Community-Based Optimization of the Management of Scarce Water Resources in Agriculture in Central and West Asia and North Africa

Rainfed Benchmark Site Selection and Characterization

Edited by

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Acknowledgements

The project "Community based Optimization of the Management of Scarce Water Resources in Agriculture in West Asia and North Africa" is run in Morocco by National Institute of Agronomic Research (INRA) and the International Center for Agricultural Research in the Dry Areas (ICARDA). The other partners of this project are the Regional Office of Agricultural Development of Tadla (ORMVAT) and the Directorate of the Development and Management of Irrigation (DDGI). The financial support has been provided by the Arab Fund for the Economic and Social Development (AFESD), the International Fund for the Agricultural Development (IFAD) and OPEC Fund for International Development (OFID).

The project aims (1) to promote the adoption of technologies to increase water productivity and thus guarantee sustainable agricultural production; and (2) to transfer those technologies to other supplementary irrigated areas of Morocco and its satellite sites.

This report presents the results of two workshops conducted in Tadla region. These participatory events involved the stakeholders (mainly farmers) from two communities, Bradia and Ouled Zmam, and researchers and extension specialists.

We acknowledge the contributions to discussion from several other scientists and officials during the workshop.

1. Introduction

Water scarcity in West Asia and North Africa (WANA) is a well-known problem. The problem threatens the economic development and the stability of many parts of the region. With rapidly growing demand for water it seems that water will increasingly be reallocated from agriculture to other sectors. A great proportion of the region's agricultural livelihoods are based on dryland farming systems where production depends on low and extremely variable rainfall. The need for special management of water under conditions of scarcity, based on maximizing the return from each unit of water available for agriculture, now applies to almost all the countries of WANA.

Technologies for improved management of scarce water resources are available. However, many of these technologies are not widely implemented or not seen as feasible by farmers. To address this, ICARDA in collaboration with INRA, Morocco, developed the Community based Optimization of the Management of Scarce Water Resources in Agriculture in West Asia and North Africa project. Known as the Water benchmark project, it is based on community participation in research and development, testing and adaptation of improved water management options at the farm level. The long term development goal of the project is to improve the rural livelihoods in the dry areas of WANA by enhancing the productivity of agriculture, based on the efficient use and sustainable management of the scarce water resources from rainfall, groundwater and surface sources.

The project is run by the National Institute of Agronomic Research (INRA) and the International Center for Agricultural Research in the Dry Areas (ICARDA). The other partners in the project are the Regional Office of Agricultural Development of Tadla (ORMVAT) and the Directorate of the Development and Management of Irrigation (DDGI). The financial support has been provided by the Arab Fund for the Economic and Social Development (AFESD) and the International Fund for the Agricultural Development (IFAD).

The project works in ten countries including Morocco. The Moroccan site represents the rainfed benchmark. The immediate purpose of the Moroccan site of the project is to develop and test, with full participation of rural communities, improved technologies for utilizing the limited water resources available in the rainfed areas.

Morocco has been hit by several years of drought and consequently, is suffering from severe water scarcity. The national agricultural research program is aggressively searching for ways to overcome the problem of water shortages and a number of options for utilizing the existing resources more efficiently have been explored. The option of implementing supplemental irrigation at a large scale as a more efficient practice than conventional irrigation has been adopted at the national level. The focus is on integrating supplemental irrigation in the farming systems and transfer the approach to other areas of the region. Although supplemental irrigation is the focus of the research, all water associated elements and cropping systems using advanced technologies are researched in an integrated manner.

In this study we selected Tadla area as the Moroccan benchmark (Fig. 1). This area is located in a semi-arid region (300 mm average rainfall). Irrigated and rainfed zones within the Tadla area constitute 26,000 ha and 133,600 ha, respectively. The area was chosen because it represents the rainfed areas in Morocco, where farmers have access to limited water. In addition, both groundwater levels and

average rainfall are falling. Two communities representative of the Tadla area were selected to implement the project.

This report describes the first phase of the Water Benchmark project in Morocco. It also considers the site selection process and the results of the characterization of the selected communities.

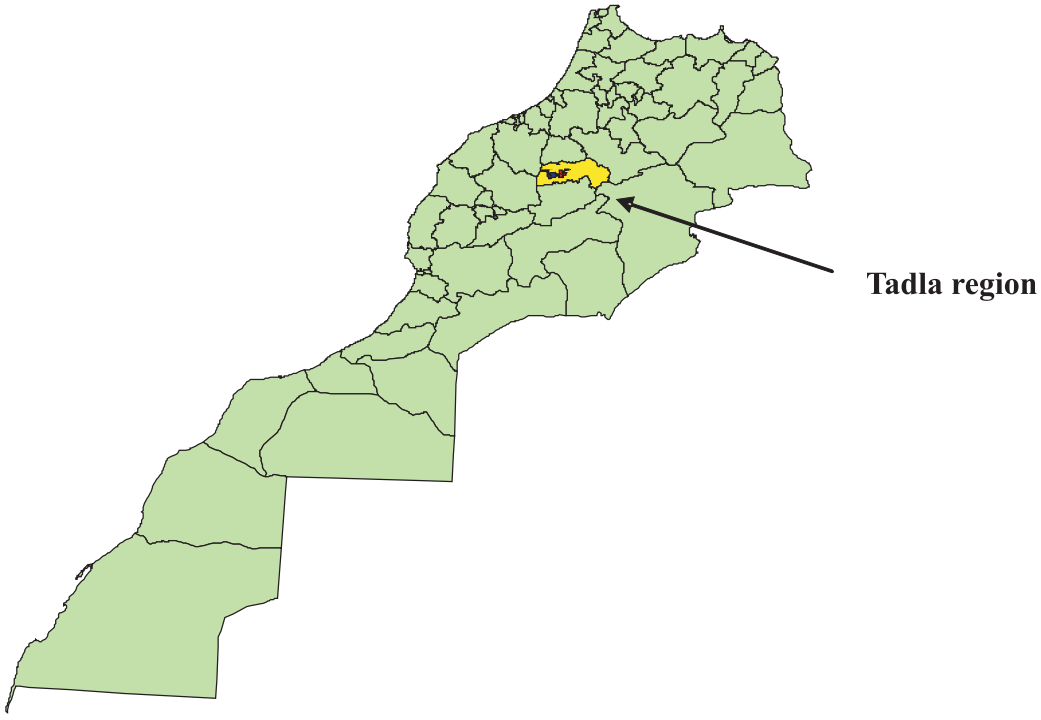

Figure 1. Location of Tadla Benchmark site in Morocco

2. General Characteristics of the Benchmark Site of Tadla

2.1. Characteristics of the irrigated perimeter of Tadla

The irrigated perimeter of Tadla (IPT) is located in the Middle Atlas of Morocco about 200 km south-east of Casablanca at an altitude of 400 m. It is bordered in the north by Khouribga plateau, in the east by Oued Zem plateau, in the west by the river (Oued El Abid) and in the south by the Atlas Mountains (Fig. 2).

2.1.1. Brief presentation of irrigated perimeter of Tadla

The perimeter is a monotonous large plain of 325,095 ha with an arable land area of 259,600 ha. The source of water is Oum Rabia river and its tributaries Oued Srou and Oued El Abid. The perimeter is divided into two zones:

- Rainfed zone called "bour" with an area of 133,600 ha which not only contains cropped land; but also forest, pasture and non productive areas. Although it is mainly rainfed, some farmers have access to irrigation (small and medium scale irrigation);
- Large scale irrigation zone with an area of 98,300 ha that is divided into two sub-zones separated by Oum Rabia river:
  - Beni Moussa sub-zone in the west with an area of 69,500 ha, which is fully irrigated from the Bin El Ouidane dam that was built on Oued El Abid River. This large sub-zone is called Beni Moussa-East and West.

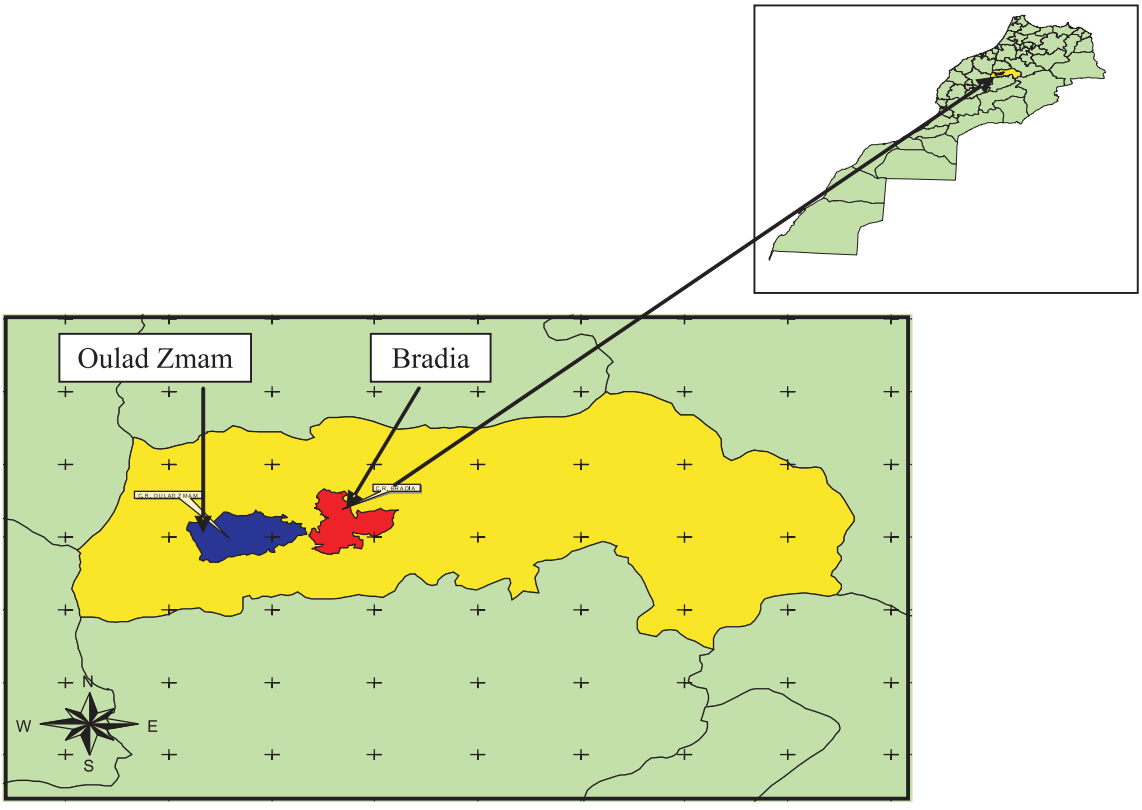

Figure 2. Geographic location of Tadla region and of the two communities covered by the project

– Beni Amir sub-zone in the right side with an area of 27,500 ha, where the water source was Oum Rabia river; but since 2001-02, it became the Ahmed El Hansali dam built on this river.

The dominant crops in the perimeter are cereals. In the bour (rainfed area), cereals cover 51% of the cultivated area and in the irrigated zones the main crops are cereals (19%), sugar beet (5.7%), vegetables (3.5%), citrus (3.4%), olive trees (7%) and forages (10.4%).

2.2. Physical environment

2.2.1 Agroecological characterisation of Tadla region

The climatic data used in the following analysis came from Ouled Gnaou weather station, which is the main weather station in Tadla area. It contains a set of complete climatic information for the period 1970-2003 (33 years data) that allows a deep analysis of general weather conditions and variability in the region. This report describes these conditions and will be completed by another that will deal with the spatialization of the agro-climatic parameters for all Tadla perimeter and the two studied communities (Bradia and Ouled Zmam).

a. Rainfall variability

Rainfall analysis (Fig. 3) shows that, the amount of annual rainfall in Ouled Gnaou varies from year to year. There is no cyclic phenomenon, some years are wet and others are relatively dry. The less rainy years became more frequent in the last twenty years. In general, the amount of annual rainfall tends to decrease. From 1970 to 2003, the average rainfall reduction is about 4.7 mm by year. The annual rainfall variability is very high. In fact, the coefficient of variation is 34%. For the studied period, the highest amount of rainfall (640 mm) was received in 1971 and the lowest (107 mm) was in 1981.
The moving average, represented in Fig. 4, shows a big change in rainfall regime at Ouled Gnaou station since 1981. From 1981 to 2003, the annual rainfall decreased, on an average, by about 100 mm. The average annual rainfall moved from 403 mm in 1970-1980 to 296 mm only in 1981-2003. Also, the variability increased. It was 27% and 36% in 1970-1980 and 1981-2003 periods, respectively.

The Standardized Precipitation Index (SPI) is the difference of precipitation from the mean for a specified time period divided by the standard deviation, where the mean and standard deviation are determined from past records. The standardized precipitation index is used to quantify the

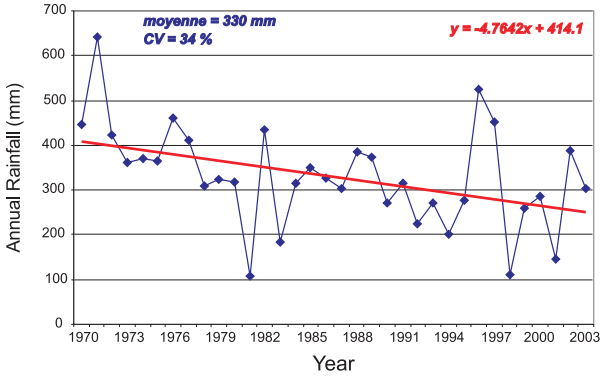

Figure 3. Annual rainfall evolution at Ouled Gnaou Station.

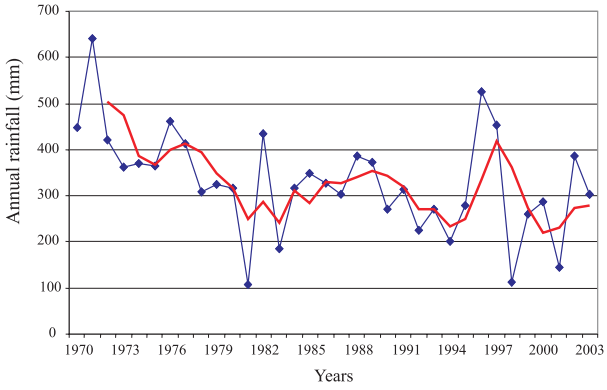

Figure 4. Moving averageof annual rainfall at Ouled Gnaou Station

precipitation deficit for several time scales. A drought event is defined for each time scale as a period in which the SPI is continuously negative and the SPI reaches values of –1.0 or less. A drought begins when the SPI first falls below zero and ends when it becomes positive.

b. Standardized Precipitation Index

The analysis of January-March period (Fig. 5) shows that drought became more frequent during this period that coincides with critical phases of crops (tillering-stem elongation). For the last half decade, this index was always negative for the period January-March, indicating that the occurrence of drought in the middle of the life cycle of crops is becoming more frequent in this area. For the set of the analyzed 33 years data, this index reached its lowest value (–2.92) for the period January-March of the year 2000, indicating an extreme drought during this year. The highest value (+2.06) was recorded in 1996. For the period October-December (Fig. 5), there is a tendency for a little increase of SPI during the last 5 years. Consequently, the SPI analysis suggests that if the trend of drought occurrence is maintained, farmers need to change their crops and water management approach. In fact, the early planting (in October) and water application (irrigation) in January-March may improve yields and water productivity.

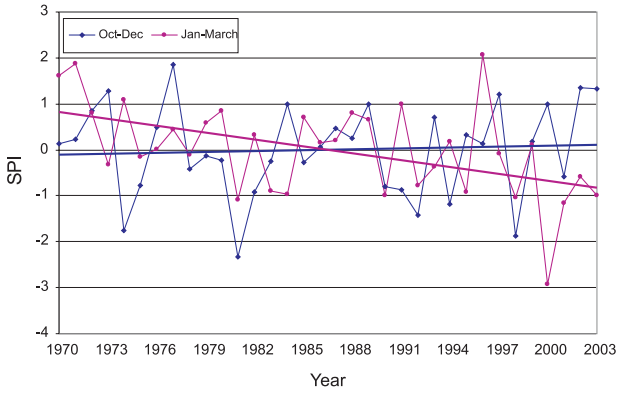

Figure 5. Standardized Precipitation Index at Ouled Gnaou station.

c. First significant rainfall

In semi arid zones, sowing is a critical operation in crop production. An optimal planting date that allows an early good stand establishment can reduce the effect of water stress due to the reduction of soil evaporation and to drought escape. However, the choice of sowing date is a difficult decision that the farmer must make under the conditions where the risk of drought is high. Consequently, the development of a decision-making tool for sowing forecast will be helpful for farmers. For this purpose, the concept of "first significant rain (FSR)" could be seen as an important tool in the decision-making to plan sowings in these areas. The FSR is defined as being the time after October when the first rainfall sufficient for both germination and emergence is received.

The analysis of the first significant rains at Ouled Gnaou station, shows that, for the period 1970-2003, the condition of having 25 mm during 10 successive days was met on about November 7. In 23% cases, it was obtained before October 16, in 46%, between October 16 and November 30 and in 31%, after November 30 (Fig. 6). During 1981, 1985, 1992 and 1998, the defined condition (25 mm of rain during 10 successive days) was not met.

The probability of receiving, in Ouled Gnaou region, the first significant rains on about November 16 is 70% (Fig. 7). Since this station is located in an irrigated area, the farmers can start sowing on November 1, which corresponds to the median (50% of chance).

d. Risks of dry periods

The risks of dry periods is an important element for crop and water management in irrigated zones. The analysis of the risks of dry periods at Ouled Gnaou station, calculated from daily rainfall records from 1970 to 2003, shows that October is the most risky month. However, in spite of the few fluctuations in time, November and December are the least risky and the most

stable. In this area, crop establishment in early November is more desirable; it has to be avoided in October.

Between the middle and the end of the life cycle, the risk of having long dry periods at Ouled Gnaou station is high during February and March (Fig. 8). This risk decreases during April and January. Consequently, it is recommended to irrigate between February and March.

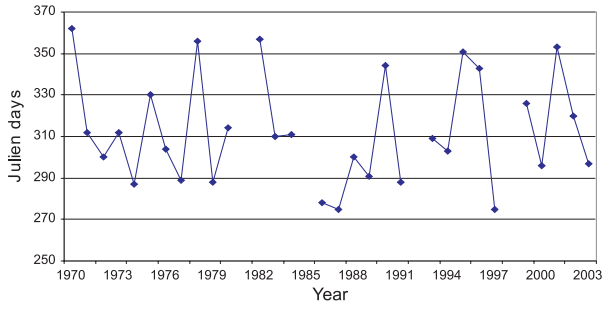

Figure 6. First significant rainfall at Ouled Gnaou station

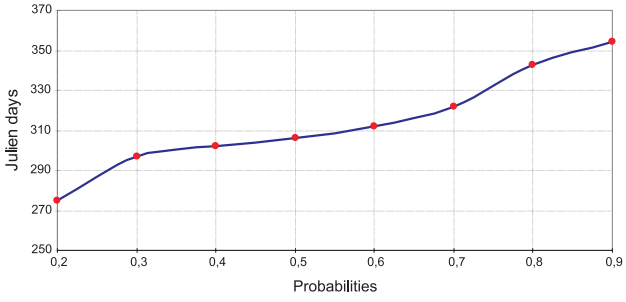

Figure 7. First significant rainfall probabilities at Ouled Gnaou station

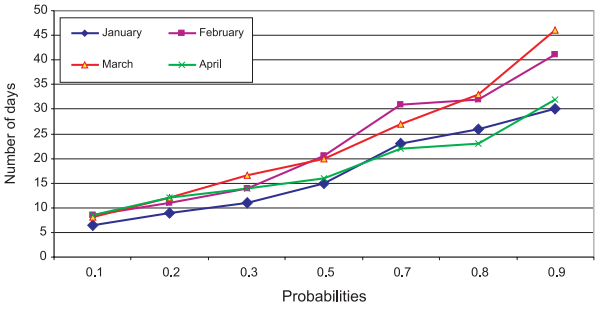

Figure 8. Length of drought periods at the end of season.

2.2.2 Soil and water resources

a. Soil

The most dominant soils in the region are mollisols (soil taxonomy), which are deep and suitable to irrigated farming. Other existing soil types are shallow and have low waterholding capacity. The most important constraint related to soil is the salinity. It comes from two sources: the aquifer (groundwater) and the origin of Oum Rabia river. The salinity level is higher in Beni Amir than in Beni Moussa east and west. This is the main difference among these three zones, because it prevents the cropping of certain species.

Another problem is the pollution of the soil by nitrates due to bad management of nitrogen fertilizer applications. Fortunately, during the cropping season the level of this pollution remains relatively low because a high proportion of nitrates is leached by rain water.

b. Water resources

Surface water. The main river in Tadla, Oum Rabia, originates in the calcareous high plateaus of the Middle Atlas. The annual average flow of this river is 35 m^3/sec with a maximum of 1700 m^3/sec and a minimum of 8 m^3/sec.The most important tributary of Oum Rabia is Oued El Abid, which has an average flow of 32 m^3/sec.

There are two dams in the Irrigated Perimeter of Tadla: Ahmed El Hansali dam built in 2001 across Oum Rabia, which has a total capacity of 740 million m^3 of water; and Bin El Ouidane dam built in 1954 on the west of Oued El Abid, which has a total capacity of 1500 million m^3. A constant decrease of the precipitation has significantly affected the level of storage in the dams. In fact, the available water in these dams does not reach even half of their storage capacity.

The irrigation and drainage network consist of:

- Main canals: 200 km
- Primary and secondary canals: 630 km
- Tertiary canals: 1800 km
- Collectors: 427 km
- Drains: 416 km.

Groundwater. Groundwater resources are composed of two aquifers: the unconfined upper aquifer and the deeper confined aquifer. The evolution of the level of water table is monitored in piezometric stations of ORMVAT and the Agency of Oum Rabia basin. The water level is continuously decreasing because of the pumping of water from wells and the low rainfall. In 1987-1993, and less importantly in 1997-1999, there was a significant rise in the level of water table especially in Beni Moussa region. This recharge was due to high rainfall and infiltration.

Water distribution. The procedure of programming irrigation is based mainly on one hand, on the amount of water stored in dams in the beginning of the growing season and on the other hand on the estimation of applications considering rainfall. The total amount of water allocated to ORMVAT is fixed by the Oum Rabia basin agency at the beginning of the season. ORMVAT, through its Department of Irrigation and Drainage Management, is in charge of the organization of water distribution in the two zones (Beni Amir and Beni Moussa) of the perimeter. The modes of distribution of water differ from one region to another. In Beni Amir, the distribution base is the area (hectares) and in Beni Moussa, it is based on the importance of the crop (sugar beet, alfalfa). These modes pose two problems:

- The problem of adjustment between crops requirements and the conception of the system of water supply. This explains the rigidity of the system of distribution in relation to the new approach of the freedom of crops choice; and
- The problem of water availability at the beginning of the cropping season, which is not a good criterion. This action benefits 27,000 farmers and an irrigation network of 3000 km. The program of water distribution is composed of a certain number of water turns (rotation) among farmers for each growing season. This program is then sent to the Network Management District (NMD) for application.

The irrigation calendar is based on:

- Crops that need to be irrigated;
- Irrigation schedule for each crop, taking into account the irrigation flow;
  - For sugar beet: 8 hr/ha if the flow is 30 l/s or 12 hr/ha if the flow is 20 l/s (= 1 allowance).
  - For fruit trees: 4 hr/ha if the flow is 30 l/s or 6 hr/s if the flow is 20 l/s (½ allowance).

Water turn is in general at weekly (168 hr per week) interval. It handles an irrigation block of 25 to 40 ha and it is distributed among farmers, after taking into consideration:

- The planned crops and their water requirements in the irrigated zone of Beni Moussa; and
- The total area of the farm independently of the grown crops in the irrigated zone of Beni Amir.

Farmers have to present, each week, their water demands to the *aiguadier*, a person who is in charge of collecting all the demands. Each *aiguadier* is responsible for 400 to 1000 farmers, and he, based on cropped areas, determines the duration of irrigation. He also measures the flows at the level of the tertiary and secondary canals taking into account water requirements per block.

Each responsible of the Center of Network Management synthesizes all the demands formulated by the *aiguadier* under his authority; and then sends them to the NMD for a possible water release that is under the control of NEO (National Electricity Office).
Copies of the irrigation programs are sent

to the water distribution agent and to the guard of water-gates, who are in charge of the execution of the pre-established program. The distribution agent regulates the flow at the secondary network and the water-gate guard at the tertiary one. Because of the degradation of irrigation network, some disturbance of water distribution operation (turn approach) can occur and make the farmers unhappy, especially the ones who are on the downstream side of the network.

2.3. Socio-economic environment

It was difficult to get the demographic data of the Irrigated Perimeter of Tadla. Consequently, only some information concerning the population and agricultural products transformation and transport infrastructures are presented in this document.

2.3.1. Population

According to the last agricultural census of 2004 (Recensement, Général de la population et l'Habilat, (RGPH)), the total population of the region (Beni Mellal and Azilal provinces) is 1,324,662 with women representing 50.2% and the population growth is remaining high. From 1971 to 1994, the number of inhabitants doubled.

The structure by age of the population is changing rapidly. The active class represents around half of the population (57% for Beni Mellal). However, it faces the problem of unemployment, which forces the young people to migrate from rural areas to the cities or even to outside the country (mainly to Italy and Spain). The structure by age shows also that the inactive population (less than 15 and more than 60 years old) remains dominant.

2.3.2. Agro-industrial infrastructure

The agro-industrial sector is well developed in the IPT. The manufacturing plants of agricultural products have increased significantly since the independence of Morocco. In fact, the industrial infrastructure was represented by only 3 units of cotton grains shattering. Now, it is more diversified and it is composed, according to ORMVAT (2004), of:

- 3 sugar refineries with a total capacity of 14,400 tons/day;
- 9 modern olive oil factories with a total capacity of 40,000 t/year;
- 496 traditional olive oil factories with a total capacity of 20,000 t/year;
- 1 milk factory with a total capacity of 70,000 l/day;
- 1 animal feed factory with a total capacity of 20,000 t/an;
- 1 freezer unit with a total capacity of 3,000 t/year; and
- Stations of oranges wrapping with a total capacity of 25,000 t/year.

2.4. Characteristics of the two communities

2.4.1. Population

The two communities belong to the district of Fkih Ben Saleh. The number of villages (called Douar) is 17 in Bradia with a population of 31,595. This number is only 13 in Bradia but with 36,530 inhabitants (Table 1). The former community is characterized by its small farm size and this explains why it has a higher number of farmers than Ouled Zmam. The general census of agriculture of 1996 showed a small difference in the number of villages between the two communities; 8 and 21 for Ouled Zmam and Bradia, respectively. This information can be used as a reference because this census is an official document although the monographic data of ORMVAT (2003) postulated figures of 17 and 13 for the two villages, respectively. This difference in data can be explained by the definition of the term "village" used in the two types of monographs. The total rural population of the two communities is estimated at 9967 in Ouled Zmam (Table 2) and 33,732 in Bradia (Table 3).

Table 1. Demographic data

Data	Bradia	Ouled Zmam
Population	36530	31595
Number of villages	13	17
Number of farmers	6415	2998
Number of households	5478	6204

Source: Monograph of ORMVAT (2003)

Table 2. Rural population in Ouled Zmam:

Family groups and villages	Population	Number of households
Oulad Amar	1044	155
Oulad Ahmed	1467	212
Oulad Ghalam	1853	261
Oulad Massoud	1519	228
Ahle Souss	3284	398
Hadrane	253	36
El Hajjaje	321	41
Ouled Mimoune ElHejjaj	226	24
Total	**9967**	**1355**

Source: General census of agriculture (1996)

Table 3. Rural population in Bradia

Family groups and villages	Population	Number of households
N'Ghamcha	738	78
Lahmara	257	30
Ouled Kacem	68	9
Msala	366	41
Bni Aouane	1771	211
Ouled Smida	2003	209
Ouled Zahra	2489	309
Oulad Jbir Labane	692	89
Skhifate	3997	628
Ouled Abdelkarim	501	69
Laassara	4971	607
Lafjagna	1617	213
Daadaa	384	47
Aamar	1511	181
Ouled Khancha	193	26
Ouled Rahou	2858	354
Lamrabta	3473	425
Labbakar	1164	149
Dhara	2194	282
Labhalil	1198	140
Aribtate	1287	149
Total	**33732**	**4246**

Source: General census of agriculture (1996)

2.4.2. Land

Collective land represents 34% of the total area in Bradia and only 23% in Ouled Zmam. In this latter community, the private (Melk) status of land dominates and it is 74% of total area. The small farms represent only 36% in Ouled Zmam and 73% in Bradia. This structural difference between the two communities explains the difference in the way the farmers chose their farming techniques and crops.

2.4.3. Crops

Cereals, sugar beet and alfalfa are grown by both communities. However, Bradia is characterized by the presence of citrus and vegetables and Ouled Zmam by olive trees. Because of salinity problems, milk production is well developed in the Beni Amir. The number of milch cows and of livestock organizations is very high in this region.

2.4.4. Extension services

The two communities rely on the regional extension services of Tadla (Office régional de mise en valeur agricole de Tadla or ORMVAT) for technical advises in agricultural production. Some farmers are members of many cooperatives and associations each having different objectives: sugar beet refinery, milk collection, irrigation management, trade of cereals and livestock. Just for milk collection alone, there are 11 cooperatives in Bradia and 9 in Ouled Zemam.

3. Site Selection

Bradia and Ouled Zmam sites were selected because they are representative of Tadla region, in terms of water sources and agricultural production systems. In fact, irrigation water source is the major criterion used in the selection process. In Bradia site, water is mainly coming from the irrigation network (surface water). While in Ouled Zmam site, the majority of farmers use groundwater in addition to surface water. Concerning agricultural production systems, the main crops grown in the region (cereals, sugar beet, alfalfa and citrus trees) are present in the selected sites.

To select relevant communities, two participatory workshops were conducted, separately, one in Ouled Zmam and the other in Bradia. The main objectives were: 1) to ensure a minimum level of participation of the community through its awareness and its attention to the objective of the project, which is the efficient use of water in supplemental irrigation; and 2) to improve the interaction of researchers with the community members and partners such as Chamber of Agriculture, local authorities, associations, cooperatives, etc.

The following are the specific objectives of the workshop:

- to explain, to the local community, the objective of the project, which is the improvement of water use efficiency in irrigated agriculture;
- to establish a network among the participants so that they address issues of communal interest and communicate better;
- to identify the community, its resources, linkages, potentialities and constraints according to the perception of its members; and
- to agree with community members to host the project demonstrations.

A participative method was used in the workshop. Interactive and flexible approaches were followed, and top priority was given to visualization as stimulus of the communication and capitalization of the information. Different tools were used to reach the assigned objectives: Venn's and fluxes diagrams in plenary sessions and agricultural activities, constraints and potentialities during the groups work.

Before organizing the workshops, many visits of the project team to ORMVAT were organized and contacts with local and provincial institutions established to prepare for the meetings. With the aid of local authorities and ORMVAT staff, potential farmers (35 for Ouled Zmam and 50 for Bradia) who attended this event had been identified. To be efficient and reach the objectives of the workshop, a discussion guideline was prepared by a group of researchers and engineers. It was, then, validated by all scientists involved in the project.

Two similar participatory community workshops were organized on April 12 and 13, 2004.

Each workshop had two sessions; one plenary meeting with all participants and the second small thematic group meetings. The first session aimed at the presentation, by farmers, of the general description of the community and its linkages and fluxes with its environment. This first meeting also facilitated the establishment of communication among participants. The second session, aimed at the exchange of information and discussion of problems concerning the following subjects:

- Agricultural activities (crop and livestock productions);
- Water resources and irrigation; and
- Institutional and socioeconomic aspects related to agricultural production and irrigation water.

3.1. Outputs of the participatory workshops: community of Ouled Zmam

3.1.1. Analysis of actors and fluxes

The importance of fluxes and relationship between the community and its environment is illustrated in Fig. 9. Four institutions have the highest level of relationship with the community. Those are ORMVAT, sugar refineries, milk cooperatives and agricultural bank. Among them, ORMVAT has the highest importance, because it allocates water, ensures maintenance of the irrigation network and provides technical assistance. Other services of ORMVAT are provided in collaboration with cooperatives and associations.

During the meetings, community members raised the problems they had with ORMVAT. These problems are summarized as below:

- Water price has become higher;
- Low technical advice of the farmers and less maintenance of the irrigation network;
- ORMVAT is not anymore involved in the commercial negotiations with the sugar refineries, which have become more powerful than the producers and impose their rules.

Farmers relations with the main partner institutions in the region were also discussed during the workshop. The results ranked ORMVAT as the main partner. The nature of these relations are summarized in Table 4.

The sugar refineries are ranked number two, in terms of services offered to the community. This institution has a monopoly of the marketing of raw sugar beet. It gives advances on the production to ensure the planting of the crop. These advances and loans are paid back by farmers at the end of the growing season with high rates of interest.

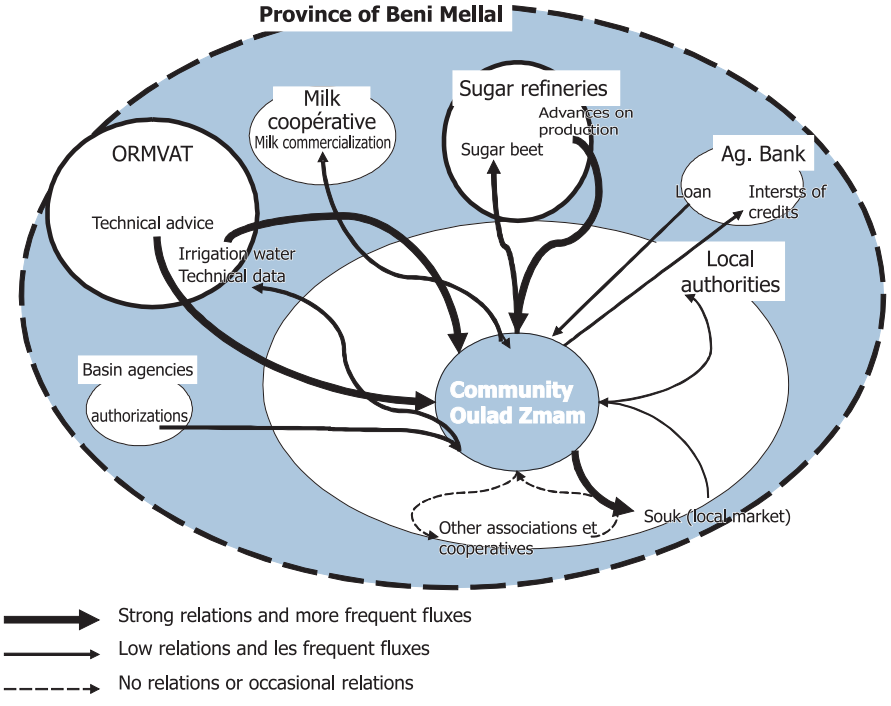

Figure 9. Fluxes and relations between the community of Ouled Zmam and its environment

Table 4. The functions of local institution and community responsibilities (Ouled Zmam).

Type of institution	Services offered by institution	Community obligations	Major problems
ORMVAT	• Irrigation water supply • Extension • Administrative certificates • Maintenance of the network • Rural development (access to village, roads) • Analyses of water and soil • Artificial insemination through cooperatives	• Payment of irrigation water • Payment of soil analyses • Provision of information through surveys • Organization into cooperatives to facilitate the interventions of ORMVAT • Contribution to the success of ORMVAT programs	• ORMVAT is not any more involved in commercial negotiations • ORMVAT is not any more involved in the program of yellow nightshade weed plant control • ORMVAT is unable to maintain irrigation network because of the lack of financial and human resources • Irrigation water allocated is not sufficient • Lack of extension staff
Sugar factories	• Gives money advances to acquire inputs (seeds, pesticides, fertilizers) • Loans • Provides sugar beet pulp	• Provides the raw product (sugar beet) • Payment of advances on inputs • Reimbursement of loans • Payment of the price of sugar beet pulp	• Problem of determination of sugar content by the refinery (underestimated) • Interest on loans is high • Absence of the role of the association of sugar beet growers of Tadla, even if the producers pay the membership • Role of the producers in the evaluation of the product quality • Elimination of the financial contribution of the refinery in the operation of early harvesting of sugar beet • No technical advice is provided by the refinery • Not all farmers are using certified and good quality sugar beet seeds
Milk cooperative	• Marketing of milk • Health coverage for members up to 25% • Facility of payment and provision of feed	• Provision of milk • Payment of membership allowance	• Price of 1 liter of milk paid by Central Dairy is very low • Monopoly of Central Dairy and absence of competition
Agricultural bank	Loans	Reimbursement and payment of interest	• Requirement for guarantee of loans (property title, etc) • Complexity of the procedures of having loans • Requirement of the mortgage operation (complex operation) • Non generalization of exemption from reimbursement of loans under drought situation as it is in rainfed agriculture • High rate of interest • High cost of suing of debtors

All farmers agreed that they have big problems with the refineries. These problems are related to the determination of sugar content and to the quality of the products.

A third important partner of the community is the milk cooperative. This cooperative ensures the collection and purchase of the milk from the cooperative members with a fluctuating price. It also offers payment facilities, provides feed and health (medical) coverage up to 25%. This last service is appreciated by the cooperative members. However, all farmers think that the price of milk remains very low because of the non existence of other milk companies in the region. Central dairy dominates milk market. This situation does not encourage the development of milk production and valorization.

Agricultural bank is an institution that is also important in the region. Provision of loans at short, medium and long terms is the main service provided by this bank. However, the complexity of the procedures and the absence of the mortgage do not encourage the farmers to deal with the bank.

Finally, we notice that there are other important institutions in terms of water management; but with which the community has very limited interaction. They are:

- The Water Basin agency that authorizes the digging of wells. It is also the one that decides how much surface water is allocated to the irrigation network. According to farmers, the agency does not, unfortunately, take into consideration the specificity of the regions when it determines the amount of water allocated;
- Local authority that is involved in the coordination and follow-up of agricultural activities. This institution also plays an important role in ensuring the security and in delivering administrative certificates; and
- Private companies that make available, at local and regional levels, agricultural inputs such as pesticides, fertilizers etc.

Other institutions were mentioned by farmers; but they are not important for them. These are research institutions, livestock producers association of Tadla, certified Seed Company, and others. It has been noticed that the association of sugar beet producers was criticized by the participants. The membership fees for the association are high and taken directly by the sugar refinery when the producers deliver their produce. According to farmers, the association is supposed to protect their interests by ensuring that the delivered sugar beet quantities are correctly determined by the refinery.

3.1.2. Results of irrigation focus group

a. Water resources

There are two sources of water in the community of Ouled Zmam; surface (dam) and underground (aquifer) water. Moreover, there are three sources of irrigation water:

- the first one where the underground (water table) water is the only source (in the case of sector 509) and it is located in a large rainfed area where only 30% of farmers own wells (90-129 m depth). The problems associated with this type of water are the more depth of wells and salinity;
- the second source is a mixture of surface and groundwater, with one-third of water coming from pumping and two-thirds from surface water (case of sector 506); and
- the third source is also mixed, where 1/3 of water comes from the dam and 2/3 from pumping (case of sector 507).

With regard to the irrigation network, it is judged to be very old and it requires rehabilitation. In fact, there is a shortage of water in the downstream of the network because of the non rehabilitation and

degradation of this system. This problem is related also to the surface irrigation system used in this region. Some tertiary canals cannot encourage the introduction of new and high water demanding cash crops (freedom of choice of crops). Also "water turn" procedure (water distribution in rotation among farmers) makes it difficult for irrigation scheduling of different crops.

b. Water use at the farm level

The most dominant irrigation technique is Robta (flooding surface irrigation of small basins). This technique is very old; but it was modified through the reduction of the dimensions and the increase of the number of the basins. This increase is due to the degradation of the leveling of the soil. It is a technique that is well adapted to the farmers' systems of crop production. The disadvantages of the Robta are the high cost of the labor, water losses, reduction of the cropped area because of irrigation furrows (water channels), and high duration of irrigation.

Farmers continue to use Robta because they have not tested any other efficient techniques in this region. Moreover, farmers are not confident in investing in new systems like drip irrigation in which salinity problems can cause the degradation of irrigation material.

Crops that are the first to benefit from irrigation water are sugar beet, alfalfa, wheat (bread wheat), olive trees, vegetables, maize and sesame. However, irrigation of the three last crops depends on the availability of water.

Professional organization

Even if farmers associations exist, they are not functional because of the problem of bad management and lack of membership. According to the farmers, the status of these associations is not clear. Moreover, there is no aid from the State as it was agreed upon with the associations of water users in agriculture. These latter, which are supposed to be involved in

Traditional technique of surface irrigation (Robta)

water management, play only a role in the negotiation of the programs of irrigation and planning. The number of members does not exceed 10% of farmers of the community.

Concerning agricultural products marketing, farmers sell their products individually immediately after harvest. This behavior expresses the level of running into debt by the farmers. Under this situation, it is difficult for farmers to conceive an appropriate strategy of marketing. For example, the milk prices remain very low and vary tremendously from year to year and within the year.

Crop management
In general, agricultural practices do not differ too much from one community to the other. However, the agricultural areas are distinct.

In Ouled Zmam, the most dominant soils are iso-humus (2/3) which is 1 to 2 m deep and calcixeroll (1/3). The problems of salinity of water and soils are becoming worse. The most dominant crops are wheat (durum and bread), alfalfa and sugar beet.

Generally, agricultural mechanization is well developed. Technical packages are specific to the crop and to the system of irrigation used.

- **Cereals**: Summer deep plowing in some situations and the offset disking and drilling are the most dominant techniques used in cereal/cereal rotation. However, the choice of the techniques and tools of soil preparation is influenced by the type of the preceding crop used. For sugar beet as a preceding crop, one offset disking is sufficient. Super-phosphate is incorporated in the soil during its preparation in fall at a rate of 150-200 kg/ha. Urea is broadcasted once during tillering stage at a rate of 200-300 kg/ha when the soil is wet. The rate of seeding is 180 to 200 kg/ha. Only 70% of farmers practice the chemical weed control. Some farmers apply this chemical early and others late. No fungicide is used. The number of irrigations varies from 1 to 5 depending on water availability (rainfall). Achtar and Merchouch are the most used wheat (bread) varieties. The rotations used are wheat/alfalfa and wheat/sugar beet.
- **Sugar beet**: Technical management of sugar beet depends a lot on the income (treasury) of farmers. Nevertheless, the adapted management is well known to most of the farmers. The well identified problems are those related to nematodes and weeds. Irrigation numbers in one cropping season vary from 11 to 14.

The level of production remains medium as compared to the potentialities of the zone. In the case of cereals, the actual yields are divided into three categories according to the techniques used: 5000-6000, 3500 and 1800-2500 kg/ha. Average yields are between 3000 and 4000 kg/ha, depending on the farms size and rainfall conditions. For sugar beet, polarization varies from 10 to 19. The level declared by the refinery presents sometimes big gaps even for harvests within the same plot.

3.2. Outputs of the participatory workshops: community of Bradia

3.2.1. Analysis of actors and fluxes

In general, the fluxes that are seen in the case of Oulad Zmam are the same ones observed in the case of Bradia community. Only the ranking of the four institutions changed. As was demonstrated in the case of Ouled Zmam Community, ORMVAT is the main institution that has the highest level of interaction, with Bradia Community. Farmers ranked the agricultural Bank relation in the 2nd, followed by the milk cooperative and finally the sugar beet refinery (Fig. 10). The services offered by these institutions remain the same. These services and problems related to different institutions are presented in Table 5.

Table 5. The functions of local institution and community responsibilities (Bradia).

Type of institution	Services offered by institution	Community obligations	Major problems
ORMVAT	• Irrigation water • Extension • Equipment and maintenance of networks • Contribution to construction of roads • Animal vaccination • Water and soil analyses	• Water dues • Payment of costs of soil analyses • Provision of information through surveys	• Reduction of the paid water flow • Non adjustment between water supply and demand • Imbalance between the amount of irrigation water released and the annual requirement. • Periods of payment of dues of irrigation water are not well adapted (February after planting of crops). Farmers suggest that payment take into consideration the level of crops production. • Lack of actions of networks maintenance. • Irrigation water dues are high. • Absence of water 'policemen' • There is a link between water allocation and cereal/sugar beet rotation (there is no freedom in crops choice)
Sugar factories	• Marketing of sugar beet • Financing of inputs for sugar beet by credits advances • Credit	Provision of sugar beet	• Ambiguity of the relation between the community and sugar refinery. There is a problem of sugar quality and sugar beet quantity appreciation. • Absence of the role of the association • No change of the prices since 1984 and non application of measures.
Milk cooperative	Sale of milk	Provision of milk to central dairy through the cooperative	Low price of milk
Agricultural bank	Granting of credits	Reimbursement of debts and payment of interests	• Credit is not granted to individuals but to cooperatives • Complexity of the procedures of granting credits • Rates of interest are high. • The amount of annual credit is not enough in the case of small farmers

3.2.2. Results of the group discussion

a. Water resources

The results of the water resources working group can be summarized as follows:

- Around 90% of irrigation water comes from the dam. The rest (10%) is from the aquifer (wells);
- Groundwater quality is low (salinity) and this limits its use in irrigation. However, the level of this use varies from one area to another. Some regions have a good quality water;
- Around 90% of wells are traditional;
- The optimization of water application depends on the conditions of soil surface. In fact, soil leveling allows the uniformity of water distribution in the field. Unfortunately, the use of this technique (leveling) that saves 40% of applied water is observed in the case of only 5% of farmers who own a tractor.

Irrigation techniques

In general, the irrigation techniques used remain traditional and not efficient. In fact:

- 98% of farmers continue to use Robta;
- Only 1% of farmers practice the drip

irrigation and irrigation by siphons. The improvement of Robta is related to the financial means of the farmers. This improvement requires the laser leveling that costs 3000 dirhams/ha (around US$300) which is considered high by the farmers and the maintenance of the canals;

- The alternative for Robta is drip irrigation; but not too many farmers can afford this technique (the equipment is expensive);
- Irrigation water delivery depends on the system of 'irrigation turn' used in the region and on the duration of irrigation controlled by ORMVAT. When the amount of irrigation water provided by ORMVAT (dams) is not sufficient, some farmers who own wells practice supplemental irrigation.

In general, farmers are aware of the importance of using new irrigation techniques in saving water; but they are worried about the cost of these technologies. Farmers are more interested in the output than in the resource saving.

b. Professional organizations

In the community, there are four associations of water users; but most of the farmers are not aware of their existence. These associations are:

- Bin El Ouidane association with 800 members, who do not pay their membership;
- Rahma association with 560-600 members, who do not pay their membership;
- Alfadl association with 500 members, who do not pay their membership; and
- Aloulja association.

These associations play a role in the negotiation with ORMVAT of irrigation canals maintenance and irrigation water release. Some associations even contribute to canals maintenance and repair.

Crop management

Around 40% of farmers resort to a deep plowing followed by 2 to 3 offset diskings. The remaining 60% use the offset disking only. The quantity of fertilizers applied is estimated, on an average, at 200 kg/ha.

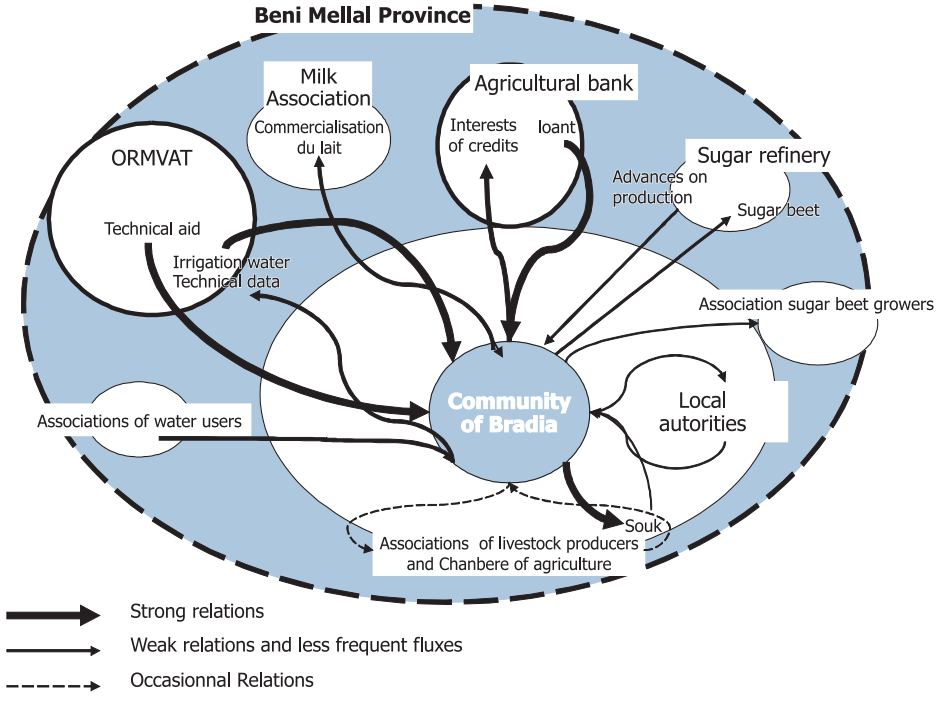

Figure 10. Fluxes and relationship between the community of Bradia and its environment

Most of the farmers broadcast the seeds at a rate of 200 kg/ha. Weed control is taken up when weeds appear. No fungicides are used on crops. Wheat yields under these situations vary from 3000 to 4500 kg/ha. The most dominant rotation is cereal/cereal (70% of cases).

For some farmers who obtain low yields (1000-3000 kg/ha) of cereals, livestock, olive and alfalfa productions provide other means of livelihood. Among the 16 farmers (participants), only 2 grew sugar beet in 2003-04. These farmers avoided growing this crop because of nematodes attack, the low price of the product and the non transparency of the sugar refinery in terms of the determination of sugar quality and quantity of the product.

4. Conclusions and Recommendations

From these workshops and analysis of the monograph of the project zone, we can conclude that possibilities of improvement of water use exist. These improvements depend not only on technical aspects, but also on organization and policy considerations. Most of the problems mentioned during the workshops are related to water, as explained by the following points:

1. Water cost: this problem is linked to the forms of possible valorizations that can be solved by the introduction of new crops that use water more efficiently, the adapted irrigation techniques or the incitement measures in terms of agricultural policies;
2. Decision-making in water management at the canal level: till now, it is the ORMVAT that decides when and how much irrigation water has to be released. This situation does not facilitate the use of certain irrigation techniques such as deficit, supplemental irrigation and drip irrigations. These new alternatives (other than surface irrigation) can be used only when there is a possibility of owning small basins and when communities have the right to participate in dams water release taking into consideration their needs and climatic conditions;
3. Investment in new technologies such as drip irrigation is considered very high by most of the farmers. In fact, the high cost of drip irrigation equipment and the low level of subsidy to acquire this technology do not encourage the farmers to use this technology. Therefore, incitement measures to shift from surface irrigation to drip irrigation are necessary;
4. Lack of knowledge in the domains of irrigation techniques: Most farmers, except the big ones, use the traditional surface irrigation (Robta) that involves a waste of huge quantities of water and a reduction of land use by crops. An improved surface irrigation technique (using land leveling) has been developed; and if used by farmers, it can improve water use efficiency. In addition to this irrigation technique, the other cultural practices including crops and varieties choice need to be adopted by farmers;
5. Organizational aspects: Many organizations (cooperatives, associations) exist in the chosen communities; however, they remain not effective. Only dairy cooperatives seem to be successful.
6. A new approach of integrated management of natural resources, especially water, need to be developed to make the community more involved in irrigation water management in order to improve water productivity.

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