confirmed in August 2004.

Demonstration Sites for Agro-Processing

Ksar Name	Kind of Processing	CMV	Khettara Name	Association
Beni Ouzième	Date Palm Paste	Boudnib	Beni Ouzième	Beni Ouzième
Ait Moulay Lmamoune	Date Palm Paste	Tinjdad	Ait Moulay Lmamoune	Nahda Lmamounia, Ait Moulay Lmamoune
Taoumart	Henna Mill	Alnif	Jdida Taoumart	Agdal, Taoumart
Sifa	Gumbo Processing	Erfoud	Haj Allal	Lamharza

The demonstrations for agro-processing and study tour on henna processing were made in September and October 2004. The results of demonstrations and study tour are summarized below:

Summary Results of d Demonstration and Study Tour for Agro-Processing

Ksar Name	Content	Date	Number of Participants	Result
Taoumart etc.	Study tour to Zagora for observation of henna processing activities	Sep. 28 – 30 (3 days), 2004	18 persons	Participants were satisfied by opinion exchange with Zagora cooperative.
Beni Ouzième	Demonstrations for Date Palm Paste	Oct.14, 2004	30 persons including 20 women	Participants were satisfied by high quality and added value of products.
Ait Moulay Lmamoune	Demonstrations for Date Palm Paste	Oct.13, 2004	43 persons including 30 women	Participants were satisfied by easy process and high quality of products.
Taoumart	Demonstrations for Henna mill	Oct.4, 2004	11 persons	Participants demanded to add generator for supply of electricity. They were basically satisfied by easy process of products.
Sifa	Demonstrations for Gumbo processing	Oct.15, 2004	8 persons	Participants were basically satisfied by easy process of products. However, some participants were apprehensive for low price of gumbo.

The above table shows the following fact-findings.

- ✓ It was clear that participants can do agro-processing work using processing machine provided by the JICA Study Team through demonstration. Participants were also satisfied by easy process.
- ✓ For gumbo processing, some participants were apprehensive for low price of gumbo. On the other hand, no participants were not worried about prices of products for henna and date palm

processing, since home consumptions of those products are high.

After implementation of the demonstrations, the associations in charge recorded operation condition of processing machines including number of participants, operation hours, weight of materials and production, selling volume. Based on the records, the operation of processing machines are as follows:

Operation of Processing Machines (October 2004 – July 2005)

Name of Ksar	Kind of Processing t	Participants	Operation hour	Materials (kg)	Production (kg)	Sales (kg)	Remarks
Beni Ouzième	Date Palm Paste	60	35	2,200	1,760	1,150	Income was DH 17,250
Ait Moulay Lmamoune	Date Palm Paste	105	26	1,400	1,110	-	All consumed as home consumption
Taoumart	Henna Mill	48	13	167	119	-	All consumed as home consumption
Sifa	Gumbo Processing	30	30	450	300	-	Sales will be made in the next winter season.

The above table shows the following fact-findings.

- ✓ Participants for processing machines of dates could not fully use the machines, since the machine was distributed during harvest season of date. However, it was confirmed that participants are very keen to use the processing machine. Therefore, operation hour and production volume will be improved in the next season.

- ✓ In the processing machines for date palm and henna, the demand on home consumption was very large and, accordingly, the production could not sometime be used for sales.

- ✓ Most of gumbo harvested in July was consumed at home due to shortage of irrigation water. Therefore, it is difficult for local population to collect gumbo as materials of processing machine. However, JICA Study team appreciated the effort on collection of materials under such conditions.

- ✓ It was confirmed that the participants for the processing machines for date palm, henna and gumbo would like to continue those activities in the next year. In the processing machine for date palm, the other Ksar requested ORMVA-TF to assist introduction of this processing machine, since the effect to reduce working hours for women is large.

Based on the above records and purchase record for the processing machines, production cost and return are estimated and the result is as follows:

Production Cost and Return of Processing Machine

Item	Unit		Beni Ouzième	Ait Moulay Lmamoune	Taoumart	Sifa
			Date Palm Paste	Date Palm Paste	Henna Mill	Gumbo Processing
Depreciation	（DH）	(1)	6,300	6,300	430	2,500
Materials	（kg）	(2)	2,200	1,400	170	450
Material Cost	（DH）	(3)	17,600	11,200	1,300	2,300
Production Cost	（DH）	(4)=(1)+(3)	23,900	17,500	1,730	4,800
Production	（kg）	(5)	1,760	1,110	119	300
Gross Income	（DH）	(6)	26,400	16,650	3,570	4,500
Net Income	（DH）	(7)=(6)-(4)	2,500	-850	1,840	-300
B/C	-	(8)=(6)/(4)	1.10	0.95	2.06	0.94

注） The price of date paste is estimated based on the actual market price of Beni Ouzièm (15 FH/kg)
The price of processed henna is estimated on the actual local market price (30 FH/kg).
The price of processed gumbo is estimated on the price which will be applied by beneficiaries (15 FH/kg).

The above table shows the following fact-findings.

- ✓ The financial feasibility of henna mill processing is good, since the initial cots for henna mill is small and the market price of processed henna is high.
- ✓ The balance between cost and return will be improved in the date paste and gumbo processing, if the unit production volume increases.

(2) Monitoring

The following indicators and targets for “Outputs” are set up for monitoring of agro-processing demonstration.

Indicators and Targets for Outputs of Agro-Processing Demonstration

Indicators	Target
Gumbo and Henna Technical aspect: Completion of production	Confirmation of that participants could complete processing
Financial aspect: Benefit/cost ratio	More than 1.0 of Benefit/cost ratio
Other aspects: Interests of farmers	More than 50% of participants indicate their willingness to continue gumbo or henna processing
Date Palm Technical aspect: Completion of production	Confirmation of that participants could complete processing
Financial aspect: Benefit/cost ratio	More than 1.0 of Benefit/cost ratio
Other aspects: Interests of farmers	More than 50% of participants indicate their willingness to continue dates processing

Achievements to targets by irrigation method and by crops are as follows:

Achievements to Targets of Indicators

Name of Ksar	Kind of Processing	Completion of Production	B/C	Willingness to Continue
Target		Confirmation in Demeonstration	More Than 1.0	More Than 50 % of Participants
Beni Ouzième	Date Palm Paste	Achieved	Achieved	Achieved
Ait Moulay Lmamoune	Date Palm Paste	Achieved	Not Achieved	Achieved
Taoumart	Henna Mill	Achieved	Achieved	Achieved
Sifa	Gumbo Processing	Achieved	Not Achieved	Achieved

(3) Observation

Based on the monitoring results for the demonstration of agro-processing machines, the following issues and countermeasure will be identified in terms of technical, financial and farmers' participatory aspects.

Issues and Countermeasures Identified through the Demonstration of Water Saving Irrigation

	Issue	Coarse Analysis	Countermeasures
Technical Aspect	- It was clear that participants can do agro-processing work using processing machine through demonstration.	-	- The monitoring will be continues. Technical assistance will be made, if necessary.
Financial Aspect	- Profitability of date processing machine is limited. - Profitability of gumbo processing machine is limited. -	- Participants for processing machines of dates could not fully use the machines, since the machine was distributed during harvest season of date. Therefore, operation hour and production volume were limited. - Most of gumbo harvested in July was consumed at home due to shortage of irrigation water. Therefore, it is difficult for local population to collect gumbo as materials of processing machine.	- The operation hour and production volume will be improved in the next season, if people use the machine from the begging of harvest season. - The production of gumbo should be stabilized. The water saving irrigation in addition to the gumbo processing should be considerd.
Farmers' participatory aspect	- Willingness to continue the processing machines for date paste and henna mill are confirmed. - The other Ksar requested ORMVA-TF to assist introduction of processing machine for date paste.	-	- The monitoring will be continues. Necessary assistance will be continues. - ORMVA-TF is trying to find other fund source for the request of date processing machine from other Ksar

(4) Feedback to Master Plan

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

D.4.4 Income Generation Activities

(1) Contents and Progress

In the Study Area, although agriculture has been main income source, the less rainfall in past ten years causes

decrease of agriculture production. It is, therefore, understood that the additional income sources other than crop cultivation have to be found, since income source is very limited in the Study area. In the verification study, rabbits and pigeon breeding as potential income source will be examined in terms of technical and financial aspects. The following five sites were selected and willingness of women groups to activities was confirmed in July 2004.

Sites for Income Generation Activities

Item	Ksar Name	Khettara Name	Association Name	Remarks
Rabbit Breeding	Tizougaghine, Goulmima	Bakkassia	Taouassoul, Tizougaghine	Many women showed their willingness to participate into the activities. Association selected some of them considering their willingness.
	Oukhite, Melaab	Oukhite	Amagha, Melaab	It was observed that access to market is not so good. However women's group showed strong willingness to the activities.
	Jorf (Ouled Aissa, Ouled Moussa and Ouled Ghanem)	Lambarkia (jorf), Souihla Lhaine, Souihla Ouled Ghanem	Lutte contre la desertification, Jorf	Association proposed that mother rabbit should be returned to association if number of rabbit increased.
	Dar Lbida, Rissani	Bidaouia	Mohamed Ben Abdellah, Rissani	Association has implemented education on literacy. Association expected that the income generation activities will contribute to more motivation of women.
	Boudnib	Jdida	Amis de la terre, Boudnib	Group shows the strong willingness to participate into the activities.
Pigeon Breeding	Boudnib	Jdida	Amis de la terre, Boudnib	Pigeon breeding will be made in the same Ksar of rabbit breeding. Market of pigeon is confirmed.

Based on the activity record made by women group and construction record made by the JICA Study Team, the progress of income generation activities is shown below:

Beneficiaries Data of Income Generation Activities (Pigeons and Rabbits) as of June 2006

Item	Ksar Name	No. of Participants	Training	Increase of Breeding Number	Decrease of Breeding Number	Beneficiaries who want to continue the activities
Rabbit Breeding	Tizougaghine, Goulmima	20persons	Field training program made by ORMVA-TF on Dec. 31 2004	19 persons	1 person	19 persons
	Oukhite, Melaab	18 persons	Field training program made by ORMVA-TF on Dec. 31 2004	6 persons	12 persons	10 persons
	Jorf (Ouled Aissa, Ouled Moussa and Ouled Ghanem)	15 persons	Field training program made by ORMVA-TF on Dec. 30 2004	8 persons	7 persons	11 persons
	Dar Lbida, Rissani	15 persons	Field training program made by ORMVA-TF on Dec. 29 2004	12 persons	3 persons	12 persons
	Boudnib	15 persons	Field training program made by ORMVA-TF on Dec. 30 2004	10 persons	5 persons	13 persons
	Total	83 persons		55 persons (66%)	28 persons (34%)	65 persons (78%)
Pigion Breeding	Boudnib	1 person	Field training program made by ORMVA-TF on Dec. 02 2004	0 person	1 person	1 person

Progress of Income Generation Activities (Pigeons and Rabbits) as of June 2006

Item	Ksar Name	No. of Participants	No. of Supply	Present Condition	No of Sales	Remarks
Rabbit Breeding	Tizougaghine, Goulmima	20persons	Male: 17 Female: 34 Hoses: 51	Male: 15 Female: 19 Baby: 73	None	Infant mortality rate ：63%(125 babies)
	Oukhite, Melaab	18 persons	Male: 18 Female: 36 Hoses: 54	Male: 07 Female: 11 Baby: 26	None	Infant mortality rate ：76%(81 babies)
	Jorf (Ouled Aissa, Ouled Moussa and Ouled Ghanem)	15 persons	Male: 17 Female: 33 Hoses: 50	Male: 10 Female: 17 Baby: 72	None	Infant mortality rate ：49%(69 babies)
	Dar Lbida, Rissani	15 persons	Male: 17 Female: 33 Hoses: 50	Male: 06 Female: 14 Baby: 59	None	Infant mortality rate ：50%(58 babies)
	Boudnib	15 persons	Male: 15 Female: 30 Hoses: 45	Male: 10 Female: 21 Baby: 57	None	Infant mortality rate ：72%(148 babies)
	Total	83 persons	Male: 82 Female: 163 Houses: 245	Male: 48 Female: 82 Baby: 287	None	Infant mortality rate ：62%(481 babies)
Pigion Breeding	Boudnib	1 person	Male: 50 Female: 50 Hoses: 1	Male: 45 Female: 45 Baby: 5	None	-

The above table shows the following fact-findings.

- ✓ For construction of rabbit house, supply of materials was responsibility of JICA Study Team, while assembling of house was responsibility of beneficiaries. It took long period to complete assembling of rabbit houses. However, all the works including distribution of rabbits has been completed in the end of January 2005.

- ✓ According to the observation made by ORMVA-TF, high Infant mortality rate is due to: i) abnormal cold weather, ii) careless management to rabbit babies, iii) damage caused by cats and rats, and iv) shortage of feed.

- ✓ Distribution of pigeon was slightly delayed due to delay of construction of pigeon houses. However, beneficiary utilized their house as temporary pigeon room. It was not reported that egg was hatched as of end of Feburary 2005. Although the number decreased in the initial stage, it was confirmed the hatch of eggs and increase of numbers as of June 2005.

- ✓ No beneficiaries have sold rabbits or pigeons, since the number increase is not sufficient and stabilized.

(2) Monitoring

For the income generation activities, the following indicators and targets as "Outputs" are set up.

Indicators and Targets for Outputs of Income Generation Activities

Indicators		Target
Rabbit breeding Technical aspect: and rabbits sold	Number of breeding rabbits	More than 70% of participants indicate their rabbits increased. More than 30% of participants indicate their rabbits was sold
Financial aspect:	Benefit/cost ratio	More than 1.0 of Benefit/cost ratio
Other aspects:	Interests of farmers	More than 70% of participants indicate their willingness to continue rabbit breading
Pigeon breeding Technical aspect: and pigeons sold	Number of breeding pigeons	Number of pigeons increased. Pigeons were sold
Financial aspect:	Benefit/cost ratio	More than 1.0 of Benefit/cost ratio
Other aspects:	Interests of farmers	A participant indicates her willingness to continue pigeon breeding.

Achievements to targets by schemes are as follows:

Achievements to Targets of Indicators

Item	Ksar	Achievement			
		No. of breeding	No. of selling	B/C	Willingness to Continue
Target		Increase	Confirmation	＞1.0	＞70%
Rabbit	Tizougaghine, Goulmima	Achieved	Not Achieved	Not Achieved	Achieved
	Oukhite, Melaab	Not Achieved	Not Achieved	Not Achieved	Not Achieved
	Jorf (Ouled Aissa, Ouled Moussa and Ouled Ghanem)	Not Achieved	Not Achieved	Not Achieved	Achieved
	Dar Lbida, Rissani	Achieved	Not Achieved	Not Achieved	Achieved
	Boudnib	Almost Achieved	Not Achieved	Not Achieved	Achieved
Pigeon	Boudnib	Not Achieved	Not Achieved	Not Achieved	Achieved

(3) Observation

Based on the above monitoring result, the following issues have been identified and countermeasures are proposed in terms of technical aspect, financial aspect and farmers' participation.

Issues and Countermeasures on Income Generation Activities (Pigeons and Rabbits)

	Issues	Course Analysis	Countermeasures
Technical Aspect	- Number increase of rabbits is not stabilized due to high rate of infant mortality. - Number increase of pigeons is not so high compared with rabbits, even though mortality rate of pigeon was small.	- All the babies of rabbits were killed by abnormal cold weather in January and February 2005. Careless management of rabbits breeding has been also observed. - It takes time to increase number of pigeons.	- It is confirmed as of June 2005 that the number of rabbits and pigeons have increased. The monitoring will be continues. Technical assistance will be made, if necessary.
Financial Aspect	- No beneficiaries have sold rabbits or pigeons, since the number increase is not sufficient and stabilized. As results, not benefit has been produced.	- Same reason as technical aspect.	- Number increase should be stabilized through same approach as technical aspect. - A part of beneficiaries made self consumption of rabbits and, as a result, they have properly cared rabbits. The self consumption should be sometimes considered instead of sale.
Farmers' Participation	- Most of beneficiaries in Oukhite lost willingness to continue the rabbit breeding, since number of death were high.	- In case of Oukhite, the main reasons are: i) monitoring is not enmough due to poor accessibility, ii) management of association is not sufficient since the association come from other area, and iii) shortage of feed due to limitation of irrigation water for fodder crops.	- In the verification or initial demonstration stage, the number of beneficiaries should be minimized, in case accessibility of Ksar was not good. - Local association of target Ksar is essential for management of activities and should be carefully selected.

(4) Feedback to Master Plan

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

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

D.4.5 Hygiene Control of Khettara

(1) Contents and Progress

Water guided through khettara is not only used for irrigation but also for drinking, livestock breeding, washing and other living activities, before it reaches to agriculture land. In some khettara, laundry place is not properly equipped and after wash water flows into irrigation canal. This causes deterioration of water quality for agriculture. In this component, ORMVA/TF and JICA improve laundry places accompanied to khettara and also carry out enlightenment activities in cooperation with local associations in order to prevent after wash water from re-entering into irrigation canal.

ORMVA/TF and JICA selected proposing sites for laundry place improvement based on discussion and site visits. During this period, present condition of proposing sites, effectiveness of improvement, draft improvement plan, existence of local associations and their interests on the project, and other issues to be concerned were confirmed. The results are summarized as below.

Results of Field Surveys at Proposing Sites

Ksar (Khettara)	Present Condition and Effectiveness of Improvement	Improvement Plan (Draft)	Existence of Association / Interest on Project	Issue to be concerned
Hannabou (Oustanita)	There is no laundry place at this moment. Women are doing laundry at open space along Khettara cannal. Moreover, water quality is deteriorated because many women pour rinsed water into irrigation canal. Therefore, effectiveness of laundry place improvement together with enlightenment activities is relatively high.	Construction of new laundry place	Association exists / Strong interest on the project	There is a concern among farmers that improved laundry place would result in decrease of water volume and more pollution for irrigation water since more ladies would come to the place for washing.
Bouya (Kadima, Jadia)	There is no laundry place at this moment. Women are doing laundry at open spaces along khettara cannal (not at one place). Moreover, water quality is deteriorated because many women pour rinsed water into irrigation canal. Therefore, effectiveness of laundry place improvement together with enlightenment activities is relatively high.	Construction of new laundry place and drainage facilities	Association exists / Strong interest on the project	Drainage should be guided to common land located near desert area (far from proposing laundry place) since these is no appropriate site along khettara.
Ait Ben Omar (Ait Ben Omar)	Although ORMVA/TF constructed laundry places along main irrigation canal, rinsed water goes back to the canal. Therefore, effectiveness of drainage improvement together with enlightenment activities is relatively high.	Improvement of existing drainage facility	Association exists / Strong interest on the project	None
Ksiba (Diba)	There is no laundry place at this moment. Previously, women did laundry at a place of khettara for taking potable water. However, people decided to prohibit doing laundry using khettara water in May 2004 because of reduction of khettara discharge.	Presently, people do not think of constructing laundry place since they have recently discussed and decided ban on laundry using Khettar water.		
Ait Moulay Mamoun (Ait Moulay Mamoun)	There is a existing laundry place just up stream of irrigation basin, but the space is not enough (Some ladies come to the place arround 5 am in order to avoid crowdedness). Moreover, water quality is deteriorated because rinsed water directly flows into irrigation basin. Therefore, effectiveness of laundry place improvement together with enlightenment activities is relatively high.	Enlargement of existing laundry place and improvement of drainage facility (including enlightenment activity)	Association exists / Strong interest on the project	None

Ksar (Khettara)	Present Condition and Effectiveness of Improvement	Improvement Plan (Draft)	Existence of Association / Interest on Project	Issue to be concerned
Taoumart (Jadida)	There is no laundry place at this moment. Previously, laundry using khettara water was rarely done since water discharge was too small. However, laundry using khettara water has been increased owing to increase in water discharge resulted from rehabilitation work supported by Embassy of Japan. Therefore, effectiveness of drainage improvement together with enlightenment activities is relatively high.	Construction of new laundry place	Association exists / Strong interest on the project	None

Based on the above survey results, Ait Ben Omar, Ait Moulay Mamoun and Taoumart were selected as candidate sites for laundry place improvement.

The observation results before and after improvement of laundry place and enlightenment activities are summarized as below.

Condition of Each Site before Implementation of Scheme

Ksar (Khettara)	Present Condition	Improvement Plan	Existence of Association / Interest on Project
Taoumart (Jdida Taoumart)	There is no laundry place at this moment. Previously, laundry using khettara water was rarely done since water discharge was too small. However, laundry using khettara water has been increased owing to increase in water discharge resulted from rehabilitation work supported by Embassy of Japan.	Construction of new laundry place with enlightenment activities	Association exists / Strong interest on the project
Ait Ben Omar (Ait Ben Omar)	Although ORMVA/TF constructed laundry places along main irrigation canal, rinsed water goes back to the canal.	Improvement of existing drainage facility with enlightenment activities	Association exists / Strong interest on the project
Ait Moulay Mamoun (Ait Moulay Mamoun)	There is a existing laundry place just up stream of irrigation basin, but the space is not enough (Some ladies come to the place around 5 am in order to avoid crowdedness). Moreover, water quality is deteriorated because rinsed water directly flows into irrigation basin.	Enlargement of existing laundry place and improvement of drainage facility (including enlightenment activity)	Association exists / Strong interest on the project

Condition of Each Site after Implementation of Scheme

Ksar (Khettara)	Enlightenment Activities	Laundry Place Condition	Interview Survey Results on Wash Water Flows into Irrigation Canal.	Impact to Water Quality Improvement.	Remarks
Taoumart (Jdida Taoumart)	Oct. 2004 – Feb. 2005: 6 times （around 400 participants）	Cleaning activities have been made twice per week. Users have kept rules of laundry place use.	According to interview survey made by association, all the interviewee noted that quality of khettara water was almost same as before.	Base condition (no laundry practice) COD: 1 ppm Surfactant: 0.5 ppm At laundry practice (before project) COD: - Surfactant: - At laundry practice (after project) COD: 1 ppm Surfactant: 0.5 ppm	To prevent excess use of irrigation water in khettara, number of users is limited to be 11 persons only per day.
Ait Ben Omar (Ait Ben Omar)	Oct. 2004 – Feb. 2005: 8 times （around 100 participants）	Cleaning activities have been made twice per week. Around 70% of users have kept rules of laundry place use.	According to interview survey made by association, all the interviewee noted that quality of khettara water was improved.	Base condition (no laundry practice) COD: 2 ppm Surfactant: 0.5 ppm At laundry practice (before project) COD: 50 ppm Surfactant: 2 ppm At laundry practice (after project) COD: 3 ppm Surfactant: 2 ppm	Number of users has decrease from 35 persons per day to 18 persons per day after the meeting for water quality improvement.
Ait Moulay Mamoun (Ait Moulay Mamoun)	Oct. 2004 – Feb. 2005: 6 times （around 150 participants）	Cleaning activities have been made once per week. Users sometimes have not kept rules of laundry place use.	According to interview survey made by association, all the interviewee noted that quality of khettara water was improved.	Base condition (no laundry practice) COD: 1 ppm Surfactant: 0.5 ppm At laundry practice (before project) COD: 30 ppm Surfactant: 5 ppm At laundry practice (after project) COD: 5 ppm Surfactant: 1.5 ppm	Rubbish was collected and burned after the meeting for water quality improvement.

(2) Monitoring

For the hygiene control of khettara, the following indicators and targets as “Outputs” are set up.

Indicator for Output and Target on Hygiene Control of Khettara

Indicator for Output	Target
Quantity of rinsed water poured into khettara from laundry place	Quantity of rinsed water poured into khettara is reduced.
Change on peoples' behavior at laundry place	It is confirmed that people have started doing laundry with following ways. - Do laundry at laundry place - Do not pour rinsed water to khettara canal, or return it to the canal according to a new rule - Do not do laundry inside khettara canal

Achievements to targets by schemes are as follows:

Achievements to Targets of Indicators

Scheme	Achievement			
	Quantity of Rinsed Water Poured into Khettara	Laundry at Laundry Place	Rule for Rinsed Water	No Laundry inside Khettara Canal
Target	Decrease	Confirmed	Confirmed	Confirmed
Taoumart	Achieved	Achieved	Achieved	Achieved
Ait Ben Omar	Achieved	Achieved	Almost Achieved	Achieved
Ait Moulay Mamoun	Achieved	Achieved	Not Achieved	Achieved

(3) Observation

As shown in the monitoring result, the awareness on water quality improvement of khettara has been improved through the pilot schemes. On the other hand, the following issues and countermeasure are identified.

Issues and Countermeasures Identified through the Hygiene Control Activity of Khettara

Scheme	Target	Issue	Coarse Analysis	Countermeasures
Taoumart	Achieved	Users have kept rules of laundry place use.	-	Farmers concern that improved laundry place would cause problems of decreasing water volume for irrigation This issue was solved, since number of uses has been limited.
Ait Ben Omar	Almost Achieved	Around 70% of users have kept rules of laundry place use.	It takes more time to keep rules of laundry place use completely, since rule was newly established.	At initial stage, only 50% of users was kept rules of laundry place use. As results of enlightenment activities, no of uses who kept rule increased. The enlightenment activities should be continued.
Ait Moulay Mamoun	Partly Not Achieved	Users sometimes have not kept rules of laundry place use.	Due to 2 m intervals from khettara to drainage, some users do not keep the rules.	Although users sometimes have not kept rules, it was confirmed change on peoples' behavior such as activity of rubbish collection. The enlightenment activities should be continued.

(4) Feedback to Master Plan

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

D.4.6 Environmental Improvement of Khettara Ksar

(1) Contents and progress

It is observed livestock dung and rubbish in Khettara Ksar, and, accordingly, those causes environmental deterioration. To improve environmental condition in Khettara Ksar, it is proposed to construct basins for organic manure for collection of livestock dung with awareness campaign of segregation between livestock dung and rubbish through local association. Through discussion between ORMVA/TF and JICA Study Team, the candidate Ksars were considered. The criteria for Ksar includes that: i) association as supporting force should be active, ii) Ksar should indicate willingness to implement of the activities, iii) khettara should be attached. As a result, the following six Ksars were investigated.

Table Investigation Result for Candidate Ksar

Ksar Name	Khettara Name	Association	Present Condition	Remarks
Alnif	Alnif	Association Bougafer	There is rubbish ground between settlement area and agricultural field. In the rubbish ground, rubbish and manures are mixed.	Activity needs are confirmed and association is active. Association proposed to install small box for rubbish near manure basin.
Taoumart	Jdida Taoumart	Agdal pour le développement	Rubbish is buried in the desert area. There is some manure around khettara basin, but the volume of manure is limited.	Activity needs is low, although association is active. The activity should be made in other Ksars.
Boutanfite	-	Association Wifaq	It is pointed out that rubbish and manure affects environmental degradation in Ksar.	Activity needs are confirmed and association is active. However, Ksar is out of the study area due to no khettara.
Bouya	Jdida Bouya	El Amal pour le développement	There are two rubbish grounds near settlement area. In the rubbish grounds, rubbish and manures are mixed.	Activity needs are confirmed and association is active. Association proposed to install two manure basin (basin area should be half of basic specification), since two families use tow rubbish grounds, separately.
Ait Ben Omar	Ait Ben Omar	Al Moustakbal pour le développement et l'environnement	Rubbish is buried in the desert area. Ksar would like to produce manure using manure basin.	Activity needs are confirmed and association is active. Association proposed to install four small manure basin (basin area should be one-forth of basic specification) considering easy management and collection of livestock dung.
Mounkara	Lambarkia	Al Moukara pour le développement des khettaras de Mounkara	Rubbish is buried in the desert area. There is some manure around khettara basin, but the volume of manure is limited.	Activity needs is low The activity should be made in other Ksars.

According to the above investigation results, Bouya, Alnif, and Ait Ben Omar is selected for implementation of Ksar.

The observation results before and after construction of basins for organic manure are as shown below.

Condition of Each Site before Implementation of Scheme

Ksar Name	Khettara Name	Association	Present Condition	Improvement Plan
Alnif	Alnif	Association Bougafer	There is rubbish ground between settlement area and agricultural field. In the rubbish ground, rubbish and manures are mixed.	Activity needs are confirmed and association is active. It is proposed to construct basin for organic manure in the existing rubbish ground.
Bouya	Jdida Bouya	El Amal pour le développement	There are two rubbish grounds near settlement area. In the rubbish grounds, rubbish and manures are mixed.	Activity needs are confirmed and association is active. It was decided to install two manure basin (basin area should be half of basic specification), since two families use tow rubbish grounds, separately.
Ait Ben Omar	Ait Ben Omar	Al Moustakbal pour le développement et l'environnement	Rubbish is buried in the desert area. Ksar would like to produce manure using manure basin.	Activity needs are confirmed and association is active. It was decided to install four small manure basin (basin area should be one-forth of basic specification) considering easy management and collection of livestock dung.

Condition of Each Site after Implementation of Scheme

Ksar Name	Association	Activities	Production of Organic Manure	Remarks
Alnif	Association Bougafer	Meetings at Ksar level: 3 times from November 2004 – June 2005 (Around 100 participants in total) Activities using manure basin: 7 times form February – June 2005	Seven times removal work of plastics in the basin has been made. Around 4 M3 of organic manure was produced.	Somebody wasted the plastics to the manure basin when the basin was managed as communal use. Ksar decided that only one family manage the basin and use the organic manure.
Bouya	El Amal pour le développement	Meetings and activities using manure basin: 4 times from February – June 2005 (Around 70 participants in total)	Each basin has family in charge. As a result, the proper maintenance has been made and qualified manure has been produced. Around 10 M3 of organic manure was produced.	Somebody wasted the plastics to the manure basin before the family for management was not appointed.
Ait Ben Omar	Al Moustakbal pour le développement et l'environnement	Meetings and activities using manure basin: 5 times from February – June 2005 (Around 70 participants in total)	Each basin has family in charge. As a result, the proper maintenance has been made and qualified manure has been produced. Around 12 M3 of organic manure was produced.	No issue on mixing plastics in the manure has been made, since the family for the management was appointed in the initial stage of the scheme.

(2) Monitoring

Monitoring plan was prepared. It will be carried out in July 2005 for monitoring and evaluation of the verification study. For the environmental improvement of Khettara Ksar, the following indicators and targets as "Outputs" are set up.

Indicator for Output and Target on Hygiene Control of Khettara

Indicator for Output	Target
Production of organic manure using manure basin	Production of organic manure using manure basin is confirmed
Change on peoples' behavior	It is confirmed that people have started doing the followings. - Do segregation between livestock dung and rubbish - Do application of organic manure in farm land

Achievements to targets by schemes are as follows:

Achievements to Targets of Indicators

Scheme	Achievement		
	Production of organic manure	Segregation	Application of organic manure in farm land
Target	Produced	Confirmed	More than 10 M2
Alnif	Achieved	Achieved	Not achieved
Bouya	Achieved	Achieved	Achieved
Ait Ben Omar	Achieved	Achieved	Achieved

(3) Observation

The constructions of manure basins were completed and some finishing works has been made in January 2005. All the manure basins excluding Alnif produced more than 10 m3 of organic manures that was applied to the farm lands. In case of the manure basin installed in Alnif, it took time to properly produce organic manure. However, it was confirmed the production of organic manure in July 2005.

Key issue is communal management of manure basin. Under the communal managements in Alnif and Bouya, segregation between livestock dung and rubbish could not be properly made. After the discussion at Ksar level, Ksar appointed only one family to manage the basin and use the organic manure. As results, proper management of the manure basin and production of qualified manure have been made. It was, therefore, concluded in the environmental improvement through use of manure basin that; i) individual small basin for each family is recommendable for proper maintenance and management of the basin, and ii) rotational management system of basin should be considered if communal use is applied.

(4) Feedback to Master Plan

Other than Alnif, all zones use the compost deeps of $10m^2$, and the farmers involved appreciate it. We had to wait by June until Alnif started to generate compost. Consequently, if the deeps are well managed, the hygiene of khettaras villages utilizing compost could be controlled by the associations.

The verification proved that the problem concerns the group management. It is the case of Alnif and Bouya, the collection of compost materials (e.g. livestock excrements) and of separated plastics is not well done. The responsible people have decided collectively to leave the management of the deep for one family, to give the priority for the compost production, and that the collection of non-recyclables will be done in the following stage. That gave good results. As we combine the awareness campaigns for the improvement of the life quality and the construction of deeps, we need to consider if the individual interests meet the collective interests: e.g. 1) construct multiple deeps and entrust the management to one family, 2) organize rotating management responsibility between individual families.

D. 5 Agriculture and Rural Development Plan

D.5.1 Agriculture Devleopment Plan

D.5.1.1 Agriculture Land Use Plan

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

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

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

(3) According to the inventory study, the agriculture areas (comprising non-cultivated lands) are of 6 600 ha, which is much more than the actually cultivated area of 3 012 ha. Consequently, it is necessary to utilize the non-cultivated lands by applying more efficient of irrigation.

(4) If the works are implemented the water volumes supplied for irrigation will increase. That increase will be the result of the rehabilitation of khettaras and canals, and party of water saving irrigation. We have calculated the additional areas cultivated thanks to the increase of irrigation water. The comparison is indicated in the following table.

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

D.5.1.2 Selection of Crops and Proposed Cropping System

We studied the systems of cultivations in case that works are implemented, assuming that the actual system of cultivations is kept. The irrigation water is extremely precious in the khettaras zones and the economic efficiency of the water is the priority for defining of the system of planned cultivation. We have calculated the unit water requirements by cultivation and the profitability by unit of water based on the benefits by hectare.

Profitability by Agriculture Product

		Wheat	Vegetables	Legumes	Alfa-alfa	Dates
Water needs by ha	M^3/ha	4 600	6 100	9 500	23 900	13 300
Benefit by ha	DH/ha	4 140	35 100	7 200	6 590	53 300
Profitability by M3	DH/M^3	0,9	5,75	0,76	0,28	4,01

It turns out that the vegetables are the most profitable products from the point of view of water economy. Therefore it is recommended to use the half of the area increased by the rehabilitation for the vegetables. The other half of the increased area could be used for the highly profitable cultivation of dates, which is strongly desired by the farmers. Otherwise, since it is necessary to wait for 7 years before a date palm gives yield, we could introduce the mixed cultivations. The mixed cultivations of dates and vegetables mentioned above are definitely not efficient from the point of view of water economy. However, we can recommend the combination with the cultivation of alfa-alfa to maintain the level of soil fertility substances and to contribute to supply of fodder, which is now lacking for the livestock. The changes in the system of cultivation with the Project comparing to the actual system are indicated in the figures D.5.1 and D.5.2, which can be summarized as follows:

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

D.5.1.3 Planned Exploitation Techniques

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

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

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

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

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

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

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

D.5.1.4 Crop Budget

We have calculated the crop budgets using the results of the interview questioner with the farmers and the data of the ORMVA/TF. The results of the calculations are indicated in the Table D.5.1 and D.5.2, and summarized below.

Crop Budgets at Present (DH/ha)

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

Crop Budgets with Project (DH/ha)

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

D.5.1.5 Marketing and Distribution

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

(1) Strengthening of cooperatives of dates and olives production

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

(2) Organizations of groups of vegetables producers

In the future, it will be very important for the vegetable production to cope with the narrow relations between the producer and the resellers. As a condition, the reseller demands that the producer ensures the regular and

stable volumes. In fact the production of each individual farm is weak and it is difficult to guarantee that stability. That is why it is necessary to organize the farmers into the producers' groups. It is necessary to group the production of all the farmers and sold together with the aim of providing stable volumes for the reseller. As the precondition, the increase in the vegetable production is necessary; the project will consider this aspect for the middle- and long-term.

(3) Creation of simple collecting installations

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

D.5.1.6 Strengthening of Agriculture Extension

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

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

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

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

We propose to introduce the demonstration and extension of the water management, the element which is lacking in the ORMVA/TF, in the zones managed by the farmers. The water management programs in the zones comprise of:

1) the research applied in the site on all the water saving irrigation methods

2) the small-scale demonstrations of the preferred water saving irrigation method

3) holding the meetings for the exchange of techniques between the farmers of the demonstration

zones

4) expansion of demonstration towards other zones

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

(3) Assistance for the distribution and marketing of vegetables

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

1) Cultivation techniques for quality improvement

2) Understanding of the prices fluctuations and relations between the quality and periods of the cultivations in order to obtain better revenues

3) Packaging techniques using local materials in order to avoid the decrease of quality as well as shipment methods.

As a precondition for this project if is necessary to wait for the increase of the vegetables production. Therefore the above mentioned actions will be undertaken in the middle- and long-term.

(4) Farmers' participation in the extension programs

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

D.5.2 Rural Communities Development Plan

D.5.2.1 Social Infrastructures Development Plan

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

Appraisal of Social Infrastructures Development Plan

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

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

D.5.2.2 Details of Program of Support for Revenues Increase

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

As given in the chapter 3.8.5, the annual average revenue per farmer in the region was of 6 064 DH in the khettaras rural communities, which is superior than the poverty line defined by the World Bank for the rural areas in Morocco (3 037 DH), but in reality the revenues directly obtained from the agriculture represent only 40% of this amount, that is 2 400 DH by year. This number does not allow for the farmers of the zone to depend only on the agriculture, and in reality the level of livelihoods depend on the remittances money sent by the emigrated families or the salaries coming from the sectors outside of agriculture.

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

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

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

Support Plan for Revenues Increase

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

D.5.2.3 Implementation of Program of Support for Income Generation

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

First phase （5 years）

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

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

Second phase（5 years)

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

Third phase（10 years)

- Production of specialities in each Ksar (promotion of one product per village).

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

Tables

Table D.3.1 Soil Survey Result in the Study Area

Zone A : Goulmima - Tinjdad

Perimeters	Soil units	Land capability classes	Land managements
Ait My El Mamoun	**Unit 1**: Very deep, coarse, typic, slightly developed alluvial soils.	II.P	- Wind erosion and sand accumulation control. - Manure application
	Unit 2: Aerial sand deposit mineral soils.	IV.T.Ee	- Wind erosion and sand accumulation control. - Manure application
Assoul Jdida	Very deep, medium textured, slightly saline, slightly developed alluvial soils.	II.R.A.T	No management required
Assoul Kdima	Very deep, fine, typic, slightly developed alluvial soils.	II.T	No management required
Bakkassia	**Unit 1**: Very deep, coarse, typic, slightly developed alluvial soils.	III.T/II.P	- Wind erosion and sand accumulation control. - Manure application
	Unit 2: Aerial sand deposit mineral soils	IV.T.Ee	- Wind erosion and sand accumulation control. - Manure application
Isilf	**Unit 1**: Very deep, medium textured, slightly saline, slightly developed alluvial soils.	I	- Wind erosion and sand accumulation control. - Manure application
	Unit 2: Very deep, coarse, sand deposit accumulated, slightly developed alluvial soils.	IV.T.Ee	- Wind erosion and sand accumulation control. - Manure application
Litama	**Unit 1**: Very deep, fine, typic, slightly developed alluvial soils.	II.T	- Wind erosion and sand accumulation control.
	Unit 2: Very deep, medium textured, typic, slightly developed alluvial soils.	I	- Wind erosion and sand accumulation control.
	Unit 3: Aerial sand deposit mineral soils.	IV.T.Ee	- Wind erosion and sand accumulation control.
	Unit 4: very deep, coarse, saline, slightly developed alluvial soils.	II.T.R	- Wind erosion and sand accumulation control.
Ouinigui	**Unit 1:** Moderately deep, medium textured, slightly developed alluvial soils.	III.P	No management required
	Unit 2: Very deep, medium textured, slightly developed alluvial soils.	II.P	No management required
Oukhit	**Unit 1**: Deep, medium textured, typic, slightly developed alluvial soils.	II.P.T	Manure application
	Unit 2: Moderately deep, fine, typic, slightly developed alluvial soils.	III.P/II.T	Manure application
Ait Ba Maati	**Unit 1**: Very deep, coarse, typic, slightly developed alluvial soils.	III.T	- Wind erosion and sand accumulation control. - Manure application
	Unit 2: Aerial sand deposit mineral soils.	IV.T.Ee	- Wind erosion and sand accumulation control. - Manure application

Perimeters	Soil units	Land capability classes	Land managements
Tarhia	**Unit 1**: Very deep, medium textured, typic, slightly developed alluvial soils.	I	Important manure application
	Unit 2: Moderately deep, medium textured, slightly developed alluvial soils.	III.P	Important manure application
Taltfraout	Very deep, medium textured, slightly saline, slightly developed alluvial soils.	II.R.A	No management required

Zone B : Béni Tadjit

Perimeters	Soil units	Land capability classes	Land managements
Ait Fdouli	Very deep, coarse, sand deposit accumulated, slightly developed alluvial soils.	IV.T.Ee	Wind erosion and sand accumulation control.
Ait Ouazzag	Very deep, medium textured, slightly saline, slightly developed alluvial soils.	II.R.A	Salt removal.
Ait Sbaa	Very deep, fine silty, typic, slightly developed alluvial soils.	II.T	No management required
Almou N'Chorfa	Very deep, fine silty, typic, slightly developed alluvial soils.	II.T	No management required

Zone C : Errachidia – Boudnib

Perimeters	Soil units	Land capability classes	Land managements
Boudnib Jdida	**Unit 1**: Very deep, medium textured, typic, slightly developed alluvial soils.	I	No management required
	Unit 2: Very deep, coarse, sand deposit accumulated, slightly developed alluvial soils.	IV.T.Ee	Wind erosion and sand accumulation control.
Ouled Ali	**Unit 1**: Very deep, medium textured, typic, slightly developed alluvial soils.	I	No management required
	Unit 2: Very deep, coarse, sand deposit accumulated, slightly developed alluvial soils.	IV.T.Ee	Wind erosion and sand accumulation control.

Zone D : Fezna – Jorf - Hannabou

Perimeters	**Soil units**	**Land capability classes**	**Land managements**
Lhayen -Bouchabia	Very deep, medium textured, very slightly saline, Slightly developed aerio-alluvial soils.	V.R.A	No management required
El Bouya Jdida	**Unit 1**: Aerial sand deposit mineral soils.	IV.T.Ee	Wind erosion and sand accumulation control.
	Unit 2**: Very deep, medium textured, Slightly developed aerio-alluvial soils.**	III.Ee	Wind erosion and sand accumulation control.
El Bouya Melha	Unit 1**: Very deep, medium textured, typic, Slightly developed aerio-alluvial soils.**	II.A	- Wind erosion and sand accumulation control. - Manure application
	Unit 2: Very deep, coarse, sand deposit accumulated, Slightly developed aerio-alluvial soils.	IV.T.Ee	Wind erosion and sand accumulation control.
Hannabou -Khtitira	**Unit 1**: Very deep, medium textured, typic, Slightly developed alluvial soils.	I	No management required
	Unit 2: Very deep, medium textured to coarse, sand deposit accumulated, Slightly developed alluvial soils.	IV.T.Ee/III.A/II.R	- Wind erosion and sand accumulation control - Salt removal
Ksiba	**Unit 1**: Very deep, fine, typic chestnut (brown) soils. (*Hamra*)	II.T	Manure application
	Unit 2: Very deep, medium textured to coarse, slightly saline, slightly developed alluvial soils *(N'til).*	II.R	Manure application
Laachouria Kdima	Very deep, fine, slightly saline, slightly developed alluvial soils.	II.R.A.T	No management required
Hannabou-Lagrinia	**Unit 1**: Aerial sand deposit mineral soils	IV.T.Ee	- Wind erosion and sand accumulation control. - Manure application
	Unit 2: Very deep, fine silty, slightly saline, slightly developed aerio-alluvial soils.	II.Ee	- Wind erosion and sand accumulation control. - Manure application
Monkara	**Unit 1**: Very deep, fine to medium textured, sand deposit accumulated, slightly developed alluvial soils.	IV.T.Ee	Wind erosion and sand accumulation control.
	Unit 2: Very deep, fine to medium textured, sodic and saline, slightly developed alluvial soils.	IV.R.A	Salt removal and drainage
Lakrayer	**Unit 1**: Very deep, medium textured, slightly saline, slightly developed alluvial soils.	II.R	Wind erosion and sand accumulation control.
	Unit 2: Very deep, fine to medium textured to coarse, sand deposit accumulated, slightly developed alluvial soils.	II.Ee	Wind erosion and sand accumulation control.
Tarra-Louaria	Very deep, medium textured to silty, typic, slightly developed alluvial soils.	I	Wind erosion and sand accumulation control

Perimeters	Soil units	Land capability classes	Land managements
Hannabou-Mostafia	**Unit 1:** Aerial sand deposit mineral soils	IV.T.Ee	Wind erosion and sand accumulation control.
	Unit 2: Very deep, slightly saline, partially sand deposit accumulated, slightly developed alluvial soils.	III.A	- Salt removal, drainage - Wind erosion and sand accumulation control.
Ouled Ghanem Kdima	**Unit 1**: Very deep, medium textured, slightly saline, sand deposit accumulated, slightly developed alluvial soils.	II.R.A.Ee	- Wind erosion and sand accumulation control - Manure application
	Unit 2: Very deep, sandy, slightly developed aerio-alluvial soils.	IV.T.Ee	Wind erosion and sand accumulation control.
Ouled Ghanem Souihla	**Unit 1**: Very deep, silty, slightly saline, slightly developed alluvial soils.	II.R.A.T	- Manure application - Salt removal
	Unit 2: Very deep, coarse, sand deposit accumulated, slightly developed alluvial soils.	III.T.Ee	Wind erosion and sand accumulation control.
Ouled Jellal	**Unit 1**: Very deep, silty, slightly saline, slightly developed alluvial soils.	II.R.A.I.	- Manure application - Flooding protection (Oued Ghris)
	Unit 2: Very deep, fine, chestnut (brown) soils.	II.T.I.	- Manure application - Flooding protection (Oued Ghris)
Ouled M'barek Jdida	**Unit 1**: Very deep, medium textured to fine, saline, slightly developed alluvial soils.	III.R.A	- **Surface drainage** - **Salt removal**
	Unit 2: Very deep, coarse, slightly saline, slightly developed alluvial soils.	III.T.Ee	Wind erosion and sand accumulation control.
Gfifat - Yahiaouia	**Unit 1**: Very deep, fine, typic, slightly developed alluvial soils.	II.T.A	- Manure application - Wind erosion and sand accumulation control.
	Unit 2: Very deep, sandy, sand deposit accumulated, slightly developed alluvial soils.	IV.T.Ee	- Manure application - Wind erosion and sand accumulation control.
Ouled Brika - Zerguia	**Unit 1**: Very deep, medium textured, saline, slightly developed alluvial soils.	III.R.A	Salt removal
	Unit 1: Very deep, light textured, saline, slightly developed alluvial soils.	III.R.A.Ee	- Salt removal - Wind erosion and sand accumulation control.

Zone E : Sifa

Perimeters	Soil units	Land capability classes	Land managements
Ighzer	Very deep, sandy, salt affected soils	V.R/IV.T.Ee.A	- Wind erosion and sand accumulation control - Salt removal
Ksour Sifa Cherchmia	**Unit 1**: Very deep, fine, slightly saline, slightly develop alluvial soils.	III.T.R.A	- Wind erosion and sand accumulation control - Manure application
	Unit 2: Very deep, coarse, sand deposit accumulated, slightly developed aerio-alluvial soils.	IV.T.Ee	- Wind erosion and sand accumulation control - Manure application
Ksour Sifa Haj allal	**Unit 1**: Very deep, medium textured, slightly saline, slightly developed alluvial soils.	II.R.A	- Wind erosion and sand accumulation control - Manure application
	Unit 2: Very deep, coarse, sand deposit accumulated, slightly developed aerio-alluvial soils.	IV.T.Ee	- Wind erosion and sand accumulation control - Manure application
Ksour Sifa Kdima	**Unit 1:** Very deep, coarse to medium textured, slightly saline, slightly developed alluvial soils.	III.T.A/II.R	- Wind erosion and sand accumulation control - Manure application
	Unit 2: Very deep, coarse, sand deposit accumulated, slightly developed aerio-allivial soils.	IV.T.Ee	- Wind erosion and sand accumulation control - Manure application

Zone F : Rissani - Taouz

Perimeters	Soil units	Land capability classes	Land managements
Beggaa	Very deep, coarse to medium textured, sand deposit accumulated, slightly developed alluvial soils.	IV.T.Ee	Wind erosion and sand accumulation control
Haroun	**Unit 1**: Very deep, very coarse, saline, slightly developed alluvial soils.	III.T.A/II.R	- Wind erosion and sand accumulation control - Salt removal
	Unit 2: Very deep, very coarse, Aerial sand deposit mineral soils.	IV.T.Ee	- Wind erosion and sand accumulation control - Salt removal
Hassi Labiad	Very deep, coarse to medium textured, saline, sand deposit accumulated, slightly developed alluvial soils.	IV.T.Ee, III.A et II.R	- Wind erosion and sand accumulation control - Salt removal
Merzouga - Talaabast	**Unit 1**: Very deep, medium textured, typic, slightly developed alluvial soils.	I	Wind erosion and sand accumulation control
	Unit 2: Very deep, coarse, sand deposit accumulated, slightly developed alluvial soils.	IV.T.Ee	Wind erosion and sand accumulation control
Merzouga - Tamaright	Very deep, medium textured, slightly saline, slightly developed alluvial soils.	II.R.A	- Wind erosion and sand accumulation control - Manure application - Salt removal
Merzouga - Tamazzant	Very deep, coarse to medium textured, typic, slightly developed alluvial soils.	III.T	Manure application

Zone G : Alnif

Perimeters	Soil units	Land capability classes	Land managements
Achich N'ait Yazza	**Unit 1**: Deep to very deep, medium textured, slightly developed alluvial soils.	II.P à III.P	No management required
	Unit 2: Very deep, coarse, sand deposit accumulated, slightly developed aerio-alluvial soils.	III.P à IV.P	No management required
Afrou N'ait Lghazi	**Unit 1**: Moderately deep, coarse, slightly developed alluvial soils on schist.	III.T.P	- Surface stones removal - Manure application
	Unit 2: Slightly deep, fine, slightly developed alluvial soils on schists.	IV.P	- Surface stones removal - Manure application
Ait Zeggane	Very deep, fine silty, typic, slightly developed alluvial soils.	III.T.Ee	- Wind erosion and sand deposit control - Manure application
Alnif	Very deep, medium textured, slightly saline, slightly developed alluvial soils.	II.R.A	Manure application
Ammar Jdida	**Unit 1**: Very deep, fine, soft calcium carbonate accumulation, slightly developed alluvial soils.	II.T	Manure application
	Unit 2: Slightly to moderately deep, medium textured, slightly developed alluvial soils.	III.P	No management required
Azag	Very deep, heterogeneous textured, slightly developed aerio-alluvial soils.	II.T	Manure application
Battou	**Unit 1**: Very deep, medium textured, typic, slightly developed alluvial soils.	I	Manure application
	Unit 2: Very deep, medium textured, saline, slightly developed alluvial soils.	II.R	Manure application
	Unit 3: Slightly to moderately deep, coarse to medium textured, slightly developed soils.	III.P/II.I	- Flooding protection - Manure application
Imi N'Ouzrou	**Unit 1**: Deep to moderately deep, silty, recarbonated chestnut soils (*Azouggagh*).	III.P	No management required
	Unit 2: Very deep, medium textured, slightly developed alluvial soils.	I	No management required
Tachaoufit	Very deep, medium textured, slightly saline, slightly developed aerio-alluvial soils.	IV.Ee/II.R.A.I	- Wind erosion and sand deposit control - Flooding protection - Manure application

Perimeters	**Soil units**	**Land capability classes**	**Land managements**
Takacha	**Unit 1**: Very deep, fine, isohumic brown soils.	II.T.Ee	- Manure application - Wind erosion and sand deposit control
	Unit 2: Very deep, medium textured, slightly developed alluvial soils.	I	No management required
	Unit 3: Very deep, coarse, slightly developed alluvial soils.	III.T.I	- Flooding protection - Manure application
Talghazit	Slightly deep, medium textured, laying on a gravelly and stony level, slightly developed alluvial soils.	III.P	Manure application
Tiguirna	**Unit 1:** Very deep, medium textured, slightly developed alluvial soils.	I	Wind erosion and sand deposit control
	Unit 2: Deep, medium textured, slightly developed alluvial soils.	II.P	Wind erosion and sand deposit control
	Unit 3: Very deep, coarse, sand deposit accumulated, slightly developed aerio-alluvial soils.	IV.T.Ee	Wind erosion and sand deposit control
Tinifift	**Unit 1**: Very deep, medium textured, typic, slightly developed alluvial soils.	I	No management required

Table D.3.2 Cultivation Area, Production, and Yield of Agricultural Crops in 2004 by Sub-Dividsion

1. Superficie

Cultures	Unit	Errachidia	Rich	Erfoud	Goulmima	Beni-Tadjit	Total
Fruits (arbres fruitiers)							
Dattes (Total)	Trees	309,500	-	601,980	408,530	41,500	1,361,510
Olives (Total)	Trees	404,300	236,700	50,300	156,390	232,000	1,079,690
Pommes (Total)	Trees	2,600	461,200	-	69,180	30,500	563,480
Others (Total)	Trees	75,590	201,300	10,700	79,000	75,000	441,590
Dattes (Productif)	Trees	253,900	-	278,300	226,000	19,900	778,100
Olives (Productif)	Trees	385,600	188,700	14,000	122,000	220,000	930,300
Pommes (Productif)	Trees	2,600	405,200	-	55,250	12,000	475,050
Others (Productif)	Trees	75,500	134,700	6,850	74,830	52,880	344,760
Céréales							
Blé de farine	ha	1,840	4,320	480	2,800	1,800	11,240
Autres blés	ha	2,000	950	6,070	1,200	1,850	12,070
Orge	ha	140	220	5,420	1,250	890	7,920
Mais	ha	480	1,700	-	100	800	3,080
Feve	ha	480	330	70	100	220	1,200
Légumes	ha	290	450	400	140	60	1,340
Pâture							
Luzerne	ha	2,800	1,400	920	1,700	310	7,130
Autres							
Henné	ha	2	-	60	20	-	82
Cumin	ha	-	-	70	10	-	80

2. Production

Cultures	Unit	Errachidia	Rich	Erfoud	Goulmima	Beni-Tadjit	Total
Fruits (arbres fruitiers)							
Dattes	ton	9,390	-	9,300	5,140	440	24,270
Olives	ton	6,680	1,130	100	1,100	1,980	10,990
Pommes	ton	30	10,140	-	1,100	200	11,470
Others	ton	1,170	3,690	400	1,100	830	7,190
Céréales							
Blé de farine	ton	4,230	11,680	1,140	6,010	3,320	26,380
Autres blés	ton	5,210	1,090	15,780	2,850	3,160	28,090
Orge	ton	220	380	10,840	2,640	1,200	15,280
Mais	ton	670	3,060	-	150	1,680	5,560
Feve	ton	720	460	60	110	480	1,830
Légumes	ton	4,120	8,000	6,010	1,870	500	20,500
Pâture							
Luzerne	ton	155,000	15,040	47,030	53,290	5,580	275,940
Autres							
Henné	ton	4	-	320	10	-	334
Cumin	ton	-	-	40	6	-	46

3. Rendementen

Cultures	Unit	Errachidia	Rich	Erfoud	Goulmima	Beni-Tadjit	Average
Fruits (arbres fruitiers)							
Dattes	kg/tree	37.0	-	33.4	22.7	22.1	31.2
Olives	kg/tree	17.3	6.0	7.1	9.0	9.0	11.8
Pommes	kg/tree	11.5	25.0	-	19.9	16.7	24.1
Others	kg/tree	15.5	27.4	58.4	14.7	15.7	20.9
Céréales							
Blé de farine	ton/ha	2.3	2.7	2.4	2.1	1.8	2.3
Autres blés	ton/ha	2.6	1.1	2.6	2.4	1.7	2.3
Orge	ton/ha	1.6	1.7	2.0	2.1	1.3	1.9
Mais	ton/ha	1.4	1.8	-	1.5	2.1	1.8
Feve	ton/ha	1.5	1.4	0.9	1.1	2.2	1.5
Légumes	ton/ha	14.2	17.8	15.0	13.4	8.3	15.3
Pâture							
Luzerne	ton/ha	55.4	10.7	51.1	31.3	18.0	38.7
Autres							
Henné	ton/ha	2.0	-	5.3	0.5	-	4.1
Cumin	ton/ha	-	-	0.6	0.6	-	0.6

Source: ORMVA/TF

Table D.4.1 Record of Crop Growth for the First Cropping

Lambarkia

Crop	Irrigation Method	Plowing	Application of Organic Manure	Basic Fertilizer	Land Preparation	Sowing	Thinning (Initial)	Thinning	Weeding	Supplemental Fertilizer	Harvest
Turnip	Drip irrigation	2004/8/15	2004/9/9	2004/9/11	2004/9/11	2004/9/11	2004/10/1-6, 2004/10/17	2004/10/15-25	2004/10/30	2004/10/1	2004/11/7-2004/12/28
	Fallow irrigation with reservoir	2004/8/15	2004/9/9	2004/9/13	2004/9/13	2004/9/15	2004/10/1-6, 2004/10/17	2004/10/10-28	2004/10/30	2004/10/1	2004/11/5-2005/01/25
	Fallow irrigation without reservoir	2004/8/15	2004/9/9	2004/9/13	2004/9/13	2004/9/14	2004/10/11-14	2004/10/21-22	2004/10/30	2004/10/1	2004/11/5-2004/12/18
	Traditional irrigation	2004/8/15	2004/9/13	2004/9/13	2004/9/13	2004/9/13		2004/10/1-2	2004/10/30	2004/10/1	2004/11/28-2004/12/30
Carrote	Drip irrigation	2004/8/15	2004/9/9	2004/9/11	2004/9/11	2004/9/11	2004/10/1-6 2004/10/10-17	2004/10/15-25	2004/10/30	2004/10/1	2004/12/17-2005/02/18
	Fallow irrigation with reservoir	2004/8/15	2004/9/9	2004/9/13	2004/9/13	2004/9/15	2004/10/1-6 2004/10/10-17	2004/10/13-14 2004/10/28	2004/10/30	2004/10/1	2004/12/17-2005/02/18
	Fallow irrigation without reservoir	2004/8/15	2004/9/9	2004/9/13	2004/9/13	2004/9/14	2004/10/11-14	2004/10/20-21	2004/10/30	2004/10/1	2004/12/22-2005/02/18
	Traditional irrigation	2004/8/15	2004/9/13	2004/9/13	2004/9/13	2004/9/13		2004/10/1-2	2004/10/30	2004/10/5	2004/12/22-2005/02/18

Ait Ben Omar

Crop	Irrigation Method	Plowing	Application of Organic Manure	Basic Fertilizer	Land Preparation	Sowing	Thinning (Initial)	Thinning	Weeding	Supplemental Fertilizer	Harvest
Turnip	Drip irrigation	2004/9/9-10	2004/9/14	2004/9/14	2004/9/17	2004/9/26		2004/10/29-2004/11/01	2004/10/19-20 (souris)	2004/10/3	2004/12/9-2004/12/11
	Fallow irrigation with reservoir	2004/9/9-10	2004/9/14	2004/9/14	2004/9/17	2004/9/26		2004/11/7	2004/10/19-20 (souris)	2004/10/3	2004/12/02-2004/12/07
	Fallow irrigation without reservoir	2004/9/9-10	2004/9/14	2004/9/14	2004/9/16	2004/9/20-22	2004/10/26 2004/11/2-3	2004/11/8-14	2004/10/19-20 (souris)	2004/10/3	2004/10/1-6, 2004/10/17
	Traditional irrigation	2004/9/9-10	2004/9/14	2004/9/14	2004/9/22-23	2004/9/24-28, 2004/10/1-2	2004/10/4-3	2004/11/7	2004/10/19-20 (souris)	2004/10/3	2004/11/18-2000412/14
Carrote	Drip irrigation	2004/9/9-10	2004/9/14	2004/9/14	2004/9/17	2004/9/26		2004/11/8	2004/10/20-19(souris)	2004/10/3	2004/10/2
	Fallow irrigation with reservoir	2004/9/9-10	2004/9/14	2004/9/14	2004/9/17	2004/9/26		2004/11/7	2004/10/20-19 (souris)	2004/10/3	2004/10/12
	Fallow irrigation without reservoir	2004/9/9-10	2004/9/14	2004/9/14	2004/9/16	2004/09/20-22	2004/10/26 2004/11/2-3	2004/11/2-4	2004/10/20-19(souris)	2004/10/3	2004/12/22-2005/02/11
	Traditional irrigation	2004/9/9-10	2004/9/14	2004/9/14	2004/9/22-23	2004/09/24-28 2004/10/1-2	2004/10/2-3	2004/11/7	2004/10/20-19(souris)	2004/10/3	2004/12/04-2005/02/10

Taoumarte

Crop	Irrigation Method	Plowing	Application of Organic Manure	Basic Fertilizer	Land Preparation	Sowing	Thinning (Initial)	Thinning	Weeding	Supplemental Fertilizer	Harvest
Turnip	Fallow irrigation with reservoir	2004/9/9	2004/9/11	2004/9/11	2004/9/11	2004/9/12	2004/10/10	2004/10/13-28	2004/10/18-19	2004/10/17	2004/10/27-2004/01/18
	Fallow irrigation without reservoir	2004/9/1	2004/9/6	2004/9/7	2004/9/8	2004/9/9	2004/10/8	2004/10/8	2004/10/19	2004/11/4	2004/10/28-2004/11/17
	Traditional irrigation	2004/8/6	2004/9/1	2004/9/3	2004/9/2-3	2004/9/10		2004/10/1-2		2004/11/5	2004/11/08-2004/01/03
Carrote	Fallow irrigation with reservoir	2004/9/9	2004/9/11	2004/9/11	2004/9/11	2004/9/12	2004/10/10	2004/10/14-28	2004/10/18-19	2004/10/17	2004/11/20-2005/02/18
	Fallow irrigation without reservoir	2004/9/1	2004/9/6	2004/9/7	2004/9/8	2004/9/9	2004/10/9	2004/10/9	2004/10/19	2004/11/4	2004/11/20-2005/02/18
	Traditional irrigation	2004/8/6	2004/9/1	2004/9/3	2004/9/2-3	2004/9/10		2004/10/1-2		2004/10/1	2005/01/02-20054/02/18

Table D.4.2 Record of Crop Growth for the Second Cropping

Ait Ben Omar

Crop	Irrigation Method	Seeding	Transplanting	Land Preparation	Pole Preparation	Thinning	Weeding	Pruning	Basic Fertilizer	Supplemental Fertilizer			Harvest	End of Harvest
										First	Second	Third		
Melon	Drip irrigation	2005/3/11	2005/3/31	2005/3/31		2005/6/1-4	2005/04/26 2005/05/20	2005/5/30	2005/3/31	2005/5/15			2005/6/6	2005/7/20
	Fallow irrigation with reservoir	2005/3/11	2005/4/6	2005/3/31		2005/6/4	2005/5/23	2005/5/30	2005/3/31	2005/5/15			2005/6/15	2005/7/20
	Fallow irrigation without reservoir	2005/3/11	2005/4/6	2005/4/4			2005/05/9-23		2005/4/4	2005/5/15			2005/6/12	2005/7/20
	Traditional irrigation	2005/3/11		2005/3/11			2005/04/29 2005/05/11-19		2005/3/11	2005/5/15			2005/6/12	2005/7/20
Tomate	Drip irrigation	2005/3/28	2005/5/24	2005/4/18	2005/05/31 2005/06/1-2	2005/06/5-6	2005/04/29, 2005/05/9-23	2005/5/5	2005/4/18	2005/5/15			2005/6/20	2005/8/15
	Fallow irrigation with reservoir	2005/3/28	2005/05/15 -26	2005/4/26	2005/6/2	2005/5/2	2005/5/23	2005/6/2	2005/4/26	2005/5/15			2005/6/25	2005/8/15
	Fallow irrigation without reservoir	2005/3/28	2005/5/1	2005/4/27	2005/6/15		2005/05/19-23		2005/4/27	2005/5/15			2005/6/25	2005/8/15
	Traditional irrigation	2005/3/11		2005/3/11	2005/06/2-12	2005/5/2	2005/05/11-19		2005/4/27	2005/5/15			2005/6/25	2005/8/15

Lambarkia

Crop	Irrigation Method	Seeding	Transplanting	Land Preparation	Pole Preparation	Thinning	Weeding	Pruning	Basic Fertilizer	Supplemental Fertilizer			Harvest	End of Harvest
										First	Second	Third		
Melon	Drip irrigation	2005/3/3	2005/4/27	2005/3/24		2005/5/13	2005/4/15	2005/5/22	2005/3/24	2005/4/21	2005/5/25	2005/6/6	2005/6/14	2005/7/12
	Fallow irrigation with reservoir	2005/3/3	2005/3/28	2005/3/27		2005/5/18	2005/4/15	2005/5/18	2005/3/27	2005/4/26	2005/5/28	2005/6/7	2005/6/20	2005/7/12
	Fallow irrigation without reservoir	2005/3/3	2005/3/29	2005/3/26		2005/5/25	2005/4/14	2005/5/24	2005/3/26	2005/4/27	2005/5/28	2005/6/7	2005/6/19	2005/7/12
	Traditional irrigation	2005/3/29		2005/3/26		2005/5/2	2005/04/15 2005/05/02	2005/5/25	2005/3/26	2005/4/28	2005/5/28	2005/6/7	2005/6/20	2005/7/12
Tomato	Drip irrigation	2005/3/28	2005/4/17	2005/3/24	2005/5/12	2005/5/26	2005/5/2-5	2005/5/23	2005/3/24	2005/4/25	2005/7/1		2005/6/25	2005/9/10
	Fallow irrigation with reservoir	2005/3/28	2005/4/19	2005/4/18	2005/5/12	2005/5/29	2005/05/2-20	2005/5/26	2005/4/18	2005/5/28	2005/7/1		2005/7/4	2005/9/10
	Fallow irrigation without reservoir	2005/3/28	2005/4/11	2005/4/6	2005/5/12	2005/5/29	2005/05/2-16	2005/5/26	2005/4/6	2005/5/28	2005/7/1		2005/7/4	2005/9/10
	Traditional irrigation	2005/4/11		2005/4/6	2005/5/12	2005/5/26	2005/05/2-19	2005/5/26	2005/4/6	2005/5/28	2005/7/1		2005/7/4	2005/9/10
Water Melon	Drip irrigation	2005/3/3	2005/3/28	2005/3/24		2005/5/13	2005/4/15	2005/5/13	2005/3/24	2005/4/21			2005/5/29	2005/7/5
	Fallow irrigation with reservoir	2005/3/3	2005/3/28	2005/3/27		2005/5/27	2005/4/14	2005/5/27	2005/3/27	2005/4/28			2005/6/21	2005/7/5
	Fallow irrigation without reservoir	2005/3/3	2005/3/29	2005/3/26		2005/5/27	2005/4/14	2005/5/2	2005/3/26	2005/4/27			2005/6/16	2005/7/5
	Traditional irrigation	2005/3/26		2005/3/25		2005/5/12	2005/5/2		2005/3/24	2005/4/28			2005/6/27	2005/7/5
Gumbo	Drip irrigation	2005/3/4		2005/3/3		2005/4/28	2005/4/15	2005/4/22	2005/3/3	2005/4/21			2005/6/2	2005/7/22
	Fallow irrigation with reservoir	2005/3/2		2005/3/2		2005/5/23	2005/04/14 2005/05/02	2005/5/23	2005/3/2	2005/4/21			2005/5/27	2005/7/22
	Fallow irrigation without reservoir	2005/3/4		2005/3/3		2005/5/26	2005/4/15	2005/5/23	2005/3/3	2005/4/21			2005/5/19	2005/7/22
	Traditional irrigation	2005/3/4		2005/3/3		2005/5/26	2005/04/15 2005/05/02	2005/5/27	2005/3/5	2005/5/27			2005/5/20	2005/7/22

Taoumarte

Crop	Irrigation Method	Seeding	Transplanting	Land Preparation	Pole preparation	Thinning	Weeding	Pruning	Basic Fertilizer	Supplemental Fertilizer			Harvest	End of Harvest
										First	Second	Third		
Melon	Fallow irrigation with reservoir	2005/3/9	2005/4/5	2005/4/2		2005/4/12	2005/4/17-30, 2005/05/09	2005/5/30	2005/4/2	2005/4/12	2005/4/22	2005/5/3	2005/6/5	2005/7/18
	Fallow irrigation without reservoir	2005/3/9	2005/4/5	2005/4/2		2005/4/23	2005/4/17-30, 2005/5/19-23	2005/5/30	2005/4/2	2005/4/12	2005/5/3	2005/5/26	2005/6/5	2005/7/18
	Traditional irrigation	2005/3/12		2005/3/10		2005/4/19-12	2005/4/2 01/05/2005		2005/3/10	2005/4/15	2005/4/24	2005/5/20	2005/6/12	2005/7/18
Tomato	Fallow irrigation with reservoir	2005/3/9	2005/4/7	2005/4/3	2005/5/7-9	2005/4/12	2005/4/20-30 ,18-22-24-31/05/2005	03-06-2005	2005/4/5	2005/4/12	2005/4/22		2005/5/31	2005/8/15
	Fallow irrigation without reservoir	2005/3/9	2005/4/7	2005/4/3	2005/5/7-9	2005/4/22	2005/5/19-23	2005/5/24-25	2005/4/3	2005/5/3	2005/5/26		2005/5/31	2005/8/15
	Traditional irrigation	2005/3/15	2005/4/15	2005/4/15	2005/5/16	2005/4/12-19	2005/04/30, 2005/05/1	21-05-2005	2005/4/15	2005/4/14	2005/6/10		2005/6/15	2005/8/15
Water Melon	Fallow irrigation with reservoir	2005/3/9	2005/4/6	2005/4/5		2005/4/12	2005/5/1		2005/4/5	2005/5/21			2005/6/8	2005/7/12
	Fallow irrigation without reservoir	2005/3/9	2005/3/30	2005/3/29		2005/4/10	2005/04/16-09-4 ,2005/05/10		2005/3/26	2005/5/24			2005/6/8	2005/7/12
	Traditional irrigation	2005/3/12		2005/2/20		2005/4/12-19	2005/5/1		2005/3/8	2005/5/23			2005/6/12	2005/7/12
Gumbo	Fallow irrigation with reservoir	2005/3/10		2005/3/9		2005/4/12	2005/04/2-8	2005/5/25	2005/3/9	2005/4/2			2005/6/12	2005/8/14
	Fallow irrigation without reservoir	2005/3/4		2005/3/4		2005/4/10	2005/4/4, 2005/5/9	2005/4/21-23	2005/3/3	2005/4/5			2005/5/27	2005/8/14
	Traditional irrigation	2005/3/10		2005/3/9		2005/4/12-19	2005/04/2 2005/05/1	2005/5/20	2005/3/5	2005/4/5			2005/5/20	2005/8/14

Table D.4.3 Production and Income in the First Cropping

Turnip

Name of Khettara	Irrigation Method	Area	Total Production (kg)	Production per Ha (Kg/ha)	Income at DH 0.5/kg (DH)	Income at Actual Price (DH)
Ait Ben Omar (Tinjdad)	Drip irrigation	0.07	1,245	17,800	8,900	17,700
	Fallow irrigation with reservoir	0.04	296	7,400	3,700	7,120
	Fallow irrigation without reservoir	0.05	300	6,000	3,000	5,760
	Traditional irrigation	0.08	1,540	19,300	9,650	19,900
Lambarkia (Jorf)	Drip irrigation	0.06	1,802	30,000	15,000	17,500
	Fallow irrigation with reservoir	0.06	1,351	22,500	11,250	12,200
	Fallow irrigation without reservoir	0.05	1,291	25,800	12,900	11,600
	Traditional irrigation	0.10	2,154	21,500	10,750	39,500
Taoumart (Alnif)	Fallow irrigation with reservoir	0.07	2,669	38,100	19,050	37,300
	Fallow irrigation without reservoir	0.07	3,629	51,800	25,900	45,400
	Traditional irrigation	0.05	1,257	25,100	12,550	13,100

Carrot (DH/ha)

Name of Khettara	Irrigation Method	Area	Total Production (kg)	Production per Ha (Kg/ha)	Income at DH 0.6/kg (DH)	Income at Actual Price (DH)
Ait Ben Omar (Tinjdad)	Drip irrigation	0.08	867	10,800	6,480	15,900
	Fallow irrigation with reservoir	0.07	200	2,900	1,740	0
	Fallow irrigation without reservoir	0.04	100	2,500	1,500	0
	Traditional irrigation	0.10	1,045	10,500	6,300	12,600
Lambarkia (Jorf)	Drip irrigation	0.08	3,008	37,600	22,560	20,300
	Fallow irrigation with reservoir	0.07	2,660	38,000	22,800	22,000
	Fallow irrigation without reservoir	0.07	1,232	17,600	10,560	12,700
	Traditional irrigation	0.05	1,186	23,700	14,220	43,700
Taoumart (Alnif)	Fallow irrigation with reservoir	0.07	4,337	62,000	37,200	59,860
	Fallow irrigation without reservoir	0.06	2,419	40,300	24,180	37,900
	Traditional irrigation	0.06	3,273	54,600	32,760	58,400

Table D.4.4 Production and Income in the Second Cropping

Tomate

Name of Khettara	Irrigation Method	Area	Total Production (kg)	Production per Ha (Kg/ha)	Income at DH 15/kg (DH)	Income at Actual Price (DH)
Ait Ben Omar (Tinjdad)	Drip irrigation	0.063	3,167	50,300	75,450	67,959
	Fallow irrigation with reservoir	0.037	1,512	40,900	61,350	64,171
	Fallow irrigation without reservoir	0.043	648	15,100	22,650	28,037
	Traditional irrigation	0.047	324	6,900	10,350	12,793
Lambarkia (Jorf)	Drip irrigation	0.025	1,467	58,700	88,050	105,906
	Fallow irrigation with reservoir	0.026	751	28,900	43,350	53,333
	Fallow irrigation without reservoir	0.022	607	27,600	41,400	40,000
	Traditional irrigation	0.012	114	9,500	14,250	16,134
Taoumart (Alnif)	Fallow irrigation with reservoir	0.023	907	39,400	59,100	71,762
	Fallow irrigation without reservoir	0.013	384	29,500	44,250	54,800
	Traditional irrigation	0.024	382	15,900	23,850	28,066

Gumbo

Name of Khettara	Irrigation Method	Area	Total Production (kg)	Production per Ha (Kg/ha)	Income at DH 5.0/kg (DH)	Income at Actual Price (DH)
Lambarkia (Jorf)	Drip irrigation	0.047	2,165	46,100	230,500	209,597
	Fallow irrigation with reservoir	0.037	916	24,800	124,000	132,514
	Fallow irrigation without reservoir	0.035	1,050	30,000	150,000	162,609
	Traditional irrigation	0.013	126	9,700	48,500	42,366
Taoumart (Alnif)	Fallow irrigation with reservoir	0.028	1,189	42,500	212,500	154,486
	Fallow irrigation without reservoir	0.037	406	11,000	55,000	53,231
	Traditional irrigation	0.052	309	5,900	29,500	48,000

Melon

Name of Khettara	Irrigation Method	Area	Total Production (kg)	Production per Ha (Kg/ha)	Income at DH 2.5/kg (DH)	Income at Actual Price (DH)
Ait Ben Omar (Tinjdad)	Drip irrigation	0.090	937	10,400	26,000	25,100
	Fallow irrigation with reservoir	0.063	575	9,100	22,750	6,151
	Fallow irrigation without reservoir	0.048	280	5,800	14,500	7,531
	Traditional irrigation	0.125	612	4,900	12,250	4,478
Lambarkia (Jorf)	Drip irrigation	0.035	544	15,500	38,750	43,804
	Fallow irrigation with reservoir	0.025	309	12,400	31,000	32,846
	Fallow irrigation without reservoir	0.041	308	7,500	18,750	19,420
	Traditional irrigation	0.013	147	11,300	28,250	28,843
Taoumart (Alnif)	Fallow irrigation with reservoir	0.019	961	50,600	126,500	141,969
	Fallow irrigation without reservoir	0.039	379	9,700	24,250	16,954
	Traditional irrigation	0.024	225	9,400	23,500	25,188

Water Melon

Name of Khettara	Irrigation Method	Area	Total Production (kg)	Production per Ha (Kg/ha)	Income at DH 2.0/kg (DH)	Income at Actual Price (DH)
Lambarkia (Jorf)	Drip irrigation	0.036	714	19,800	39,600	32,423
	Fallow irrigation with reservoir	0.028	557	19,900	39,800	38,799
	Fallow irrigation without reservoir	0.020	383	19,200	38,400	40,099
	Traditional irrigation	0.015	269	17,900	35,800	31,172
Taoumart (Alnif)	Fallow irrigation with reservoir	0.072	1,649	22,900	45,800	32,497
	Fallow irrigation without reservoir	0.050	700	14,000	28,000	16,962
	Traditional irrigation	0.026	458	17,600	35,200	29,922

Table D.4.5 Unit Cultivation Cost for 1st Cropping

Inputs Cost	Volume for One Ha	Unit Price	Unit Cost per Ha
Seeds			
Turnip	5.5 kg/0.5ha	48 DH/kg	260 DH
Carrot	5.5 kg/0.5ha	130 DH/kg	720 DH
Organic Manure	10 ton/ha	120 DH/ton	1,200 DH
Chemical Fertilizer			
14-28-14	622 kg/ha	2.95 DH/kg	1,830 DH
N-Amoni (21%)	484 kg/ha	1.84 DH/kg	890 DH
Agro-Chemicals	1.38 bottle/ha	40 DH/bottle	60 DH
Tractor	15.9 hr/ha	60 DH/hr	950 DH
Labor Cost	22.8 man-day/ha	40 DH/man-day	910 DH
Total Input Cost per ha			6,820 DH

Irrigation Cost	Volume for One Ha	Unit Price	Unit Cost per Ha
Water Charge			
Drip Irrigation	2,689 m3/ha	0.12 DH/m3	320 DH
Furrow with reservoir	8,469 m3/ha	0.12 DH/m3	1,020 DH
Furrow without reservoir	7,813 m3/ha	0.12 DH/m3	940 DH
Basin	11,627 m3/ha	0.12 DH/m3	1,400 DH
Fuel Charge for Pump			
Drip Irrigation	299 lit/ha	6.14 DH/lit	1,830 DH
Furrow with reservoir	282 lit/ha	6.14 DH/lit	1,730 DH
Furrow without reservoir	- lit/ha	6.14 DH/lit	0 DH
Basin	- lit/ha	6.14 DH/lit	0 DH
Depreciation Cost Per Crop Season			
Drip Irrigation			8,425 DH
Furrow with reservoir			695 DH
Furrow without reservoir			0 DH
Basin			0 DH
Total Irrgation Cost per ha			
Drip Irrigation			10,575 DH
Furrow with reservoir			3,445 DH
Furrow without reservoir			940 DH
Basin			1,400 DH

Total Cultivation Cost per ha	Inputs Cost	Irrigation Cost	Total
Drip Irrigation	6,820 DH	10,580 DH	17,400 DH
Furrow with reservoir	6,820 DH	3,450 DH	10,270 DH
Furrow without reservoir	6,820 DH	940 DH	7,760 DH
Basin	6,820 DH	1,400 DH	8,220 DH

Table D.4.6 Unit Cultivation Cost for 2nd Cropping

Inputs Cost	Volume for One Ha	Unit Price	Unit Cost per Ha
Seeds			
Tomate	0.1 kg/0.25ha	1,400 DH/kg	140 DH
Gumbo	10.1 kg/0.25ha	50 DH/kg	510 DH
Melon	1.4 kg/0.25ha	800 DH/kg	1,120 DH
Water Melon	1.5 kg/0.25ha	410 DH/kg	620 DH
Nursery Preparation			
Plates	151 nos/ha	9.5 DH/kg	1,430 DH
Peat	24 bag/ha	150 DH/kg	3,600 DH
Plastic sheet	21 m2/ha	25 DH/m2	530 DH
Organic Manure	11.8 ton/ha	120 DH/ton	1,420 DH
Chemical Fertilizer			
14-28-14 (For basic fertlizer)	592 kg/ha	3.25 DH/kg	1,920 DH
14-28-14	426 kg/ha	3.25 DH/kg	1,380 DH
N-Amoni (33%)	149 kg/ha	3.0 DH/kg	450 DH
K-Sulfate (50%)	184 kg/ha	4.0 DH/kg	740 DH
Agro-Chemicals	11.1 bottle/ha	40 DH/bottle	440 DH
Banboo	1 set/0.25ha	1700 DH/set	1,700 DH
Tractor	3.7 hr/ha	60 DH/hr	220 DH
Labor Cost	79.9 man-day/ha	40 DH/man-day	3,200 DH
Total Input Cost per ha			19,420 DH

Irrigation Cost	Volume for One Ha	Unit Price	Unit Cost per Ha
Water Charge			
Drip Irrigation	3,038 m3/ha	0.23 DH/m3	700 DH
Furrow with reservoir	4,758 m3/ha	0.23 DH/m3	1,090 DH
Furrow without reservoir	4,203 m3/ha	0.23 DH/m3	970 DH
Basin	6,907 m3/ha	0.23 DH/m3	1,590 DH
Fuel Charge for Pump			
Drip Irrigation	338 lit/ha	6.14 DH/lit	2,070 DH
Furrow with reservoir	159 lit/ha	6.14 DH/lit	970 DH
Furrow without reservoir	- lit/ha	6.14 DH/lit	0 DH
Basin	- lit/ha	6.14 DH/lit	0 DH
Depreciation Cost Per Crop Season			
Drip Irrigation			8,425 DH
Furrow with reservoir			695 DH
Furrow without reservoir			0 DH
Basin			0 DH
Total Irrgation Cost per ha			
Drip Irrigation			11,195 DH
Furrow with reservoir			2,755 DH
Furrow without reservoir			970 DH
Basin			1,590 DH

Total Cultivation Cost per ha			
Drip Irrigation			30,615 DH
Furrow with reservoir			22,175 DH
Furrow without reservoir			20,390 DH
Basin			21,010 DH

Table D.4.7 Specification of Processing Machine and Necessary Attachments

Item	Specifications	Unit	Quan
For Date Processing			
Datte processing machine	Cylinder L 30 cm, diameter ; chamber for cylinders and motor : L60 cm, l 45 cm support 60 cm Input table (cm) L 75, l :40 thickness 10 cm ; reception pan (cm) L25, depth 10 cm	U	2
Mold for datte pasting (1 kg)	18 cm x 10cm x 8cm dia 3 mm	U	2
Datte grinding mill/ Pasting machine	650 kg/ hour weight of machine 52 kg hole diameter of grid : 3,2 mm	U	2
Dietary plastic for dattes	l 30 cm, 130 microns	Roll	2
Datte press	L= 18 cm, l=10 cm ; H=08 cm, thickness : 1,3 cm, all steel made	U	2
Table	2x2 (m) made of Formica	U	2
Plastic box	Vegetable type	U	8
Chair	Normal wood	U	8
For Henna Processing			
Henna mill	Production : 30 à 60 kg/1hour; 3 grids	U	2
For Gombo Processing			
Vegetable cutting machine	Motor 0,7 Hp et 515 W ; disc tours 300 / min, weight 24 kg, cutter for vegetable cutting in slices	U	1
Bagger and Welding machine	320x440x293 mm, welding rudder: 1x270 mm capacity : 8 m^3/ H	U	1
Plastic pouches for vegetable packing	L=280 ; l=150 ; thickness 80 microns	U	5000
Drying rack	Made of wood ; (L: 1 x l: 0,5 m) diameter of mesh holes (0,05 x 0,05)	U	4
Others			
Electric extension	10 m	U	5

Table D.5.1 (1/5) Present Crop Budget

Articles	Unite	Carotte Prix	Quantite	Cout total	Onion Prix	Quantite	Cout total
Charges				6,720			7,980
Charges							
1. Travaux	DH/day			1,600			800
Labour	DH/hr	100	8	800	100	8	800
Preparation de lit de semis	DH/hr	40	20	800	40	0	0
Semis	DH/hr	40	0	0	40	0	0
Enfouissement fumier	DH/hr	28	0	0	28	0	0
Entretien	DH/hr	28	0	0	28	0	0
Irrigation	DH/day	32	0	0	32	0	0
Recolte	DH/day	28	0	0	28	0	0
2. Fourniture				4,800			6,450
Semences	DH/kg	100	5	500	800	0.4	320
Agro chemiques	DH/kg						
Engrais	DH/kg	50	3	150	100	3	300
Engrais	DH/kg						
Fumier	DH/ton	175	10	1,750	175	10	1,750
Eau d'irrigation	DH/M3	0.48	5,000	2,400	0.48	8,500	4,080
3. Divers (5% of Article 1.+2.)				320			730
Produits				18,900			49,140
Rendement	Kg			14,000			18,200
Produits Commercialisable	%			90%			90%
Prix Unit.	DH/kg			1.50			3.00
Revenue Net				12,180			41,160

Articles	Unite	Tomate Prix	Quantite	Cout total	Poivron Prix	Quantite	Cout total
Charges				13,990			11,270
Charges							
1. Travaux	DH/day			1,600			1,480
Labour	DH/hr	100	8	800	100	8	800
Preparation de lit de semis	DH/day	40	0	0	40	0	0
Semis	DH/day	40	0	0	40	10	400
Enfouissement fumier	DH/day	28	0	0	28	0	0
Ridging	DH/day	40	20	800			
Entretien	DH/day	28	0	0	28	0	0
Irrigation	DH/day	32	0	0	32	0	0
Recolte	DH/day	28	0	0	28	10	280
2. Fourniture				11,720			8,765
Semences	DH/kg	1100	1	1,100	50000	0	2,500
Agro chemiques	DH/lit	7	110	770			
Engrais	DH/kg	300	3	900	100	3	285
Engrais	DH/kg				50	3	150
Fumier	DH/ton	175	10	1,750	175	10	1,750
Eau d'irrigation	DH/M3	0.48	15,000	7,200	0.48	8,500	4,080
3. Divers (5% of Article 1.+2.)				670			1,020
Produits				33,080			31,500
Rendement	Kg			21,000			14,000
Produits Commercialisable	%			90%			90%
Prix Unit.	DH/kg			1.75			2.50
Revenue Net				19,090			20,230

Table D.5.1 (2/5) Present Crop Budget

Articles	Unite	Ble Prix	Ble Quantite	Ble Cout total	Feve Prix	Feve Quantite	Feve Cout total
Charges				4,888			7,700
Variable Cost							
1. Labour	DH/day			840			560
Labour	DH/hr	70	12	840	70	8	560
Preparation de lit de semis	DH/day						
Semis	DH/day	28	0	0	28	0	0
Enfouissement fumier	DH/day	28	0	0	28	0	0
Nivellement/Planchage	DH/day	28	0	0			
Entretien	DH/day	28	0	0	28	0	0
Irrigation	DH/day	32	0	0	32	0	0
Recolte	DH/day	20	0	0	20	0	0
Battage	DH/day	50	0	0			
2. Fourniture				3,818			6,435
Semences	DH/kg	140	4	560	150	8	1,200
Agro chemiques	DH/lit	0	110	0	50		50
Engrais	DH/kg	0	3	0			
Engrais	DH/kg	50	4	175			
Fumier	DH/ton	175	5	875	125	5	625
Eau d'irrigation	DH/M3	0.48	4,600	2,208	0.48	9,500	4,560
3. Divers (5% of Article 1.+2.)				230			700
Produits				7,680			11,340
Rendement	Kg			1,800			2,100
Produits Commercialisable	%			90%			90%
Prix	DH/kg			4.00			6.00
Unit.							
Production de paille	DH/kg			1,200			
Revenue Net				2,792			3,640

Table D.5.1 (3/5) Present Crop Budget

Palimier Dattier

Articles	1st Annee (Installation)	1st Annee (Entretien)	2nd Annee	3rd Annee	4th Annee	5th Annee	6th Annee	7th Annee	8th Annee	9th Annee	10th-30th	
Charges	32,485	1,495	1,185	1,605	1,605	1,605	1,605	1,730	1,730	1,650	1,650	2,710
Charges												
1. Travaux	560	300	0	0	0	0	0	0	0	0	0	
Labour	560	0	0	0	0	0	0	0	0	0	0	
Piqetage/Confestion des trous	0	300	0	0	0	0	0	0	0	0	0	4
Semis	0	0	0	0	0	0	0	0	0	0	0	
Entretien	0	0	0	0	0	0	0	0	0	0	0	
Irrigation	0	0	0	0	0	0	0	0	0	0	0	
Recolte	0	0	0	0	0	0	0	0	0	0	0	
2. Fourniture	30,375	1,125	1,125	1,525	1,525	1,525	1,525	1,650	1,650	1,650	1,650	
Seedling/Planting	30,000	0	0	0	0	0	0	0	0	0	0	
Funier	375	1,125	1,125	1,125	1,125	1,125	1,125	1,250	1,250	1,250	1,250	
Engrais	0	0	0	0	0	0	0	0	0	0	0	
Agro chemiques	0	0	0	400	400	400	400	400	400	400	400	
Eau d'irrigation	0	0	0	0	0	0	0	0	0	0	0	
3. Divers (5% of Article 1.+2.)	1,550	70	60	80	80	80	80	80	80	0	0	
Produits	0	0	0	0	0	0	0	11,592	17,388	23,184	28,980	22,020
Rendement	0	0	0	0	0	0	0	920	1,380	1,840	2,300	
Produits Commercialisable	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
Prix Unit.	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	14.00	
Revenue Net	-32,485	-1,495	-1,185	-1,605	-1,605	-1,605	-1,605	9,862	15,658	21,534	27,330	19,310

Table D.5.1 (4/5) Present Crop Budget

Olivier

Articles	1st Annee (Installation)	1st Annee (Entretien)	2nd Annee	3rd Annee	4th Annee	5th Annee	6th Annee	7th Annee	8th Annee	9th Annee	10th-30th	
Charges	7,140	0	0	0	0	0	0	0	0	0	0	240
Charges												
1. Travaux	800	0	0	0	0	0	0	0	0	0	0	
Labour	800	0	0	0	0	0	0	0	0	0	0	
Piqetage/Confestion des trous	0	0	0	0	0	0	0	0	0	0	0	
Semis	0	0	0	0	0	0	0	0	0	0	0	
Entretien	0	0	0	0	0	0	0	0	0	0	0	
Irrigation	0	0	0	0	0	0	0	0	0	0	0	
Recolte	0	0	0	0	0	0	0	0	0	0	0	
2. Fourniture	6,000	0	0	0	0	0	0	0	0	0	0	
Seedling/Planting	1,000	0	0	0	0	0	0	0	0	0	0	
Funier	5,000	0	0	0	0	0	0	0	0	0	0	
Engrais	0	0	0	0	0	0	0	0	0	0	0	
Agro chemiques	0	0	0	0	0	0	0	0	0	0	0	
Eau d'irrigation	0	0	0	0	0	0	0	0	0	0	0	
3. Divers (5% of Article 1.+2.)	340	0	0	0	0	0	0	0	0	0	0	
Produits	0	0	0	1,800	3,600	5,400	7,200	10,800	10,800	10,800	10,800	9,240
Rendement	0	0	0	500	1,000	1,500	2,000	3,000	3,000	3,000	3,000	
Produits Commercialisable	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
Prix Unit.	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	4.00	
Revenue Net	-7,140	0	0	1,800	3,600	5,400	7,200	10,800	10,800	10,800	10,800	9,000

Table D.5.1 (5/5) Present Crop Budget

Luzerne						
Articles	1st Annee (Installation)	1st Annee (Entretien)	2nd Annee	3rd Annee	4th Annee	
Charges	8,110	790	790	790	790	2,300
Charges						
1. Travaux	1,240	0	0	0	0	
Labour	840	0	0	0	0	
Nivellement/Planchage	400	0	0	0	0	
Semis	0	0	0	0	0	
Entretien	0	0	0	0	0	
Irrigation	0	0	0	0	0	
Recolte	0	0	0	0	0	
2. Fourniture	6,480	750	750	750	750	
Seedling/Planting	1,200	0	0	0	0	
Funier	5,000	750	750	750	750	
Engrais	280	0	0	0	0	
Agro chemiques	0	0	0	0	0	
Eau d'irrigation	0	0	0	0	0	
3. Divers (5% of Article 1.+2.)	390	40	40	40	40	
			0			
Produits	0	7,938	8,820	8,820	8,820	6,900
Rendement	0	25	28	28	28	22
Produits Commercialisable	90%	90%	90%	90%	90%	
Prix Unit.	350.00	350.00	350.00	350.00	350.00	
Revenue Net	-8,110	7,148	8,030	8,030	8,030	4,630

Table D.5.2 (1/5) Proposed Crop Budget

		Carotte			Onion		
Articles	Unite	Prix	Quantite	Cout total	Prix	Quantite	Cout total
Charges				9,240			20,480
Charges							
1. Travaux	DH/day			1,600			1,600
Labour	DH/hr	100	8	800	100	8	800
Preparation de lit de semis	DH/hr	40	20	800	40	20	800
Semis	DH/hr	40	0	0	40	0	0
Enfouissement fumier	DH/hr	40	0	0	40	0	0
Entretien	DH/hr	40	0	0	40	0	0
Irrigation	DH/day	40	0	0	40	0	0
Recolte	DH/day	40	0	0	40	0	0
2. Fourniture				7,200			17,020
Semences	DH/kg	100	5	500	800	0	320
Agro chemiques	DH/kg						
Engrais	DH/kg	400	3	1,200	200	3	600
Engrais	DH/kg						
Fumier	DH/ton	250	10	2,500	250	10	2,500
Eau d'irrigation	DH/M3	2.0	4,000	3,000	2.0	6,800	13,600
3. Divers (5% of Article 1.+2.)				440			1,860
Produits				32,400			84,240
Rendement	Kg			20,000			26,000
Produits Commercialisable	%			90%			90%
Prix	DH/kg			1.80			3.60
Unit.							
Revenue Net				23,160			63,760

		Tomate			Poivron		
Articles	Unite	Prix	Quantite	Cout total	Prix	Quantite	Cout total
Charges				33,360			23,620
Charges							
1. Travaux	DH/day			1,600			2,000
Labour	DH/hr	100	8	800	100	8	800
Preparation de lit de semis	DH/day	40	0	0	40	0	0
Semis	DH/day	40	0	0	40	20	800
Enfouissement fumier	DH/day	40	0	0	40	10	400
Ridging	DH/day	40	20	800			
Entretien	DH/day	40	0	0	40	0	0
Irrigation	DH/day	40	0	0	40	0	0
Recolte	DH/day	40	0	0	40	0	0
2. Fourniture				30,170			19,470
Semences	DH/kg	1100	1	1,100	50000	0	2,500
Agro chemiques	DH/lit	7	110	770			
Engrais	DH/kg	600	3	1,800	200	3	570
Engrais	DH/kg				100	3	300
Fumier	DH/ton	250	10	2,500	250	10	2,500
Eau d'irrigation	DH/M3	2.0	12,000	24,000	2.0	6,800	13,600
3. Divers (5% of Article 1.+2.)				1,590			2,150
Produits				56,700			54,000
Rendement	Kg			30,000			20,000
Produits Commercialisable	%			90%			90%
Prix Unit.	DH/kg			2.10			3.00
Revenue Net				23,340			30,380

Table D.5.2 (2/5) Proposed Crop Budget

		Ble			Feve		
Articles	Unite	Prix	Quantite	Cout total	Prix	Quantite	Cout total
Charges				7,860			9,000
Variable Cost							
1. Labour	DH/day			1,200			800
Labour	DH/hr	100	12	1,200	100	8	800
Preparation de lit de semis	DH/day						
Semis	DH/day	40	0	0	40	0	0
Enfouissement fumier	DH/day	40	0	0	40	0	0
Nivellement/Planchage	DH/day	40	0	0			
Entretien	DH/day	40	0	0	40	0	0
Irrigation	DH/day	40	0	0	40	0	0
Recolte	DH/day	40	0	0	40	0	0
Battage	DH/day	100	0	0			
2. Fourniture				6,290			8,200
Semences	DH/kg	140	4	560	150	8	1,200
Agro chemiques	DH/lit	7	110	770	50	1	50
Engrais	DH/kg	200	3	600			
Engrais	DH/kg	100	4	350			
Fumier	DH/ton	250	5	1,250	250	5	1,250
Eau d'irrigation	DH/M3	0.6	4,600	2,760	0.6	9,500	5,700
3. Divers (5% of Article 1.+2.)				370			0
Produits				12,000			16,200
Rendement	Kg			3,000			3,000
Produits Commercialisable	%			90%			90%
Prix	DH/kg			4.00			6.00
Unit.							
Production de paille	DH/kg			1,200			
Revenue Net				4,140			7,200

Table D.5.2 (3/5) Proposed Crop Budget

Palimier Dattier

Articles	1st Annee (Installation)	1st Annee (Entretien)	2nd Annee	3rd Annee	4th Annee	5th Annee	6th Annee	7th Annee	8th Annee	9th Annee	10th-30th	
Charges	33,585	10,945	10,945	10,945	10,945	10,945	10,945	3,545	4,295	4,295	4,295	6,720
Charges												
1. Travaux	560	1,200	1,200	1,200	1,200	1,200	1,200	0	720	720	720	
Labour	560	0	0	0	0	0	0	0	0	0	0	
Piqetage/Confestion des trous	0	600	600	600	600	600	600	0	0	0	0	
Semis	0	0	0	0	0	0	0	0	0	0	0	
Entretien	0	0	0	0	0	0	0	0	720	720	720	
Irrigation	0	600	600	600	600	600	600	0	0	0	0	
Recolte	0	0	0	0	0	0	0	0	0	0	0	
2. Fourniture	31,425	9,225	9,225	9,225	9,225	9,225	9,225	3,375	3,375	3,375	3,375	
Seedling/Planting	30,000	0	0	0	0	0	0	0	0	0	0	
Funier	375	1,125	1,125	1,125	1,125	1,125	1,125	1,250	1,250	1,250	1,250	
Engrais	750	4,500	4,500	4,500	4,500	4,500	4,500	1,125	1,125	1,125	1,125	
Agro chemiques	0	1,800	1,800	1,800	1,800	1,800	1,800	400	400	400	400	
Eau d'irrigation	300	1,800	1,800	1,800	1,800	1,800	1,800	600	600	600	600	
3. Divers (5% of Article 1.+2.)	1,600	520	520	520	520	520	520	170	200	200	200	
Produits	0	0	0	0	0	0	0	23,040	34,560	46,080	57,600	43,780
Rendement	0	0	0	0	0	0	0	1,600	2,400	3,200	4,000	
Produits Commercialisable	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
Prix Unit.	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	16.00	
Revenue Net	-33,585	-10,945	-10,945	-10,945	-10,945	-10,945	-10,945	19,495	30,265	41,785	53,305	37,060

Table D.5.2 (4/5) Proposed Crop Budget

Olivier

Articles	1st Annee (Installation)	1st Annee (Entretien)	2nd Annee	3rd Annee	4th Annee	5th Annee	6th Annee	7th Annee	8th Annee	9th Annee	10th-30th	
Charges	8,930	6,290	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,360	3,760
Charges												
1. Travaux	1,200	600	0	0	0	0	0	0	0	0	0	
Labour	800	0	0	0	0	0	0	0	0	0	0	
Piqetage/Confestion des trous	0	300	0	0	0	0	0	0	0	0	0	
Semis	400	0	0	0	0	0	0	0	0	0	0	
Entretien	0	0	0	0	0	0	0	0	0	0	0	
Irrigation	0	300	0	0	0	0	0	0	0	0	0	
Recolte	0	0	0	0	0	0	0	0	0	0	0	
2. Fourniture	7,300	5,390	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	3,200	
Seedling/Planting	1,000	0	0	0	0	0	0	0	0	0	0	
Funier	5,000	0	0	0	0	0	0	0	0	0	0	
Engrais	1,000	3,200	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	
Agro chemiques	0	750	600	600	600	600	600	600	600	600	600	
Eau d'irrigation	300	1,440	600	600	600	600	600	600	600	600	600	
3. Divers (5% of Article 1.+2.)	430	300	160	160	160	160	160	160	160	160	160	
Produits	0	0	0	4,320	8,640	12,960	17,280	25,920	25,920	25,920	25,920	22,180
Rendement	0	0	0	1,000	2,000	3,000	4,000	6,000	6,000	6,000	6,000	
Produits Commercialisable	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	90%	
Prix Unit.	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	4.80	
Revenue Net	-8,930	-6,290	-3,360	960	5,280	9,600	13,920	22,560	22,560	22,560	22,560	18,420

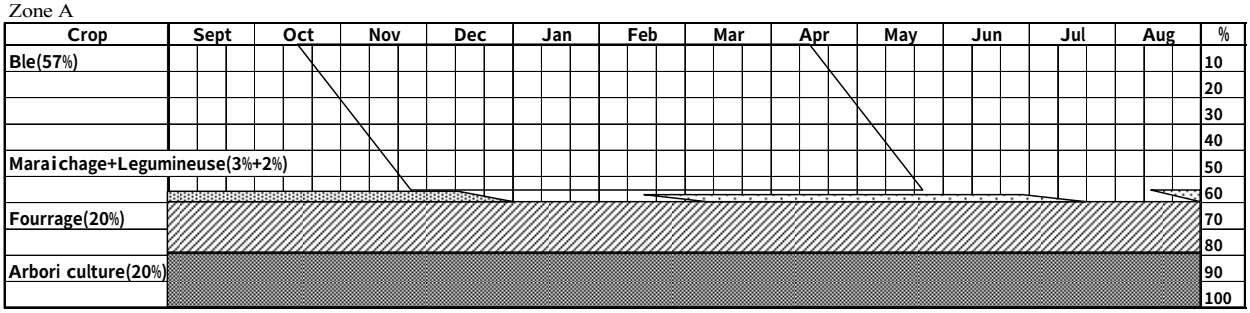
Table D.5.2 (5/5) Proposed Crop Budget

Luzerne

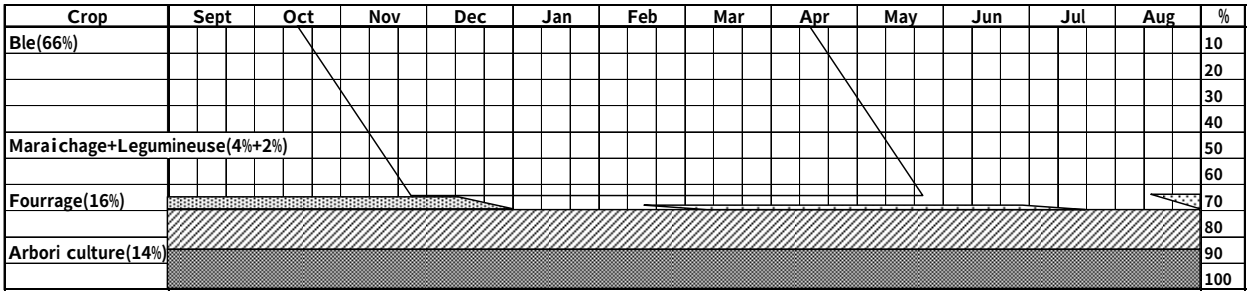
Articles	1st Annee (Installation)	1st Annee (Entretien)	2nd Annee	3rd Annee	4th Annee	
Charges	9,030	7,930	7,930	7,930	7,930	8,150
Charges						
1. Travaux	400	0	0	0	0	
Labour	0	0	0	0	0	
Nivellement/Planchage	400	0	0	0	0	
Semis	0	0	0	0	0	
Entretien	0	0	0	0	0	
Irrigation	0	0	0	0	0	
Recolte	0	0	0	0	0	
2. Fourniture	8,200	7,550	7,550	7,550	7,550	
Seedling/Planting	1,200	0	0	0	0	
Funier	5,000	750	750	750	750	
Engrais	1,400	800	800	800	800	
Agro chemiques	0	0	0	0	0	
Eau d'irrigation	600	6,000	6,000	6,000	6,000	
3. Divers (5% of Article 1.+2.)	430	380	380	380	380	
Produits	0	17,010	18,900	18,900	18,900	14,740
Rendement	0	54	60	60	60	47
Produits Commercialisable	90%	90%	90%	90%	90%	
Prix Unit.	350.00	350.00	350.00	350.00	350.00	
Revenue Net	-9,030	9,080	10,970	10,970	10,970	6,590

Figures

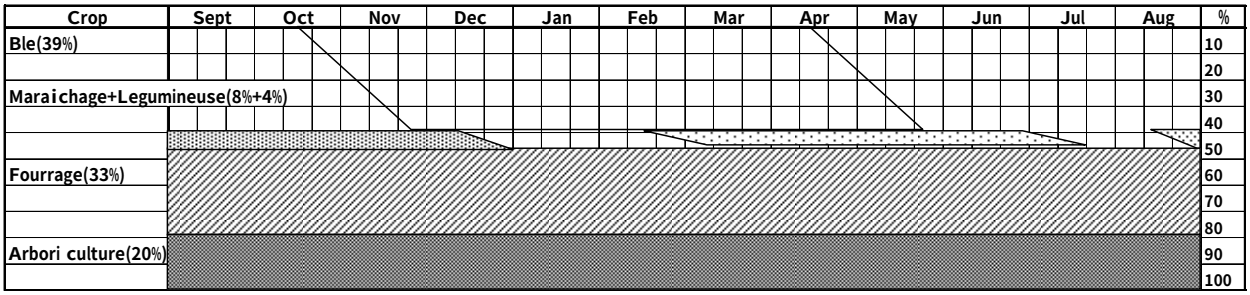
Zone A



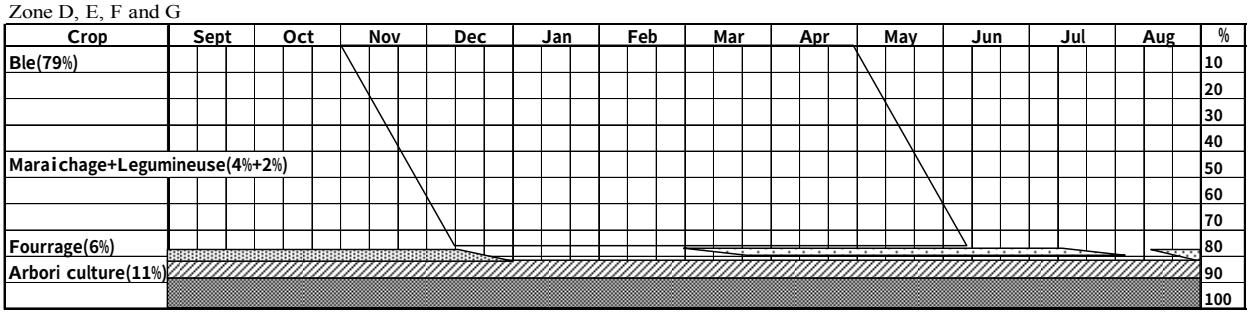
Zone B



Zone C



Zone D, E, F and G



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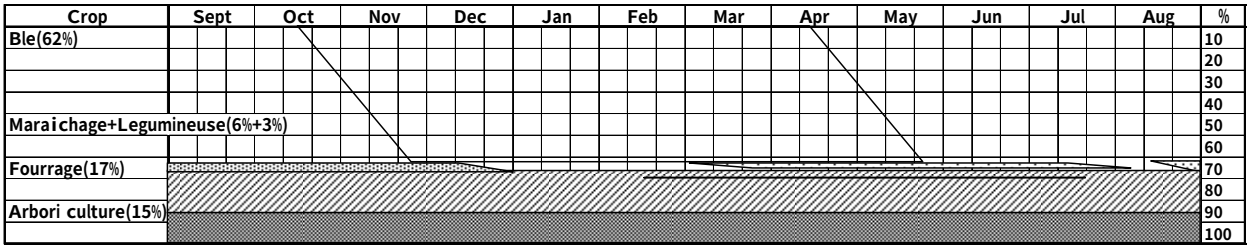
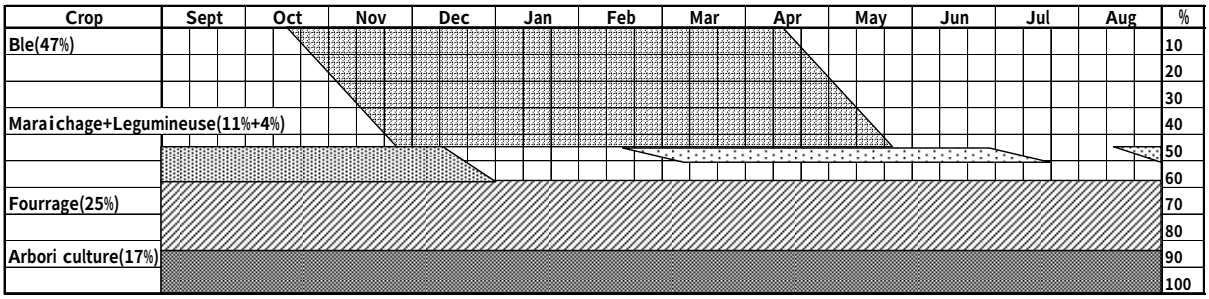


The Development Study on Rural Community Development Project in Semi-Arid Atlas Regions with Khettara Rehabilitation in the Kingdom of Marocco	**Figure D.5.1.** **Present Cropping Pattern**
Japan International Cooperation Agency	

Zone A



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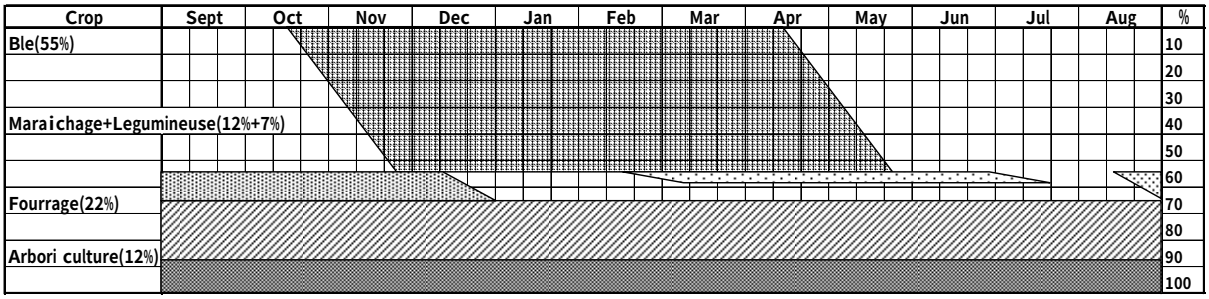

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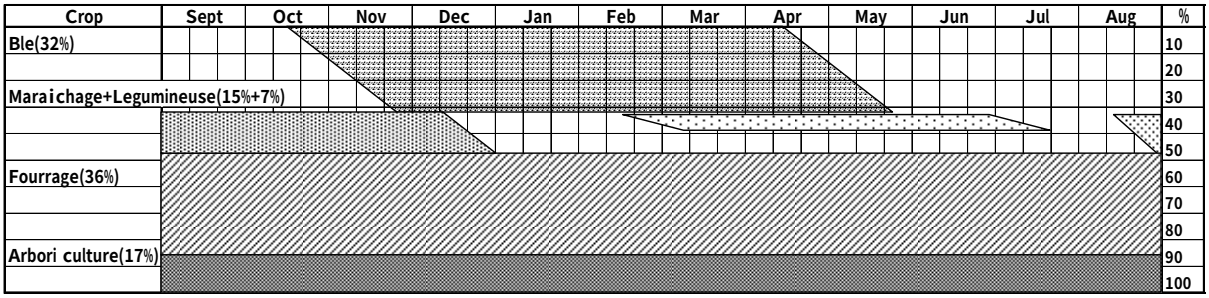
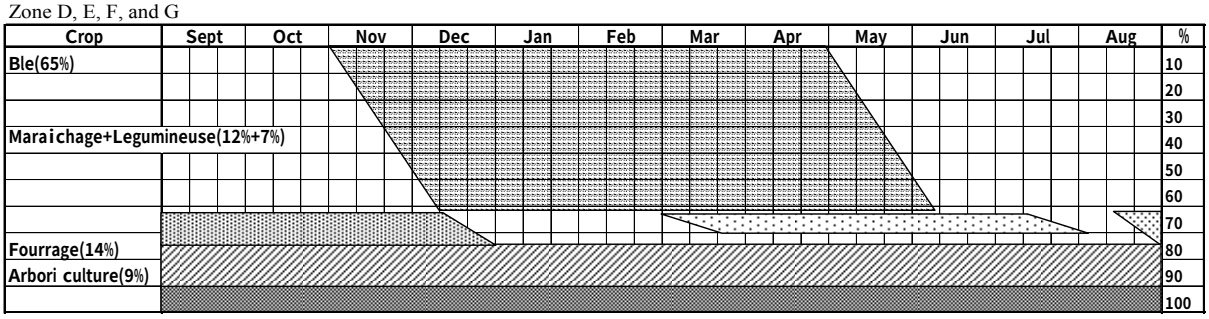


Zone D, E, F, and G



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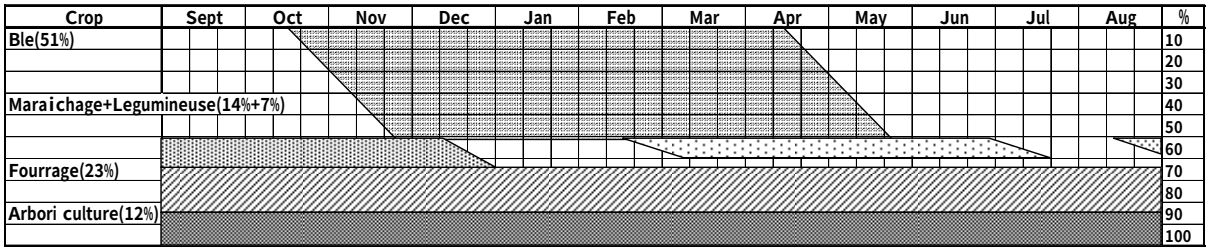
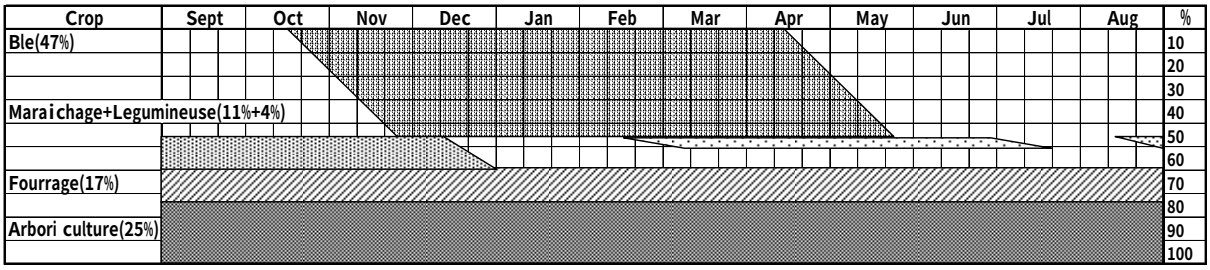


The Development Study on Rural Community Development Project in Semi-Arid Atlas Regions with Khettara Rehabilitation in the Kingdom of Marocco	**Figure D.5.2 (1/2).** **Proposed Cropping Pattern** **(1-6 years)**
Japan International Cooperation Agency	

Zone A



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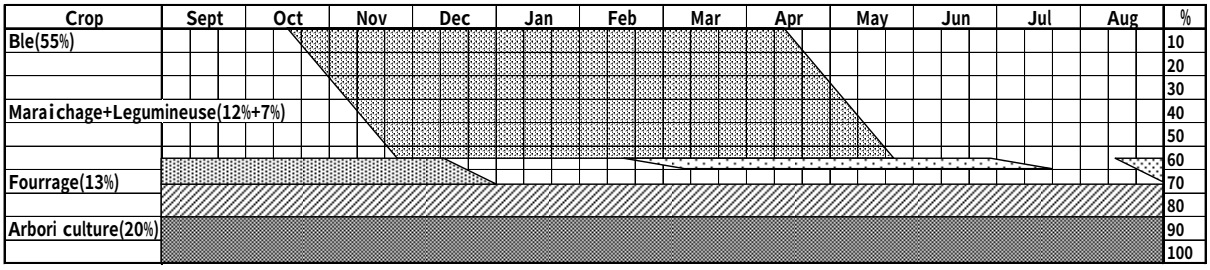

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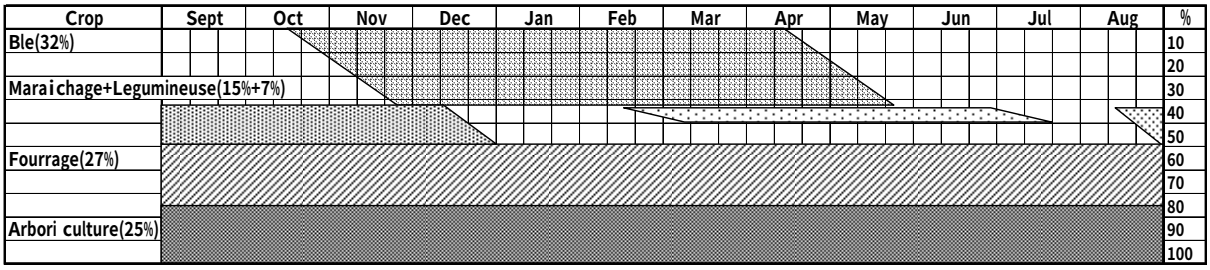
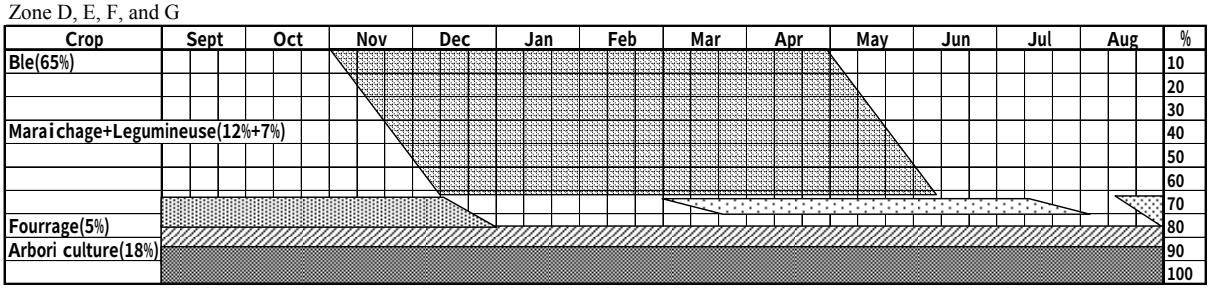


Zone D, E, F, and G



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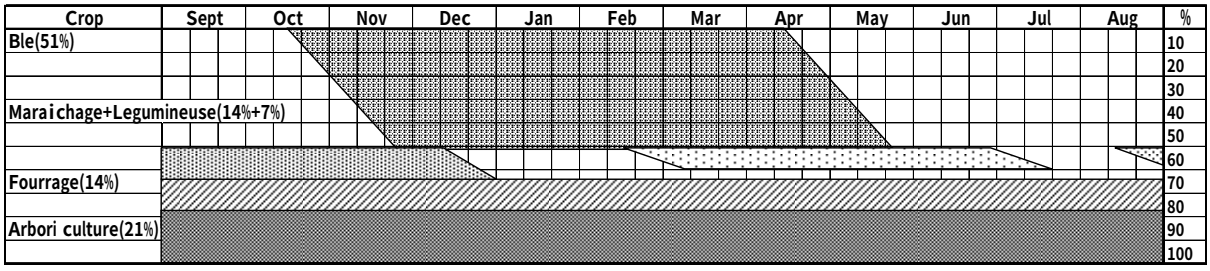

The Development Study on Rural Community Development Project in Semi-Arid Atlas Regions with Khettara Rehabilitation in the Kingdom of Marocco	**Figure D.5.2 (2/2).** **Proposed Cropping Pattern (after 7 years)**
Japan International Cooperation Agency	