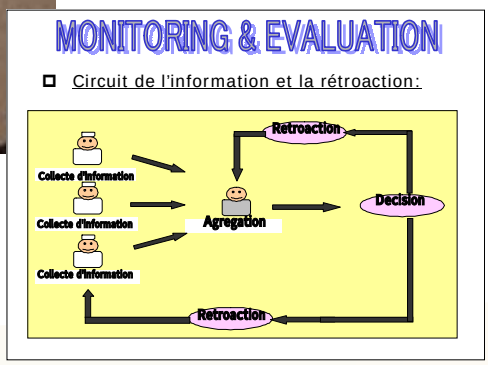
No.

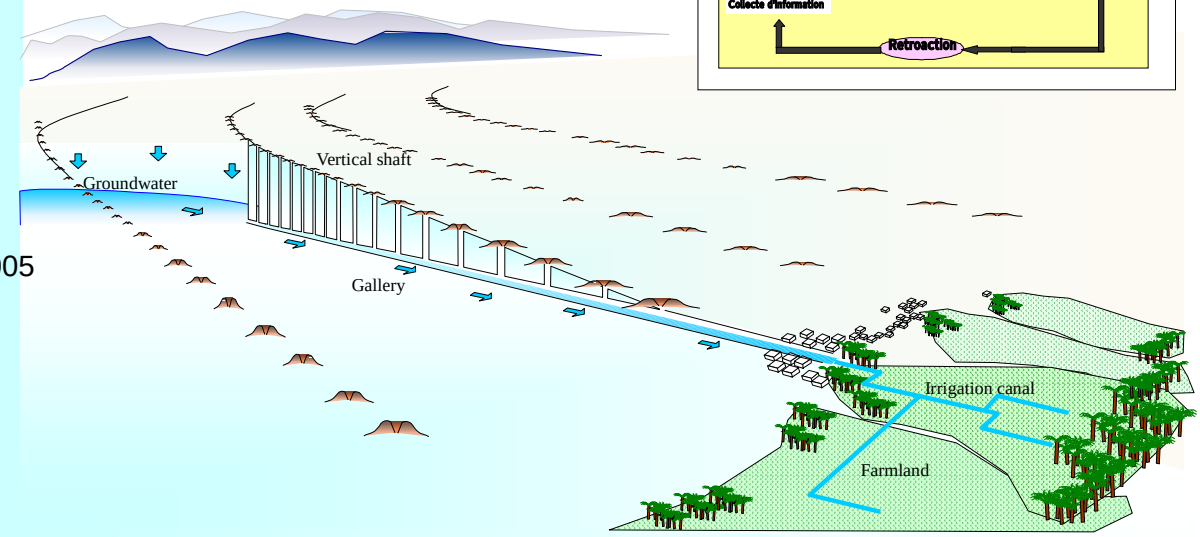
JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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

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

SEMINAR TEXT





DECEMBER 2005

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

Seminar Text

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1st siminar in Octobre 2003

2nd Seminar in Octobre 2005

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General Information of the Seminar

1. Objective of the seminar

The objective of the seminar is to provide an opportunity of getting together for participants engaged in "The Development Study of Rural Community Development Project in Semi-Arid East Atlas Regions with Khettara Rehabilitation in the Kigdom of Morocco" and beneficialries of this project, to identify problems they face, and to discuss measures of their problems in the most effective and efficient ways from the view points of agricultural and rural development.

2. Theme of the seminar

Theme 「Rural Community Development with Khettara rehabilitation」

Sub-Theme ① To recognize with the feature of khettara in the hydro-geology field

② What should ORMVA/TF and JICA do about the rural community development with Khettara Rehabiliration?

③ What should farmers do about the rural community development with khettara

3. Programme

October 22 2003

- Dr. TAKAMURA, University Rissho- Japon

  Thema: ARID LAND IRRIGATION METHODS

- Dr. L. EDDAHBY., F.S.T. Errachidia

  Thema: Contribution of Hydrogeological and Geotechnical Studies To The Replenishment And Stability Of Khettaras.Case Of Tafilalet Plain – Morocco

- Mr. OURAHOU, ORMVA du Tafilalet

  Thema: Heritage Conservation Study of Fezna-Jorf-Hannabou khettarAS

- Dr. BOUKHARI., E.N.A de Meknes

  Thema: Approach and Methodology for an Overall, Rapid and Participative Diagnosis (ORPDI)

- M. H. RAHAOUI et A. OUBERHOU, ORMVA du Tafilalet

  Thema: Study tour to Oman

- M. S. Allaouzi, DRH d'Errachidia

  Thema: Water Resources in Tafilalet Area (Superficila water supply)

- M. K. El Mouquadem, DRH d'Errachidia

  Thema: Water Resources in Tafilalet Area (Under ground water)

- Discussions

October 23 2004

- Mr. A. ABAOUZ., ORMVA du Tafilalet

  Theme : Rationalization of the exploitation of water irrigation

- Dr. M. KABIRI, F.S.T. Errachidia

  Theme : *Water Participation of a non governmental local association of the rationalized exploitation of water in a ferkla oasis. (Tinejdad Errachidia Morocco).*

- Dr. BOUKHARI., E.N.A de Mekhnès

  Thema : Participative approach and agricultural organization

- M. H. LAMRANI, Association de l'environnement et de la lutte contre l'ensablement

  Sujet : The associative work for the qualification of the 3ird millennium khetaras .

- Discussions

4. Participants

(1) On 22nd, October (Total 100 members)

i) Presentater
ii) Resident representative of JICA Morocco Office
iii) JICA Study Team
iv) Representative of Ministry of Agriculture in Morocco
v) ORMVA/TF

(2) On 23rd, October (Total 50 members)

i) Presentator
ii) JICA Study Team
iii) Representative of Khettara Associations
IV) ORMVA/TF

ARID LAND IRRIGATION METHODS

Hiroki Takamura
Geo-environmentalSciences
Faculty Rissho University, Japan

1- Effective utilization and improvement of small scale irrigation systems.

(1) Since large scale irrigation does not bring about the expected results, we turn back to traditional small scale irrigation. The latter, whose technical applications and canal management are easy to implement by farmers rest on the principle of an actual application of local techniques and materials considering the farmer as the central factor.

(2) Submersion irrigation is traditionally utilized in the sub-saharian regions. It is constituted of two types of irrigation: mangrove and cost line marshes irrigation and inland basin irrigation. The former relies on dikes and embankments construction to counteract sea water seepage and allow impounded water to be utilized to irrigate rice crops. This irrigation method is found all along the Atlantic coastline, from Gambia to Liberia. Basin irrigation consists of rice crop irrigation in inland marshes covering areas as large as 100 ha.

(3) Irrigation by flood water spreading is a method developed in North Africa by the Romans. Generally, this method is widespread in the Arabian Peninsula and North Africa and consists of Oued water collecting and spreading on farmland and plains. This practice is not largely used in the sub-saharian regions even though in Sudan farmers resort to this method to irrigate sorgho and hima using Gassh river water and, in Ethiopia, to irrigate garden and fodder crops grown in the Omo river depressions. It's a dynamic irrigation method that requires high technical know how and much experience.

(4) Low land irrigation using river flow flood water is done in winter time to irrigate rice crops.

A) Controlled flooding irrigation: water inflow is limited to 30 mm per day for rice paddies and 50 mm per day for deep rice paddies. The system may be made of simple earthen embankments or canals and water intake gates according to the technical status (FAO. 2001). During the dry season, various gravity techniques or pumping are used in order to harness shallow groundwater or accumulated flood water.

B) Residual irrigation: when floods recede, water is held back within small embankments and used for irrigation. This method is commonly used in West Africa flood land for rice cropping and nearby Tchad lake to grow mais and sorgho.

C) Utilization of residual water: this method is similar to the one above, except that in this case residual water surface flow is not used but impounded by earthen dikes. It is frequently used where floods are intensive. In East Africa, it is carried out in a large number of seasonal marshes called "dambo".

D) Pumping irrigation: river, streams and lake pumping is simple, largely used and often run individually. Since it entails additional expenses, this type of irrigation is kept for cash crops agriculture rather than cereals.

E) Hill irrigation is widely spread in central Ethiopia, in Tanzania and in Malawi. Water resources come from small hill lakes water supplied by mountain streams. Water is then conveyed to farmland by means of open canals or under low pressure ducts, by gravity or simple pumping devices. This type of irrigation is done individually or by groups of farms (FAO 2001).

F) Irrigation using groundwater deeper than 30 m is carried out throughout the year but requires highly sophisticated techniques since it relies on submerged pumps power driven or activated by diesel generators. This type of profitable irrigation encourages several pumping methods and farming practices. However, since drilling boreholes and pumping expenses are quite high, it is saved for industrial crops or grand aid subsidized ones (FAO, 2001).

2- Sub-saharian irrigation

International organizations, of which the World Bank, and also some investigators, made various proposals based on past experience in order to foster irrigation methods in the sub-saharian regions. Generally, successful irrigation methods reveal the following features:

(1) Irrigation meets the farmers' expectations since they execute all the works from the start and remain dedicated to the management of the implemented facilities (participative management).

(2) The utilized techniques are simple and the farmers get soon acquainted to them. The cost is also low.

(3) Many options are planned for as preventing measures adapted to draught critical situations.

(4) Utilization of maintenance equipment and spare parts which are locally available.

(5) Purchase of investment equipment and installation of market supply infrastructures.

(6) Possibility to grow at least two crop categories, not only industrial products but also self consumption products as well.

(7) Utilization of local skill and human resources

(8) Farmers' understanding is necessary to refrain from excess pumping and allow water saving when no water utilization planning is set up or when prompt utilization of easily accessible interflow water resources is possible.

(9) Farmers are made aware of the environmental and health problems, and that irrigation may have drastic effects on health, slowing down drainage and causing erosion.

Irrigation development in the sub-saharian regions is impeded by cost limitations and environmental factors. Schistosomiasis and other endemic diseases are water transmitted. Special care must be given to the following factors:

(1) Gathering of precise hydroclimatic data taking into account long fluctuation periods.

(2) Giving priority to small scale schemes whose facilities maintenance is easy and cheap.

(3) Supporting cropping systems using traditional irrigation methods adapted to the country's land formations, giving good results and requiring low investments (for instance, supplying additional irrigation to crops irrigated with residual water in flood areas).

(4) Participation of the beneficiary farmers and their good understanding of the irrigation process from the planning stage throughout to the works implementation.

(5) Implementation of the irrigation facilities participative management reducing maintenance costs and improving outputs.

(6) Respecting landholding and water rights.

(7) Planning environment friendly facilities and management systems.

(8) For few years,low cost technology have been developed that is adapted to each sub-saharian region and is intended to eradicate water transmitted endemic diseases, so information sharing in each area is likely to increase productivity.

3. Securing safe drinking water in rural areas

The death rate in the sub-saharian regions was 10.7 % in 1990 and 10.1 % of the diseases was caused by unstable water supply, bad sewage and health facilities. In fact, 87 % of death occurrences were due to dysentery that infects 87 % of the children population. (Murray & Lopez, 1996). More sanitary facilities, residual water and drinking water supply in the rural areas are required to solve these problems.

The proportion of rural population having access to drinking water resources is at its lowest in Gongo reaching 8 % only and the highest is recorded in the Mauricious Island with 92 % (WHO, 1996).In addition to tap water, WHO includes well and spring water as health water sources but excludes river and lake water. Furthermore, the concept of "reasonable access" to water means that women do not spend much time fetching water required by their homes and that the distance to cover for that purpose does not exceed 200m.

WHO assessment of water requirements for drinking, hygiene and domestic needs is 20 l per day and per person (WHO, 1996). These standards are not set on clear foundations, but this quantity is considered as the minimum subsistence level. Some investigators assert that 25 l/day/person are enough to meet drinking and sanitary requirements, but a 25 l daily supplement should be included for bathing and cooking, which is 50 l in total (Gleick, 1998). Water amounts consumed in developed countries largely exceed these figures since the less water consuming countries use 110 l / day/person. Japan water consumption is 342 l and USA amount to 668 l (Rosen and Vincent, 2001).

In sub-saharian coutries daily consumption show huge variance ranging from 1.3 to 4.8 l/person and would be in average 10 l per day and per person, which is far lower than the standard 20 l/day/person estimated

by WHO. These studies do not take into consideration laundry and bathing done in rivers which finally make the average real consumption much higher (Yoshinobu Kitamura, 2003, “Desert Research” in Japan Desert Academic Society).

HERITAGE CONSERVATION STUDY OF FEZNA-JORF-HANNABOU KHETTARAS

OURAHOU Mohamed
Ingéniur d'état Génie Rural
Chef de subdivision SER
ORMVA/TF, Erfoud

In the Tafilalet region 1 Mm^3/year sustains the livelihood of 3 to 4 inhabitants per flood irrigated hectar and about 15 inhabitants in case the flow is perennial, ie, 4 to 5 times or more (J. Margat).

The study area extends along the Gheriss right bank zone on a 4000 ha area of which 420 ha are exclusively irrigated by khettara water resources. The rest is irrigated by means of pumping stations and flood water.

The climate is saharian marked with cold winters and a low precipitation reaching bellow 100 mm/year. The average temperature is 28° C reaching 42° C maximum in July and 2,200 m mean annual evaporation rate.

The area water resources are as follows:

- Four dams (El Guefifat, Sidi Mejbar, El Gara and Lahmida dams) harnessing about 42 m^3 /s.
- More than 197 pumping stations producing 8 Mm^3 /year.
- And 60 khettaras of which twenty only are operational and are still yielding a low discharge.

1- Study object

The study is dealing with the various Khettaras applied techniques and heritage conservation proposals. So, it is essential to:

- Restate the actual situation of the khettaras' operation, management and organization.
- Carry out geological and hydrogeological surveys of the khettaras water abstraction zone.
- Outline the various technical systems applied and those likely to be applied to khettara rehabilitation.

2- Study method

It is based on:

- Bibliographical survey of the study area inlcuding in countries with similar environment.
- Inventory work of the 60 khettaras using inventory sheets and interviews.
- 197 pumping stations inventory.
- Monitoring and supervising of academic achievements papers concerning the area.
- Monitoring groundwater level.

- Khettaras discharge measurements
- Khettaras water salinity measurements
- Analysis of soil samples
- Site investigation in cooperation with the farmers.

3- Outline of the khettara system

a. General

ORMVA/TF command area has about 570 khettaras of which 170 were still operational in 2003 and allow the irrigation of 3500 ha. These khettaras total length is 2900 km and the area covered is about 16,500 ha. The estimated total annual water volume supplied is 90 Mm^3.

Fezna-Hannabou-Jorf area covers 4000 ha, harbours 60 khettaras with totaling 417 km. twenty of which are operational at the present time and permit the irrigation of about 420 ha only with a 123 l/s discharge.

Khettara water resources management, which is carried out by the "Cheich" and his Mezrags is governed by costumary law of water rights distributed according to "nouba" as a hydraulic unit. Each nouba is equivalent to 12 hours irrigation time. Water distribution is done according to a "water rotation system".

b. Current situation

At the present time, khettaras suffer the following contingencies:

- Groundwater drawdown subsequent to years of successive draughts and water resources over utilization through pumping which generated a 60.5 % depletion and noticeable discharge decrease.
- Tunnel and vertical shafts collapsing and caving in.
- Aggradation of manholes and irrigated land plots
- Decrepit galleries reprofiling
- High leakage losses (30~70%).

4-Zone's geology and hydrogeology

4-1 Geology

The zone's geological layout is made of two strictly different elements:

a- Folded primary era bedrock: whose tectonics are relatively simple and oriented east-west and characterized by more than 500 m thick strategraphy (ordonvician, Gothlandian, denovian and carbonifer)

b- Quaternary alluvium capping: made of wind erosion formation, "regs", river alluvium and a 15 m thick fluviolacustrine layer which is composed of loam, marl and pudding stones. These pudding stones are the major flow route and groundwater impounding of site.

4.2- Pedology

Within a layer not exceeding 20 m deep, the texture is in general balanced and composed predominantly of sand and silt. This equilibrium is due to the annual and frequent soil works implementation. Beyond 20 m deep, the texture is variable (balanced to loamy). Generally, salt content is high in the upper layers because of the upward capillary motion.

4.3 Groundwater hyrodynamics

The groundwater layer was formed during the upper quaternary era at a time where rainfall was abundant and water infiltration intensive. There existed also an impervious primary era bedrock. Groundwater storage estimate is 50 Mm^3 (at the present time : 25 Mm^3).

a- Groundwater regimen

Groundwater level records (1995-2000) show that fluctuations are more significant at the upstream zone (Fezna) than downstream towards Hannabou : at Fezna-Achouria, annual variations may reach 9.00 m, while in Krair and Hannabou water elevation is rather stable. Therefore, the water table seems to be convex, but disturbed by flood flow and natural drainage flow lines of Gheriss river.

b- Groundwater flow

It seems that groundwater flow orientation is slightly directed west-north-west to east-south-east and shows a 2 ‰ average hydraulic gradient. Such orientation as well as that of the water table outlets is altered by the Devonian ripple (Jbel Ougnat, Koudiats Tantana, Mounkara, Maha and Bin Jbilat) acting as a natural subsurface dam.

c- Water chemical composition

Khettara water analysis show that the electrical conductivity is 2.73 mmhos/cm and varies between 1.98 and 4.03 mmhos/cm. water classification is generally C3-S1 and C4-S1. It is chlorinated and containing sodium. Salt content decreases gradually moving downstream.

Thus, we may differentiate, from the technical point of view, two distinct water tables:

- a groundwater formation extending to the north along Ghriss river and flowing beyond Jorf.
- Another south-west groundwater that follows towards Tafilalet zone and that replenish the khettaras.

Khettaras water salinity in Fezna-Jorf-Hannabou zone (2000)

N° Laboratory	Zone	Name of khettara	Salinity (g/l)	EC (mmhos/cm)	Class	Average CE
38	Jorf	Lambarkia Fougania	1.77	2.47	C4	2..99 i.e. class C4
47		Souihla	2.88	4.03	C4	
56		El Aissaouia	1.72	2.40	C4	
57		Saida	1.57	2.19	C3	
39		Lakbira	2.77	2.87	C4	
41	Mounkara	Lambarkia Tahtania	2.83	3.96	C4	2..46 i.e. class C4
48		Lahloua	1.72	2.40	C4	
55		El Aissaouia	2.84	3.97	C4	
43	Bouya	Jdida	1.77	2.47	C4	2..43 i.e. class C4
54		Lakdima	1.72	2.40	C4	
42	Krair	Jdida	1.71	2.39	C4	2..39 i.e. class C4
50		Lakdima	1.72	2.40	C4	
40	Hannabou	El Oudtania	1.78	2.49	C4	2..47 i.e. class C4
44		Khtitira	1.42	1.98	C3	
45		El Alouiya	1.78	2.49	C4	
46		El Moustaphia	1.77	2.47	C4	
49		El fougania	1.82	2.54	C4	
51		Sayed	1.88	2.78	C4	
52		Lakdima	1.74	2.43	C4	
53		Lagrinia	1.83	2.56	C4	
Mean value			1..95	2.73	C4	2..73 i.e. class C4

Salinity of pumping stations and wells water in Fezna-Jorf-Hannabou zone

N° Laboratory	Zone	Name of khettara	Salinity (g/l)	EC (mmhos/cm)	Class	Average CE
637	Fezna	SP El Ghafaouli	2.78	3.97	C4	3..36 i.e. class C4
638		SP Laksiba	1.94	2.78	C4	
217		Fezna Shaft	2.35	3.35	C4	
216	Achouria	Achouria Shaft	2.46	3.51	C4	3.86 i.e. class C4
636		SP Achouria	2.95	4.21	C4	
639	Jorf	SP Sidi Mejbar	1.99	2.85	C4	2..85 i.e. class C4
Mean value			2.41	3.45	C4	3.45 i.e. class C4

d- Groundwater balance

Assets	Liabilities
- Upstream groundwater flow: 12.2 Mm^3 - Flood water infiltrations: 02.2 Mm^3 - Water spreading infiltrations: 11.0 Mm^3 - Rain infiltrations:- Total: 25.4 Mm^3	- Downstream flow: 11.0 Mm^3 - Withdrawal 11.7 Mm^3 Pumping: 8.0 Mm^3 Khettaras 3.7 Mm^3 -Discharge 0.5 Mm^3 -Evapotranspiration: 2.2 Mm^3 Total 25.4 Mm^3

Water spreading infiltration (43 %) has a major role in groundwater recharge.

5- Khettaras development techniques

Several techniques have been applied by farmers and the engineering departments.

- Traditional techniques: using dry masonry, stone slabs and palm branches through farmers rudimentary means and empirical knowledge.
- Mixed techniques that combine both farmers skill and improved techniques (wall construction with rubble stone masonry or with ordinary concrete slab covered with concrete mortar).
- Modern techniques: based on data collecting expertise (land survey, hydrogeological survey, geotechnics, soil survey, discharge measurements…).

6- Heritage protection proposal

In order to protect the khettaras, maintenance and improvement of the groundwater level is of tantamount importance. So, it is necessary to:

- Cut down the number pumping stations number and collectively regroup them.
- Construct hill lakes on Oued Batha and Oued Ougnat and water collecting basins on Oued Hnich.
- Rehabilitate diversion dams and flood water spreading networks that play a major role in groundwater recharge.
- Rehabilitate the khettaras and irrigation networks
- Protect irrigation farmland against desertification.

Approach and Methodology for an Overall, Rapid and Participative Diagnosis (ORPDI)

Dr. BOUKHARI, E.N.A de Mekhnès

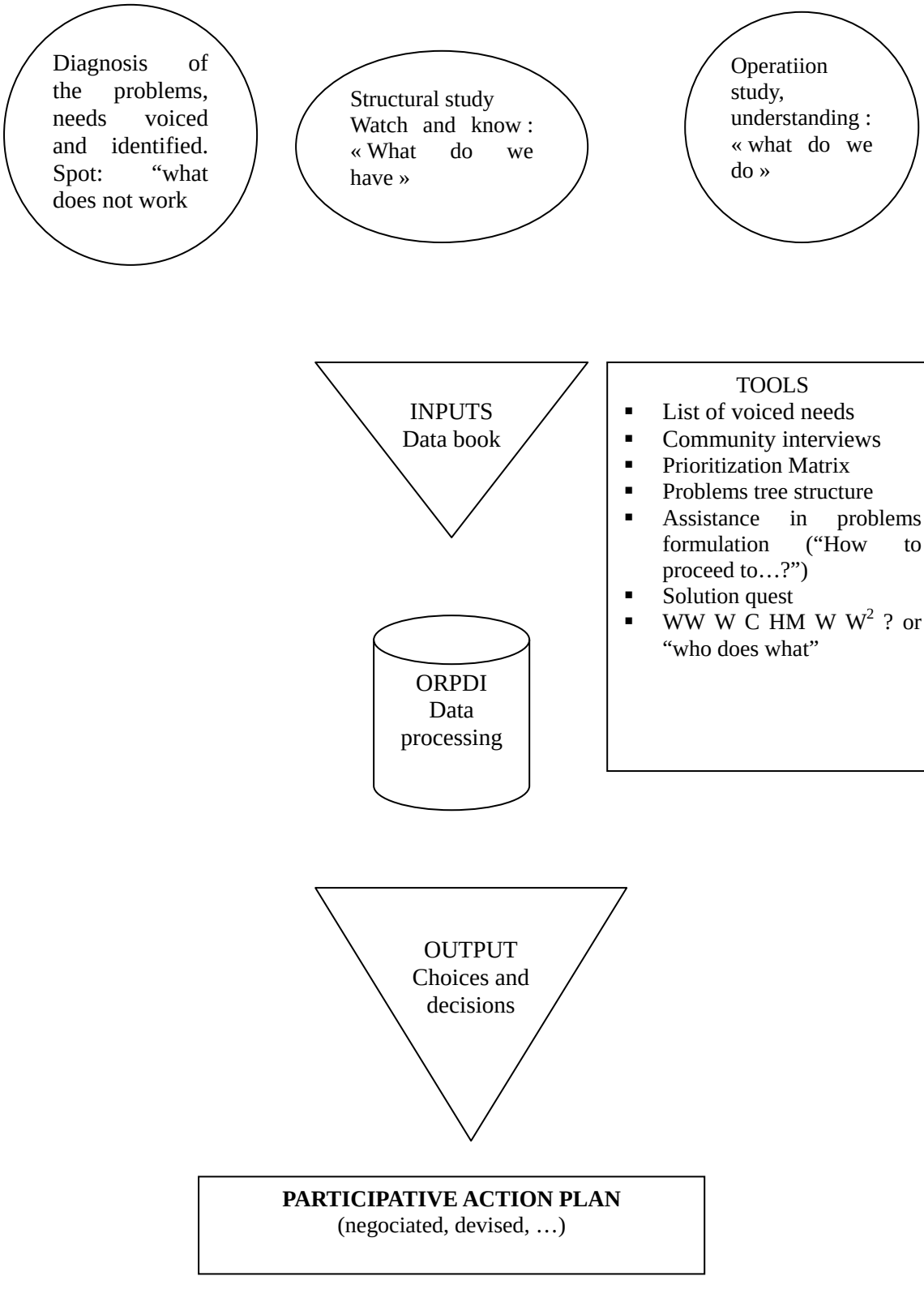
This method permits us to evaluate the conditions of the system's current situation by determining the whole set of constraints and advantages and searching for and proposing solutions or action plans.

It can be defined as the activities involving both the intervenors and the populations, whose object is information and ideas exchange that permits to:

- Identify:
  - the constraints, problems, needs, expectations, ….(all that is not functioning well or is missing)
  - The advantages : benefits, potentialities, resources…(possibilities of improvement).
  - To prioritize the problems, and find out the relevant questions.
- To search for solutions and make proposals therewith
  - To make proposals and negotiate with the actors the activities to be carried out in order to improve the current situation.
  - To estimate the costs, the benefits, impacts and risks of the program's implementation.
  - To determine "who must do what" and the relevant responsibilities.

The ORPDI's utilization as a system allows a better organization of actions and a discussion framework that is likely to improve the communication process. This method consists of knowledge sharing, collecting, analyzing and comparing data, helping the populations solve their own problems and have them participate to the making of the Participative Douar Development Plan (PDDP) through a systematic procedure:

- "to rise in order to see": study of the system, the existing situation and the resources ;
- "Bridging in order to understand": considering the inner flow or the system's inner interactions and the ingoing and outgoing flow, to reach a clear idea about the kind of operating system.
- "locating in order to act": it's a diagnosis whose purpose is to make proposals of additional and integrated actions within the participative development plan concerning the Douar and the locality.


Diagnosis of the problems, needs voiced and identified. Spot: “what does not work
Structural study Watch and know : « What do we have »
Operatiion study, understanding : « what do we do »
INPUTS
Data book
TOOLS
List of voiced needs
Community interviews
Prioritization Matrix
Problems tree structure
Assistance in problems formulation (“How to proceed to…?”)
Solution quest
WW W C HM W W2 ? or “who does what”
ORPDI
Data processing
OUTPUT
Choices and decisions
PARTICIPATIVE ACTION PLAN
(negociated, devised, …)

4 – 1 SYNTHETIC TABLE OF THE ORPDI APPROCH

PHASES	ACTIVITIES AND PRODUCTS	TOOLS AND METHODS
1- Inception phase	Information, training, documenting, preparing	Data II, privileged community contact,…
2- Expectations, needs, problems list	Problems identification, prioritization	Community interviews, brainstorming, Checklist
3- System analysis and understanding	Understanding How and Why "What we do have" and What do we do".	Maps, calendars, profiles, flow diagrams, pie charts, SEPO…
4- Problems formulation and solutions researching	Going from problems to solutions, action choices and objectives formulation	"How do we do to?..., problems tree chart, PPO…
5- Elaboration of indicative participative action plan	Framework, project planning diagram, SPP and SPA activities, Participative Douar Development Plan	Systematic questions: WW W HM H W, Who does what?...
6- Devising, negotiating and approval by intervenors and service partners	Partnerships, integrations and coordination of interventions in coherent action plan and technical and financial feasibility	Additional studies, project coordination, expertise and feasibility study
7- Population's organizations (associations, committees, …)	Organized associations, created, responsibilities,…	Organizations' support, coaching, training
8- Signature authentication and program contracts	Signed program contracts and validated action plan	PPO, Participative planning
9- Objectives operationalization and IOV choices	Operational objectives, simple observable and measurable (physical realizations and CAP)	APO, logical framework and diagram of SPP project planning
10- Participative realization of programmed actions	Actions appropriation by the participating population	Participative management, Protected decision, contribution, devising, negotiation,…
11- Participative monitoring and evaluation	System of Monitoring and evaluation participation operations	Dash board with simple, meaningful and readable indicators

1st phase: Prerequisites to the implementation of Overall, Rapid and Participative Diagnosis (ORPDI) targeting the elaboration of a participative and sustainable development plan

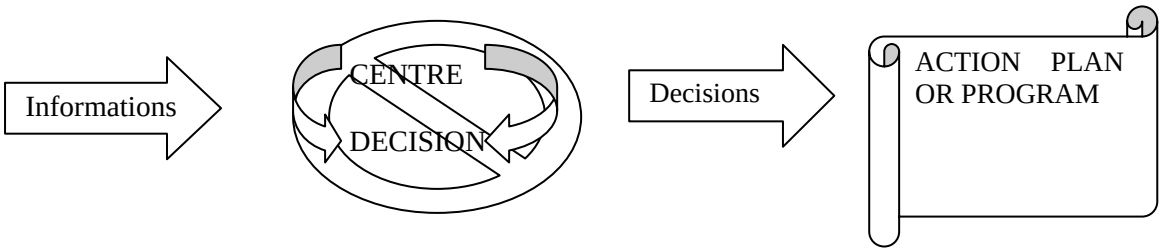
This first stage is important to the exchange of information, the training of the team's new members and for clarifying, specifying, harmonizing the different opinions that each partricipant may have concerning the basics concepts, terms and expressions used in the field of the sustainable and participative development plan.

- The systematic approach
- Local development
- Sustainable development

- Mentalities changes or KAP (knowledge, Attitude, Practice) or KTB (what do we know ? what do we think ? what do we do).
- Setting up a participative project and its relevant framing
- Principles and tools of the participative communication
- Participative approach
- Rapid methods/conformist methods
- Few participative diagnosis methods
- Participative planning
- Gender approach and SEAG (socio-economic approach according to gender)

Informing the population, the intervenors and local authorities and fixing the activities' date and location.

The relevance and quality of the action plan depends tightly on the quality and relevance of the information required for its elaboration. Since, as it shows in the following diagram, we won't succeed in setting up an action plan unless we first process the collected data.



Action requires understanding and to understand it is peremptory to have the data concerning the system we intend to act upon. It is then peremptory to filter the useful information least some unnecessary data weigh down on the processing activity whose target is to take the right decisions and set up the relevant action plan.

That's why one must select a minimum useful range of information and never overload the system with unnecessary data. Once we launch the first operations, we may be able to locate the missing information and only then it will be more judicious to fill in the gaps than waste time and resources in iterative actions.

The participative approach does not consider the population as an information repository but rather a partner with whom useful information ought to be exchanged and shared. In addition, data processing is not anymore an expertise matter but it is the opportunity for analysis and consideration together with the population whose target is to compare alternatives, and choose the actions must be undertaken. As we pointed out above, to discuss with and involve the populations in the decision making is the participative basic principle, it is knowledge and decision sharing.

We still have to point out that we are operating with executives and technicians who possess a lot of information, each in his respective field of knowledge or discipline and who believe solely in theories and practices considered more rational than the non learned farmers' knowledge.

But the main participative approach principle is knowledge sharing based on respect of others' point of view, exchange of information, compromise negotiation between different opinions and attitudes, choices and decisions.

2nd Phase: Establishing a list of the population's problems and needs

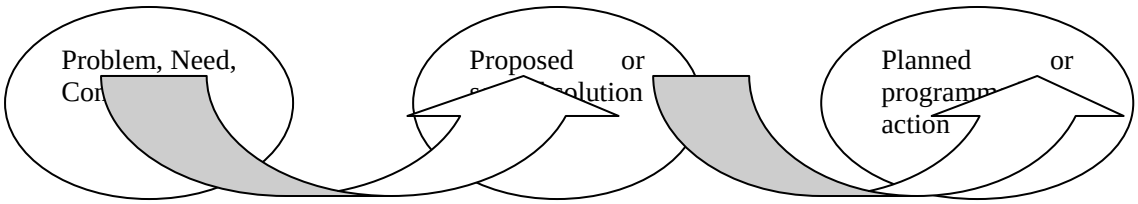
A problem is defined as an obstacle or a constraint that limits or impedes the realization of a certain objective or the accomplishment of a required action.

We set up a list of problems, needs, expectations…of the population, then we give the proper reply to the question (during collective brainstorming enquiries freely carried out): "What are the problems and needs concerning …?).

- **To target directly the problems**

  We would like to recapitulate the diagram we have made in the first section concerning the action process.

  An action is but a solution to a problem



  So, during this initial working session with the population we must simply listen to their answears to the following question:

  "What does not work out" or "What is missing in …?".

  This question must be completed by including the subject matter activity or component. For instance, "what does not work out or what is missing to better tap the natural resources? ".

  In other words, if we let the population voice their opinion and list all the problems related to the relevant question that will lead us to:

  "the list of problems, needs, expectations… conveyed by the population".

  To make up a participative program by means of the ORPDI we suggest to list up the problems and need (see ORDPI figure), then we may tackle other aspects in order to understand the system, using the two other approaches: the structure study "what do we have" and the function study "what do we

do".

To list the problems and needs requires engaging in discussions and enquiries with population groups.

1°- "What do we have?" which will let us encompass the available resources… and the way they are distributed, the established ownership rights and the social relations.

2°- "What do we do?" lets us know the operating, utilization and management process of the natural resources and environment…

3°- "What are the problems and the needs?..." (concerning livestock feeding and the utilization of graze land and forests…)

Once the inventory of the population's needs is finalized, the next step is prioritization and classification from the population point of view. Then follows the system's participative and exploratory study which will permit the members of the intervening team to understand the relation between the population problems and needs, the system structure "what do we have" and the operational level "what do we do".

We have used the system approach principles as a design framework of the ORPDI.

For that purpose, the utilization of the ORPDI sets forth improved intervention actions and offers an adequate discussion framework that permits:

- Working with the population (and not working for the population)
- Communication
- Sharing knowledge and data collecting
- Analyzing, discussing, comparing…and so examining together…
- Helping the populations solve their problems, and
- Have the populations participate in the making of the PDDP.

3rd Phase : Survey and understanding of the participative system

("what do we have and what do we do?)

To understand and identify the constraints and the advantages

Normally, this phase follows the assessment list of the populations' problems and needs and is the phase in which an additional list will established stating further observed problems and needs by the operators.

In this case, those needs and problems that have not been roused by the populations are discussed by the operators to find out the KAP (Knowledge, Attitude, Practice) progress conditions which is the first stage in awareness raising and communicating information because these exchange sessions are the appropriate participative learning moments….

At his stage, we may utilize the two information access platforms to the ORPDI (refer to the ORPDI

diagram)

- Structure study or overall description of “What do we have”
- Function study or understanding why and how we implement a given activity system “What do we do”.

This stage’s objective is to endeavour to understand the multiple causes behind the problems and needs expressed by the population and identify subsequent ones.

The time spent collecting and processing data during this phase is considered as the main stage of the participatory communication since it is the time to build the canvas that synthesizes the data conveying facts as lived by the populations and understood and conceived by the operators.

For that purpose, we may use some of the following tools to exchange, analyse, comprehend and find out the weak points or problems and the strong points or potentialities as well…

4th phase: problems formulation and searching proposed relevant and recommended solutions thereon

Assistance in the assessment of problems: or switching from complaints to problems formulation using the formula “How to do….?”

Resume all the points brought up as “problems” which are initially just complaints and elucidate them as problems using the formula: “How do we do to….?”.

At this stage, these complaints are of no avail to the quest for solutions. A more operational stance would be straight forward questions, because they let us apprehend and better orientate the reasoning activity.

To express a complaint as a problem we may use the following formula: “How do we do to…”.

5th phase: Drawing up the participative action plan

Getting the population involved and communicative by resorting to the systematic questioning: W-W-W-H-HM-W-W.

Participation is negotiation and selection of solutions and type of actions

W: What: Subject matter or roused problems

W: Who: who does what ? the intervening operator and the population

W: why: objectives and results

H : How: activities and methods

HM: How many: quantification and measurements as well as the cost/benefit ration

W: Where: location and sites

W: When: schedule, time and duration of the activity

6th phase : Choice of objectively verifiable indicators (OVI) Operationalization of objectives : objectives analysis (OA)

One of the major problems of any monitoring and evaluation activity, planning and implementation remains the lack of operational objectives, since, generally, during the objectives formulation, we lay stress rather on the overall objectives solely.

Such objectives are hard to plan, implement, monitor and evaluate because the efficiency is assessed comparing realizations and objectives. So, if the objectives are not clearly defined, the evaluation cannot be carried out.

The objectives' analysis method (OA): let's us operationalize the overall objectives through a breaking down into simpler objectives.

Breaking down of an objective permit to simplify and clarify the objectives until we reach its operational level. It is considered operational when the output is a physical realization (equipment, constructions, facilities,…) or a change in behaviour that can be qualified as simple, observable, measurable, appraisable…

Activities and tasks will continue being defined and specified to attain the most elementary, simple, clear, precise operation level as a target we consider as objective.

7th phase: establishing of a letter of intent (or program contract) and accountability of a village organization

We have to point out that there will be no participation without an organization in charge of the project's realization, maintenance, sustainability and reproduction.

On the other hand we consider that discussions must continue and deal with organizational matters, letters of intent even on an informal level to start with as an incentive to find out "who must what?".

Some basic grounds ought to be emphasized prior to any joint implementation with the population of the ORPDI.

- 1- we have innovated, adopted and adapted this new method even though there exist many other methods (RRA, MARP,…) because of the following reasons:

A- The MARP and other methods are disseminated models that may be efficient and operational in their own context, but are not fully adapted to the Moroccan environment.

B- These methods have been instituted within systems where the major, and maybe the only operator, is one or many NGO in a sub-saharian environment where we observe little government involvement if not a non existent government intervention. Whereas in our case, generally, there are many official operators and we may say that there is rather a high involvement of the government, international organizations and more and more NGOs. Consequently, we have to address the problem of procedures

coordination of the intervenors system.

C- On the other hand, the populations are less organized, because the social system structure is traditional, not fully functional and lacks vivacity. The organizations instituted by the local government representations according to the cooperative model did not cultivate the cooperation spirit within the target populations.

D- In case we plan to apply the communication tools used by the other methods, they prove to be non operational because the moroccan farmer's culture is quite different. We quote, for instance, the constraints we underwent while introducing some tools that are not adapted to the local culture: role-playing game, theatre representations, puppets, models.

The selection of the target populations and localities with whom we carried out the ORPDI experiment was made: we instructed all the participants on the proposed applied procedure. Consequently, we have identified the various categories of villages and population groups using natural resources and causing environment degradation or are prone to engage into the struggle against it as well as against soil erosion, and carry out the natural resources management.

During these workshops, various ORPDI tools and methods were experimented in the framework of a systemic approach in order to identify the populations problems, needs and expectations to counteract land degradation and promote land development.

Likewise, in order to obtain the population's support and participation, the project must have noticeable economical spin-offs and improve their life's conditions, increase the agricultural produce, entail activities' diversification (namely women's activities), enhancement of the socio-economical organizations, labor promotion through training and extension services, etc.

Equipement, timing and implementation conditions

Concerning the equipment required by the PIV (participants ideas visualisation), we will need 20 large sheets (1mx64cm), 3 to 4 permanent markers, one adhesive tape for board pasting on schools, mosques and house wall boards, or push-pins for earthen walls.

Concerning the time allotted, there is no standards to abide by. This aspect depends on the history, evolution and dynamics of the project, activities approach applied for the population of a specific area.

It will be much more interesting to plan to stay in the site and to live there throughout the implementation period of the ORPDI. The conviviality between the team members and the local communities allows a better interchange in a atmosphere of mutual reliance and respect.

Also, to stay continuously in the Douar is time and transportation expenses saving and increases the chances and time to collect and process data on site.

We should not neither forget that we may finally turnout to be a burden for the population, so we should cover the cost of the meals prepared by the population care.

The stay periods should never exceed three days in each locality, even if the work schedule is not completed, it can be done at a late time, during a short visit to the target site.

It is preferable to plan short collective interview sessions both with men and with women, mainly in the afternoon, right after the afternoon prayer since the farmers tend to go back to the field right after.

Morning time would be better for group activities, data processing, analyzing, synthesizing, documents preparing and data sharing. At the end of these sessions we must determine the aspects, subjects and data to be worked at together with the farmers.

The groups' number of persons depend on the number of participating population groups and also, the sphere of intervention, schedule, components, type of project, activities to be undertaken and target populations.

To mainstream the gender approach, it is necessary, from this phase and on, to organize workshops with the attendance of men groups and women groups, youngsters, elders, girls, boys….

Exemple: ORPDI along with technicians:

1- Sites selection for a viable rehabilitation
2- Water shortage
3- Climatic conditions
4- Poverty
5- Remotness
6- Subsidies
7- Complex administrative procedures
8- Marketing
9- Isolation
10- Absence of the private sector for commitment with the government
11- Groundwater depth/depletion
12- Illiteracy
13- Lack of non farming activities
14- Silting
15- Rural depopulation
16- Wind
17- Groundwater drawdown
18- Olive tree leaves fall

19- Gallery digging difficulties

20- Lack of know how for khettaras digging and rehabilitation (mâalamine)

21- Water quality

22- Lack of supervisory staff (low)

23- Bayoud (date palm)

24- Estate parcelling

25- Khettara cleaning

26- Collective landholding (Aarchia)

27- Low farm income

28- Technical assistance

29- Community conflicts

30- Floods

31- Young generation abandon the khettaras

32- Lack of the region hydrogeological studies

33- Renewal cycle of groundwater is slow

34- Arrival of other chalenges: pumping stations

35- Difficulty of extending the khettara in other communities' territory

36- Water overuse and lack of water saving techniques

37- Water and land parcelling

38- Cessation of new khettaras' creation

39- Collapsing (sandy soil)

40- Lack of groundwater recharging dams

41- Infiltration losses

Rationalization of the exploitation of water irrigation

Abrouz Ali, ingénieur spécialité hydrogéo-technique.

Tafilalet region which is situated in the south East of the kingdom, is considered among the most ancient and the oldest traditional irrigation circumscriptions in Morocco. In spite of the roughness of the climate and the shortage of the water resources and the acute heat disparity, the filali fellah was able to concentrate on his living on developing an agricultural system based mainly on exploiting periodical water floods and the extraction of the profound underground water by various means.

The khetara system for example, which has been adapted for ayes which is considered as a human and cultural patrimony enables us to bring profound water through attraction to the surface soil to irrigate vegetation.

This ancient system of exploitation profound water could show the most important attention and particular care of water and the big efforts undertaken by fellahs in order to exploit underground water supply and which the regional office of agricultural does much every year to carry on the efforts in order to preserve these systems and that by managing and modernizing them.

As for the surface water there is an other technique to promote it as old as history and this is shown in the way that we exploit floods, springs, sources by means of transformation dams built by stones and Gibbs or by weak obstacles in the form of small stones dunes or wooden obstacles.

The amount of water derived through these small dams and obstacles enables fellahs to irrigate plantations and promote water platforms. These edifices also take profit from the management and the modernization which is made early by the regional office.

In addition to the early mentioned constructions, the region has profited also from a colossal hydro-agricultural management and which is incorporated in the building of the HASSAN EDDAKHIL DAM on ziz oued (river).

In parallel with this traditional construction modern irrigation channels have been set as to enable the old system to distribute water better and raise its output efficiency.

On the other hand, the exploitation of underground water through pumping has known a remarkable development in the last few years because plantations has more than doubled in addition to the saving of thousands of plants in the times of drought.

In spite of all these efforts and the techniques displayed and because of different and several raisons the Tafilalet region in general has known and still undergoes crisis due to the shortage of water resources and it is very spectacular between the offer and the demand in all pants of the Province.

This delicate situation impels us and without doubt to make more effort in order to guarantee the continuity of the ecological system to this region and that by overtaking an integrated and very acute strategy in which the economy of water takes a very big attention we mention among other factors.

- To promote the profit of water canalization system and channels used to drain and distribute water.
- To enhance water use inside fields.
- To set up and form association of water users designed for agricultural purposes to develop Association manipulation for irrigation.
- To encourage fellah to create cooperatives for collective pumping.
- To give permission and special favors to use public property water mentioned in the directory programs of integrated management of water resources within the region competence.

Participation of a non governmental local association of the rationalized exploitation of water in a ferkla oasis.(Tinejdad Errachidia Morocco).

Dr. M. KABIRI, F.S.T. Errachidia

1-Surface formation (construction) laboratory; geology branch.
Faculty of science and techniques Errachidia.University My Ismail.

2- Association of Farkla oasis for environment and patrimony. Tinejdad Errachidia Morocco.

- This allocution takes part in the formwork of a development project for the inhabitants of the countryside which financed by the Japanese government and it is concerned with the planning of khettaras in the dry(arid) region or semi-dry in Morocco.

Oct 22, 2003.

Introduction:

Ferkla oasis is situated in the south of Morocco about 70 km South-Ouest of Errachidia. The number of its inhabitants is about 40 000. it's about 1000 m high on the sea level palm trees are the first plants according to quantity.

The oasis has known an acute shortage in drinkable water and irrigation which pushed people to dig wells locally and use pumping apparatuses to take out profound underground water on the expense of archaic techniques which have been used since a long time and this has to do with AGHROUR and the khettara.

Water and the climate:

Three(3) oueds (rivers) are the backbone of ferkla oasis.

Sat oued in the South, ferkla in the middle and tataghafa in the North, and the rate of rain precipitation never reaches 150mm a year and this goes down when heading from North to South (see diagram).

This region has known a lot of years of drought we mention specifically the following years: 1913; 1918; 1927; 1931; 1933; 1939; 1945; 1947; 1955; 1957; 1973; 1976; 1979; 1984; 1987; 1988; 1993; 1995; 1998; 2001.

Geology:

- ferkla oasis has been constituted between the great Atlas on the North and the little Atlas on the south.

An it could be divided geologically speaking into 3 parts:

- The Northern part: which concerns the caritas basin .

. Errachidia- Tinghir (in fracenomanien) .

- The middle part: ferkla plateau (quaternary) .
- The Southern part: the little Atlas(the first geological era and the Cambrian and paleozoique).

Hydro-geology:

The water resources its distribution its quality are directly concerned with climate fluctuations and change and also with the geological constructions and these resources could be humanized as follows.

Water resources concerned with the quaternary and is distributed among the main oueds in the region.

- Resources concerned with the Curtsy (infracenomanien).
- Resources concerned with the profound geological floors (the first geological era and Percampri in the South and the jorseek in the North).
- Water exploitation and irrigation techniques:

According to classical surveys water resources in this region were as follows: 61% permanent water 30% underground and 09% of floods.

During that period and before man in ferkla used this waters for irrigation and drinking and exploited underground water by using traditional means as Aghrour and khetara and also some pumping apparatuses of agricultural cooperatives. This traditional exploitation has not influenced the water-sheet because of the water –amount exploited and also thanks to the straight forwardness followed in the exploitation of water. But the continuous and numerous years of drought that Morocco knew in general and the region in particular had a bad impact on the surface water resources. And due to technological progress fallahs in ferkla have used a great number of modern pumping systems in different parts of ferkla in general and particularly in Bour fields irrigated by rain fall region which knew an agricultural prosperity in the first years.

The use of modern pumping and in a savage way on one hand which replaced Aghrour (irrigating by means of animals) which has been extinguished completely and also the khetaras which few of them are still operating (1). On the other hand, the weakness of the alimentation and provisioning of the underground water-sheet has led to the wear of that water-sheet which has caused dangerous ecological results that have never happened before (6,7) where the loss of environment balance has taken place. Among these bad results of this environmental crisis the death of plants, the extinction of animals and the spreading of poverty and unemployment (men, women and youth).

According to this catastrophically situation the Moroccan government has made big efforts in Tinejdad region to save what could be saved of plants and animals. In spite of all this efforts which have been made, ferkla still lives an acute ecological crisis resulting especially from the weakness of supervising. From here and believing in what the associative work could do in reinforcing the saving of this beautiful oasis, some brave people set up and association called: **ferkla oasis association for environment and patrimony.** Among its objectives that have been underlined in its fundamental code we mention:

- To sensibly people of the importance of the protection of the environment.
- To fight dryness and desertification.

- The preservation of green spaces.

And since the creation on May 13th 2001, the association has been able to get financing for projects of development directly concerned with water.

Project 1:

Supporting the preservation of oasis in the South of Morocco. Ferkla as a model of this with:

-The international sector for environment.

- Program of small subvention.

- The united nation program of development.

The main purpose is to participate in preserving the ecological systems of the oasis.

And to reach this aim we have underlined the following points.

. The participation in finding successful solutions to improve the irrigation styles in the oasis.

. The participation in ideas deposit and solutions to alleviate the oppression on the vegetation covering.

. Reinforcing and supporting the local capacities to preserve the oasis system.

Project 2:

The project of hope to improve and reinforce the resources of IMMANDAR khetara; this project is going to be achieved with the cooperation of social development agency.

The main objective from the project is the improvement of the khetara flow. To enlarge the surface of the irrigated area to fight the plague of poverty in this region of ferkla.

Project 3:

.Rationalized exploitation of water in irrigation¥ ferkla as a model.

.This project is a sort of a gift (donation) from the regional office of agricultural valorization of Tafilalet – FIDA.

The ferkla oasis for environment and patrimony Association has chosen as a non governmental organization for this project in ferkla. Among its principal roles to participate in creating specialized irrigation associations to irrigate by pumping, khetaras and floods.

It also plays a major role in the fields of sensibility forming, supervising and communication between the regional office of agricultural valorization of Tafilalet and specialized Association for irrigation (AUEA).

In addition to what was mentioned before, the ferkla oasis association has made a partnership convention with the Regional office of Agricultural Valorization of Tafilalet, the regional direction of water and forests (Meknes, Errachidia) and the regional delegation that follow. National education and youth, the National

Cooperation and culture in which the environment education plays a major role.

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The associative work for the qualification of the 3ird millennium khetaras .

The jorf region as a model

HASSAN LAMRANI
M^ED KANOUN
Fighting desertification
And the preservation of
Environment . Jorf.

The contents of the allocution :

- thanks word.
- projection of a film about the khetaras shifting between the abundance and shortage of water.
- Presentation of the paper about the associative work for the qualification of the third millennium khetaras.

Presentation :

The oasis society in the dry and semi-dry areas, is considered among the societies which excel in dealing with the abundance and the shortage and takes special ways of life that helps to face the various hardships and crisis and the most outstanding system undertaken in this situation is the khetara system.

Can this system survive and develop in our Epoch to face the hardships and challenges ? or is it just an archaic system waiting for special care in order to be preserved as a human heritage ? and how can the association of promoting khetaras take part to renew and to rehabilitate the economic place of this system and its essential role in the development of the region?.

The khetara as a cultural patrimony and a style prevent Mankind from water-wars in the future:

The khetara can be considered as a genius outcome in which were displayed technique that show the supreme place of the oasis spirit and deepens the invention and finds suitable solutions to face the shortage of resources and the wear of the khetara, a style to prevent humanity to wage a war about water. We also have to be proud of the khetara system because it incorporates rules to avoid war in the 3ird millennium. The recognition of the right of water for the others and the respect of the amount and time of exploitation is the principle that all society need for the shared exploitation of water. It's this that will avoid any destruction caused by water problem between countries in the future.

II- Jorf khetaras historically rich with a negative reality and difficult mutations:

The Jorf region exceptionally comprises about 11,22% of all the khetaras to be found within the competence territory of the Regional office of the Agricultural Valorization of Tafilalet 65 of them are on the right bank of Ghris Oued (river)and 3 are the left bank.

1. Desertification and sand expansion are negative mutation aspects.

The surface which used to be irrigated by the means of khetaras is estimated to 4000 hectares. And because

of the succeeding years of drought in the region, the irrigated area by khetara last season 1999-2000 represented only 12% and 25% were irrigated by artificial pumping which means 37% whereas 63% remained without irrigation.

The phenomenon of sand expansion remains the biggest threat menacing the infrastructure because the satellite pictures showed in a study from 1951 to 1978 that the sands have crept to a distance of 347 meters at a rate of 24,2 meters a year as shown in the study.

2. The inhabitants stability in the region:

If the oasis in the post has provided the means of settlement and stability, in the present time in spite of the natural proliferation resulting from the high rate of fertility and general better conditions of health and the low rate of mortality the rate immigration in this region is still negative.

III- Associations, a new system to qualify the khetaras and the human being.

1- **Necessity of qualifying the human being**:

All the projects done are very necessary and vital for the development of the region but part of it has neglected the promotion and qualification of the human factor to manage the constructions and to exploit (the) water resources.

2- Associations of qualifying khetaras to modernize the system and promote it:

In the appearance of khetaras associations in Jorf can be considered as natural and objective since the region contains a great number of khetaras, its foundation came to shed light on the system again and the search of ways to qualify them.

In 2000, with the coordination of the regional office of Agriculture Valorization of Tafilalet, the association of fighting desertification and the preservation of environment worked to help land owners to create association for the khetaras in Jorf. And of the difficulty to come out with the same opinion in order to create one sole association, 9 associations cropped up 91% of its members are fellahs and 57% are Cheikhs and Mezrags and 72% of them are over 40 years old. Moreover their educational level is very low because 42% did not finish primary school. Only 2 members are graduates (licence).

The first founders of that generation have never been expected to play a leading role so we can say that the land-owners expectations are from these offices are same traditional expectations.

⇨ To find financial resources for management.

⇨ To prop up the amount of water resources and the irrigated surface.

⇨ To master the managing of finance and administration of the system.

⇨ Stop sand expansion.

These associations expect assistance to put the basis and techniques for a new strong start and permanent development activities.

3- Great expectations:

If the land-owners expectations at this phase, are classical expectations, what is to be done is the qualification of the human being so as to rationalize the exploitation of the resources and to work in the sense to make these khetaras a profitable and a competitive investment.

In the shade of Globalization locally, regionally and internationally and to work for the continuity of security and stability of the inhabitants.

Conclusion:

In the end we wonder: what do khetaras need? What's missing?

- To financing and convenient technology to this field as seen by developed countries.
- Or just to revive the archaic oasis system its rules and its traditions?
- Or we can say that it is in need of setting a new complete strategy to exploit water.
- The khetaras are a human soaked in plenty of problems because of this it is urgent and very necessary for the government sectors and the civil society even the international community to multiply efforts to save them and preserve them. And if the founding groups of the associative work haven't reached the expected position and they are in need of a lot of support and assistance, the helps of all partners will make the khetara get back. It's economic role and its principal role and will find its glory and will give a development push up to this region.

Annex 1

Comparative Study on Underground Water Conduits
- Foggara and Mambo -

Hiroki TAKAMURA
Faculty of Geo-Environmental Service,
Rissho University, Japan

Objectives

Since M.A. Butler (1934) and F. Hartung (1935) and others publicized their reports on qanats (foggaras) in India, similar conduit-type groundwater intake facilities have been identified in various regions around the world, including the Middle East, North Africa and Central Asia (Wulff, 1968). Meanwhile, Hisashi Koyanagi (1931), Yoshio Hattori (1971) and others have publicized their studies on conduit-type groundwater intake facilities called "mambo" of Japan, featuring cases in the city of Suzuka and the Tarui Basin, among others. Although those conduits called "foggara" and "mambo" are quite similar to each other in terms of the structure, specific comparative studies are scarce. In particular, there have been hardly any studies on the logistics, usages or origins (to determine whether they originate from a single source or from multiple sources).

In order to contribute to fill the gap in the studies, the author conducted surveys, spending eleven years from 1969 to 1980, on mambos at the eastern foot of the Suzuka Mountains, particularly in the city of Suzuka, in Hokusei-cho and Tarui-cho (Takamura, 1973) and, in 1976 and 1981, on foggaras in Central Asia and North Africa (Takamura, 1980a). This paper reports the author's comparative studies on foggaras and mambos, focusing on their similarities and differences, as well as introducing existing materials and bibliography.

1. Distribution of Mambos and Foggaras, and their Name Variations

Variations exist for names given to facilities similar to mambos and foggaras in different countries and regions (Wulff, H. E., 1968; Takamura, 1980b). Mambos seem to be derived from tunnels, underground paths, bypaths, or mine pits (called "mabu"). They are called "mambo" in Niigata Prefecture, Haibara-gun in Sizuoka Prefecture, Shitara-gun in Aichi prefecture, Kitamuro-gun and the city of Suzuka in Mie Prefecture, Hokuseicho at Inabe-gun in Mie Prefecture, and Tarui-cho at Fuwa-gun in Gifu Prefecture, "mamboh" in Higashi-Tsukuma-gun in Nagano Prefecture, Shimada in Shizuoka Prefecture, Gamo-gun in Shiga Prefecture, and in Tenkawa at Yoshino-gun in Nara Prefecture, "mampo" in Enuma-gun in Ishikawa Prefecture, Fukui Prefecture, Ayama-gun in Mie Prefecture and Ikaruga-gun in Kyoto Prefecture, "mampu" in Ono-gun in Fukui Prefecture and Takeno-gun in Kyoto Prefecture, and "mambori" in

Uda in Nara Prefecture, showing a range of local flavors.

"Foggara" is the equivalent to quanat (Qanat) in Arabic. Like "mambo," there is a broad range of variations for different countries. In Iran, for example, similar facilities are referred to as Connought, Kanayet, Qanat, Ghannat or Khad. In Iraq and Afghanistan, their aliases include Karaz, Kariz, Kahriz, Kahrez, Karaz and Kakoriz. In Arabia (Oman), they are called Faraj, Fellej, Felledj or Aflaj. In Algeria, they are called Foggara, Mayon, Iffili, Ngoura, Khettara, Khottara or Rhettra. In Tunisia, Rettara, Rettahra, and Rhettara are used, Socavones in Chile, Kanchin (Kan-tin) in China (Shindand), ma-nu-po in Korea, and mampo, manpo, manpho, or manbho in Japan. Similar facilities are also distributed in Mexico, Peru and Bohemia, but how their names are unknown.

In short, mambos are found across eleven prefectures, mainly in the Kinki District. Phonetically, they can be grouped into three types. According to ancient documents, different characters were used for different groups.

A number of researches support the assumption that quanats originate in Persia though the ground for negating the assumption that there were multiple origins is weak. From a historical viewpoint, however, the technology involved can be assumed to have spread around the world via two routes, eastbound and westbound, centering around Persia. The eastbound route seemed to have reached Japan via the Silk Road, passing through Pakistan, Afghanistan, Russia, China and the Korean Peninsula.

On the other hand, along the westbound route, King Darius, in 6th century B.C., brought the technology into Greece, from where it was conveyed to Tunisia and Algeria. Furthermore, it can be assumed that the technology was delivered to Spain, Portugal and Morocco via northbound and southbound routes around Mediterranean Sea, and then to Latin America (Mexico, Peru and Chile).

What is called "mambo" of Japan and what is called "ma-nu-po" of Korea are very close to each other in terms of their characters and pronunciations. Based on this fact, some assume that the Japanese mambo originates from the ma-nu-po in the Korean Peninsula (Kayane, 1973).

3. Site Conditions and Water Intake Methods

1) Site conditions

One common feature is that the demand level for water sources is high. However, foggaras in dry districts are located in areas where water sources are relatively accessible (in high-water areas) while mambos are located in areas where water sources are relatively scarce (in low-water areas). Needless to say, this statement is based on relative classification with considerations given to the climatic environment of the respective areas. As for water volumes, the former category provides relatively stable water supplies through the year while the latter is subject to significant fluctuations in water supply volumes between summer and winter, in which season many of mambos dry up. The dependency level is also different; foggaras are the absolute necessities for life in oasis communities throughout the year, providing water for living, stockbreeding, and plantation while mambos are utilized mainly for irrigation.

2) Water intake forms

Mambos mainly collect groundwater through culverts. On the other hand, a typical foggara has a sar-char (mother well) at the uppermost section, as shown in Fig. 1 (Takamura, 1980b). Therefore, the role of the lateral conduits differs; its water-collecting function is an absolute requirement for some sections of a mambo (see Fig. 2), while it is necessary but not an absolute requirement for a foggara. In other words, a foggara's culvert is more important as a water distribution channel than as a water collection device.

Also, a foggara functions as a measure against parching heat, preventing water within the channel from evaporating and being heated up.

As pointed out by Kayane and others, a typical mambo has its upstream section beneath the groundwater surface and its downstream section above the groundwater surface. From April through August, or during the period with a high water level, in particular, water recharge by natural precipitation and leakage from irrigation facilities (such as canals and rice paddies) cause the groundwater level to become higher than the most of the mambo's bottom, enabling it to fully demonstrate its function as a lateral water-collecting well. However, like the Okubo mambo located in the alluvial fan at the mouth of the Utsube River in the city of Suzuka, the water sources of some mambos

are underflow waters or holding ponds, resulting in various water intake forms. Based on past surveys results and other literature, water intake forms can be classified into four types as shown in Fig. 3: (1) those with the only water source being groundwater, (2) those with the only water source being river water, (3) those collecting water both from river water and groundwater, and (4) those collecting water from underflow water and ground water.

On the other hand, pits have mainly been required for the purpose of ventilation and discharge of soil, sand and gravels during excavation works, both with mambos and foggaras, and any other function is not identified. Nevertheless, some of those pits have been reinforced with stone frames, as shown in Fig. 4, since mambos/foggaras are prone to collapses in locations where the foundation is weak.

3) Functional difference

The functional differences between mambos (M) and foggaras (F) are summarized in Table 1.

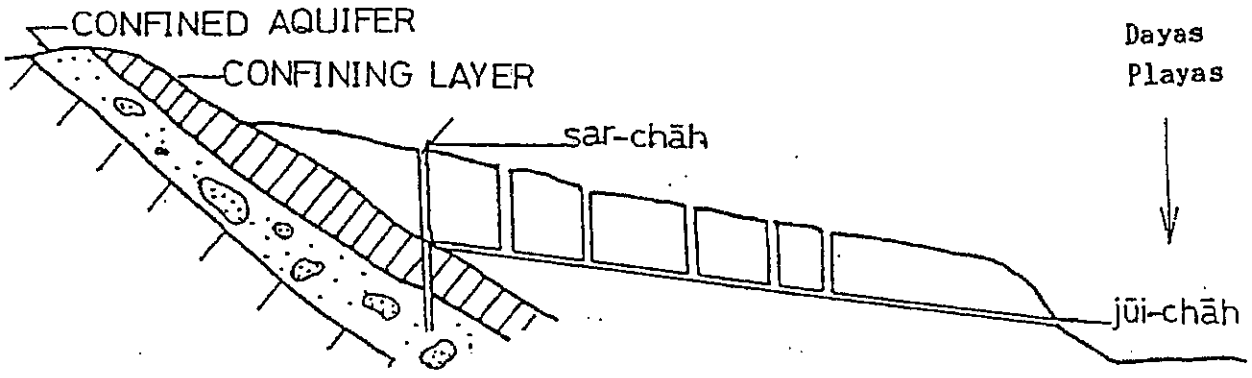
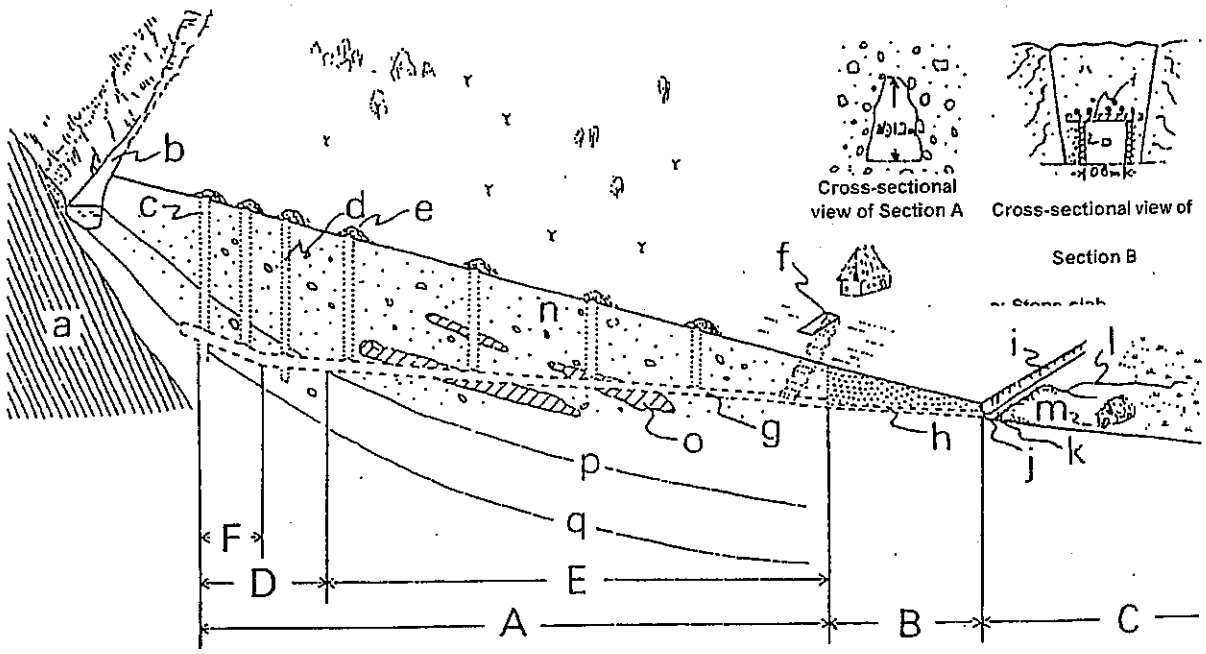


Fig. 1. Cross-Sectional Illustration of Foggara



A:	Unsupported section	B:	Concealed Fusekoshi section	C:	Open conduit section	D:	Water-recharging section
E:	Water-collecting section	F:	Extended section				
a:	Basement rock	b:	River	c:	Additional pit	d:	Pit
e:	Mambo mound	f:	Entrance of stairs to the water place	g:	Conduit (culvert)	h:	Concealed conduit
i:	Terraced cliff	j:	Outlet	k:	Weir	l:	Irrigation channel
m:	Domestic channel	n:	Gravel layer	o:	Clay bed	p:	High-level groundwater surface
q:	Low-level groundwater surface						

Fig. 2. Illustration of Mambo at Alluvial Fan on Eastern Slope in Suzuka Mountains

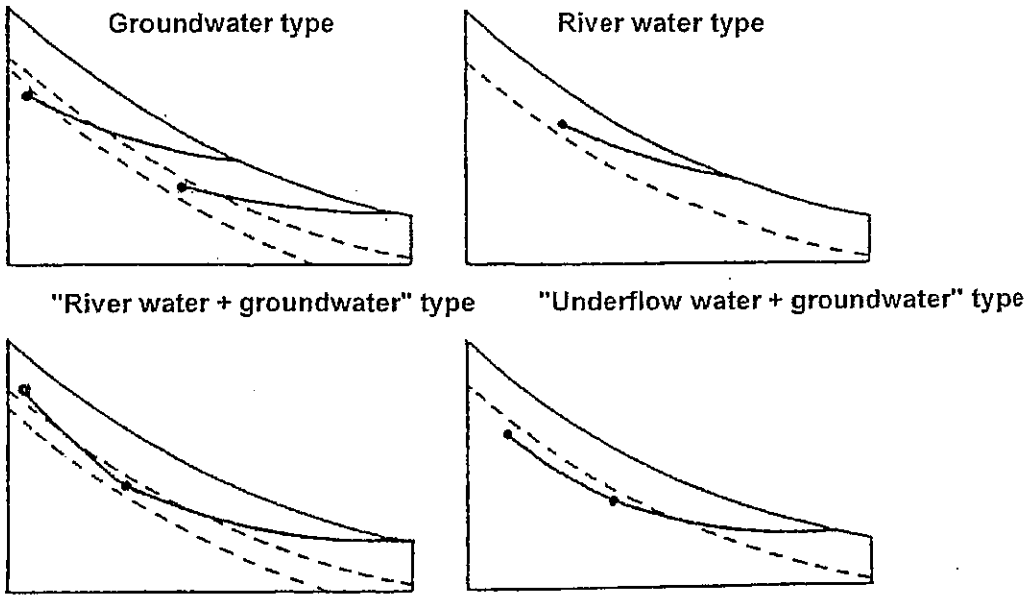


Fig. 3. Mambos Typified by Water Recharge Source

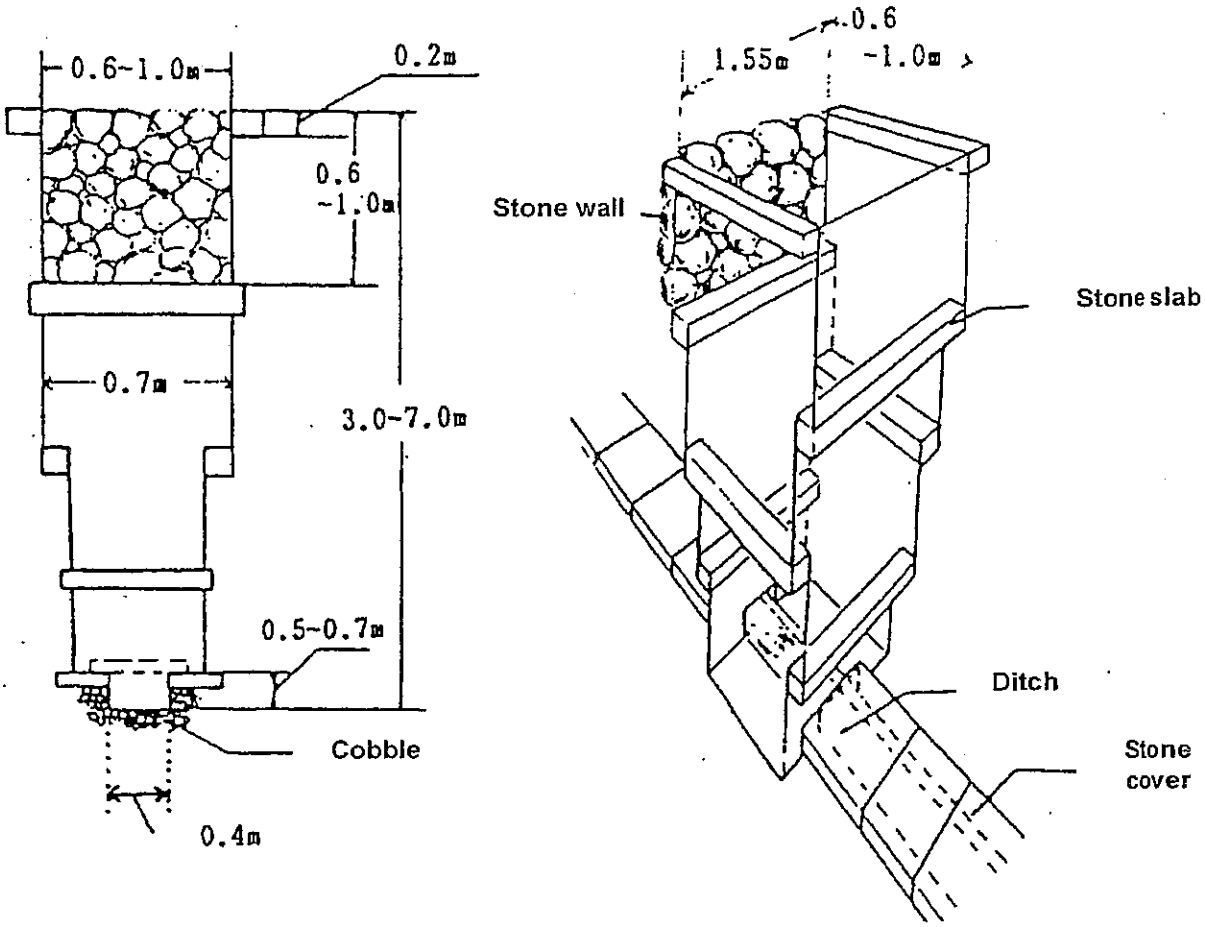


Fig. 4. Okubo Mambo B's Pit No. 12

Table 1. Comparison between Mambo and Foggara

	Mambo	Foggara
Water source	Non-artesian groundwater and underflow water	Mainly non-artesian groundwater
Conduit	Total length: Several hundred meters - 1.6 km Water recharge and collection	Total length: 5 km (on an alluvial fan) - 35 km (on plateau) Mainly water collection
Pit	Depth: Several meters - 14 or 15 m Pitch: 10 - 25 m Unsupported structure (stone / wood)	Depth: Several meters - a few dozen meters Pitch: 35 - 300 m Unsupported structure (stone/dirt/bricks)
Topographical features	Alluvial fan/terraced cliff	Not limited to alluvial fans/land of colluvial deposits (glacis colluviel)

	Steep slopes	Gentle slopes
Water-distribution method	By water distribution weir/clock	By kersia Chegfa / xolar clock
Water utilization right	Mmbo union	Trading under joint-stock company
Construction manpower	Farmers	Slaves
Functional difference	Water collection	Water distribution from the mother well
Lateral hole	Water collection	Evaporation prevention

Generally, both mambos and foggaras can be divided into two functional segments: water-recharging and water-distributing segments. In order to prevent evaporation and enhance the water delivery function in a dry climate, foggaras need to have culverts made as long as possible in the water-distributing segment. On the other hand, mambos need to have the water-recharging segment (where lateral conduits reside beneath non-artesian groundwater surfaces) made as long as possible, and in terms of the water distribution performance, mambos can function properly even without culverts as long as lateral conduits are located on the layer of clay.

4. Considerations

The author has been taking all possible opportunities to conduct comparative studies on groundwater intake technology and water intake methods in Japan and overseas, including comparisons between foggaras and mambos in countries in North Africa such as Algeria, Morocco and Egypt, between the St. Patrick Well with a double-spiral staircase in Italy and spiral wells (maimaizu well) of Japan, and between the Chinese well-digging technology and Japan's Kazusabori well-digging method.

All of the above studies, as well as this paper, indicates that similar natural environments including geographical/geological features and climates can lead to development of very similar water intake forms across different countries and regions, regardless of differences in manners and customs. Although it would be an extremely difficult challenge to identify historical evidences for that on a global scale, the author is quite confident that studying the historical evidence concerning folk migrations and

exchanges in the ancient and medieval times will uncover a certain route or multiple routes for propagation of groundwater utilization cultures (or hydrological culture propagation) originating from a single source.

Concluding this paper, the assumption that the technology used for Japanese mambos was conveyed from the Korean Peninsula or from the continent of China before the Edo era can be evidenced more easily than any other assumptions.

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Annex 2

Forms of Water Utilization in the Sahara Desert
(Monthly "Geography", Vol. 25, No.7, 1980)

Hiroki TAKAMURA
Faculty of Geo-Environmental Service,
Rissho University, Japan

Introduction

I had an opportunity for researching the state of utilization of the water resources in Algeria, Niger, Egypt and Morocco from January to the end of March 1979. Since it was a short-term research, I could not research it sufficiently. However, I will mainly report the state of water utilization in the Sahara Desert on the Algeria side referring to literature and material.

The "sun-tanned vacant earth", the Sahara Desert spreads in a belt-like shape almost along the tropic of Cancer on the African Continent and is said to cover an area of as large as around 9.065 million km^2. However, the desertification in the dry regions is a worldwide trend and its velocity is said to be several kilometers or ten and several kilometers but its actual situation is unknown. The Sahara Desert is not an exception for the desertification. There is no doubt that the reduction or disappearance of greenery accompanying the change of climate there causes the desertification. However, not a few scientists explain that the factors that have expedited this phenomenon and expanded its scale are slash-and-burn farming, and deforestation by nomads as well as the devouring of their livestock.

Many developing countries are located in the Sahara Desert. The governments of these countries are making efforts to build the environment in which the nomads can settle carrying out projects such as "digging wells", "construction of apartment complexes and enrichment of oases" and "vocational training" as a part of measures for tree-planting in deserts in cooperation with FAO and UNESCO etc. Furthermore, exploitation of the underground resources such as uranium, petroleum and natural gas, and construction of plants related to those resources greatly contribute to construction and maintenance of main roads and re-development of oases. On the contrary, however, the young people in settlements in oases and cities in the rural areas flowed into large cities and became the cause to generate the depopulated areas and the overcrowding cities. This trend is especially remarkable in the three countries of Algeria, Libya and Niger, and constitutes a serious social problem.

Development of the Sahara Desert is promoted carrying out mainly construction of new settlements with the bases for the exploitation of the underground resources as the strongholds of development, and enrichment/maintenance and redevelopment of the existing oases aiming at

letting the nomads settle. However, since these areas are located inland without exception, the necessity of life such as meat, vegetables, fruits and clothes can not be smoothly supplied from the sites producing them on the coast though the roads are constructed and maintained rather well. Therefore, these areas are greatly dependent on oases, and stability of oases is the most important item of those nations. The basis of the development of stable oases is nothing but the stable supply of the water resources. Furthermore, when thinking of nomadism of the Tuareg people that have survived for hundreds of or thousands of years and Bedouin known as the blue people, they can not be considered without the problems of the location of the water source, the amount of the water and the quality of the water. Those people skillfully incorporate the places for water supply into the courses that they take to move searching for grass and shrub for their livestock. These courses have been developed as a result of the accumulation of failures that their ancestors have made since the ancient time. The types of the water sources are various such as riverbed water of wadis, fissure water under cliffs, puddle water and well water.

Hydrological Environment of the Sahara Desert

It has been described above that the life and the location of settlements in the Sahara Desert are limited by the state of distribution of the water resources. However, the distribution of and the amount of water stored in water sources are influenced by the amount of rainfall, geographical features and the geological environment. Then, before discussing the subject matter, the hydrological environment of the areas in question will be described.

The amount of rainfall in the Sahara Desert differs by year and by place. However, a more inland place has less rainfall reaching less than 100 millimeters except the mountainous areas. The pattern of the climate in terms of the rainfall in Ghardaia located in the south about six hundred and several tens kilometers away from Algiers is dry in summer and rainy in winter. The amount of the rainfall is 116.3 millimeters in 1958 (rainy days: 24 days), 22.9 millimeters in 1961 (rainy days: 14 days) and 96.7 millimeters in 1969 (rainy days: 12 days). According to the record for 25 years of 1913 to 1938, the annual average rainfall is 115 millimeters (the minimum: 9 millimeters, the maximum: 200 millimeters); the annual average number of rainy days: 22 days; the month with the most rainfall: November (the monthly average: 15 millimeters); and, the month with the lease rainfall: July (the monthly average: 3 millimeters). The rainfalls with the amount of 30 millimeters or more per 24 hours in this area have been recorded ten times in those 25 years.

Furthermore, in an inland place, Agades in Niger, the rainfall is little such as several millimeters to several tens millimeters. There are many areas in deserts where the surface runoff does not

appear unless there is rainfall of 10-20 millimeters in a short time. Though most of the rainfall evaporate into the air or infiltrate into the ground, its absolute amount is little. The surface runoff forms outcrops of pools and groundwater in depressions, depending on the geographical features and geological conditions. However, most of them are saline lakes with water showing its quality of 3,000-10,000 p.p.m. of TDS (Total Dissolved Substance). The water in the saline lakes is rarely used for irrigation not to mention for drinking. Lakes formed in a depression made by digging of wind down to the water level of the groundwater are sometimes neutralized and have become brine water. In such a case, the value of that water as a water resource is high and the water is utilized for many purposes.

The Forms of Water Utilization

In terms of water source, water utilization can be classified into six categories of groundwater, riverbed water of wadis, spring water, hot spring water, surface water and separated water. One typical form of taking water in from the groundwater in the Sahara region is "foggara". A separate section will be given to foggara to describe it. There often is shallow groundwater present at a depth of 10-50 meters at places where is a large scale alluvial fan or glacial layer. In such places, the groundwater is typically taken in through the open wells that have been constructed there. Since the amount of water stored is relatively much, the wells do not dry out so often.

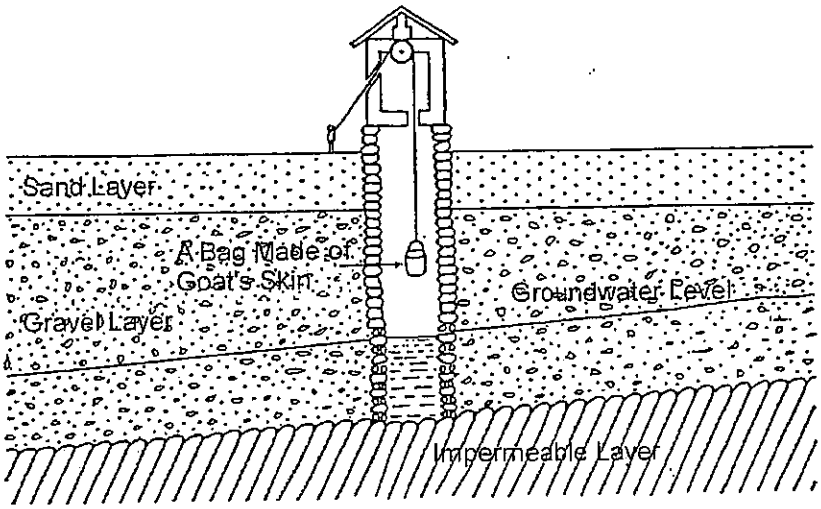


Fig. 1: The Typical Open Well in the Sahara Desert

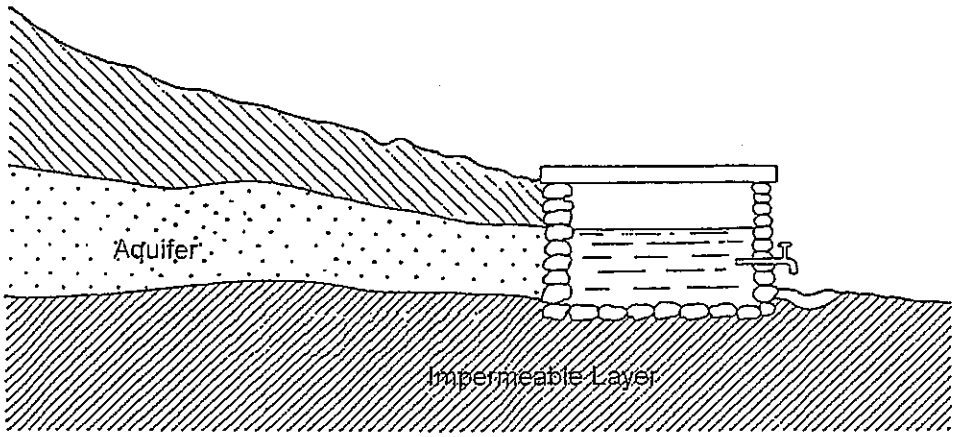


Fig. 2: A Water Tank Storing Spring Water

However, it is the current state that large settlements have not developed so much.

Wadis where the widths of rivers are wide, and diluvium and aeolian deposit are accumulated so thickly are gifted with rich riverbed water and many types of water intakes can be seen there. For example, a water intake having a diameter of 4-5 meters and a depth of 5-10 meters is constructed and it is utilized for taking in the water for irrigation, people's life, livestock etc. In such a place, the scale of the oasis agriculture is large and its products (vegetables, fruits and meat) are supplied to rural settlements. However, in the areas where the amount of riverbed water in wadis is not stable through the year, even though there are wells, they often are dried up in the dry season and are of little utility value. In the vicinity of agression cliff on Tinghert plateau, the spring water seeping out from crevices is stored in tanks made of clay or bricks and is used as the source of water for use.

In the areas where shallow groundwater can not be obtained, groundwater is taken in through deep wells. This form of taking the water in is most widely spread in the Sahara Desert and contributes greatly to oases as well as construction of bases for exploiting the underground resources and tree-planting in deserts. For example, the bases for natural gas wells such as in Hassi R'mel, In Amenas, El Agreb could not have been developed without utilizing the deep groundwater. However, there are places where hot water at 60℃ (K_{18}: 5,600 μ mho/cm) spouts out from a layer at a depth of 350 meters (Cenomanian layer) such as Zelfana. In Zelfana, the temperature of the hot water is lowered to 40℃ in a cooling pool and the water is used for irrigation.

Hassi R'mel is a small settlement developed based on an open well (depth: 20 meters, water height: 12 meters, Senonian layer) dug in 1891 when this area was a colony of France. The

water temperature of this well is 18.5℃, and the water has the electric conductivity of 740 μ mho/cm and the salt concentration of 430 ppm as its quality and is taken out from glacial layer. The water of this well and a boring well next to it having a depth of 80 meters (water temperature; 18℃, K_{18}: 490 μ mho/cm, Albian layer) is currently distributed to the construction site of a plant for natural gas of Nikki Corp. of Japan in addition to the use as water for living of the local residents.

In Zarzaïtine, water (TDS: 10,000 ppm) separated from the natural gas spouting from a gas well having a depth of 800-1,000 meters (Devonian layer) is processed until its TDS reaches 3,000 ppm and is utilized for the plantation there. The processing method for this water includes a method in which the water is neutralized with the groundwater collected from Senonian layer, in addition to a chemical processing method.

The typical plants seen in the plantation include coconut palm, castor-oil plant, fig. pine, wheat, rugosa rose, snow pea, *Hamaogusa(?)*, raw cotton, acacia, eucalyptus, grape, loquat, plum, olive, apricot and other flowering plant. The technique for plantation was instructed mainly by engineers from the Soviet Union. However, the underground irrigation method that is seen in Hungry desert in Soviet Union is not employed here.

Utilization of surface runoff has not advanced in the Sahara Desert. However, in a part of Hoggar mountains, a scene is often seen in which a vertical hole is dug on a riverbank and the riverbed water is guided through a horizontal hole that is dug under the riverbed to the bottom of the vertical hole and the water is taken in from the vertical hole using a pump.

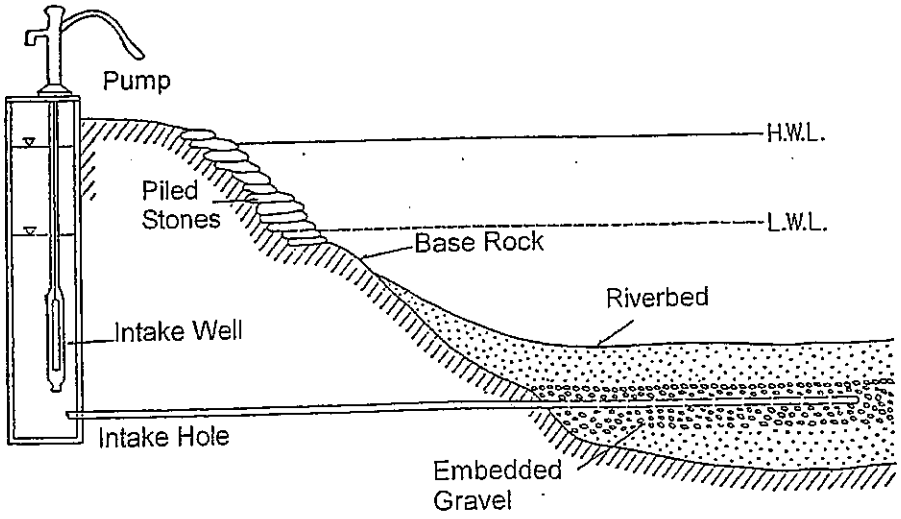


Fig. 3: Utilization of Water in a River

Foggara that Makes Oasis

The basis of the development of the oasis culture is nothing but the stability of the oases; in other words, the stable supply of rich water resources. It is said that the origin of the emergence of oases has two types, one is based on natural spring water and surface runoff and the other is based on artificial development by introducing water from places where groundwater can be easily obtained. In either case, the location of an oasis is situated on a flat place where is a bit lower than the surrounding areas, such as wadi, daiya, agression cliff or tlaya. In recent years, most of the oases have been applied with artificial remedies since the amount of water spouting out there has decreased due to the increase of the demand for water and the change of the climate. Next, I will introduce Aoulef in Algeria because it is the most typical artificial oasis in the Sahara Desert.

Aoulef is an oasis located in the middle of In-Salah City and Reggane Town, in the desert part of Tidikelt plateau and consists of three settlements of Arab, Timokten, Cheurfa. The initial condition for locating of a settlement is the presence of surface runoff and clean water obtained from more than 50 foggara (including those not verified yet) currently support the settlements. Foggara is a tunnel-type facility for taking the groundwater developed in B.C. 3,000 in the area that is currently Iran.

This technique, "foggara" is considered to have been spread worldwide along two routes of the western route and the eastern route. In the case of the western route, it is considered that it was brought through the northern side and the southern side of the Mediterranean Sea, i.e., it was introduced by King Darius in the Sixth Century B. C. into Greece and was later brought to Tunisia and Algeria. Then, it was joined to the irrigation culture that had been propagated to these areas through Egypt by Phoenician people in the Tenth Century B.C. and was later brought to Spain. In the case of the eastern route, it is considered that it was brought along the Silk Road and it reached Korea and Japan through Pakistan, Afghanistan, India and China. It may be investigated historically that it was brought to Bohemian region and the American Continent from Spain. The name, "foggara" differs by region and it is called such as Qanat (Iran) Rhettara (Morocco), Karaz (Afghanistan), Kanchin(China), ma-nu-po(Korea) and mambo (Japan). However, their structures are almost same

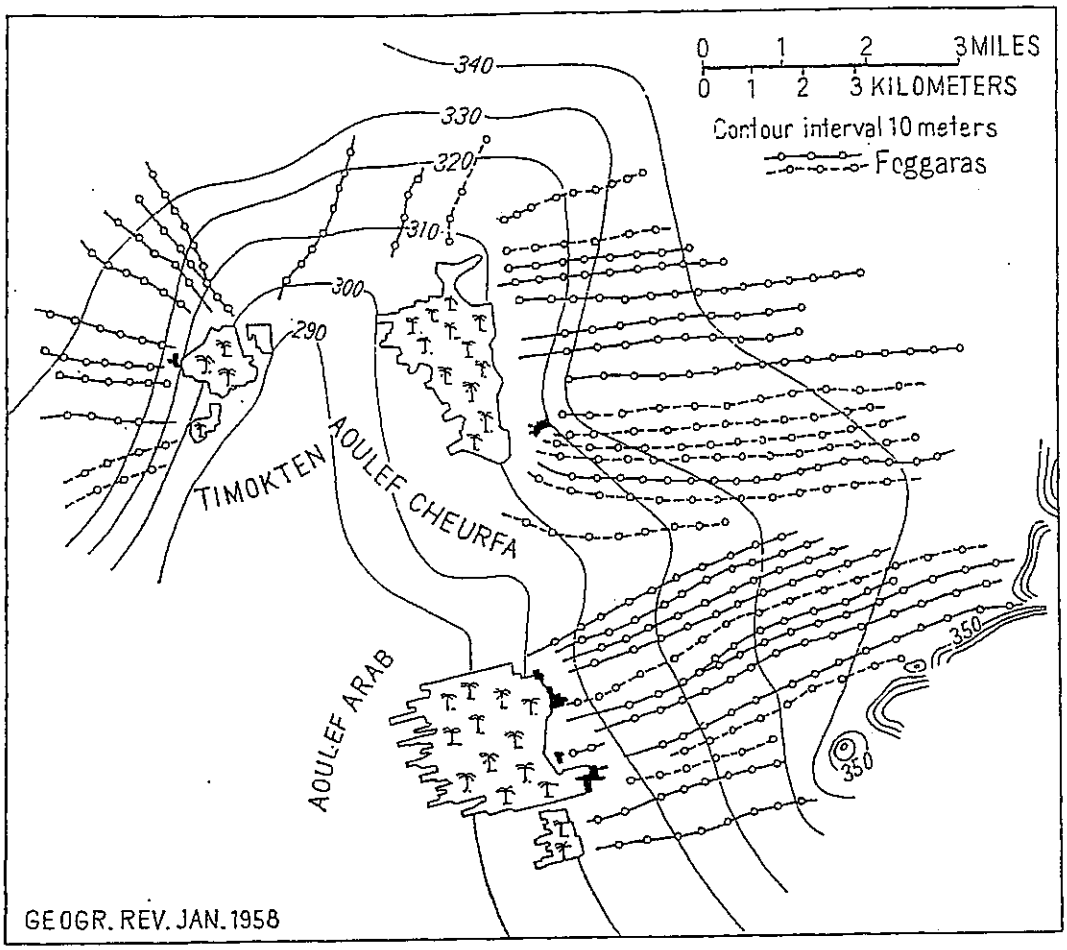


Fig. 4: Distribution of Foggara in Aoulef

The distribution of foggara in the Sahara Desert is generally dense in such geographical features as alluvial fans and glacial layer (colluvium land). One foggara has a structure comprising a horizontal hole having a height of 1.2-1.3 meters and a width of 0.6-0.7 meters and vertical holes having a diameter of 0.6-0.7 meters. The length of the horizontal hole is short (100-500 meters on an average) at a place where the inclination of the land is steep and is long (ten and several kilometers at longest) at a place where is a plateau with mild inclination. The vertical holes are spaced by 10-30 meters and are connected with the horizontal hole. The vertical holes play the role of being used for conveying the rock pieces out onto the surface while digging the horizontal hole and for ventilation. Most of the vertical holes have the depth of 10-50 meters.

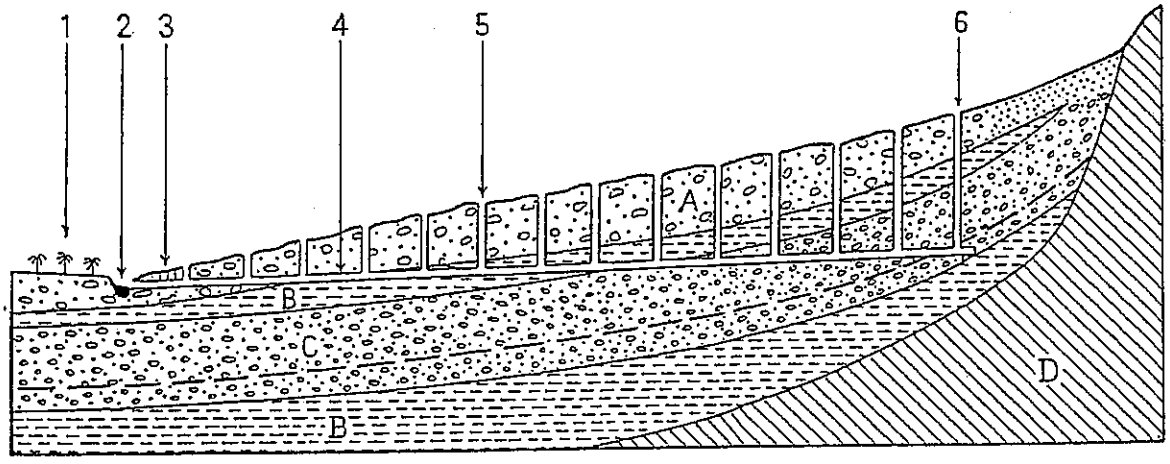
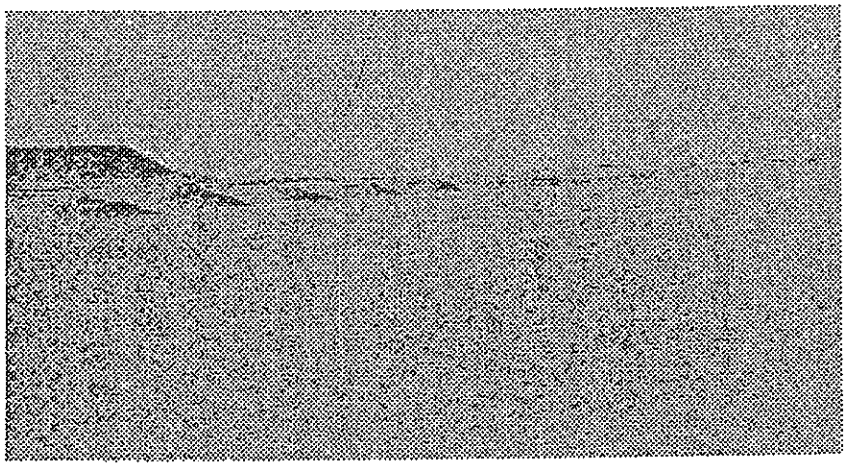


Fig. 5: A Schematic Cross-sectional View of Foggara

1. Oasis 2. Open Conduit 3. Closed Conduit 4. Underground Conduit (Horizontal Hole)
5. Vertical Hole 6. Mother Well
A. glacial layer or Alluvial Fan Gravel B. Clay Layer C. Gravel Layer
D. Limestone (Senonian layer)

In the method for taking the groundwater in, the groundwater being pressurized is collected from the mother well that is a vertical hole dug at the most upstream part, and is guided to the oasis in the horizontal hole. In the areas where the groundwater being pressurized is rather easily obtained, no mother well is provided and the horizontal hole has the function of collecting water over the section on the upstream side (where the bottom of the hole is lower than the groundwater level). The horizontal hole is dug from a lower point to a higher point and digging is stopped at the point where groundwater being pressurized or groundwater being not pressurized can be obtained. However, the water sources are often secured by digging further the horizontal hole over an additional length when the level of the groundwater is lowered and the water amount of the mother well is decreased depending on year.



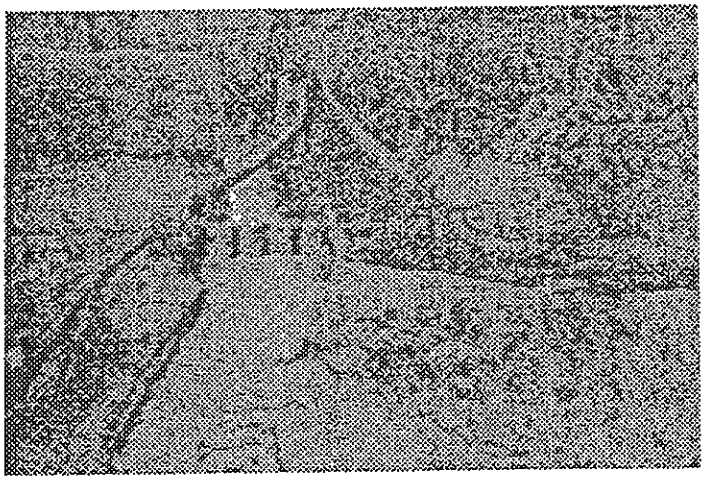
Foggara in Aoulef:

Since Foggara in Aoulef is located on a relatively flat landform, the horizontal hole extends over a length of ten and several kilometers. Therefore, the horizontal hole is deep and, furthermore, the spacing of the vertical holes is small.

The water of foggara is utilized as the drinking water for the local residents and for the irrigation and livestock for the oasis agriculture. The amount of the water used totals several tens thousand tons per day. The quality of the groundwater around this area becomes worse as the point the water is collected becomes deeper (salt concentration: several to ten thousand p.p.m.) and it becomes better as the point of collection becomes shallower (salt concentration: 300-500 p.p.m.). The water temperature is around 15℃. Therefore, this water is most suitable for use as irrigation water not to mention as drinking water taking into consideration the temperature of the ground surface. The exit located at the point where the underground conduit of foggara becomes the open conduit is generally located on a flat landform, and a comb-shaped dam called Kesria is provided at this point to distribute the water to houses and private farm land. It is the custom in this area to decide the water amount according to the concession corresponding to the number of stocks (Khappa・mahbuod) held by a person, that have been obtained by trading the stocks. A leader of the Islam, Shaheed takes the role of observation for the trade of stocks as the custom there. There are several stock holders and they are in charge of the maintenance and management of the faggara using the money they have obtained with the Khappa・mahbuod. Since a large amount of subsidy had been given from the French government to foggara until Algeria became independent, the operation of foggara was carried out smoothly. However, in recent years, the number of foggara in the Sahara Desert has shown a tendency to decrease because of the influence by the governmental project for digging deep wells, and the prevalence of small pumps. For example, foggara in oases such as Adrar, Timimoun, In Salah, Fogaret

have collapsed or are utilized as sites for dumping waste. The maintenance and management seen in the case of Aoulef are not carried out at all for the foggara and its function has ceased.

The agriculture in oases is conducted within the areas surrounded by 3 to 4-meter-walls. Various vegetables and trees such as date, eucalyptus, oleander, grape, orange, plum, lemon, tomato, cabbage, carrot are grown there and the areas are really the paradise in a desert. The oases surrounded by walls are supplied sufficiently with the clean water from foggara and the scenery filled with the rich green is enough for letting people forget the severe world of nature outside the walls. Considering a nomad who spends a day with a glass of water, I thought I could understand the pride of the people in Aoulef. (The School of Literature, Rissho University)



Kesria of Foggara in Aoulef:

A comb-shaped dam, Kesria is a facility for sharing the water from foggara according to the number of stocks (Khappa·mahbuod) bought with the observation of Shaheed (a leader of Islam)

Annex 3

TRADITIONAL DIGGING METHOD OF QANATS IN IRAN (KHETTARAS IN MOROCCO)

Hiroki Takamura
Geoenvironmental Sciences Faculty
Rissho University, Japon

How to probe for groundwater

There is residual water in lands located at the mountain foot and it is particularly abundant in extremely porous soils; It is also know that where lowland soil is black there is water.

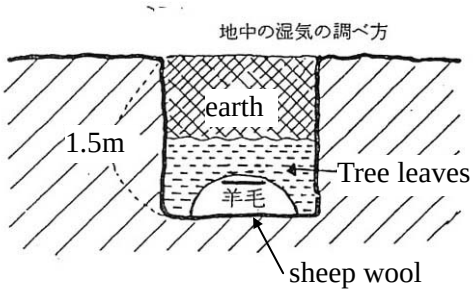
Groundwater is found when floods marks remain on the surface of mountain valleys soil. Plants growing on rocks indicate the presence of residual water in the soil.

There is water if, in morning time, dew, fog or steam are observable in large quantities. In order to measure the ground humidity, we suggest to use the following method:

Attach with wax some sheep's wool in a zinc, copper or earthen pot bottom. At sunset, dig a 1.5 m deep hole and inside place the pot upside down, cover it with green tree leaves, then backfill the hole. Next day early morning, dig out the pot and, if it is wet or that the sheep wool is detached from the bottom that the soil contains water.

It is also possible to do this experiment in day time. In this case one must light a fire and put it off before proceeding as explained above. (figure 1)

Figure 1



Checking groundwater

Topographical survey

(1) Traditional method

Land survey is essential for Qanats (Khettara) digging. In case of long tunnel Qanats (khettaras), it is rather impossible to spot exactly the outlet if no land survey has been carried out, and, as we will see

later, it is not possible to fix precisely the trenching depth either.

In the 10th and 11th centuries, land survey used to be carried out prior to the actual works implementation.

Survey using one level indicator and two poles

We use 6 hand-span wooden sticks as poles (1 hand span measures about 20 cms). On the pole we plot 60 scale marks. To check that the poles are vertically set we stretch a string between the poles' upper ends and we hang down ward a second string.

This is how the survey is done:

First, we select two survey points where we drive in the two poles vertically. Then, we stretch a string between the top end of both sticks, and then we hang another string halfway from the first string. A long enough string may measure 30 cubits, i.e. about 15 m (1 cubit : about 50 cm). (figure 2).

Figure 2

Hand width
(length between the fingers tip and the elbow)

Different types of level indicators used in survey works

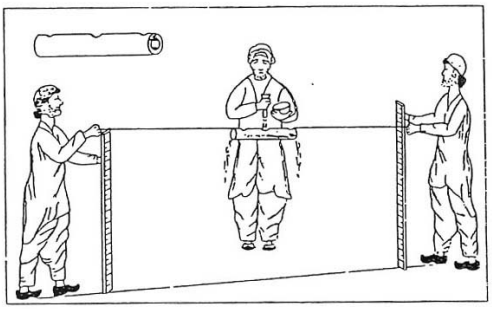
Glass tube level (figure 3)

We make a hole in the middle of a glass tube (or a wooden or reed tube) measuring about 30 cm (a one and a half hand-span) that we hang horizontally and where we pour water by the central hole ; it must flow out through both ends at the same time.

The level indicator is hanged by the stretched string between the two poles and we pour water in the central hole. If water flows though one end of the tube we adjust the string until it flows through both ends at the same time. The string is actually in a horizontal position and we may read on the poles the 2 land elevations.

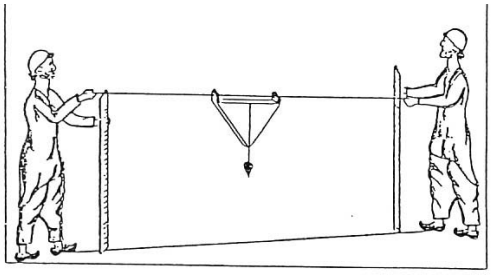
The string used between the two ropes may be made of silk or wax smeared linseed material and should be carefully stretched or shortened.

The other level indicator type is a device made in the shape of an isosceles triangle and of light material, rigid wood or zinc. We plot a perpendicular line from the middle of the triangle base centre up to the vertex, then we lower a silk plumb line from the triangle's centre until it goes past by two fingers'width (1 finger : 2 cms). Whe the plumb line overlays the perpendicular line, the string is horizontal. (figure 4).



Stretch the string to let the water flow through both ends at the same time and read the level differences on the pole's marks

Figure 3



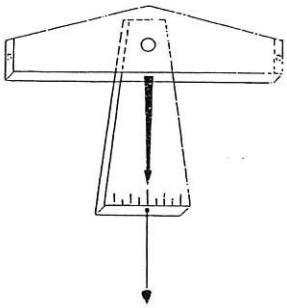
Stretch The string so that the string to which is hang the plumb passes by the triangle's vortex and read the level differences on the pole's graduations

Figure 4

There was also a steel level indicator having a scale's shape. This type of device was made of light steel plate, hard enough to avoid folding, on which a 50 gr (5 dirhams coin) weight is attached at the other end of a fine string as shown in figure 5. The weight is flat and its end is arrow shaped.

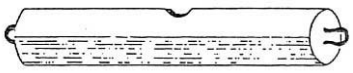
Another tube like level indicator was made out of glass whose both ends are plugged and having a central hole. A horizontal line is plotted on the tube which is string held horizontally by both ends. Then we pour water through the hole so that water and the horizontal line overlap (figure 6). The procedure is the same.

Figure 5



Scale shape level

Figure 6



Glass tube level indicator. The dotlines show the water filled portion

(2) Karaji survey method

We carried out a survey according to methods that utilize a stretched string between two poles and reading

the elevation difference between the two land spots. Karaji method is more evolved and designed to read the elevation differences on the level indicator.

Hereinafter the first level type:

We use a square wooden or brass plate; we make a hole in the middle of the upper side and we plot a line from this hole to the plate's centre, then we hang a plumb string from the hole.

We set up, on a levelled ground, two poles bearing vertically 60 scale marks and we stretch a string measuring about 15 m (30 cubit) in the middle of which we hang the square plate. We move down on the pole by one scale mark then we plot a gradation at the intersection of the plumb line and the lower side of the square plate.

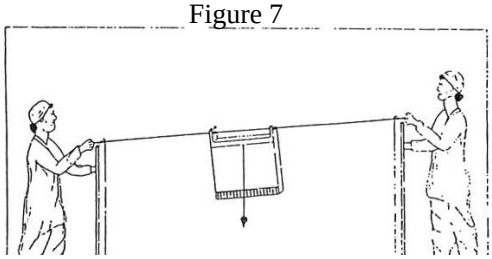
This operation is repeated down to the last pole's scale mark. Once one pole is thus completed, we proceed likewise on the other pole and we plot the intersection points. The poles' marking is thus completed.

The following is the way the survey is carried out:

We position one pole on the spot to be surveyed, we stretch a string on the pole's end and we attach the level indicator in the middle of the string. We read the graduation indicated by the plumb line on the square plate, so that we know the level difference between the two measured spots. (figure 7). This method does not require raising or lowering the string to a horizontal line since we obtain the elevation difference on the level indicator. In this case the scale marks must be plotted accurately and carefully.

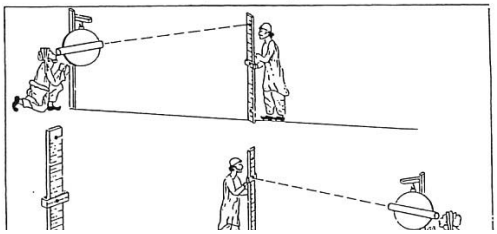
Karaji designed another more performing level indicator (figure 8).

Figure 7



The string is not horizontal but we read the level differences on the level gradations

Figure 8



Collimation of the mark on the pole (upper left side). Next, we switch sides and without changing the tube's angle we collimate the mark on the pole's slide (lower right side). We read the level differences on the level gradations

In the middle of round or squarea wooden or brass plate, we position a brass tube measuring 1.5 hand-span (about 30 cm) with a shaft in the middle to make it rotate like a telescope. The tube is slightly longer than the plate's diameter.

We then place a stop pin on the disk and we hang to a vertical 4 hand-spans beam (about 80 cm) so that the tube is set on the eyes level when one is kneeling.

We use, as a pole, a rectangular parallelepipede measuring about 1.8 m (1 fathom-9 hand-spans). On one pole's side we plot 60 scale marks subdivided to the smallest possible unit. Throughout a length of about 8

cm on both pole's ends we do not plot any gradation. The first and the last gradations are marked in red or black and are as large as one dirham coin to be visible from a certain distance. We insert on the pole a square wooden slider and on which we plot the same guide mark as thick as the ones plotted on the pole's both ends.

Then we make a string with a well strewn silk string or wood fibre string 100 cubits long (50 m) and we shape a ring on both ends. We stretch the string horizontally in order to fix the distance between the level indicator and the pole. The string's length is selected accordingly to fit the surveyor sight range, so that if he is able to see beyond 50 m then the string may be longer.

Let's consider figure 9:

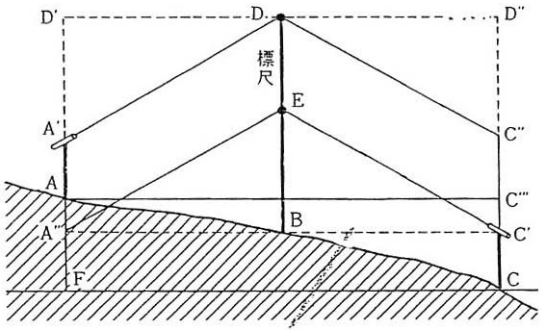
From point A level position, we direct the tube towards the pole to view the D guide mark plotted on the pole's upper end.

Then, we move the level indicator towards the pole's apposite direction on a distance equal to the sting length only. We keep the tube's angle steady and we again aim at the pole. Next, we move the pole's slider so that one can see its E guide mark.

We plot the graduation between the observed mark D from point A and the slider mark E observed from C. The difference DE is the specific height AF of points A and C.

Karaji proved that we may find the specific height of both points combining two parallelograms (A′A"ED and DEC'C").

Figure 9



Karaji demonstration

Let's stretch CF horizontally
Let us stretch EA" from E parallel to DA'
Let us stretch DC" from D parallel to EC'
A'A"//DE//C"C'
DD'=DD'
The two quadrilaterals (A'A"ED and DEC'C") coincide
< A"EB = < BEC', A"E=EC'
Δ EA"B = ΔEBC'
< EBA3 = < EBC' = 90°
A"C' // FC, AF = C"C
A'A = C'C = A"F
AF = A'A" = C"C' = DE
Thus, DE is equal to the level difference (AF)

Qanat (Khettara) construction process

(1) Sinking a mother well

So once we find the proper location for the excavation of a qanat (khattara) from the point of land elevation and farming, we start digging a mother well.

First, we carry out the area's survey between the planned qanat outlet and the mother well site according to the described above methods, in order to find out the relative height (level gap).

At Yazoud, it seems no pole is used. We lay the string's end on the surveyor's head, and then we stretch it horizontally to measure the relative height with a glass level indicator (figure 6).

Next, we dig the mother well that is fixed as the qanat starting point as long as the borehole depth to the water sheet is less that the surveyed relative height, i.e. if the area where the qanat outlet is fixed is lower than the water sheet. We dig a drain between the bottom of the test well and the water sheet in order to have water come out at the irrigation elevation fixed for the farmland.

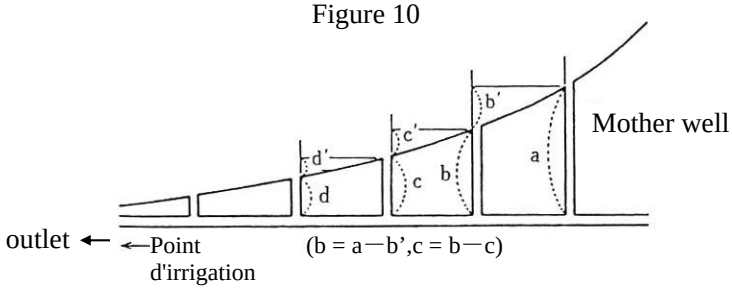
It occurs that the outlet is lower than the irrigation elevation when the well is over dug. In this case, we dig a new mother well to reach the proper point.

It is preferable to undertake this operation in the dry season (which occurs in Iran between the end of August and the end of October), to pump up all the well's residual water and check if the impounded water volume is sufficient (it must be 2 m high in one night).

(2) Qanats construction (khettaras)

Next, we dig a few wells between the mother well and the irrigation water delivery point. The wells' bottom line must be horizontal with the mother well base. In other words, the depth of well (b) is equal to the mother well depth (a) less the elevation difference between the top of the mother well and that of well (b) (figure 10)

Figure 10



Determination of a qanat shafts' depth

Excavation of the underground channel starts at the permeable layer that holds no water and digging is continued in both directions from two wells simultaneously. Hollowing must be as much in a straight line as possible without any level differences.

To check if the channel line is horizontal, we use a T-square (figure 11). Once we have dug about 50 cm long, we lay the T-square on the channel bed and we check if its plumb line overlaps the square line in order to find out if the channel is horizontal.

Karaji uses an inventive method for the same purpose that consists of a level indicator provided with one finger size brass tube of about 30 cm and one finger thick (figure 12).

Figure 11

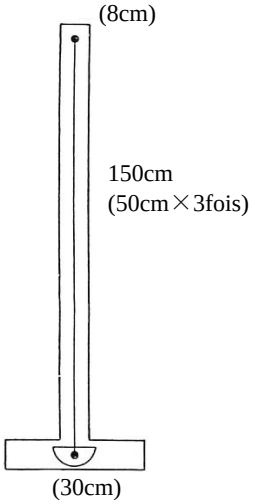
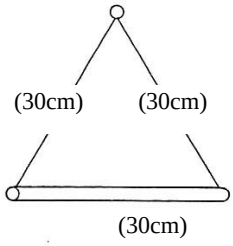


Figure 12

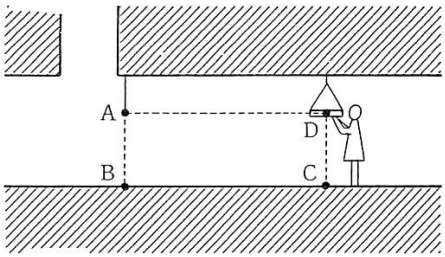


We attach a chain or a wire at both ends of the tube and we hang it at a ring to set it horizontal. To check that the tube is horizontal we proceed as follows:

We dig in a 15 cubits prop (about 7.5 m) and we hang on it the level indicator. We observe the wall from the tube and we plot a mark on the wall to locate the observed point. We reverse the tube and we again look through it : if we see the plotted mark on the wall then the level is horizontal.

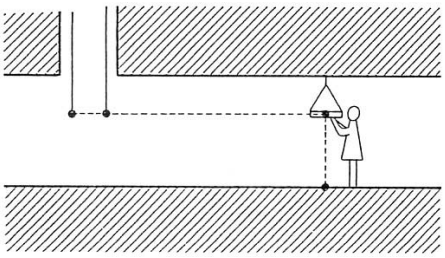
On the ceiling of the excavation starting point, we suspend a string to which a chestnut. After digging 75 cm we hang down the level from the ceiling down to the same height as the chestnut (AB=CD) and we observe the chestnut through the level (Figure 13). If we see the chestnut then the channel is laid out straight (if we see the chestnut ABCD is rectangular and BC is horizontal). Next, we check the line as in figure 14.

Figure 13



Checking method of the horizontal line of the channel

Figure 14



Checking method of the channel straightness

On the ground surface, we stretch a string between two wells and on both sides of the well we hang down a string tied to two weights (chestnuts). When we excavate out a given volume we suspend the level in the

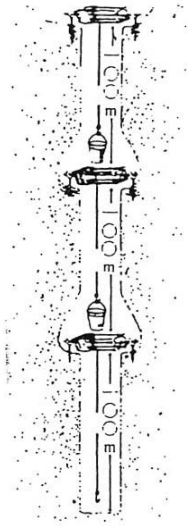
tunnel and we check if the two chestnuts overlap on the same line. In other words, for the channel to be faultless, the string to which are hanged the chestnuts must be in the good direction and the level indicator in its line. Furthermore, the level and the chestnut must be hanging in a way that brings them on the same level than the channel bed.

Inside the aquifer, since we know the elevation of the channel bed from the water sheet, we must excavate taking into account the direction, in order to avoid level fluctuations. We select a gentle slope to avoid water erosion. The gradient must not exceed 1/3000th, i.e. a 0.5 m slope every 6 km.

This method is the one conveyed by Karaji, but we may as well proceed as follows.

At Gonaabad in Khorassan the qanat well depth may reach 300 m, in which case we install a hoist every 100m to lift sand buckets to ground surface. Three men are placed at the hoists (figure 15).

Figure 15



In the deep wells winch hoists are installed

Concerning the HARIM (security distance between two wells), a few research works refer to the civil code provisions, but Karaji gives detailed explanations.

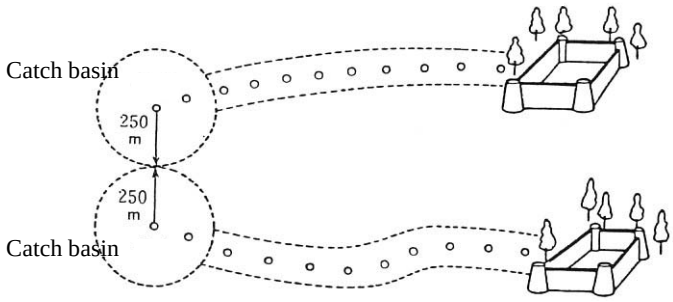
In case of HARIM, as well as for other questions, there are some discrepancies between the muslim theologists. Concerning the well HARIM, Abou Hanifa (699-767) of the Hanafi school advocates a 20 m radius for wells intended for sheep drinking, and a 30 m radius for wells intended for large animals livestock and camels and for irrigation. On the other hand, Hassan Bassouri (642-728, a renown theologist of the Omeyyade dynasty) or Zoufouri (671-742) a renown Kuraishe tribe scientist, recommend a 20 m radius for wells intended for livestock drinking water. Some jurists consider that the HARIM radius should surpass 30 m for a rope length of the top bucket higher than 20 m.

About this subject, the civil code (May 8th , 1928) determines the well HARIM in 20 m for drinking water and 30 m for farming water (provision 137).

According to Karaji, Abou Hanifa, Abou Youssouf (brother of Abou Hanifa, 731-798) ou Zoufouri establish the qanats HARIM as 500 cubits (about 250m). Each qanat should abide by a 250 m HARIM so a

new qanat should be at 500m from the former (figure 16).

Figure 16



Qanat's HARIM

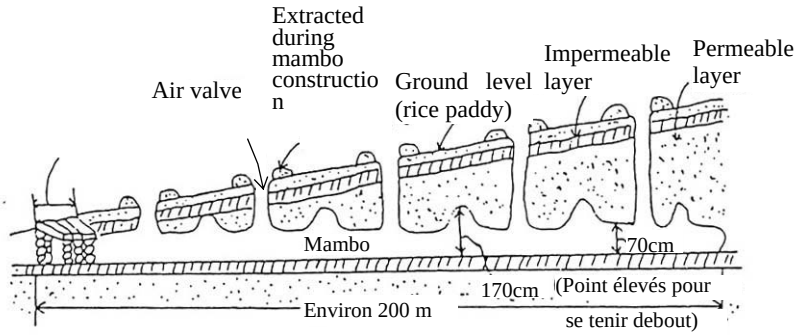
The HARIM radius is variable according to the soil nature. The civil code determines it to be 500 m for loose soil and 250 m for hard soil (article 138).

Karaj indicates concerning this matter that the HARIM must be shorter for the qanats constructed on hard soil than on loose soil, and the harder the soil the shorter is the HARIM with a minimum length of 40 cubits (about 20 m).

In addition, the civil code allows the necessary extension if the determined distance is not sufficient to avoid damages.

Qanats are protected by HARIM ; no one may dig or build on the area delineated by the dotted line.

Figure 17



Longitudinal section of a Mambo

2nd Seminar
in octobre 2005

General information of the seminar

1. Date October 19 and 20, 2005

2. Theme of the seminar

Theme 「Rural Community Development with Khettara rehabilitation」

Sub-Theme ① To summerize the result of verification study by JICA Study team

② To share the knowledge of water saving technique

③ To promote water saving technique to farmers in Tafilallet area

3. Programme

	Name	Profession	Thema
1. First day (for fermers)			
1-1	Mohamed SAADA	SER, ORMVA/TF	Khettara rehabilitation
1-2	Abdelhafid MEFTAH	SER, ORMVA/TF	Rehabilitation of irrigation canal
1-3	Abdelkader BABA-KHOUYA	SGRID, ORMVA/TF	The importance of adopting water saving Irrigation systems and their Applicability in the domain of Khettaras
1-4	Zahara AIT BELLA	SVOP, ORMVA/TF	Economic irrigation at the demonstration farms by JICA and reinforcement of khettara organization
1-5	Fatima JARI	SVOP, ORMVA/TF	Income generation activities
1-6	Abdelkader CHIKI	INRA	Breeding of D'man (Sheep)
2. Second day (for ORMVA/TF)			
2-1	Ryuzo NISHIMAKI	JICA	Official Development Aide by JICA
2-2	Mr. Menjo	JICA Study Team	Explanation of Master Plan
2-3	Takahiro KATO Tetsunari GEJO	JICA Study Team	Explanation of Master Plan
2-4	BOUKHARI Mohamed-Hamid	Ecole Nationale de l'Agriculture	DIGRAP
2-5	Dr. Eddaby	Professor of University of Errachidia	Salinity and agriculture
Discussion			
Conclusion			

A study of the development of the rural communities through the rehabilitation of "khettaras" in the semi-arid region of the Atlasique south east of the Kingdom of Morocco

Mohamed Saada ***Abdelhafid Meftah***

Preamble:

Khettara , underground water catchments system, was discovered in Iran and spread on in Maghreb by the Arabs during their conquest. The denomination of this technique changes from one country to another. It is "Quanat" in Iran, "Kiras" in Afghanistan, "fougara" in Algeria and "khettara" in Morocco.

This technique has been introduced by Tafilalet farmers in the twelfth century. It was imposed /dictated by the following factors:

- Water resources mobilisation in the absence of a system of wells of high-performance.
- The construction does not require any financial expenses at the beginning. It demands only a good amount of work with quasi-absent opportunity.
- The transport of water in tunnels allows minimizing water evaporation and the use of blocks as a result to sand storms that characterize this region.

A simple comparison of this factors and the goals of the actual strategy developed by the Regional Office of Agricultural Development in Tafilalet in the field of water resources mobilizing, that has a modernization pretensions, shows clearly the inventive spirit by which this irrigational infrastructure was set.

Tafilalet used to have 570 khettara that used to irrigate about 9000 Ha. Now it is deprived of a good part of this resources as in 2000 only 250 khettara were operational. The others are either dried up or completely abandoned. This situation is a result to climatic variation characterized by the succession of humid and dry years and consequently the water sheet trend of rising and drawdown.

Taking into consideration the available data, a regression of the flow of this infrastructure was recorded during the period of 1930-1936 during which the flow reached its lowest level of 180l/s. the situation sat upright starting from the campaign of 1940/41 and further improved after 1970 as a result to the lining intervention invested on a great part of these infrastructures.

By the early 80s, the flow in khettaras was estimated to be at 460 l/s which means a rate of 14.5 million m3 per year. This flow knew a sharp drawdown during the draught periods of 1981 -1987 and 1992 – 2002 during which the water table decreased from 6 to 11m according to places.

Consequently, a series of intervention programmes were realized by the Regional office of Agricultural development in Tafilalet to preserve this heritage and water resource.

An illustration of this is provided by the annual PHM programme that touches about ten Khettaras every

year and the PDRT programme that includes an important component concerning the laying out and the rehabilitation of Khettaras that covered more then 50 Khattaras.

The aforesaid directory of intervention programmes, conducted by the office reveals people's and government's interest in straitening up the situation of this structures that continue to give life to the palm groves in difficult climatic conditions and to a population that sticks to this structures as a mark of its identity and its cultural heritage.

This interest is strengthened by the study of rural communities' development through the rehabilitation of Khettaras by sitting a plan of general intervention by components on all Khettaras within the office's action zone.

Introduction

The study of rural communities development through the rehabilitation of Khettaras in the semi-arid region of the Atlantic south east of the Kingdom of Morocco is subject to a convention signed in October 2002 between the regional Office of agricultural development in Tafelalet and the Japanese Agency of international cooperation. This study aims to prepare a master plan of rehabilitation of Khettaras and technology transfer to the Regional office of agricultural development in Tafelalet personnel and to the farmers of project zone.

The study begun in February 2003 and will end in December by the final report. The study is composed of 2 stages. The first stage is based on the analysis of the actual situation through the processing of the data, the conduct of the complementary studies and the elaboration of an interim master plan. The second stage is based on a feasibility study and in-field verification of the obtained results, in-the-field revision of the plan in order to formulate a final master plan of the development of the rural communities through the rehabilitation of Khetarras.

The master plan as it is suggested in the interim report expects the development of the schedule spread over 20 years and envisaging the following components

- Rehabilitation of Khettaras.
- Renewing irrigation installations.
- Farming and water management.
- Institutional strengthening.
- Gainful activities.
- Protecting and fighting against desertification.
- Structures and refilling dams.

The strengthening and the development of these components are scheduled according to the priority of realisation at

- Short term scenario (5 years).
- Short term scenario (5 years).
- Long term scenario (10 years).

The feasibility study and the verification covered 7 major Khettaras with priority selected according to a number of criteria. The choice of Khettaras was based essentially on the criterion of the flow, rehabilitation effect, geography and the farmers' degree of availability; participation and concern in the sites of the major Khettaras subject to study and verification.

khettaras	CR	TUNNEL	Network	Localised irrigation	Institutional strengthening
Ait Ben Omar	F.Soufla	X	X	X	X
Diba	F.Soufla	X			
Taomart Jdida	Alnif		X	X	
Timarzit	Alnif				X
Ouastania	A.S.Gheris	X			
Lagrina	A.S.Gheris	X			
Lambarkia	Jorf	X	X	X	X

General summary of the interventions:

Constituents of study	Techniques and experimental procedures
Rehabilitation of Khettaras (5 Khettaras)	• Installation of PVC pipes of different diameters. • Follow up of flow measurements. • Installation of division boxes. • Punctual rehabilitation of Khettaras.
Demonstration farms (3 Khettaras)	• Installation of 4 irrigation systems for comparative study : ➢ Drip irrigation. ➢ Furrow irrigation with reservoir. ➢ Furrow irrigation without reservoir. ➢ Traditional.
Creation of gainful micro-projects	• Installation of 250 hutch furnished with 200 head of rabbits to benefit of the farmers • Installation of pigeon loft. • Means and materials of agricultural production.
Fighting desertification	Plantation of 200 feet of a triplex by the double bags method in order to judge the technique vis-à-vis its adaptability to the region.
Structure of reinforcing water sheet alimentation	• Outlining the feasibility area of refilling structures. • Follow up of the piezometry and the flow of Khettaras. • Formulation of underflows simulation model.

In the light of the results of the feasibility study and verification, the plan of the development of rural

communities through the rehabilitation of Khettaras in mapped out by components and indicators (see figure 1 & 2).

Component: rehabilitation of Khettaras and irrigation network

Major containing factors:

- Hydraulic resources.
  - Fall of pluviometry
  - Transition to irrigation by pumping.
- Khetteras
  - Fall of the water sheet as a result to consecutive droughts.
  - The importance of maintenance charges.
  - Fall of the volume of waters mobilized by Khettaras because of water leakage.
  - Lack of expertises and hydro-geologic studies.
  - The customary right in waters hinders the flexibility of rehabilitation.
  - Fall of the ground water level as a result to chaotic pumping.
  - Stapes and sections restrict the chances of rehabilitation.
  - Flow variation.
- Irrigation network
  - Water quality is threatened with pollution.
  - Weak efficiency of main and secondary tunnels.
  - Water loss at water intakes.

The inventory and the preliminary studies on Khettaras in 2003

In 2003, the inventory of Khettaras brought to light to what follows.

zone	Number of khettaras	Khrttaras with flow
Zone A	137	80
Zone B	24	20
Zone C	8	8
Zone D	69	21
Zone E	25	14
Zone F	44	11
Zone g	103	37
Total	**410**	**191**

The creation of a data base of Khettaras in GIS (geographic information system) provides a complete information bank on Khettaras in the action zone. Consequently, a Khettaras file was created to collect the data relating to the system: geographical localization water resources, population, area and technical

data…

Khettaras rehabilitation program:

The elaboration and the study of the prototypes of the rehabilitation of Khettaras system Both at the level of the experimental farms. In fact, in addition to the rehabilitation of channels and the surfacing of SEGUIAS, generally conducted by the office, the project has tested during the stage of verification some methods of rehabilitation and irrigation through a verifying study of 7 sites of Khettaras selected to know:

- At the level of tunnels of Khettaras.
  - Layout based on the use of PVC ducts with varied diameters according to the flow (400 mm & 200 mm).
  - Rehabilitation of Khettaras (tunnel) with concrete.
- At the level of irrigation network
  - Construction of the distribution network to the experimental farm and the layout of intakes.

This programme is spread over 10 years and is interested only in the operational Khettaras (191) at short and medium term of 5 and 10 years respectively. The rehabilitation and the layout of the dry Khettaras (219) is condition to the significant effects of refilling structures.

Rehabilitation of Khettaras and the irrigation network

1- short and medium term :

Increase of the flow of Khettaras

Flow	Q>= 10	5<Q<10	Q<5
Increase (l/s/Km rehabilitated)	2.5	2	1.5

The program is concerned with 30% of the total length of Khettaras being 600 ml per Khettaras in an efficient and equal way between all operational Khettaras.

- Building of 100% of irrigation network especially main SEGUIAS.
- Strengthening the water table by building refilling structures in relation to the Khettara zone.

2- Long term (from 11 to 20 years).

According to the results of the studies lead through the building at a medium term of the refilling structures and the efficiency of refilling, the action plan of rehabilitation of revitalized Khettaras will be achieved.

The importance of adopting water saving Irrigation systems and their

Applicability in the domain of Khettaras

Abdelkader
BABA-KHOUYA
SGRID, ORMVA/TF

Exposition summary

The regional agricultural investment office is working seriously on elaborating a strategy based on water by introducing new irrigation techniques especially that its water resources are sharply deteriorating as a result of the difficult climatic conditions in the region and which has become a structural problem that negatively affects farming and the region's economy as a whole.

Consequently, and in order to preserve resources, great concern was given to the water-saving irrigation systems.

In this prospect, the government has made great efforts to provide farmers with donations to equip their lands with the new irrigation systems:

- The states support varies from 30% to 40% of the project budget.
- An account of the procedures to be followed to get this donation is available in agricultural investment centres.
- The technique of localised irrigation quickly spread in Morocco since introduction in late 20s.

- ***On the national scale:***
  - 1987-1997 the equipped area per year is of 2500 ha.
  - 1997-2004 the equipped area per year is of 10.000 ha.
  - The total equipped area is 10.000 ha.
- ***On the local scale:***
  - The total equipped area (in order 2005) 507 ha.
  - The area under equipment: 626 ha.
  - Drip irrigation development 280ha per year.

In spite of the complicated peculiarities of the region and thanks to the cooperation of farmers and the technicians, drip irrigation was introduced to the perimeters that use pumping or Khettaras. This technique perfectly answered the needs of the crops.

- ***Future perspective:***

In the future, this technique will provide good solution to perfectly exploit the other water resources.

- Pumping waters.
- Submersion waters.
- Khettaras waters.
- Hassan EDDAKHIL Dam waters.

Water saving irrigation systems in khettaras

Ait Bella Zahra, ORMVA of TAFILALET

Introduction:

As part of the verification/ check up stage scheduled in the study of the development of rural communities through the rehabilitation of Khettaras that has been conducted by JICA at in the Zone since February 2003 till July 2005, the Regional office of agricultural development in Tafilelt suggested to begin extension pilot activities at the level of the perimeters dominated by Khettaras especially the demonstration farms of water saving irrigation systems adapted to the environment of the oases.

I. Presentation of motives:

1) Limited water resources and draught:

The action Zone of ORMVA/TF is characterised by it's a ride semi-desert climate and its limited water resources. Furthermore, the Zone passes through a period of drought that engenders an ever enlarging hydric deficiency year after another.

This situation has a negative effect on the oasis life. It impedes the rural development in general and agricultural development in particular.

Consequently, the ORMVA/TF intervenes to soften the noxious effects of this phenomenon and to bring adequate solutions to small farmers who spare no effort to preserve their exploitations especially if we consider their attachment to their lands no matter what are the circumstances.

2) Very convincing results of drip irrigation at the level of pumping stations.

In Tafilalet, farming is possible only with irrigation from Hassan EDDAKHIL Dam, pumping stations and the submersion waters.

The zone contains about 6700 private well and 114 pumping station managed by the cooperatives and the associations.

The experience of introducing drip irrigation systems adapted to the oasis environment (the existence of fruiter arboriculture especially palm trees and olive trees altogether with the underlying faming) has given impressive results at the level of the demonstration parcels lead at the level of private pumping stations as part of FIDA donation. This system made it possible for these farmers, among other things, to keep exploiting their lands in spite of the difficult conditions of the drought.

3) The Khettaras provide very important volumes of water that should be developed.

The Zone contains 570 Khettaras of which 410 are operational,191 amongst home confirmed flow of and maintains a regular flow overage of 5,7 l/s/Khettara even in droughts periods and irrigates an area of 3.012 ha.

In Khettaras, the irrigation by submersion system is adapted in spite of the water loss that it engenders and that is estimated at 30% to 40%. The water's of Khettaras is distributed by turn of water, in the best conditions, may go up to one week.

Thus, it is difficult to adapt the volume of irrigation to the needs of farming that differs according the crops; its stage of development and the climatic obligations at the level of these perimeters dominated by Khttaras, the intensification of farming activities is possible only with extra pumping.

4) **The birth of the idea of testing the system at in Khettaras in collaboration with JICA**:

For a rational and efficient use of the volumes of irrigation water provided by Khettaras, The ORMVA suggested to test the water saving irrigation systems on date palms and olive trees altogether with the practiced underlying farming at the level of the zone especially OKRA, melon, watermelon and tomatoes as summer crops and carrots and navel orange as winter crops.

II. Realization approach:

The realization approach of this action consists of:

- The choice of sample sites with testing one or many technologies in each site.
- The spreading of the successful technologies around the pilot site and the other Zones.
- The development of partnerships with local forces (cooperatives, ONG, Associations…) for the expansion of the successful technologies.

III. Demonstration farms:

Four irrigation modes, including the traditional irrigation by submersion, furrow irrigation without reservoir are compared at the level of three sites:

- Ait ben Omar at Tinjdat discharge Q=7 l/s.
- Lambarki at Jorf discharge Q= 12 l/s.
- Taououte at Alnif discharge Q= 1.5 l/s.

The following table exhibits the data according to places.

Locality	Irrigation system applied	Area locality	Practiced farming
Lambarkia to jorf	-Drip irrigation -Furrow irrigation with reservoir - Furrow irrigation without reservoir -Basin irrigation	0.15 0.11 0.13 0.22	Palm dates Olive trees Carrot. Turnip Melon Watermelon Okra Caper
Ait Ben Omar to Tinjdad	-Drip irrigation -Furrow irrigation with reservoir - Furrow irrigation without reservoir -traditional irrigation	0.15 0.09 0.09 0.22	
Taoumart to Alnif	-Furrow irrigation with reservoir -Furrow irrigation without reservoir -Basin irrigation	0.13 0.14 0.16	

IV. Results

1) Volumes of consumed waters:

- Drip irrigation had a notable positive effect; in fact, the consumed water makes only 38 % of the volume of waters consumed in the irrigation by submersion.
- The quality of waters consumed in furrow irrigation with reservoir is 70% of that consumed in irrigation by submersion and it allows the frequent watering.
- The quality of waters consumed in furrow irrigation without reservoir is 65% of that consumed in irrigation by submersion.

2) Appreciation of m3 of water:

Drip irrigation gives the best production per m3 of water, the furrow irrigation comes in the second place followed with irrigation by submersion.

3) Soil humidity:

Being irrigated everyday in the drip irrigation, the soil humidity is higher than in other types of irrigation for which the watering intervals are much longer.

4) The production:

The drip irrigation give a production of good quality that is appreciated by the consumers.

5) Labour saving :

The drip irrigation doesn't require labour to insure the irrigation like in submersion or furrow irrigation and fertilizers may be brought with irrigation water as well.

6) Forming activities are not hindered.

Unlike the other types of irrigation, drip irrigation does not necessitate waiting the drying up of the soil to take care of the craps or to pick it at any time.

V. Spread of the technique:

During this period of crops' growth, guided visits of 400 farmer and technician were organized to the demonstration farms.

Most of the farmers who participated in those visits are convinced of the water saving irrigation systems especially the drip irrigation. However, there are many constraints that limit their adoption of this system namely:

- The problem of pumping authorizations.
- The problem of land title for some exploitations.

- As to Khettaras and perimeters, the law of agricultural investment does not for see the procedures specific to this kind of lay out.

Thus, the team in change of this staff training days suggests the fallows steps:

- A consciousness raising campaign concentrating on the government aids in water saving irrigation systems and the steps to be followed to get them.
- To give examples concerning the problematic of pumping authorities and land titles, the legal procedures to be followed by the farmers of Khettaras and the eventual government help to encourage them to adopt the new technique.

VI. Strengthening farmers organization at the level of Khettaras perimeters:

The goals of this component consist of encouraging the establishment of modern associations that may formulate projects to the benefit of the population of Khettaras, to tap the capitals in the zone and establish the partnership spirit in the population in the realization of the projects.

Thus, two workshops were organized to the benefit of 200 farmers. The participants attended to:

- Talks on the role of partnership and the farming development at the level of the zone, on the administrative and financial management of the cooperative and associations.
- Visits to demonstration farms on water saving irrigation systems.

On this occasion, a data collection on the participating Khettara associations and their problems took place.

The third workshop was established to the benefit of 130 farmers and was devoted to the adoption of water saving irrigation systems.

The goals of the workshop are: raising the awareness of the associations' members on the water saving irrigation systems, the legal procedures to be followed to form their applications to get subsidy and the marketing techniques of agricultural products.

VII. Future programs:

To follow up the dynamic of launching the extension of the water saving irrigation systems and taking into account the encouraging results of the verification study, the following steps are suggested:

- To conduct a campaign to spread the obtained results.
- To organize guided visits to the experimentation sites.
- To induce the associations of Khettaras to formulate irrigation equipping projects localized in the favourable perimeter and providing then with support in technical study the follow up of the execution of the project.

Income generating activities and production appreciation

Fatima JARI, SVOP, ORMVA/TF

Introduction:

As part of the verification stage scheduled in the study of rural communities development through the rehabilitation of Khettaras conducted by JICA, ORMVA in Tafelalet suggested to begin the extension of pilot activities at the level of some Ksar dominated by the Khettaras. The main goal of this is to test the Income generating activities, the practical technologies of farming production upgrading with the aim of improving the rural population conditions.

I. Income generating activities to the benefit of rural women:

In order to diversity the sources of revenue to the rural women and bearing in mind the opportunities the Zone provides for some activities we tested:

- The introduction of pigeon aviary: an Egyptian model and a modern one (two sites).
- Realization of a project of modern rabbit breeding.

1) Rabbit breeding :

- ***Objectives.***

The project aims at developing rabbit forming in the order to reduce protein insufficiency in the food of rural women and child. Rabbits will be given to poor women and those with high family charges.

The project aims to realize the following steps:

- To ameliorate the revenue of rural women.
- The integration of rural women in the development progress.
- The technical training in rabbit breeding.
- The improvement of the nutritional condition of the rural women in proteins.

- ***Consistency :***

The project consists in giving 5 groups of rural women (15 women in each group) rabbits of local race.

Each woman had 2 does and one reproducing rabbit to exploit according a semi-traditional system.

The beneficiaries will be gathered in service cooperatives that aim:

- To supply the members with rabbits food.
- Selling the production.

The demonstration sites are: Boudnib, Tizgharine, Mellab, Jorf and Rissani.

- ***Results and recommendations:***

During the first stage of the project, we noted that the mortality animal's rate is elevated because of cold, mal-nutrition, lack of hygiene and non-adaptation of the local race of rabbit to the hutches. However, the livestock is rebuilding thanks to the training efforts by applying the following recommendation:

- Strengthening the technical training and rising the awareness of the beneficiary.
- The improvement of the places where the rabbits are kept.
- Inducing women to buy food additives.
- To keep vaccinating the reproductive rabbits.

2) Pigeon breeding:

Pigeon breeding to produce meat is on of the favourable activities of many families in the plain of Tafilalet. Pigeon is part of the food habits in the Zone and known as the 'farci' pigeon.

This breeding requires a small capital and little work and parent pigeons take care of the rest. This kind of breeding is to adapted to the region and very productive.

Selling this product doesn't put any problems as it is appreciated and looked for all along the year.

The pigeon production system practiced in this region is purely traditional. The improvement of its management may contribute in the development of this activity.

Thus, the pigeon project traced the following goals:

- The improvement of the rural families' revenues.
- Integration of rural women in the development of this breeding.
- The improvement of the management techniques of this breeding.

- ***Consistency:***

The project consists of two attempts of intensified breeding through the construction of two aviaries that shelter a good number of pigeon.

- One in Rissani Egyptian type.
- One in Boudnib Modern type.

- ***Results and recommendations:***

Bearing in mind the short duration of the beginning of the project, the primary results do not enable the evolution of the profitability of the project. However, the beneficiary home shown an interest in this activity.

II. Production upgrading:

The upgrading of the productions is a good opening to ameliorate the farmer revenue in Khettaras. The

productions subjects to projects are dates, Henna, Okra.

1) Dates:

- ***Objectives***

Date palms are the skeleton of farming in the region of Tafilalet. It has an important place at the economic, social, environment and cultural levels. The number of date palms in the zone is about 1.399.000 feet that produce an overage of 26000 tonnes /year and constitute, thus, the first fruit tree in the Zone.

The dates of good quality make only 26% of production while 'Khalts' is of more than 40%. More than half of the production is of the difficult to stock soft dates. Traditionally, rural women used to transform a part of it in very unclean condition and this used to take much time.

The goal of the project is to improve soft dates transforming by introducing stoning and mining machines.

- ***Consistency:***

The undertaken steps are:

- The preparation of an aromatized and conditioned date's paste.
- The organization of women.
- The marketing of the product.

To achieve this, the office, JICA and a private society developed a small kit adapted to the oasis exploitation to upgrade the soft dates. The kit is composed of a locally made electric stoner of 220 V and a 50/60 Kg capacity, an electric mixer with the capacity of 650 Kg/h, a hand press of dates past and food wrapping plastic and other more accessories were provided to 'Nahda Mamounia Association' in Tinejdad and 'Bahia cooperative' in Boudnib. The goal of this action was to make those activities easier to the rural women who prepare dates pate, to get a product in hygienic conditions and to improve its presentation to the consumers.

- ***Results:***

The product obtained with the introduced material was appreciated by the consumers during the exhibition organised at the level of zone. In fact, the paste was produced in healthy conditions. In addition to this, this material enabled:

- Upgrading dates paste in culinary preparation.
- Saving women's time and labour.
- Creating of a new incentives at the level of the Zone concerning the soft dates appréciation.

2) Henna:

Being practiced in herbaceous farming, at the level of the zone action of the ORMNA/TF, the henna occupies an overage area of 600 ha every year with an annual production overage area of 1560 tonnes.

The leaflets are first dried off in the sun and end in airy places.

The production is marketed in its crude state as the traditional milling is very difficult.

With the aim of upgrading the product of Henna, two electrical mills with a capacity of 30/60 Kg/h, wrapping plastic and other accessories were provided to 'Agdal association' in Taoumarte. In fact, this village commercialises in bulk about 5 tonnes of Henna every year. With the same objective a study trip on Henna upgrading and producers' organization was organized to the profit of 16 farmer of Alnif Zone in Tamgroute/Zagoura. This action enable arousing the farmers interest in Henna upgrading and are asking now for material with big capacity.

3) Okra:

In the action of the ORMNA/TF, the Okra farming occupies an annual area of 70 ha. The overage production is of 600 tonnes, 30% of this is consumed by the farmer's families, 25% is commercialised, 45% is traditionally dried off without any hygienic though this farming is prepare to be preserved fresh.

The upgrading of Okra and other vegetables is one of the components of the project. Thus, a vegetables cutting machine with different discs, L-type, drying stages, food plastic and other accessories were provided to Khattarate Lamharza in Sifa. The aim is to facilitate the job to the rural women and the its wrapping. If the machine has satisfied in carrot and the navel it was adapted to the ring cuts of Okra.

The evaluation of such an activity is expected in the 2005-2006 campaign.

III. Technology transfer:

In order to realize the different components of the project, training models were organized for the technicians on rabbit and pigeon management. Moreover, and in order to assure the spread of the introduced technologies, 3 inter-trips were organized for 75 rural women and one out-zone trip for 16 farmers.

Moreover, many guided visits were organized for the local ONG, students, experts…to the sites of the aforementioned projects.

Reproduction performances of the Sheep Race D'Man in the Experimental Station of INRA in Errachidia, Morocco

M. Kerfal, A. Chikhi and B. Boulanouar,
National Institute of Agronomy Research
Morocco

Abstract

This paper intends to evaluate the D'Man's race reproduction and production potential in the breeding station and determine non genetic factors that influence this potential in order to take them into account during animal production assessment. The study concerned the analysis of 1653 ewe's reproduction performance, 3799 growth and vitality performance and 303 lamb fattening performance. Determination of non genetic factors' effect has been carried out using the least square method and the application of the SAS software GLM procedure. Data analysis shows that the D'Man ewes have at birth a litter of 2.41 lambs in average, a lamb size at 90 days of 2.20 lambs, a lamb weight at birth of 6.14 kg and a lamb weight at 90 days of 43.4 kg. These performances are generally influenced by the ewe's age, the lambing season and the ewe's body weight at mating. D'Man's race lambs weigh at birth 2.60 kg in average, 7.69 kg at 30 days, 19.8 at 90 days and 28.4 at 135 days. Average growth speed obtained in periods of 10-30 d, 30-90 d and 90-135 days are respectively 166 kg, 201 kg and 189 kg. The mean value of death rate between birth and 135 days is 8 %. The large part of deaths occurred between birth and the 5^{th} day (80 %). These characteristics are influenced by the mother's age, the lambing process and the birth's season of the lambs. D'Man lambs fattened for about 3 months have gained an average daily weight gain of 226 g/day and a 5.75 kg dry matter food conversion ratio per kg weight gain. We concluded that the D'Man race has promising potentials if it is possible to breed in order to improve meat production in Morocco and to increase productivity of other races through cross breeding programs.

Keywords: *Ovine D'Man – Reproduction – Growth – Viability – Fattening- Non genetic factors – Morocco.*

1.INTRODUCTION

The yield of ovine livestock breeding is measured by the cattle's production. The latter is the result of several components, namely, the ewes' prolificity and the lambs' growth. If we are interested in the annual productivity, we may as well include the lambing times per year. So, to improve the cattle's productivity, we must optimize each one of these components. Now, it was proved that productivity depends on lambs proliferation rather than on the other components.

Prolificity or the born lambs' number may be improved according to two patterns, by increasing the number of the born number by one lambing or by increasing the number of lambing per year. The first way may be implemented by the selection of the best reproducers on prolificity basis or by cross breeding with other prolific races, similar to D'Man. Increasing the number of lambing per ewe and per year may be realized through lambing acceleration rhythm.

This study aims at assessing the reproduction and production potentialities of D'Man race in breeding stations and determine non genetic factors that influence its potentialities.

2. EQUIPMENT AND METHODS

2.1. Data sources

The analysed data have been collected in the Errachidia Experimental Domain (EED) under the National Institute of Agronomic Research (INRA) of Errachidia. This domain is located in the pre-saharian zone in A sector's resettlment farm, at the crossroad of two main roads N°21 linking Meknès-Rissani and N° 32 linking Agadir-Bouarfa, at Errachidia entering point (longitude 4.25 – latitude 31.75) and latitude 1060 meters. The EED is pat of the saharian bioclimate department. The annual rainfall is generally low and irregular, timewise as well as in space, and ranges between 50 to 250 mm. The total number of rainy days is low and varies between 20 to 30 days per year. Temperatures range from – 6° C to 50° C, with a 7 months hot season and monthly highest average temperatures are higher than 30° C. The annual mean temperature is 23° C, fluctuating between 10° C in winter and 35° C in summer. The prevailing winds are chergui in the summer blowing towards the north and the sahel blowing along the line south-west in the spring.

2.2. presentation of D'man' race

D'Man race is the ovine local race of the south of Morocco palm canopies. The breeding is done in small size flocks (one ram and 3 to 4 ewes in average) and kept indoors throughout the year. The total stock of D'Man race is 616,966 heads, which represents 3.7 % of Morocco's ovin stock (MADRPM, 1998; Boujenane, 1999).

It is characterized by its outstanding reproduction performance, specially its special precocity, its ability to double lambing and its high prolificity. The pigmentation is diversified (brown, black, white and mixed). The fleece of the D'Man is light and does not cover some body parts. Average fleece weight is one kg and varies from 0.25 to 2.80 kg. The wool has a bad quality. It weighs 30 to 45 kg for the ewe and for the ram it weighs 50 to 70 kg. (Benlekhal, 1996; Boujenane, 1999).

2.3. Animal stock

The study concerned 1653 D'Man ewe reproduction performances, 3799 growth performances and vitality and 303 fattening perforamances. These data have been collected during sixteen years, from 1988 to 2003. Average charecteristics show the average lambing is about 2.8. Average ewe's age is 30 months. Average weight at mating and lambing is respectively 44 kg and 47 kg.

Data distribution according to age showed a 34 % maximum frequency for ewe less than 18 months.

2.4. Management method

Reprodcution method

The ewes managed in one flock undergo a controlled mating for three periods: from february 1st to March 15th, from October 1st to November 15th and June 1st tp july 15th. These matings result is three lambing periods extending from July 1st to August 15 th, from March 1st to April 15th and November 1st to December 15th. Mating lasts 45 days and lambing happens every 8 months, in autumn, spring and summer.

Feeding management

In Errachidia Experimantal Domain, breeding of D'Man is intensive, the animals are in constant housing and get their food in sheep-pen. Ewe food is basically alfa alfa which is the major fodder crop of the palm canopies. In addition, we find barley and sorgho, vetch grass and straw. Concentrated food is also used, namely beets dry pulp, bran, barley grain and dates waste.

Feed rations formulation is made to meet the animals' needs in relation to the physiological stages. Thus, in case of ewe at the last stage of pregnancy, we add an 8 month fœtus requirements. At the suckling stage we take into account the requirements in consideration of milk production estimated at the 1st, 2nd and 3rd suckling months.

Lambs feeding during the first month is exclusively milk. From the 2nd month, the lambs are fed barley and sunflower oil cakes and mineral and vitamin supplement (MVS). From 30 to 45 days, the distributed mixture has a nutritive value of 18 % total nitrogen matter (TNM). From 46 to 135 days, its nutritional value is about 16 % of MVS. In addition, the lambs get alfa alfa and water at will. Lambs are weaned at 70 days and the males are seperated from females.

Prophylactic management

To avoid accidents such as pulpy kidney disease, inner and outer parasitism, animals are regularly vaccinated. The following treatments have been applied :

- All the flock : parasitic dip preferably in July and after shearing against scabies and other parasites.
- For ewe at their last pregnancy third period : vaccination against pulpy kidney disease, inner antiparasites treatment, bronchitis, and vitamin supplements.
- For lambs, the following interventions have been made :
    - At birth : disinfection of the umbilical cord with iodine tincture.
    - From 1 to 5 days : administration of mineral and vitamin supplement
    - At 30 days : first vaccination against pulpy kidney disease
    - Between 45 and 60 days: second vaccination against pulpy kidney disease
    - At 90 days : internal antiparasitic treatment.

2.5. Implemented controls

A data base has been compiled using the records of D'Man ewes and lambs' performances. The controls and observations carried out are:

- Ewe, ram and lamb numbers
- Mating and lambing dates
- Ewe weight at mating and at lambing
- Rank, year and season of lambing
- Ewe age at mating and at lambing
- Size and weight of the lambs at birth and at 90 days.
- Birth and death dates of lambs
- Sex and method of lambing
- Weight at birth, 10, 30, 90 and 135 days.
- Lambs double weighing at the begining and end of the fattening period
- Lambs simple weighing every 15 days during the fattening period

These controls allowed to determine the following performances :

- The litter's size at birth and in 90 days.
- The litter's weight at birth and in 90 days
- Weight at birth
- Weight at 30, 90 and 135 days
- Average daily gain (ADG) 10-30 days, 30-90 days and 90-135 days
- Final fattening weight
- ADG at fatteining
- Ingestion level
- Food convertion ratio (FCR)

2.6. Statistical analysis

Data analysis has been implemented using variance analysis procedure of least squares by means of the SAS (statistical analysis system, 1996). The utilized statistical models for variance analysis are those kept after elimination of the non significant interactions.

Mixed models adopted for variance analysis of reproduction performances include the ewe random effect,

ewe age fixed effects, lambing season and covariable weight of the ewe at mating. Surveyed factors level are: 6 levels for the ewe birth (Age ≤18 months, 18≤age≤24 months, 24≤age≤30 months, 30≤age36 months, 36≤age≤42 months and age >42 months) and 3 levels for the lambing season (autumn, spring and summer).

Mixed models have been used for growth performance analysis. They include the random effect of the mother, the mother's age fixed effects with 6 levels (Age ≤18 months, 18≤age≤24 months, 24≤age≤30 months, 30≤age36 months, 36≤age≤42 months and age >42 months), the sex (male, female), birth method and the birth season.

3. RESULTS AND DISCUSSION

3.1. REPRODUCTION PERFORMANCES OF D'MAN EWES

3.1.1. PERFORMANCES ARITHMETICAL MEANS

Arithmetical mean, standard deviation and variation coefficients of the litter's size at birth and at 90 days are given in table 1.

Data analysis revealed that D'Man ewes have in average at birth a litter of 2.41 lambs, a litter's size of 2.20 lambs at 90 days, a litter's weight at birth of 6.14 kg and a litter's weight at 90 days of 43.4 kg.

The litter's size at birth varies between 1 and 7 lambs. Litter's size distribution at birth shows that the ewes have to perform 16.4 % in simple litters, 41.6 % in double litters, 31.1 % in triple litters, 9.3 % in litters of four and 2.6 % in litters of five lambs and more. Double and triple litters have a high incidence representing 71.7 %.

3.1.2. EFFECTS OF NON GENETIC FACTORS

Adjusted mean values of size and weight of a litter at birth and at weaning are presented in table 2.

The ewe's age has a significant effect on all the surveyed reproduction characters. The weakest performances have been obtained by primipara ewes, meanwhile the highest have been recorded for adult ewes 36 to 42 years old. The difference is 0.33 for the lambs' size at birth, 0.27 at weaning, 1.41 kg for the lambs weight at birth and 8 kg at weaning. This superiority is explained by the fact that milk production increases with age and has a positive impact on the lambs' growth. Boujenane and Kerfal (1992) found out that milk production increases with the ewe's age and that adults produce 30 % more than young ewes.

The results of the age's impact on the ewe's reproduction performances match those of Khallouk (1987) and Kerfal (1995) who confirm that the ewe's age is significant for reproduction performances. Chikhi (2002) reported that a difference of 0.27 lambs per litter at birth, 0.23 at weaning, 1.26 kg for the lambs weight at birth and 6.0 kg at weaning between the primipara Boujâad ewe (less than 30 months old) and adult ewes older than 78 months. These results match those obtrained by Chafik (1994).

Lambing season influences significantly the litter's size at birth, at weaning and the litter's weight at birth, but has no effect on the lamb's weight on weaning. D'Man ewes have weaned at least an average weight of

42 kg during the three season. That represents about 90 % of their live weight. This high productivity, EED, demonstrates their interesting genetic potential.

Mating weight of D'Man ewe has a significant influence on the reproduction character surveyed except for the litter's weight at weaning. Regression coefficient of reproduction character on the mating ewes weight indicate that 1 kg increase in the ewe's weight during mating improves the litter's size at birth and at weaning by 0,021 and 0,018 lambs and the litter's weight at birth and at weaning by 0,048 and 0,169 kg. These results confirm those obtained by Kerfal (1995), El Fadili (1997) and Chikhi (2000) who have reported that the mating ewe weight affects significantly reproduction performances. Indeed, Boujenane (1989), Khallouk (1987), Chafik (1994) et Chikhi (2000) have observed that each kg average increase of mating ewe generates an improvement of the litter's size at birth by 0,009 lambs, the litter's size at weaning by 0,008 lambs, the litter's weight at birth by 0,035 kg and the litter's weight at weaning by 0,21 kg.

3.2. D'MAN LAMBS PERFORMANCES AND GROWTH

3.2.1. ARITHMETICAL MEAN OF PERFORMANCES

Arithmetical mean, standard deviation and variation coefficients of growth performances recorded in INRA of Errachidia are recapitulated in table 3.

At birth, the lambs weigh in average 2.60 kg, 7.69 kg at 30 days, 19.8 at 90 days and 28.4 at 135 days. Growth average speed is 166g/day between 10 and 30 days, 201 g/l between 30 and 90 days and 189 g/day between 90 and 135 days. These weights and growth performances indicate the satisfactory growth potential of the D'Man race.

3.2.2. EFFECTS OF NON GENETIC FACTORS

Adjusted average values of birth weight, at 30 days, 90 days and at 135 days and ADG 10-30 days, 30-90 days and 90-135 days by variation factor are summed up in talble 4.

The mother's age has a significant effect on the surveyed growth characters. These characters improve with age. Lambs coming from adult ewes weigh more that those born to young ewes. The variances are 0.56 kg, 1.27 kg, 1.90 kg, 1.60 kg, 14 and 12 g respectively for the weight at birth, at 30 d, 90 d, 135 d and the ADG 10-30 and 30-90 days. These results match those found by Boujenane et Kerfal (1990) and Kerfal (1995), who have highlighted the significant effect of the mother's age on weight and ADG. Indeed, Chafik (1994) reposrted for each 100 days' increase in the mother's age corresponds a 0,11, 0,30 et 0,55 kg increase for weight at birth, at 30 d, 90 d and 135 d respectively and 7 g and 3 g for ADG 10–30 and ADG 30–90 days respectively, and this fact lasts till the mother's optimum age of 72 months.

The lamb's sex influences as well all the surveyed characters. Indeed, males performed higher weight and ADG than females. The observed difference between the two sexes increases with age. The male's superiority on females is 0.20 kg, 0,87 kg, 3,40 kg and 6,1 kg and 24 g, 45 g and 63 g respectively for weights and birth, at 30d, at 90d, at 135d, the ADG 10-30 30-90 and 90-135 days. This superiority may be

explained by the gain's difference in structure. Part of the female's milk goes to the elaboration of the adipous tissue which more costly energy wise. These results concerning sex significant effect on lambs growth performances meet the the results obtained by Chikhi (1986), Berger and al. (1989) and Boujenane and Kerfal (1990).

Birth method of the lamb has a significant effect on weight and ADG surveyed except for the ADG 90-135 days. Simple lambs weight more at various ages and grow more rapidely than double, triple quadriple and more lambs. The birth method effect on weight and ADG decreases with the lamb's age. The superiority of simple lambs in comparison with the quadruples is 1,35 kg, 4,75 kg, 7,90 kg, 7,80 kg, 111 g and 63 g respectively for the weight at birth, 30, 90 and 135 days, ADG 10–30 and 30–90 days. This facts prove that quadruples lambs and more tend to compensate the slow growth recorded at the start. This trend has been also observed for D'Man race by Chikhi (1986), Boujenane and Kerfal (1990) and Kerfal (1995).

Birth season has also a significant influence on weight at birth, at 30 d, at 90 d and at 135 d and on the ADG 10-30 and 30-90 days, but it has no significant effect on ADG 90-135 days. Lambs born in autumn tend to realize weights and ADG higher than that of those born in the spring and summer. But the difference between seasons are not significant.

3.3. VIABILITY PERFORMANCES OF D'MAN LAMBS

Death frequency among D'Man race lambs according to age shows that 80 % death rate affects lambs between birth and the fifth day, 11 % between 6 and 30 days, 7 % between 31 and 90 days and 2 % between 91 and 135 days. These results tally with those announced by Tchamitchian and al. (1976), Ricordeau al. (1976 et 1977) and Ricordeau (1982) who reported that 50 to 80% losses happen during the first week of the lamb's life.

The viability mean rate between birth and 135 days is 91.7 % with a 22 % standard deviation and a 24 % variation coefficient. This rate is higher than the one found in the D'Man race recorded by Benlakhal (1983), Essaadi (1984), Boutgayout (1980), Chikhi (1986) and Boujenane and al. (1991) and that varies between 70% and 81% from birth to 90 days.

3.4. FATTENING PERFORMANCES OF D'MAN LAMBS

Male lambs fattened during 3 months in the EED of Errachidia INRA have put forward a satisfactory fattening capacity (Table 5). Indeed, D'Man lambs have performed in average a ADG of 226 g/day; a 42.5 kg final live weight, 1.63 kg ingestion level of dry matter/animal/day and a 5.75 kg of dry matter/kg and 5.50 UF/kg weight gain.

These results are better than those obtained with D'Man race and which are in average 156 g/j for fattening ADG, 30 kg for fattening final live weight, 1.40 kg DM/animal/day for ingestion level and 7 kg of DM/Kg weight gain for food convertion ratio (Roudies, 1998; Benmira, 1999).

GENERAL CONCLUSION

It appears, according to the hereby survey, that reproduction potentialities of D'Man race are specially high

and that the D'Man sheep is a genetic material meeting perfectly the vital requirements of palm canopy farming, i.e. maximum production intensification.

With a litter's average size at birth of 2.41 born lambs, and the litter's average weight at 90 days of 43.4 kg, the D'Man ewe is capable of weaning in average 3.62 lambs and producing 65 kg live weight per year in an intensive production system. Consequently, its beneficial interest is not limited to the palm groove environment. The D'Man sheep can be used in crossbreeding programs with other local races in order to improve their reproduction performance and increase their productivity.

Death rate between birth and 135 days is in average 8 %. The major part of death occurrences happen from birth to the fifth day (80 %). Thus, to improve the lambs viability of this prolific race, it is necessary to try to regroup the lambings and reinforce the surpervision activities using qualified labor able to look after the ewes in case of problems

Mean weights of D'Man lambs at 90 days (20 kg) and at 135 days (28 kg) and the ADG 30-90 days (201 g/day) and ADG 90-135 days (190 g/day) confirm the possibilities of precocious lamb production. Male lambs fattened during 3 months have yielded a fattening ADG of 226 g/d and a Food Convertion Ration of 5.75 kg DM per kg of weight gain. Consequently, it will be interesting to use the D'Man race performances to improve meat production in Morocco.

It will be interesting as well to take into consideration variation factors determined in this study to apply them in the evaluation carried out by producers of this race.

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Table 1

Arithmetical mean, standard deviation and coefficient of variation of D'Man ewe reproduction performances

Characters	Number	Arithmetical mean	Standard deviation	Coefficient of variation (%)
Litter's size at birth (lambs)	1653	2,41	0,84	34,7
Litter's weight at birth (kg)	1653	6,14	1,63	26,5
Litter's size at 90 days (lambs)	1541	2,20	0,77	34,9
Litter's weight at 90 days (kg)	1541	43,4	12,5	28,4

Table 2

Adjusted mean ± standard error of D'Man ewe reproduction performances

Variation factors	Number	Litter's size at birth (Lambs)	Litter's weight at birth (kg)	Litter's size at 90 days (lambs)	Litter's weight at 90 days (kg)
Ewe's age		*	***	*	***
age≤18 months	313	2,21 ± 0,09 a	5,02 ± 0,17 a	2,01 ± 0,08 a	37,1 ± 1,3 a
18<age≤24 months	240	2,29 ± 0,07 b	5,71 ± 0,13 b	2,09 ± 0,06 a	41,3 ± 1,0 b
24<age≤30 months	207	2,29 ± 0,07 b	5,93 ± 0,13 b	2,16 ± 0,06 a	43,1 ± 1,0 b
30<age≤36 months	290	2,48 ± 0,06 c	6,43 ± 0,11 c	2,27 ± 0,05 b	44,4 ± 0,8 c
36<age≤42 months	209	2,54 ± 0,07 c	6,43 ± 0,13 c	2,28 ± 0,07 b	45,1 ± 1,1 c
age>42 months	394	2,38 ± 0,07 d	6,26 ± 0,14 c	2,10 ± 0,07 a	42,5 ± 1,1 b
Lambing season		***	***	**	NS
Autumn	694	2,24 ± 0,04 a	5,83 ± 0,07 a	2,08 ± 0,03 a	41,9 ± 0,6
Summer	308	2,37 ± 0,06 a	5,86 ± 0,11 a	2,15 ± 0,05 a	42,1 ± 0,8
Spring	651	2,49 ± 0,04 b	6,21 ± 0,07 b	2,22 ± 0,04 b	42,7 ± 0,6
Linear regression (Weight at mating)		** 0,021 ± 0,007	*** 0,048 ± 0,014	* 0,018 ± 0,007	NS 0,169 ± 0,116

The mean values followed by various letters inside a factor are significantly different at a threshold of 5%.
NS > 0,05 * P < 0,05 ** P < 0,01*** P < 0,001

Table 3
Arithmetical mean, standard deviation and coefficient of variation of D'Man ewe reproduction performances

Characters	Number	Arithmetical mean	Standard deviation	Coefficient of variation (%)
Weight at birth (Kg)	3799	2,59	0,43	16,6
Weight at 30 days (Kg)	3420	7,69	1,28	16,7
Weight at 90 days (Kg)	3305	19,8	2,89	14,6
Weight at 135 days (Kg)	2142	28,4	3,74	13,1
ADG 10-30 j (g/d)	3417	166	43	26
ADG 30-90 (g/d)	3366	201	37	18
ADG 90-135 (g/d)	2179	189	47	25

Table 4
Adjusted mean ± standard error of D'Man ewe growth performances

Variation factors	Number	Weight at birth (kg)	Weight at 30 d (kg)	Weight at 90 d (kg)	Weight at 135 d (kg)	ADG 10-30 d (g)	ADG 30-90 d (g)	ADG 90-135 d (g)
Age des mères		***	***	***	***	***	***	*
age≤18 months	633	2,28 ± 0,02 a	7,03 ± 0,06 a	18,7 ± 0,15a	27,6± 0,21a	163 ± 2 a	194 ±2 a	186±3 a
18<age≤24 months	512	2,56 ± 0,02 b	7,78 ± 0,07 b	20,1 ± 0,16b	29,2± 0,27b	171 ± 2 b	205 ± 2 ab	197 ± 3 ab
24<age≤30 months	467	2,71 ± 0,02 c	8,20 ± 0,07 c	20,4 ± 0,17 c	29,6 ± 0,31 c	178 ± 2 c	203 ± 2 cd	188 ± 4 cd
30<age≤36 months	704	2,79 ± 0,02 c	8,16 ± 0,06 c	20,4 ± 0,14c	29,3 ± 0,22 c	174 ± 2 c	204 ± 2 bc	191 ± 3 bc
36<age≤42 months	529	2,82 ± 0,02 c	8,28 ± 0,07 c	20,6 ± 0,16c	29,1 ± 0,25 c	177 ± 2 d	206 ± 2 bc	187 ± 3 bc
age>42 months	954	2,84 ± 0,02bc	8,30 ± 0,07 c	20,6 ± 0,15 c	29,2 ± 0,25 c	176 ± 2 cd	204 ± 2 d	183 ± 3 d
Sex		***	***	***	***	***	***	***
Female	1867	2,57± 0,01 a	7,52 ± 0,04 a	18,4± 0,10 a	26,0± 0,16a	161 ± 1 a	180 ± 1 a	157 ± 2 a
male	1932	2,77± 0,01 b	8,39 ± 0,04 b	21,8 ± 0,10 b	32,1 ± 0,16 b	185 ± 1 b	225 ± 1 b	220 ± 2 b
Birth method		***	***	***	***	***	***	NS
simple	256	3,35 ± 0,03 a	10,5 ± 0,10 a	24,2 ± 0,22a	32,80 ± 0,40 a	234 ± 3 a	234 ± 3 a	189 ± 5 a
double	1342	2,88 ± 0,01 b	8,68 ± 0,05 b	21,4 ± 0,11b	30,6 ± 0,18b	189 ± 2 b	213 ± 1 b	192 ± 2 b
triple	1436	2,43 ± 0,02 a	6,92 ± 0,05 a	18,5 ± 0,12a	27,6 ± 0,18a	146 ± 2 a	192 ± 1 a	190 ± 2 a
Quadruple and more	765	2,00 ± 0,02 b	5,75 ± 0,08 b	16,3 ± 0,18 b	25,0 ± 0,28 b	123 ± 3 b	171 ± 2 b	183 ± 3 b
Birth season		***	***	***	*	***	***	NS
Autumn	1537	2,70 ± 0,01 a	8,05 ± 0,05 a	20,5 ± 0,10a	29,30 ± 0,19 a	174 ± 1 a	208 ± 1 a	190 ± 2 a
Summer	734	2,61 ± 0,02 b	7,75 ± 0,06 b	20,0 ± 0,14b	28,8 ± 0,19 b	168 ± 2 b	203 ± 2 b	188 ± 2 b
Spring	1528	2,70 ± 0,01 a	8,07 ± 0,04 a	20,0 ± 0,10 b	28,9 ± 0,17 a	177 ± 1 a	197 ± 1 b	187 ± 2 b

The mean values followed by various letters inside a factor are significantly different at a threshold of 5%.
NS > 0,05 * P < 0,05 ** P < 0,01*** P < 0,001

Table 5
Arithmetical mean, standard deviation and coefficient of variation Concerning fattening perforamances of D'Man Race male lambs

Caractères	Arithmetical mean	Standard deviation	Coefficient of variation (%)
Fattening initial weight (kg)	23,8	2,3	9,88
Fattening initial age (days)	104,4	14,1	0,1
Fattening period(days)	86,8	5,5	0,1
Fattening final age (days)	191,2	13,8	0,1
Fattening final live weight(kg)	42,5	4,0	9,4
Fattening at ADG (g/d)	226	12	5
Ingestion level (kg DM/Animal /d)	1,30	0,17	13,2
Ingestion level (g DM/kg $P^{0,75}$.dour)	93,4	9,4	10,0
Food conversion ration(kg DM/kg weight gain)	5,75	0,60	10,4
Food conversion ratio (UF/kg weight gain)	5,50	0,75	13,6

Participative evaluation : Rural Communities Development Through Khettaras' Rehabilitation

Proposed subjet : By BOUKHARI

Objectives and results :

1. Refer to the findings of the initial situation before the project's inception ;

2. Refer to the objectives and results fixed for the study and likely to meet the farmers expectations ;

3. Refer to the main problems, constraints and needs formulated at the inception of the project: (main results of ORPDI)

4. In relation to the pre-project situation, animate exchanges with association members to highlight the achievements and failures of actions undertaken in the framework of this project using the method SEPO :

   - Achievement of the project,
   - Failures of the project,
   - Potentialities stressed, and
   - Obstacles encountered

   And participative evaluation made jointly with the pariticipating farmers using the FFOM method:

   - Project's Strong points,
   - Porject's weakenesses,
   - Opportunities appreciated in the framework of the project,
   - Threats that may reduce the durability of actions undertaken in the framework of the project,

5. **Participative evaluation jointly with the participating farmers** :

   - **Relevance** : (objectives/ Needs) actions carried out in the framework of this project,
   - **Effectiveness** : (results/ Objectives) of the undertaken action,
   - **Efficiency** : (cost/ benefit) of the undertaken actions,
   - **Appropriation** by farmers of the undertaken action,
   - **Durability and reproductibility** of the project's actions,
   - **Participation of farmers,** men and women,
   - **Involvement** of women,
   - **Partnership** with local actors, (NGOs, irrigation associations, development local and regional associations, ORMVAT, INRA, Universities, JICA, Private, local collectivities,…)
   - **Technical feasibility** of khettaras facilities and water saving mehtods observed and appreciated by the farmers' activity,
   - **Economic profitability** / Farmers' investments and contributions with respect to achieved results,
   - **Social acceptability** of various types of undertaken actions,
   - **Direct effects** on women's income and farming,
   - **Effects on community development in general, struggle against poverty, water economy and the environment in the arid zones…**

Refer to of problems and needs voiced by men and women farmers and related to :

1- Infiltration losses
2- Site selection for rehabilitation
3- Water shortage
4- Climatic conditions
5- Poverty
6- Isolation
7- Subsidies
8- Procedure complexity
9- Marketing
10- Land isolation
11- Lack of the private sector for joint undertaking with the government
12- Water recession and depletion
13- Litteracy
14- Lack of non farming activities
15- Silting
16- Rural immigration
17- Wind
18- Driking water shortage
19- Loss of olive trees leaves
20- Difficulties in digging tunnels
21- Lack of know how for khettara digging and maintenance
22- Water quality
23- Supervision and guidance problems
24- B*ayoud* (palm trees)
25- Land fragmentation
26- Khettara cleaning
27- Collective land status
28- Farmers low income
29- Technical assistance
30- Community conflicts
31- Floods
32- Young generation abandon the khettaras
33- Lack of hydrogeological surveys in the region
34- Water renewal long cycle….
35- Competition of new other systems : pumping stations
36- Difficulties to extend the khettara in the land of other communities
37- Excessive water use and lack of water saving methods
38- Dispersion of water and land due to inheritance
39- No khettara construction
40- Land slides (sand soil)
41- Lack of water supply dams

Results of the Participative diagnosis (ORPDI)

In this region, we have assessed the main problems related to khettara opertions, as well as the ones related to community sustainable development using the ORPDI method.

Hereinafter are summery of the results according to a analysis based on problems noted in specific field activities.

- Problems related to khettaras

❖ Hydro-agricultural equipment

- Infrastructure
- Farming problems
- Natural environment
- Socio-economical environment
- Market and private services
- Government services and exterior interventions
- Population organizations
- Woman integration in developement

3.1 KHETTARAS' PROBLEMS

- Khettara rehabilitation
- Dam construction upstream of khettaras
- Seguia (earthen canals) maintenance
- Dams construction
- High cost works
- Land slide control
- Pumping stations
- Khettara construction
- Vertical shafts sinking
- Construction equipment
- Silting
- Wells drying up
- Neglect and lack of maintenance
- Digging of wells and pumping stations installation upstream of khettaras
- Irrigation canals construction
- Upstream khettara extension
- Maintenance difficulties
- Prohibition to dig wells nearby khettaras
- Covering khettaras' vertical shafts against pollution
- Population participation in the implementation works

3.2 HYDRO-AGRICULTURAL PROBLEME

- Wells' digging
- Land levelling
- El Oued dam
- Flood water spreading canals
- Construction of groundwater recharge dams
- Seguias maintenance
- Irrigation canals with no lining
- Flood control
- Boreholes' drilling
- Water productivity increase (floods)
- Bridge construction

3.3. INFRASTRUCTURE PROBLEMS

- Problems of paved roads' shortage
- Isolated zones
- Dispensaries
- Access
- Souk
- Electricity
- Drinking water
- Water rotation does not work
- Driking water shortage
- Lack of health centers
- Hospitals
- Junior high schools remotness
- Creation of training centers
- Women's centers (embroidery, dressmaking, textile…)
- Lack of daycare centers/centers with no facilities
- Mosques

- Land offer for housing
- Lack of cellular phones networks
- Postal services
- Youth centers and sport centers creation
- Solid and liquid wastes

3.4 FARMING SYSTEM

- Farming improvement
- Olive tree pesticides shortage
- Intrusion of other activities in farming (tourism…)
- Problem of palm tree *bayoud* disease
- Lack of farming subsidies
- Deficit of wheat harvest
- Farming training
- Imporvement of palm tree quality
- Decrease of livestock
- Low palm tree yield
- Lack of new planting
- Fodder shortage
- Farm land isolation
- Insects
- Low farm production

3.5 PROBLEMS RELATED TO THE NATURAL ENVIRONMENT

- Desertification
- Drought
- Silting
- Erosion
- Sand invasion threathening houses
- Farm land scarcity (High land)
- Wind

- Forest isolation
- Lack of reforestation
- Water shortage
- Bad quality of drinking water (salinity)
- Pollution
- Salinity
- Solid waste

3.6 SOCIO-ECONOMICAL ENVIRONMENT

- Unemployment
- Poverty
- Low income
- Vulnerability, risks lack of social security services
- Rural immigration
- Permanent immigration
- Lack of transportation
- Bad access roads
- Bad quality
- Lack of packing facilities

3.7 MARKET AND PRIVATE SERVICES

- Marketing
- Produce sale
- Creation fo show rooms
- Souk for selling of home made produce
- High cost of power
- No micro credit
- Creation of weekly markets
- Supply of good quality flour
- Labour exploitation (working hours >salary)
- Shortage and remoteness of flour mills

- Shortage and remoteness of public baths
- Lack of public bakeries (ovens)

3.8. POPULATION AND ORGANIZATIONS

- Litteracy
- Population developement
- Lack of agricultural cooperatives (machinery+fertilizers+fodder+seeds)
- Lack of associations

3.9. GOVERNMENT SERVICES AND OUTER INTERVENTIOIN

- Support and subsidies
- Lack of teachers motivation
- Lack of any sort of assistance
- Shortage of agricultural cooperatives (machinery+fertilizers+fodder+seeds)
- Lack of social services
- Lack of micro credit
- Negligence and isolation of local authorities
- Widows with no social support or assistance
- Improvement of education
- Supply to associations textile facilities and materials.
- Association creation : assistance and training
- Medical care : epidemic disease control
- Schools remoteness
- School dining halls
- Teching equipment
- Isolation of government services
- Difficulties caused by the government services

3.10. WOMEN INTEGRATION IN THE DEVELOPMENT PROCESS

- Hard activities and work
- Widows with no support
- Improvement of women’s conditions
- The vacancy caused by rural immigration, local and to foreign countries

- Lack of assistance and support to women
- Lack of medical care
- Disease control
- Agricultural improvement
- Offer to women study opportunities
- Marketing of home made products
- Lack of awareness of the women's role.

4.9. Gender approach and women integration in development :

We hereby present the main constraints and problems met with for women's integration and development according to the GSEA (Gender Socio-economical Analysis) for a sustainable community development through the khettara rehabilitation :

Remotness of health centers
Basic health care access
Lack of hygiene
Problems of childbirth
Infants' death
Undernourishment
Malnutrition
Lack of basic infrastructure
Land isolation
Drinking water supply
Electrical power
Schools remoteness
Absence of junior highschools
Absence of residential school buildings
Lack of women's premisses
Absence of residential establishments
Absence of day-care centers
Poverty
Lack of income generation activities
Low income
Low living standards
Access to means of production
Access to resources
Access to benefits
Access to loans
Financing problems
Water fetching duties
Wood fetching duties
Home work overload
Farm work overload
Marketing problems
Mentality problems
Illetracy
Access to knowledge
Low skill
Access to eduction
Dependance
Social assistance
Social welfare
Nombre élevé d'enfants
Travail non valorisé
Ignorance of own rights
Social status
Social exclusion
Access to succession
Deficient rerpresentation
Shortage of organization
Social and intuitional constraints
Absence de projet de promotion féminine
Participation to self development
Low supervisory support
Manque sensibilisation
Access to information
Girls' schooling
Access to education

4.10. RECOMMENDATIONS

Devolop eligibility criteria of priority khettaras for rehabilition and integrate socio-economical criteria with reference to the actual situation of indicators assessed in the hereby study namely :
Discharge quantitiy and evolution ;
Khettara irrigated areaS ;
Number of Khettara water beneficiaries ;
In addition to irrigation, supply of khettara water as potable water and livestock driking ;
Non existence of other irrigation systems ;
Dynamics and operation of traditional organizations for irrigation management ;
Willingness to participate to costs ; investment and khettara works ;
Willingness to organize locally and in a regional network AUEA (agriculture water' users association) ;
Commitment and involvement in interviews ; responsability for the management of the implemented facilities ;

Include other activities for community development in order to succeed in reviving community life arround the khettara integrating:

Actions concerning women in development trying to meet their daily problems to improve life conditions but above all to promote activities likely to improve their socio-economical situation by reinforcing their capacities (Empowerment) : (refer to results and conclusions of ASEG)

Integrate other categories of populations who do not benefit directly from khettara water but who are related to community life development such as young unemployed people, and develop organizations ; training offered to young people as well as access to micro credit access in order to promote other production activities ; para-agricultural business and services (cooperative of D'Man genetic improvement ; beekeeping cooperatives ; handcraft cooperatives ; oasis rest houses cooperatives ; supplies cooperatives ; packing cooperatives ; equipment maintenance cooperatives ; social assistance cooperatives ; subcontracting cooperatives (Oil mills, Grain mills, textile)

Concerning the rehabilitation of khettara we ought to take into account errors and success of former experiences and learn the lessons therewith trying:
To get involved and take part with the populations starting with the identification of the problems by using the participative diagnoses;
To promote the AUEA by individual khettara ; and only later would it be necessary to encourage regrouping in networks or in the form of unions and federations of AUEA of proximity;
As regards to khettara works, to take into account the gallery dimensions to provide for maintenance and adaptability to changes and gallery bed slope.;
Offer training to young people and promote quality maintenance work of the khettara ; subsidies for the undertakings of khettara digging ; vertical shafts constrcution ; cleaning seguia lining ;…

Concerning the institutional and water rights aspect, review customary law and help in negociations involving the responsible staff and representatives in acceptable spokesmen in order to pursue the amendment of law in force governing the utilization and management of khettara water and their environment :

Negociate and manage neighbour communities conflicts in order to find out the possibilities to sink wells upstream. ;

Ban drillings and pump stations in the khettara water drainage zone (locally a 50 to 100 m radius is admitted meanwhile research in Algeria proved that the impact circle radius is about 500 m) ;

Harmonize vertical shaft sinking located in the same influence zone to avoid depths likely to drain neighbouring khettara water (see Siffa khettaras case)

Salinity and farming in the tafilalet plain :

Impact assessment of irrigation and methodological approach to control water utilizaton

EDDAHBY* L.

* Laboratoire de Géologie Appliquée (G.R.G.A.), Département de Géologie, Faculté des Sciences et Techniques, BP 509-Boutalamine, 52 000, Errachidia, Maroc,
(**E-mail : leddahby@yahoo.fr**).

Abstract :

Negative effects of bad quality water on natural resources (water, soil and plants) are everlasting risks of resources decrease in the near future.

In the Tafilalet plain, these effects follow an accelarated step behind which the main responsable factors are : water quality, irrigation method and the region's climate characteristics (water evaporation of interflow groundwater)

Inspite of the plain's facilities, the irrigation effect problem continues. It is correlative to over utilization of groundwater by a large number of pumping stations, of soil fertility degradation consequent to the utilization of chlorine and sodium rich water and fertilizers. Those effects end up in yield limitation and decay of some plants.

Key words :

Effect, Irrigation, Physical and chimical properties, Salinity, Soil, Water resources, Water utilization control, Tafilalet.

INTRODUCTION

In the Tafilalet region, water resources are extremely decresing by excessive exploitation :

* Unfavorable climatic conditions ;
*Resources excessive utilization ;
* Quality that does not meet the standards.

These new challenges are a threatening danger to the agricultural, industrial and tourist sector development in the region.

Thus, thanks to its historical heritage and its tourist sector activity (palm grooves, sand dunes,…), the region has formerly been the subject matter of many investigations. Along this line and well aware of this problem, we hereby suggest to carry out a synthesis in order to evaluate the irrigation effects on natural resources (soil, water and palm grooves,…) in the region. A quantitative and qualitative management model of these resources in the Tafilalet plain has been elaborated aiming at the preservation of regional heritage.

I- INTRODUCTION TO THE STUDY AREA

I.1- Geographical and administrative background

The Tafilalet plain is located in the South-East region of Morocco (Fig. 1), extending south of the High Atlas ranges within the pre-saharian zone where water shortage is a severe phenomena. The total area is about 630 Km² (5 to 18 km wide and 40 km long). It is bordered to the north by the Infra-cenomanian formation (12 km north of Erfoud). Considering these characteristics, the region is marked by the cropping of the primary era formation that constitute the bedrock (Schist, sandstone which sometimes quartzite and limestone)of the Tafilalet groundwater.

The district is part of Errachidia province. It is divided in two circles:

- Erfoud Circle ;
- Rissani circle.

This region comprises more than 160 ksars which converys that the region is a rural area.

I.2- Socio-economical background

Ethnically, the region is largely varied : the Tafilalet plain inhabitants (FILALA) belong essentialy to arab tribes, but many Ksars are inhabited by berbers : Ait Atta or Ait Marrahad.

The 1982 census resulted in a population of 129,166 inhabitants, distributed in small communities (Douar or Ksar) and Erfoud, Jorf and Rissani centres. Meanwhile the 1994 census outcome is nearly 144,925 inhabitants. These figures indicate that the population's annual growth rate is 1.22 %. To adapt these figures to the size of an irrigated hectar for a normal year, which is the region normal trend, the population would be 9 inhabitants/ha.

The financial resources of Tafilalet plain inhabitants are very limited : the main sources are farming, tourism and some traditional small mining. Indeed, this region's inhabitants are the most affected and deprived among the country's population, forcing them into immigration to the big cities (Meknès, Fès, Nador, Rabat, Casablanca,...).

Farming in the region is traditional and characterized by irrigated food crop produced in small land plots. Date trees are the major tree crop of the plain. It is indispensable and inherent to the region's economical development.

Actually, the date palm tree constitutes the basic farm product as a food source during the drought years and a cash crop as well. In 1994, the number of date trees estimate was 760,000 plants. However, in 1981, the aerial photo coverage estimate of the plants number was 793,000 individual plants. So, a 4 % decrease has been recorded.

I.3- Geological and geomorphological background

The Tafilalet plain is a component of the Quaternary basin. The latter is mainly large erosion depression where clastic formations accumlated from the clearing of the secondary era erosion (Jurassic and cretaceous) and the epigenesis of Ziz, Ghriss, Ferkla and Todgha valleys in the primary era substratum. The deposits encountred in this basin differ largely by their extension, power, distribution and lithological nature (Fig 1.2). The deposits in the Tafilalet plain belong to the recent quarternary (Soltanien), but include, in addition, fluviolacustrine deposits of the medium Quaternary, covered by the previous formations, so that they can not form a layer. The power of this gravely alluvium and silt deposits vary arround 15 and 35m in average.

I.4 – Soil and vegetation

The cultivated soil's composition is alluvium clay silt resulting from many centuries of flood irrigation. Salt deposits, subsequent to evaporation, produce a higher soil salinity on ground surface and an alkalizing trend of groundwater (pumping and flood water irrigation). Outside the irrigated sectors, the soil is little matured due to drastic climatic conditions.

The plain's vegetation cover is rather poor. The cultivated areas are mainly located on Oueds Ziz and Gheris riverbank side lands. The main cultivated species are : date palm trees, olive trees, cereals, alfa alfa, market gardening crops and henna. Irrigation of these crops is done essentially using Hassan Addakhil dam, pumping stations, khettaras and flood water.

I.5- Hydro-geological background

I.5.1- Climate

The region's climate is arid or semi-desertic with a strong continental influence, meanwhile in the valleys and the cultivated areas (palm canopies) a microclimate dominates, different from the surroundings, characterized by humidity and less intensive potential evaporation. Knowledge of this area's climate is still deficient : the pluviometric network is still scant and the number of observation stations is low.

**** Precipitation :***

Rainfall in the Tafilalet plain is irregular in time and space. It occurs in the period between September and April, depending on the years fluctuations. The most rainy months are December and January. Also, we notice a decrease in rainfall from north to south :

Mean annual rainfall : Erfoud = 75mm ;

Rissani = 65mm.

**** Temperature :***

Available information is insufficient (the only useful data are those collected at Erfoud and Rissani). It seems that July is the hottest month and January is the coldest. Maximum day time temperature reach 50°C in Erfoud. Winter months with temperatures below 20 °C are scarce. All summer months are 40° C hot or

more and May may have the same trend as well.

Minimum negative daily temperatures are limited to the period between December and February. From July until September, minimum daily temperatures vary between 10 to 20 °C. Mean value of minimum temperature of the coldest month (January) is – 1.5° C. Mean value of maximum temperature of the hottest month (July) is 37.5° C. Mean annual temperature is 18° C. Mean actual insolation between October 1st and March 31st is approximately 1,350 hours.

**** Evaporation :***

Mean annual potential evaporation (Evaporation pan), in the Tafilalet plain, reaches 2500 mm. The actual microclimate of the palm canopy produces less genuine climatic conditions with a 220 mm maximum potential evapotranspiration (ETP) during July and a minimum of 12 mmm in January, i.e. the annual mean ETP value is 1,200 mm.

The prevailing wind direction is North-East. Chergui (Hot and dry wind blowing from South-East) blows generally in the spring and autumn.

I.5.2 – Hydrology

Oueds crossing Tafilalet plain are Ziz and Rheris. Hydrological measurements are carried out regularly. The interpretation of the available data show some variance of the yearly Ziz and Gheris regimen. Its outline shows two high water seasons, Automne and Spring, separated by two low water periods, during which the discharge is very low or null. Annual mean discharge of these two rivers is repectively 5m^3/s and 3.8^3/s.

I.6- Hydrogeological background

Tafilalet groundwater is located downstream of the system Ziz-Ghriss-Todgha. It is a confined basin between the Cretaceous and the Anti-Atlas. The primary era substratum (schist, quartzites and limestone) is 15 to 35 m deep.

There are two aquifer levels in the plain of Tafilalet:

- At the base layer, conglomerates and lacustrine limestone including gravel layers.
- On top, sand, stones and pebbles, covered with powerful unevenly distributed silt.

Permeability is very high (10^{-3}m/s), but concerning upstream sectors, marly predominates predominate and permeability is very low. As a whole, permeability varies considerably according to lithological heterogeneity of the Quaternary layer. The most noticeable variations of permeability are transversal.

The average transmissivity ranges from 10^{-2}m²/s to 2.10^{-2}m²/s. The mean hydraulic gradient is 2 ‰ and it decreases unevenly and gradually on the way downstream. Storage capacity is approximately 5 %.

The water level map shows neatly many drainage lines (high permeability fossil layers). In addition, Oued Ghris seems to be another drainage line of the aquifer. Aquifer thickness varies between 1 and 19 m and decreases noticeably from north to south and towards the borderlines.

I.7- Water quality

I.7.1- General

Salt content in large quantities in Tafilalet water has two sources:

- Ziz high salt load (1 to 2 g/l in average).
- Evapotranspiration leads to salt concentration in infiltration water.

However, many cycles of basin irrigation practice has considerably accelerated the salinity phenomenon, reinforced by the absence of outlets southward and the utilization of groundwater, which already highly mineralized, salt recycling between the soil and the aquifer.

I.7.2- Groundwater

-a Khettaras

Groundwater chemical quality shows a large unevenness of the salt rate that varies between 1.75 g/l in the khettaras of Jorf and 4.79 g/l in Sifa khettaras.

Triangular diagrams analysis allowed us to conclude that the water features are of the following type:

- Sodium sulphate in Jorf Khettaras;
- Sodium chlorine in Siffa khettaras.

According to **WILCOX** classification we obtain the following classes:

C_4S_3, C_4S_4 respectively in Khettaras of Jorf and Siffa.

-b Wells and boreholes of the plain

We may determine three separate sectors according to the groundwater salinity:

-b1 Tizimi sector - Ouled Zohra

Salt concentrations usually stand between:

4.5 and 5.5 g/l with local peaks of 7.5 g/l.

-b2 Right-bank sector

Salt content is ranging from 6 to 7 g/l with peaks of 8.5 g/l.

-b3 Left-bank sector

Characterized by a high salt content ranging between 5 and 6 g/l with peaks of 8 g/l.

Generally, salt concentration increases moving downstream.

Triangular diagrams interpretation permitted to determine groundwater facies in Tafilalet perimeter which is sodium chlorine in almost all the sector.

-c Wells and boreholes of the Infra Cenomanian

According to water test analysis of some Infra Cenomanian water catchment points, sodium rate is very high such as the one located at Erfoud invert showing dry solid matter ranging from 4.9 to 12.7 g/l.

Facies type of the Infra Cenomanian water is :

∗ Sodium carbonate (F.Ain Elâatti) ;

WILCOX classification diagram shows the following classes:

∗ C4S1 (F.Ain Elatti);

I.7.3 Superficial water

Hassan Addakhil water is slightly mineralized (0.5 g/l at reservoir level). During floods or water flushing, water is loaded while flowing in the river. Mineralization may attain 4 to 6 g/l at Erfoud foundation invert, subsequent to leaching of the gypsum soil penetrated by water (évaporites).

Chemical facies type of this water is as follows:

∗ Sulfate sodium in Hassan Addakhil water ;

∗ Sodium chloride at ElBrouj dam.

According to **WILCOX** classification we obtain the following classes :

∗ C_2S_1 (B.Hassan Addakhil) ;

∗ C_4S_4 (B.Lebrouj).

Remarks:

C1 : Low salt content water (1 to 1.75g) entails no risk for irrigation.

C2 : Medium salinity content water may engender, if no action is taken, a slow saliniation of the soil and decrease the yield of salt sensitive crops.

C3 : High salt content water may engender a fast soil salinization impairing the yield of salt sensitive crops.

C4 : High salt content water may be used to irrigate salt resistant crops only.

S1 : Low alkaline water carrying less than 12% of [Na^+] to the soil absorbing complex.

S2 : Medium alkaline water carrying less than 20 % of [Na+] to the soil absorbing complex.

S3 : High alkaline water carrying less than 27 % of [Na+] to the soil absorbing complex.

S4 : Very high alkaline water carrying more than 27 % of [Na+] to the soil absorbing complex.

Conclusion:

Tafilalet groundwater facies is chlorinated and sodic. It entails alkalinization hazards. This water type can not be used to irrigate only salt resistant plants. However, surface water (Hassan Eddakhil dam) has a good quality.

So, IN ORDER TO COUNTERACT THE GROUNDWATER SALINITY PHENOMENON, ALTERNATE USE OF THIS WATER AND HASSAN ADDAKHIL DAM WATER IS RECOMMENDED.

I.8- Utilization method of water resources in the Tafilalet plain

Farmers alternate irrigation water sources when surface water (dam water) is available. Otherwise, they use groundwater (cooperative or private wells) to irrigate tree crops (palm tree, etc…). Groundwater is mostly in use in spite of its bad quality.

II- Effect of irrigation on water and soil quality

II.1- METHODS AND EQUIPMENT

IN ORDER TO HIGHLIGHT THE MODIFICATIONS OF THE SOIL' PHYSICAL AND CHEMICAL PROPERTIES GENERATED BY IRRIGATION, THREE DISTINCT ZONES IN THE TAFILALET PLAIN (TIZIMI, RIGHT BANK AND LEFT BANK) HAVE BEEN INVESTIGATED. INDEED, BEFORE AND AFTER IRRIGATION SAMPLING HAS BEEN DONE AT EVERY 20 CM INTERVAL AND 120 CM DEEP. THEN ANALYSIS OF THE SAMPLES WAS CARRIED OUT. SOLUBLE SALTS HAVE BEEN DETERMINED, SUCH AS THE IONS : CL^-, SO_4^{2-}, HCO_3^-, CO_3^{2-}, NA^+, K^+, CA^{2+} AND MG^{2+} AS WELL AS THE N, P AND K FERTILIZERS. AT THE SAME TIME, THE CHEMICAL COMPOSITION OF IRRIGATION CANALS AND PUMPING STATION WATER HAS BEEN ANALYSED.

AT THE SAME TIME, CONTROL SOIL PROFILES OF THE SAME TYPE HAVE BEEN INVESTIGATED IN EACH ONE OF THE THREE ZONES, WHERE NO IRRIGATION HAS BEEN APPLIED.

II.2- RESULTS AND DISCUSSIONS

ANALYSIS OF THE FIGURES 1, 2 AND 3 REPRESENTING EACH ZONE REVEALS THAT IRRIGATION CAUSES SIGNIFICANT MODIFICATIONS OF PHYSICAL AND CHEMICAL SOIL CONDITIONS. SOIL TEXTURE, IRRIGATION WATER QUALITY, IRRIGATION METHOD AND CLIMATIC CONDITIONS ARE THE FACTORS THAT ALTER THE EVOLUTION OF THE SOIL'S PHYSICAL AND CHEMICAL PROPERTIES.

II.2.1- EFFECT ON THE SOIL'S PHYSICAL AND CHEMICAL PROPERTIES

According to the tests results and those already carried out by the ORMVA/TF and that concerned a few stations concerning the soil salinity evolution, we notice that :

● ***Tizimi – Ouled Zohra*** **(Fig II.1)** : This zone is located north of the plain. It includes the following sectors: A, B, C, D, E, F and N. The tests carried out in sectors C and F (Fig.1), show that :

* Soils are sodic with increasing downward (6.38 to 9,01mS/cm) ;

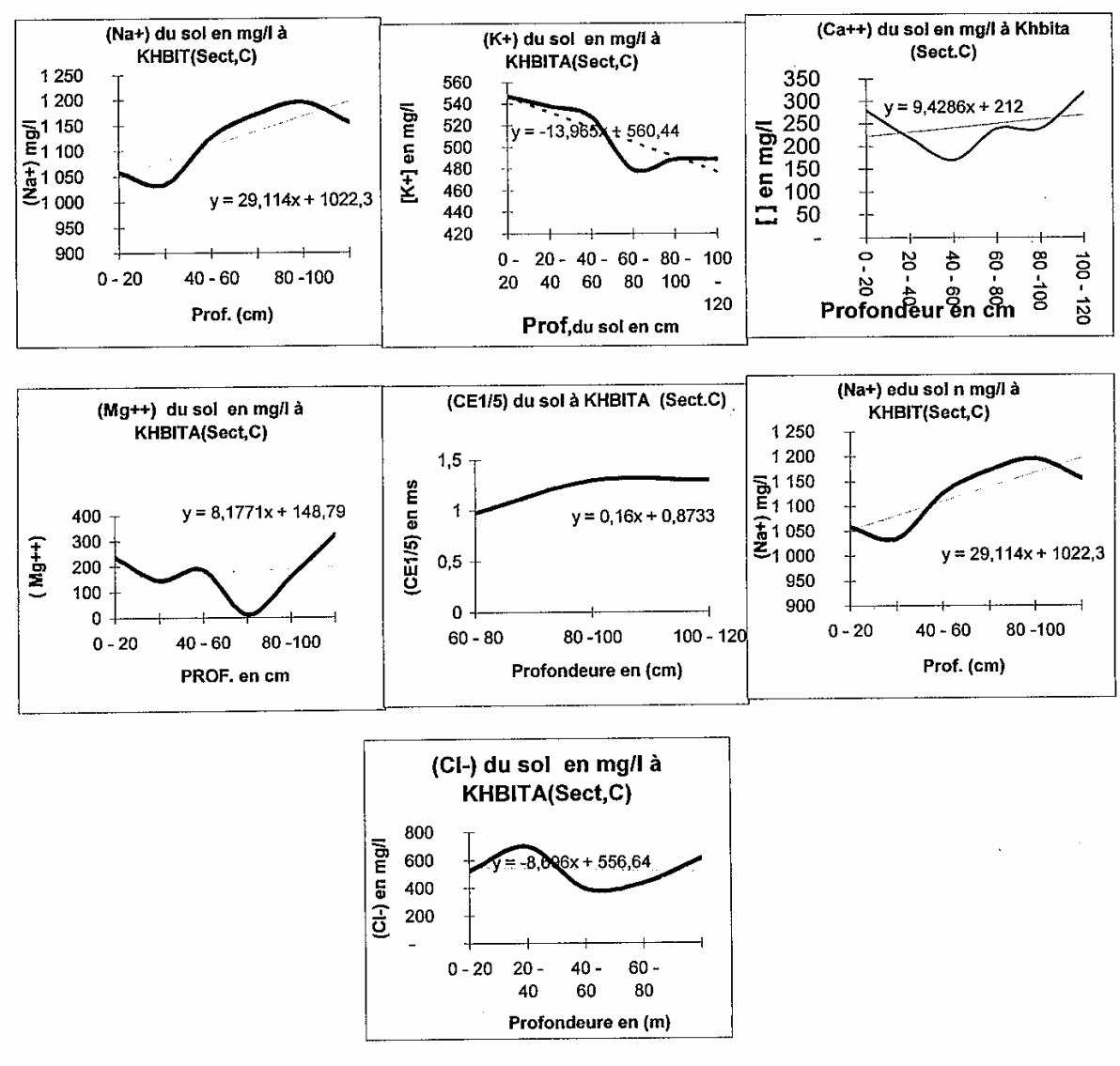
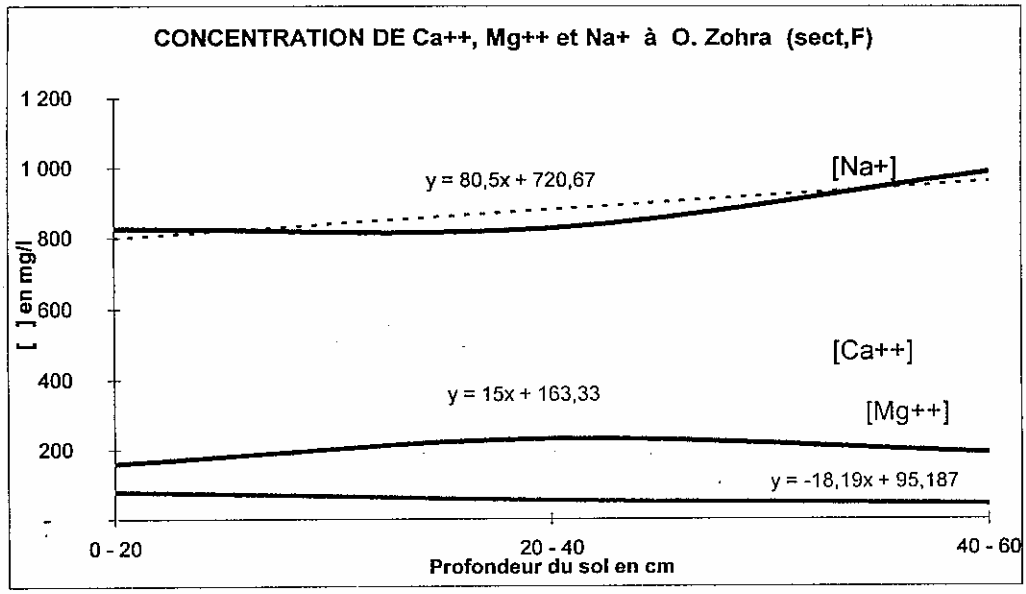


Fig. II.1(A) : Evolution, according to depth, of the soil physical and chemical properties in KHBITA (Zone 1 (Sector C)



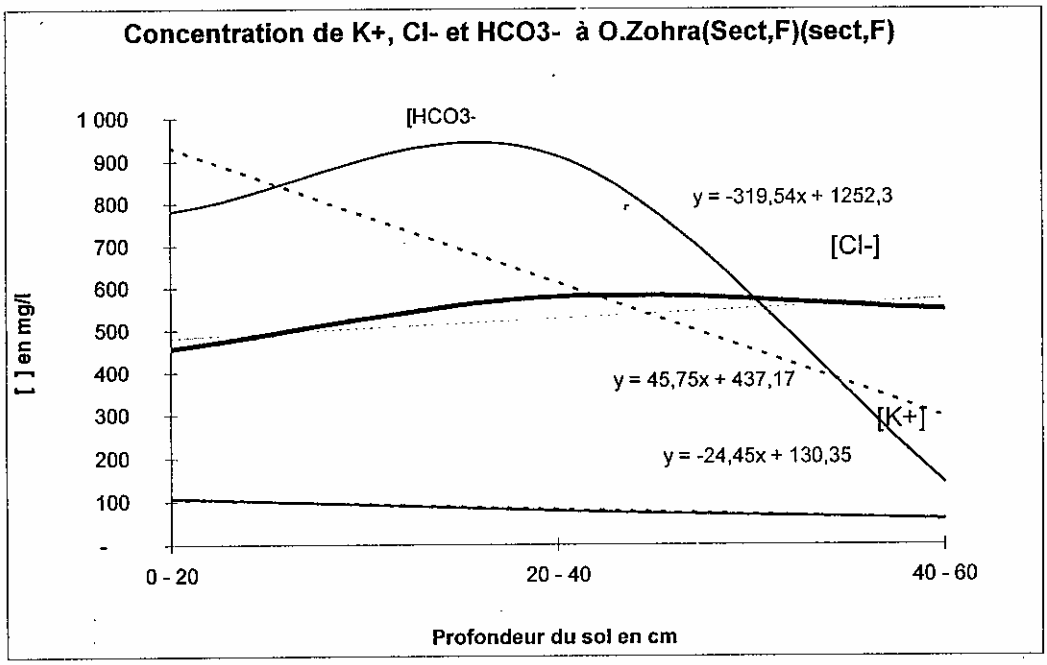


Fig. II.1 (B) : Evolution, according to depth, of the soil physical and chemical properties O. Zohra (Zone 1 (Sector F)

* Sodium, magnesium and calcium content increases with depth, meanwhile potassium decreases (sodium proportion is 60 % of the total cations) ;

* Chloride (more than 70% of the total anions) increase with depth ;

* Bicarbonates tend to increase with depth in Khbita (sector C) meanwhile in O. Zohra they decrease.

Salinization is essentially chloride and sodic. Soil texture allows salt drainage and leaching except in some sectors where they are rather difficult. Irrigation with El Brouj station water brings about a strong mineralization (4,69g de salt/l) and its use should be limited in order to avoid salinization.

● **Oued Ziz right bank (Fig II.2) :** This zone covers the southern part of the palm groove on the Oued Ziz right bank. It aggregates the following sectors : M, O, P, R, S, T, U and V. Dam water is supplied by the canal P3 and the two pumping stations.

The soil has a high salt content, alkalinity is rather low, but the texture (silty, sandy silt and clayey silt), often unfavorable (mpostly in sectors P and V), impeded soil leaching, meanwhile in sector V, the soil is mostly drained (silty texture).

V and P water samples (pumping staitions), show a mineralization rate higher than 7 g/l and a conductivity higher than 9mS/cm.

In sector V, Na^+ and K^+ increase (Na^+ is higher than the total cation) and a slight decrease of Ca^{2+} and Mg^{2+} during the year 1993, meanwhile in 1994, we notice an increase of the latter parameters downward (250mg/l).

Chloride content is higher than 80 % of the total anion and bicarbonates decrease downward.

SOIL SALT CONTENT IS HIGH TO VERY HIGH. EXCESSIVE IRRIGATION AND LOW PERMEABILITY IS LIKELY TO INCREASE DRASTICALLY THE SALINIZATION PHENOMENA. SO, THE GROUNDWATER DRAWDOWN MAY ENTAIL THE INCREASE OF WATER SALT CONTENT, AND, CONSEQUENTLY, SOIL CONTAMINATION.

● **Oued Ziz left bank (Fig II.3) *:*** This zone embraces six sectors : G, H, T, J, K et L. According to the soil tests carried out in sector K, we notice that:

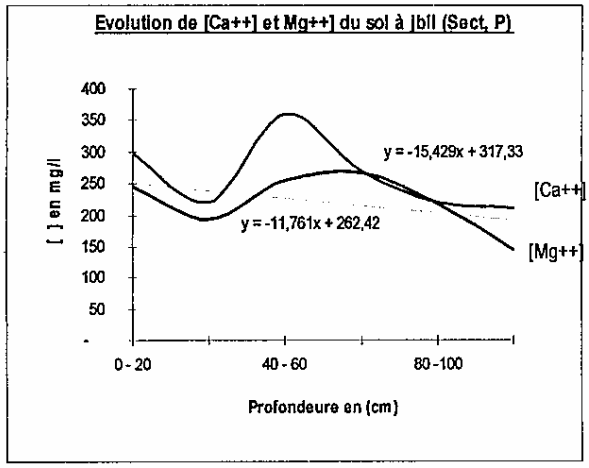
- Sodium represents 60 % of the total cations ;
- Magnesium percentage is 20 % while potassium and calcium are respectively 6% and 12% ;
- Chloride represents 85 % of the total anions and bicarbonates are lower than 15%.

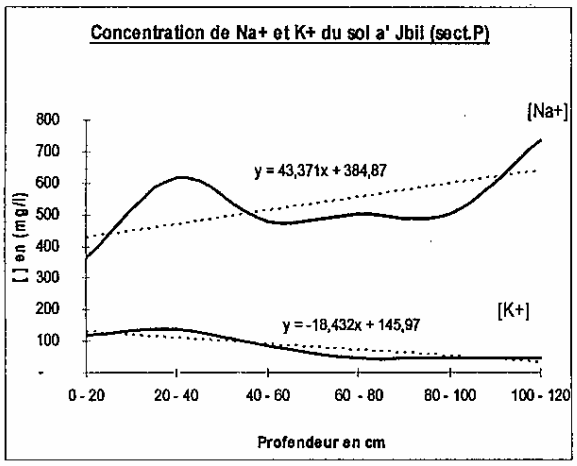
This zone's soils show a chloride sodic salinization and have, in their majority, poor drainage capacity, so that the groundwater use for irrigation increases the salinization phenomenon, meanwhile the dam water irrigated sectors (volume supplied is insufficient) do not entail any salt leaching effect, which causes salt crusts that will have a toll on crop growth (mainly in the zone's outskirts).

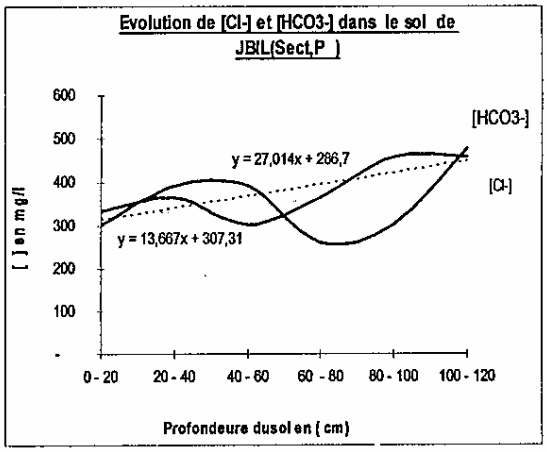
Conclusion :

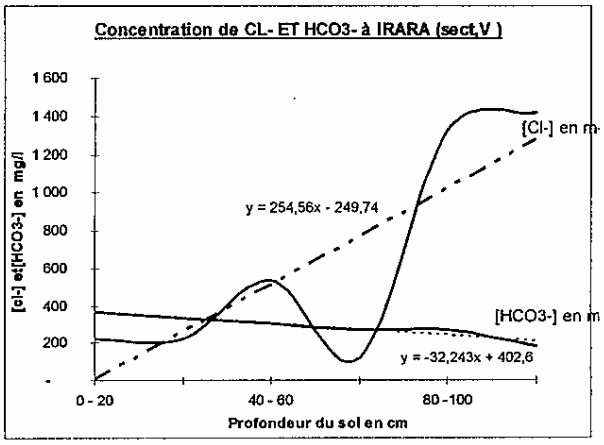
- According to these results, we notice that the salinization phenomenon is heterogeneous.
- More than the soil's 45% is little salty to salty. Salinity of the horizons varies in accordance with fertilizers' application, irrigation and evaporation.
- Less than the soil's 32% is salty. This salinity varies or changes in proportion with groundwater and flood water irrigation (dam water). Desalination of these soils is easy using fresh water in case the soils have a favourable texture (draining soil).

  Less than 23% are very salty or have very salty horizons.









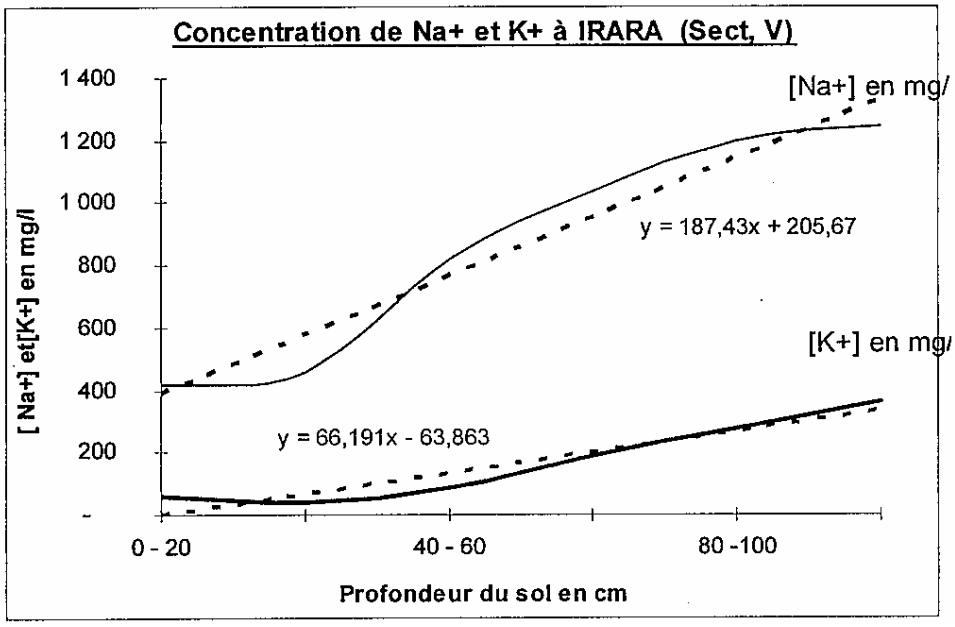


Fig. II.2 : Evolution, according to depth, of the soil physical and chemical properties in Jbil et Irara (Zone 2 (Sectors P et V))

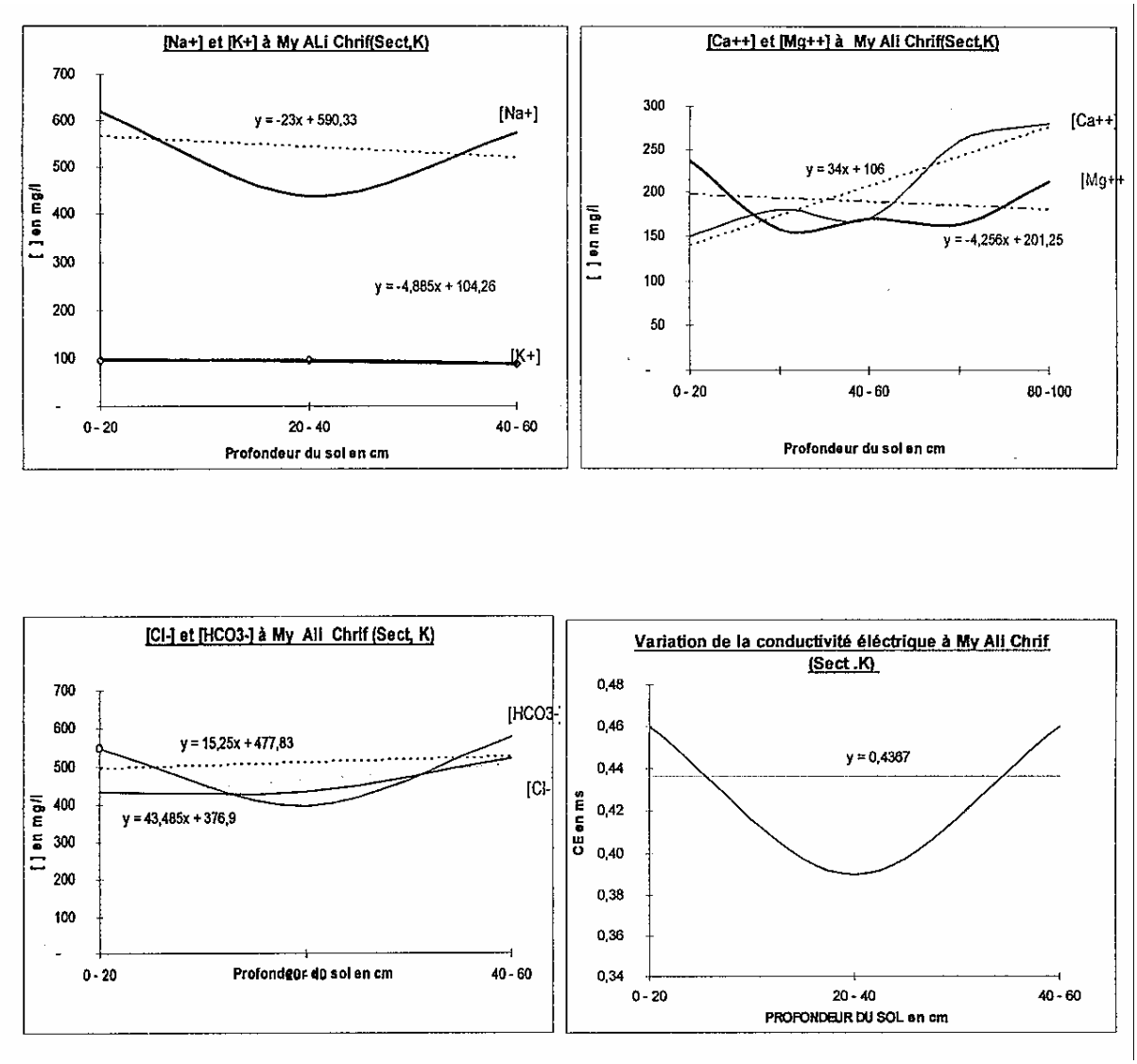
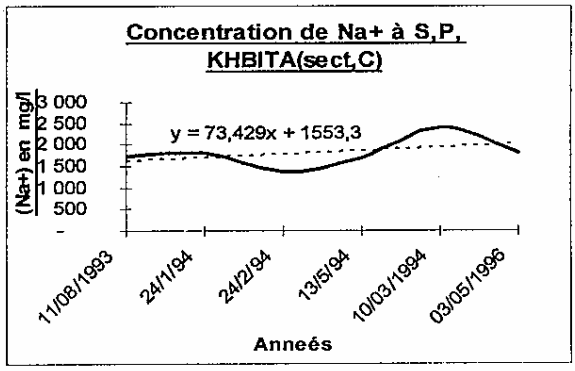
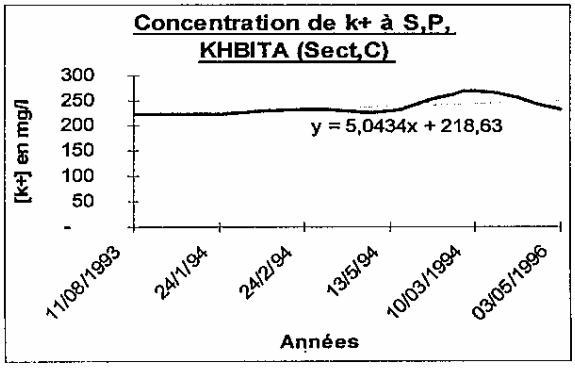
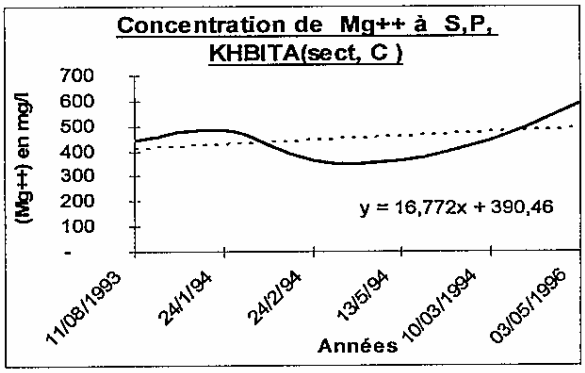
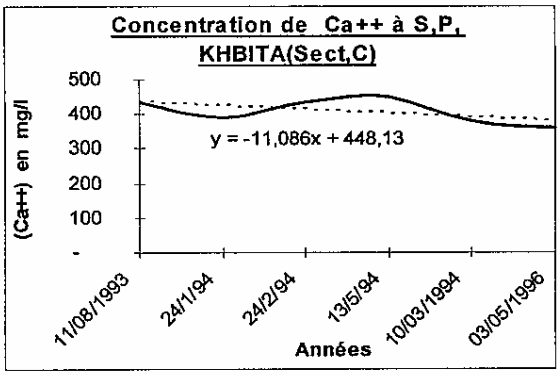


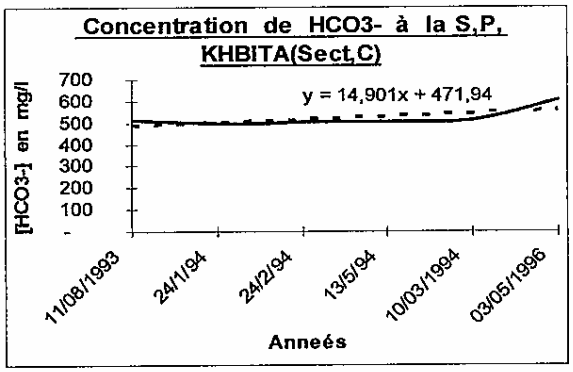
Fig. II.3 : Evolution, according to depth, of the soil physical and chemical properties in My Ali Chrif (Zone 3 (Secteur K))

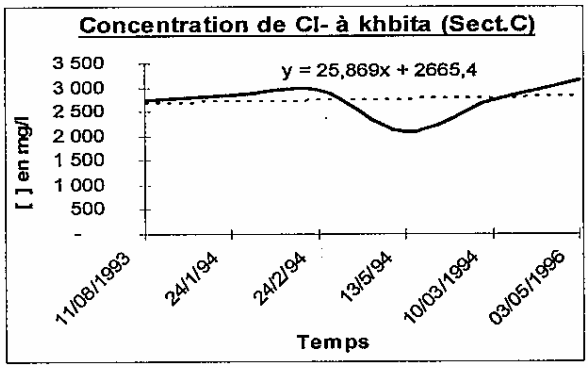


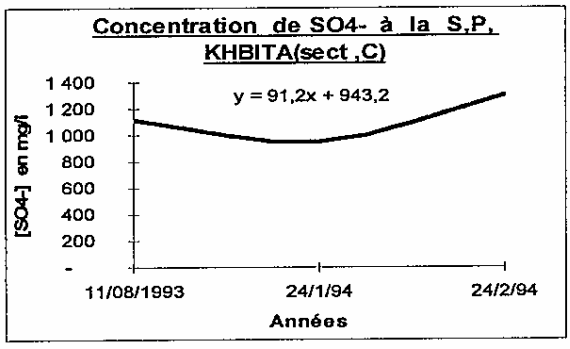


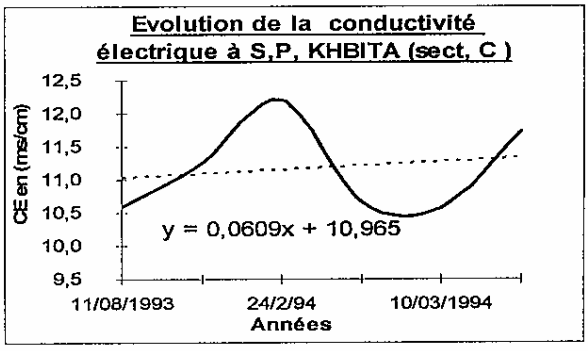




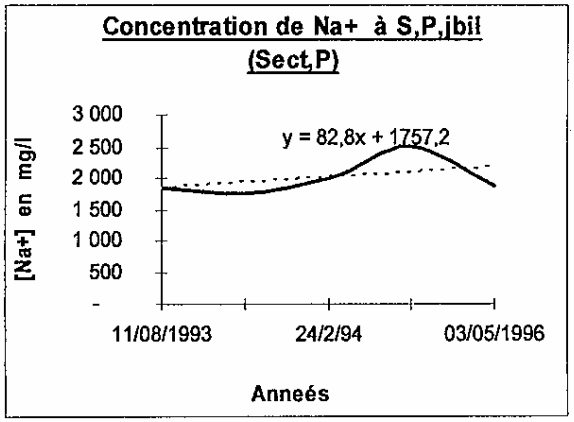


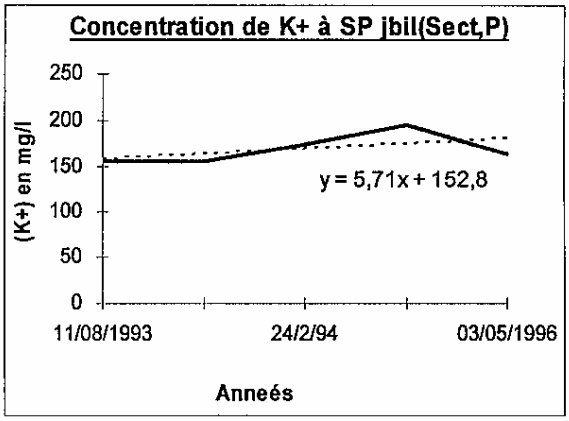


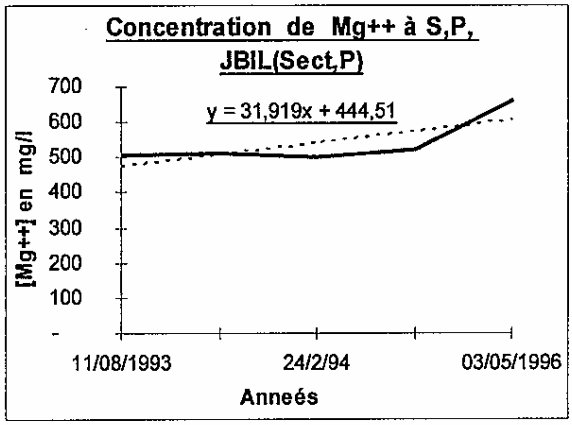


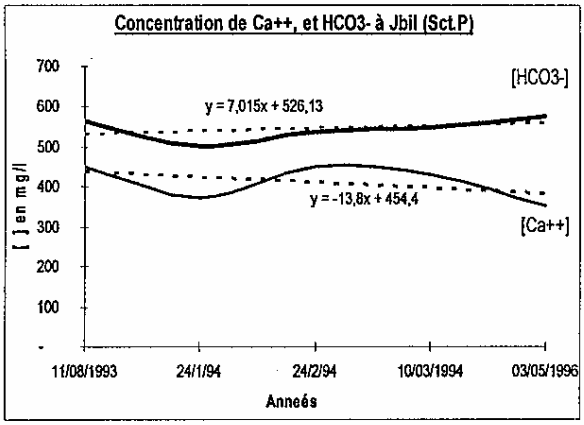


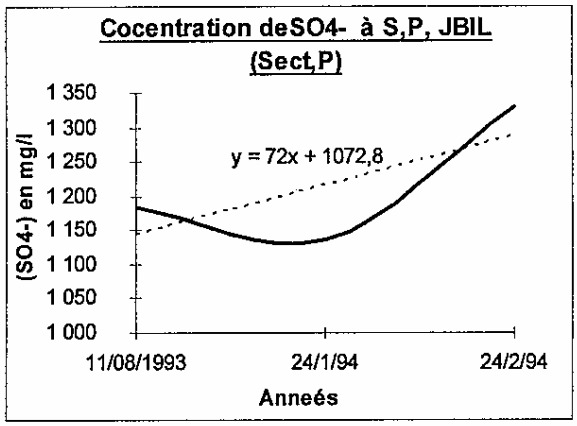
Evolution, timewise, of major ions concentration in zone 1

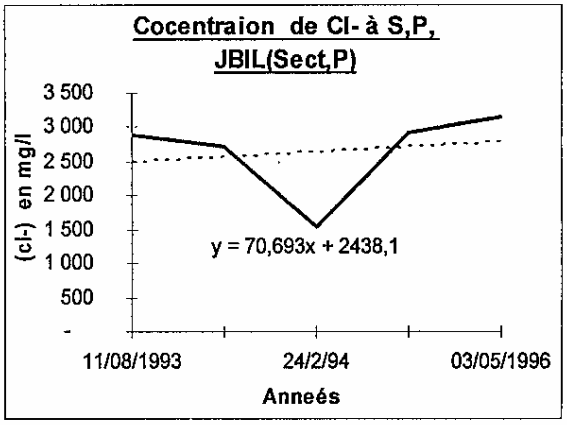


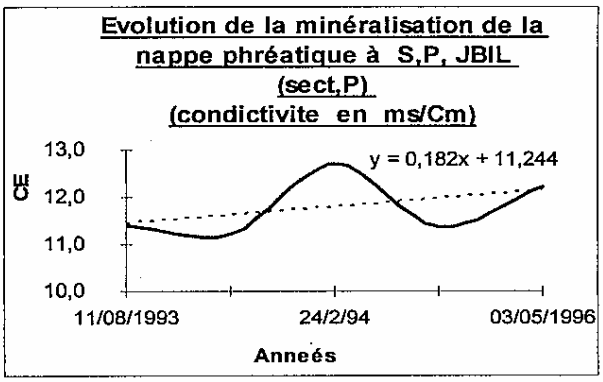




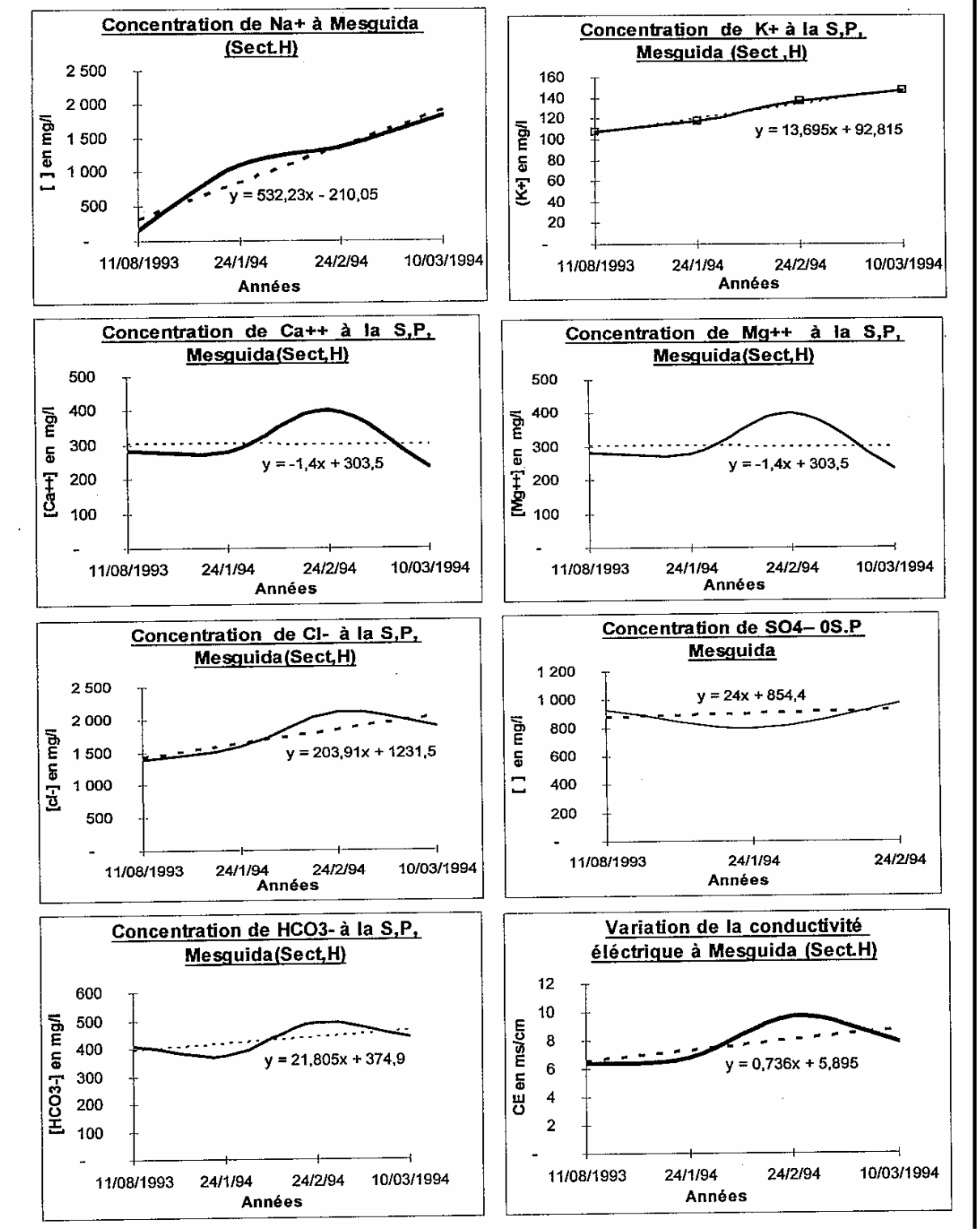








Evolution, timewise, of major ions concentration in zone 2



Evolution, timewise, of major ions concentration in zone 3

III-METHOLOGICAL APPROACH TO WATER UTILIZATION CONTROL

III.1- General

Operational research is a scientific analysis method of the problem in hand, a method particularly orientated towards the search of a better way to understand facts and take decisions likely leading to better results.

Among these optimization methods, linear programming share is significant. Indeed, some consideration shows that most optimization (minimum or maximum) actual problems belong to this class or may be formulated in a similar way. Its target is to extract a better element from the whole set of studies.

Consequently, **DANTZIG (in 1951)** was the first to establish linear programming through the elaboration of an iterative method named « SIMPLEXE » and which will be developed in the long run since it became the major line along which computations are made.

III.2 Definition and fundamental results

III.2.1- General

Linear programming problems arise when we try to optimize (minimum or maximum) a multiple variable linear function, these variables being subjected to linear constraints, i.e., first degree function, generally presented as follows :

$$\underline{\text{Optimize}}\ F(x) = [C]*[X] = \sum_{i=1}^{n} (C_i * X_i)$$

$$\underline{\text{Under the constraints}}: \quad g_i(X) = [A] * [X] = \sum_j (a_{ij} * Xj) \geq 0 ;$$

$$g_k(X) = [F] * [X] = \sum_j (f_{kj} * Xj) \leq 0 ;$$

$$g_l(X) = [D] * [X] = \sum_j (d_{lj} * Xj) = 0$$

$$X = (x_1, x_2 \ldots\ldots\ldots\ldots xn) \text{ de } R^n$$

Where the functions **F** and **g** are linear affine functions of $x_1, x_2 \ldots\ldots x_n$ variables.

We may still suppose that the variables x_i are restrained not to be non negative. Indeed, if there is a variable of any real value, (positive, negative or null), we may replace x_i by the difference $(x_i^+ - x_i^-)$ of the two restrained variables x_i^+ and x_i^-, not taking only negatives values.

III.2.2 Standard format of an linear program

It is commonly known that a linear program is set in standard format if the constraints of non negativity are equalities.

We still may set any linear program under the standard form introducing additional variables named variance variable. To that purpose we will study, hereinafter, only linear programs under standard form of the following type :

$$\underline{\text{Optimize}}\ F(x) = [C]*[X] = \sum_{i=1}^{n} (Ci * Xi)$$

Under contsraints : $g_i(X) = [A] * [X] = \sum_j (a_{ij} * X_j) = [b1]$

$g_k(X) = [F] * [X] = \sum_j (f_{kj} * X_j) = [b2]$

$g_l(X) = [D] * [X] = \sum_j (d_{mj} * X_j) = [b3]$

$X = (x_1, x_2 \ldots\ldots\ldots x_n) \quad R^n$

Where:

n : Number of variables ;

m : Number of constraints ;

[A], **[F]** and **[D]** Constraints real matrixes ;

[b1], [b2] et **[b3]** second members vectors ;

[C] linear cost vector.

Finally, we obtain the following standard table:

x1 x2 x3……..…xn	b
A11 a12 a13……..a1n	b1
a21 a22 a23……...a2n	b2
f11 f12 f13…..……....f1n	.b3
fk1 fk2 fk3…….fkn	bk
d11 d12 d13……..d1n	.bm-k+1
dm1 dm2 dm3…….dmn	bm
C1 C2 C3…… Cn	

III.4. Linear programs' solving

III.4.1 SIMPLEXE Algorithm

Suppose that we dispose of a starting feasable base **[B0]**

([A] = [B, N]). The different stages of the **SIMPLEX** algorithm are the following : **(refer to .Fig.III.1) :**

-a/ [B0] feasable starting base ; iteration **= 0**.

-b/ iteration = iteration + 1.

-c/ let **[B]** common base, **[X] = [Xb, Xn]** the solution of the corresponding base.

Calculate

[b*] = [B^{-1}] * [b]; [P] = [Cb] * [B^{-1}] ; [Cn*] = [Cn] - [P] * [N]

-d/ si [Cn*] < 0 thus fin : optimum is reached.

si ∃ s such as **[Cs*]> 0 alors :**

-e/ Calculate **[Cn*] = [B-1] * [As]** (where **As** is the column **s** of **[A]**).

Si a_{is*} < 0 ∀ i ∈ [1,m] alors fin : non bounded optimum **(+∞).**

Other wise, calculate:

xs' = br* / a_{rs}* = min { bi* / a_{is*} } with **bi / a_{is*} > 0.**

-f/ let **xr** be the corresponding variable to the rth base column, i.e. such as that **[B-1] * [At] = er** (**m** vector whose components are all null except the **r** component equal to **+1**), so the variable s takes the value xs' (enters in the base), the variable **t** is null at **xt' = 0** (leaves the base) ; the common solution **[X']** corresponds to the new feasible base : **[B'] = [B] + {s}- {t}.**

Set [B] = [B'] and return at **b/-**

Geometrically, the procedure is interpreted as a path of extreme adjacent points along the borderline of **S** (S : a set of feasable solutions).

Algebraically, it is interpreted as the determination of a sequence of adjacent bases **[B0], [B1], [B2].....[Bq]** and of solutions bases **[X0], [X1], [X2].....[Xq].**

III.5- Results application and interpretation

III.5.1- Formulation of the linear program

The field of study of our linear program is the Tafilalet plain, which is constituted of three zones. For each sector and for each crop type, we introduce two decision variables: the irrigation volume inflow of Oued Ziz **(Vi)** and that which is brought in as an additional volume through pumping **(Vp).** Thus, the number of overall decision variables **n** is the double of the main crop number cultivated in the farm.

The **« objective »** function is :

F = $\sum_j$ (Cij * Vij) + (Cpj * Vpj)

We target to minimize this function which a mass dimension. Indeed, it reflects salt quantity drained by irrigation water.

This function is submitted to constraints. For each crop, land use tolerates a determined concentration **Ct** ; This is conveyed as constraints in the form of :

(Cij * Vij) + (Cpj * Vpj) ≤ Ctj * Vtj

Where :

Cij : Salt concentration in superficial water supplied to crop **j.**

Cpj : Salt concentration in groundwater supplied to crop **j**.

Ctj : Tolerated salt concentration for crop **j**.

Vij : Irrigation water volume supplied by the network to crop **j.**

Vpj : Irrigation water volume supplied by pumping to crop **j**.

Vtj : Total water requirements of crop **j (Vtj = Vij + Vpj).**

Therefore, the number of constraints are equal to the number of crops. The "**Objective**" function undergoes equality constraints that somehow reflect the total volume needed by each crop (crop water requirements).

These constraints take the form :

Vij + Vpj = Vtj

Since water requirements in the Tafilalet farms are expressed in terms of planted crop water requirements, we proceed to data homogenization taking into account the corresponding areas for each crop category in order to obtain the monthly requirements per sector. These volumes are used for the numerical fromulation of linear programs constraints.

III.5.2- Parameterization and Standard Matrix:

As we have said above, for each crop **j**, we apply two decision variables : supplied volume through irrigation canals **Vij** and the pumped volume **Vpj** .

Thus, the problem in the first phase consists of generating the variance variables for ≤ and ≥ constraints and the artificial variables for ≥ and « = » variables.

Consequently, the generated variance variables are :

$\mathbf{m_1 + m_2}$ against $\mathbf{m_1 + m_3}$ artificial variables with :

- $\mathbf{m_1}$ constraints number **≥ 0**
- $\mathbf{m_2}$ constraints number **≤ 0**
- $\mathbf{m_3}$ constraints number **= 0**

This determines the matrixe **[A]** dimensions**.**

- Columns number : $\mathbf{Np = n + (2* m_1) + m_2 + m_3 + 1}$.
- Lines number : $\mathbf{Mp = m_1 + m_2 + m_3 + 1.}$

In order to limit the study whole set, specially when the solution is unbounded, we have defined two limit vectors:

- Vectors (lower bound) $\mathbf{[I_i]}$ et $\mathbf{[I_p]}$ for interflow and groundwater ;

- Vectors (upper bound) **[S_i]** et**[S_p]** for interflow and groundwater.

CONCLUSION AND RECOMMANDATIONS

The plain's soils may become sterile (loss of fertility) subsequent to salinity and alkalanization. If a solution to this problem is not found, groundwater drawdown and intensive evaporation will lead to more salinization.

Groundwater utilization for irrigation must be as limited as possible because of its salinity and alkalanization potential, so soil salinization must closely monitored in order to sound an alarm at the appropriate moment. We presume that salt removal requires good permeability and drainage.

Concerning surface water (Hassan Addakhil dam water), they benefit to irrigation since their quality is good (soil desalination).

Groundwater quality is a source of worry. Indeed, we notice an increase of chloride and sodium content. The counter measures against this soil and aquifer pollution (salinity) are :

- Utilization of dam water for irrigation ;
- Salt drainage outside of the plain ;
- Utilization of a sand layer on the soil to filtrate irrigation water ;
- Selection of high salt tolerance plants.

ETUDE DE DEVELOPPEMENT DES COMMUNAUTES RURALES A TRAVERS LA REHABILITATION DES KHETTARAS DANS LES REGIONS SEMI-ARIDES DE L'EST SUD ATLASIQUE

P.V DE SÉMINAIRE DE CLÔTURE

19-20 OCTOBRE 2005

- P.V DU SEMINAIRE
- RECOMMANDATIONS GENERALES

OCTOBRE 2005

P.V DE SÉMINAIRE DE CLÔTURE 19-20 OCTOBRE 2005

Le séminaire organisé en cette occasion de clôture de l'étude de développement des communautés rurales travers la réhabilitation des khettaras dans le Tafilalet, a permis à la suite des discussions et débats de soulever un certain nombre de points importants à savoir :

1- Unanimité sur :

- Nécessité d'une approche participative des agriculteurs dans l'élaboration et l'exécution des projets de développement;
- Importance de sauvegarde des khettaras source de vie des oasis;
- Nécessité d'adopter des systèmes à économie d'eau;
- L'importance de l'étude réalisée qui constitue une opportunité de remédier aux problèmes des communautés rurales dans les zones arides.

2- Propositions et compléments d'idées à insérer dans le plan directeur :

- Insister sur le problème de pompage l'ennemi potentiel des khettaras;
- Développer davantage les techniques économes en eau en prenant en considération les particularités par khettara;
- Chercher à exploiter conjointement les eaux de crues et celles des khettaras pour l'irrigation notamment en goutte à goutte;
- Nécessité d'approfondir et d'accorder l'importance nécessaire aux ouvrages de recharge de la nappe;
- Améliorer l'aspect de création d'activités génératrices de revenus en particulier ce qui se rapporte à l'efficacité coût/bénéfice.

PROGRAMME DU SEMINAIRE :

19-10/2005 : 120 participants(dont 100 agriculteurs homme et femme),

20-10/2005 : 70 participants (ORMVA/tf, JICA, DRH, ONEP, Province)

RECOMMANDATIONS GENERALES :

1- Poursuite de cette mobilisation de ces différents acteurs de l'ensemble pour l'aboutissement d'un plan de financement.

2- Projet intégré élaboré dans un cadre d'une approche participative et qui s'intègre bien dans la stratégie globale de l'INDH pour le développement et l'amélioration des conditions de vie des communautés rurales du Tafilalet.

3- Exploitation de la base de données sur les khettaras tout en assurant sa mise à jour et son actualisation.

4- Poursuivre et renforcer les visites commentées au profit d'un grand nombre d'agriculteurs et femmes rurales.

5- Poursuite du processus et dynamisme relatif à l'introduction des systèmes à économie d'eau surtout au niveau des khetrtaras.

6- Aviser les pouvoirs publics pour faire bénéficier les zones de khettaras des subventions de l'Etat en matière d'investissement en système de goutte à goutte.

7- Entamer la recherche de financement du projet en collaboration avec la JICA.

8- Organiser des campagnes de sensibilisation auprès de bailleurs de fonds, et examiner les possibilités d'organiser un séminaire à la fin du projet, pour inviter les bailleurs de fonds internationaux et encore présenter le projet dans sa version finale et faire de la publicité.