Chapter 2: Rainfed benchmark Site selection and characterization

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M. Boughlala, A. Laamari, M. Karrou, M. Boutfirass, H. Benaouda, B. Benli, A. Bahri, A. Arfani, A. Bouufatma, K. Shideed and T. Oweis

2.1 Characteristics of the TadlaIrrigated Perimeter

The Tadla area was selected as the Moroccan benchmark site for this study, (Figure 2.1). This area is located in a semi-arid region (300 mm average rainfall) and was chosen because it represents the rainfed areas of Morocco and of many other countries, where farmers have access to limited water. In addition, both groundwater levels and average rainfall are decreasing. Two communities representative of the Tadla area were selected to implement the project.

The Tadla Irrigated Perimeter is located in the Middle Atlas of Morocco, about 200 km south-east of Casablanca at an altitude of 400 m. It is bordered to the north by the Khouribga plateau, to the east by the Oued Zem plateau, to the west by the Oued El Abid River and to the south by the Atlas Mountains (Figure 2.2).

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

- The rainfed zone, known as '*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);
- The large-scale irrigated zone with an area of 98,300 ha is divided into two sub-zones separated by the Oum Rabia River:

Figure 2.1: Location of the Tadla Benchmark site in Morocco.

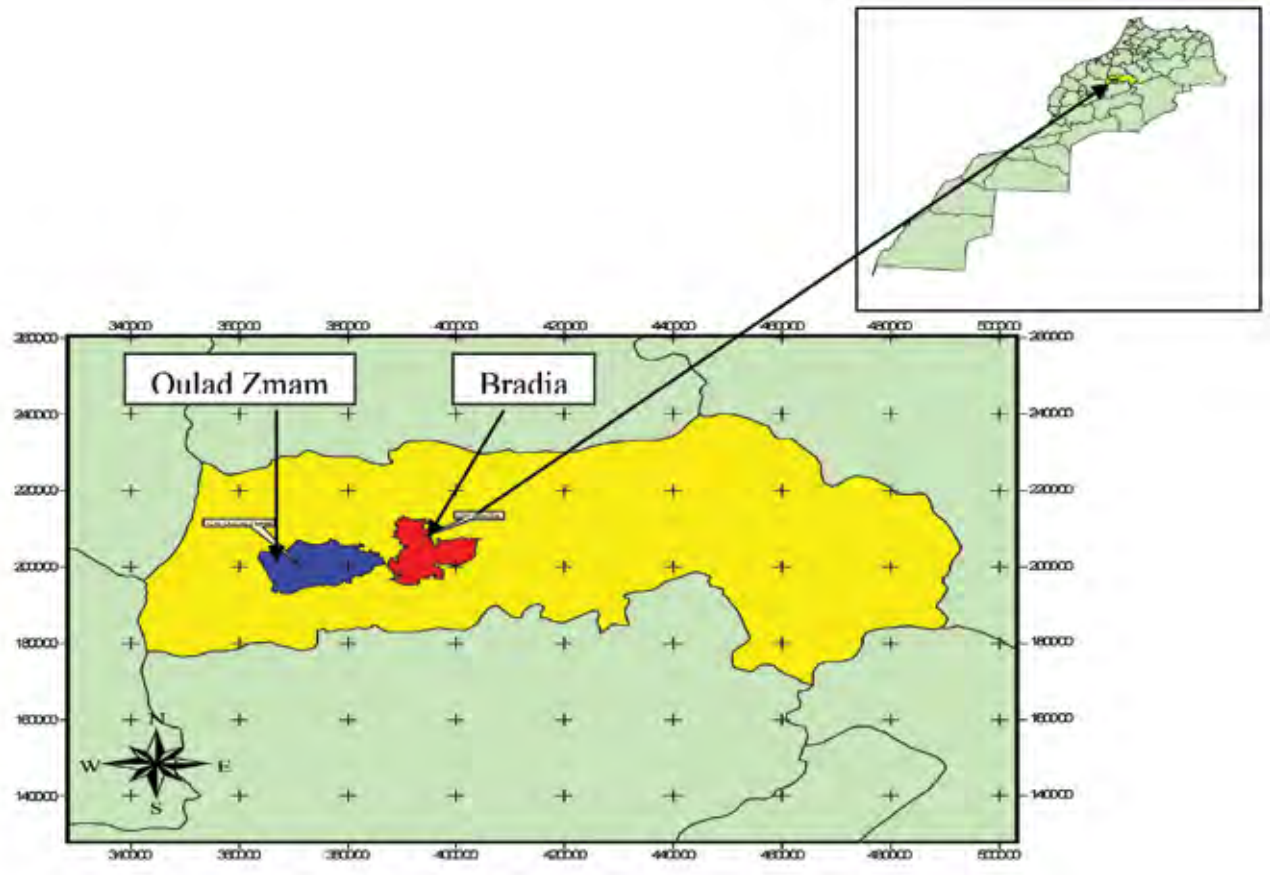

Figure 2.2: Geographic location of the Tadla region and of the two communities covered by the project

- 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 the Oued El Abid River. This large sub-zone is called Beni Moussa-East and West.
- Beni Amir sub-zone on the right-hand side with an area of 27,500 ha, where the water source was the 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 areas the main crops are cereals (19%), sugar beet (5.7%), vegetables (3.5%), citrus (3.4%), olive trees (7%) and forages (10.4%).

Physical environment

Agroecological characterization of the Tadla region

The climatic data used in the following analysis came from Ouled Gnaou weather station, which is the main weather station in the Tadla area. It has a complete record of climatic data for the period 1970–2007 (37 years of data) that allows for a deep analysis of the general weather conditions and variability in the region. This report describes these conditions and will be complemented by another that will deal with the spatialization of the agro-climatic parameters for the whole of Tadla perimeter and the two communities studied (Bradia and Ouled Zmam).

A graphical presentation of the rainfall data (Figure 2.3) shows that the annual amount varies from one year to another. No cyclic phenomenon of wet and dry years is observed. However, the data show that less rainy years have become more frequent during the last two decades and in general, the amount of annual rainfall has tended to decrease. From 1970 to 2006, the average rainfall reduction was about 4.3 mm per year. The annual rainfall variability was very high (CV=34%). For the period studied, the highest rainfall amount (640 mm) was received in 1971 and the lowest (107 mm) in 1981. The moving average, in Figure 2.4, shows the change in the rainfall regime at Ouled Gnaou Station since 1971.

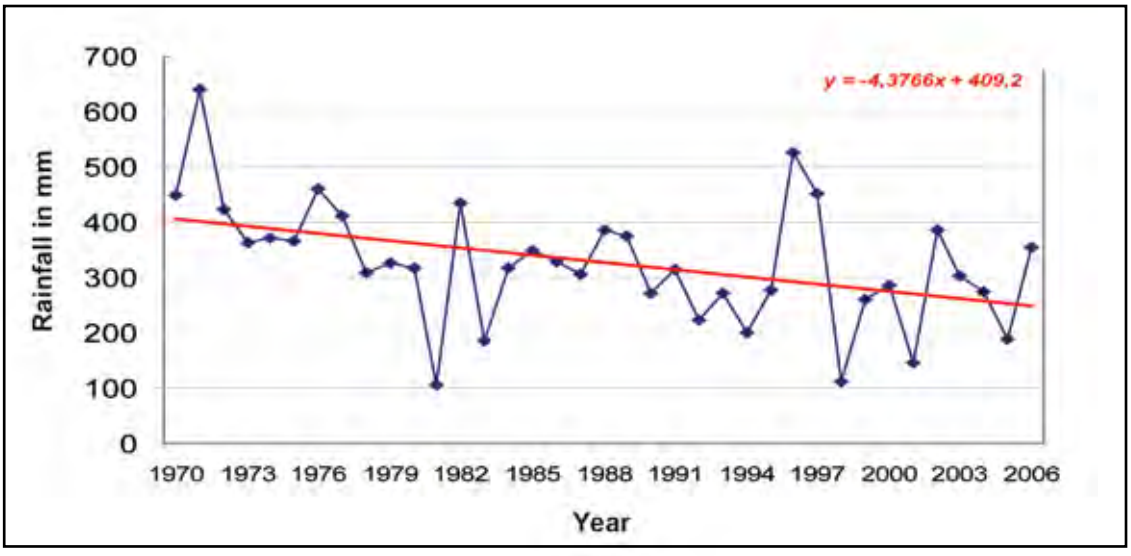

Figure 2.3: Annual rainfall variation in the Tadla area.

The Standardized Precipitation Index (SPI) is used to quantify the precipitation deficit for selected time scales. A drought event is defined for each time scale as a period in which the SPI is continuously negative, reaching values of -1.0 or less. A drought begins when the SPI first falls below zero and ends when the SPI becomes positive. The SPI analysis for January–March shows that the values of the index have decreased and have always been negative over the last five years (Figure 2.5). This means that droughts have become more frequent during this period of the year that usually coincides with the critical phases of crops growth (tillering and stem elongation of wheat). For the set of 33 years' data analysed, this index reached its lowest value (-2.92) for the period January–March during the year 2000, indicating an extreme drought during that year. The highest value (+2.06) was recorded in 1996.

For the October–December period, there has been a tendency for a small increase in SPI over the last 5 years. Consequently,

Figure 2.4: Moving average of annual rainfall at Ouled Gnaou Station.

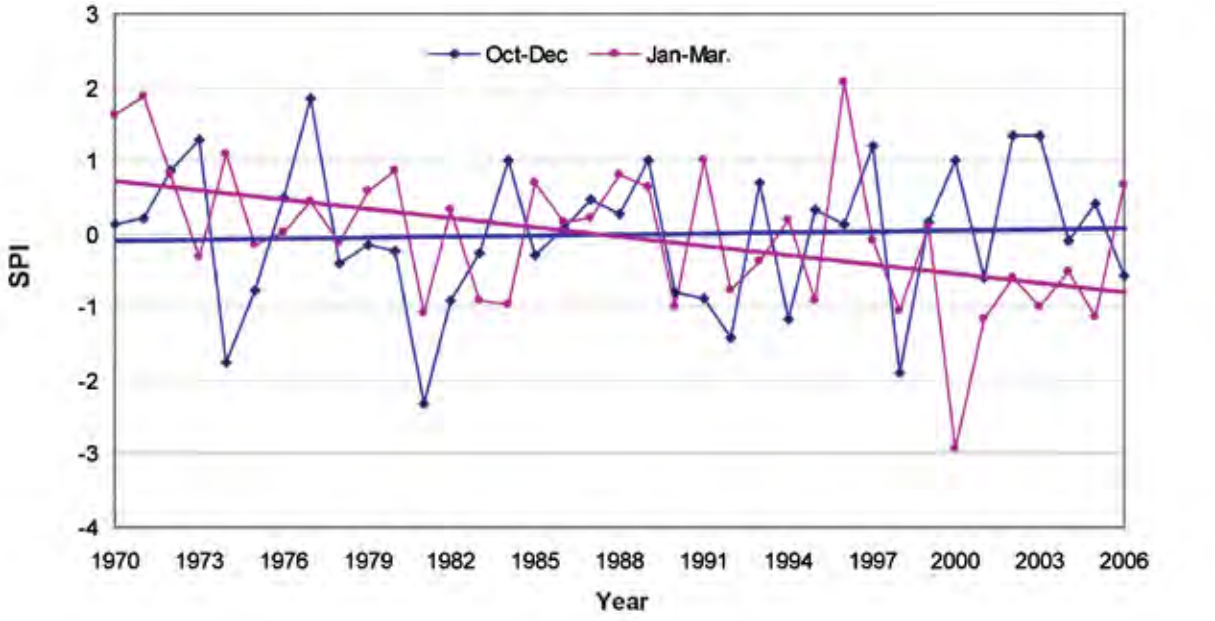

Figure 2.5: Standardized Precipitation Index in the Tadla area.

the analysis suggests that if the trend for the occurrence of droughts is maintained, farmers need to change their water management approach. Early planting (in October) and supplemental irrigation in January–March may improve yields and water productivity.

In semi-arid zones, sowing is a critical operation in crop production. An optimal planting date that allows for the early establishment of a good stand can reduce the effect of water stress due to the reduction of soil evaporation and allow the crop to escape drought. However, the choice of sowing date is a difficult decision for the farmer to make under conditions where the risk of drought is high. Consequently, the development of a decision-making tool to forecast sowing will be helpful to farmers. For this purpose, the concept of 'first significant rain' (FSR) was seen as an important tool in 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.

An analysis of the first significant rains at Ouled Gnaou Station (Figure 2.6) shows that, for the period 1970–2003, the condition of having received a total of 25 mm during 10 successive days was met on about 7 November. This threshold was reached in 23% of the studied time series before 16 October, in 46% between 16 October and 30 November and in 31% after 30 November. During 1981, 1985, 1992, and 1998, the defined condition (25 mm of rain during 10 successive days) was not met.

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

Knowing the risks of dry periods is an important element for crop and water management in irrigated zones. The analysis of the risk 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 a few fluctuations over time, November and December are the least risky and the most stable. In this area, crop establishment in early November is more desirable; it should be avoided in October.

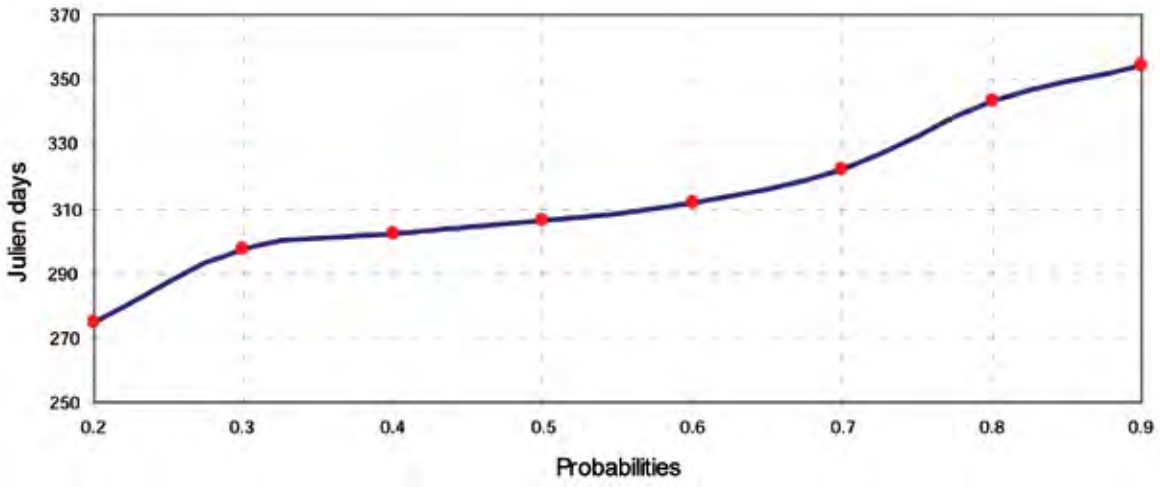

Figure 2.6: First significant rainfall at Ouled Gnaou Station (Tadla).

Between the middle and the end of the growth-cycle, the risk of having long dry periods at Ouled Gnaou Station is high during February and March (Figure 2.7). This risk decreases during April and January. Consequently, irrigation is recommended between February and March.

Soil and water resources

The dominants soils in the region are mollisols (soil taxonomy), which are deep and suitable for irrigated farming. Other soil types are shallow and have low water-holding capacity. The most important constraint related to soil is salinity. It comes from two sources: the aquifer (groundwater) and the origin of the Oum Rabia River. Salinity levels are higher in Beni Amir than in Beni Moussa, both East and West. This is the main difference among these three zones, because it prevents the cropping of certain species.

Another problem is pollution of the soil by nitrates due to inadequate management of nitrogen fertilizer application. During the

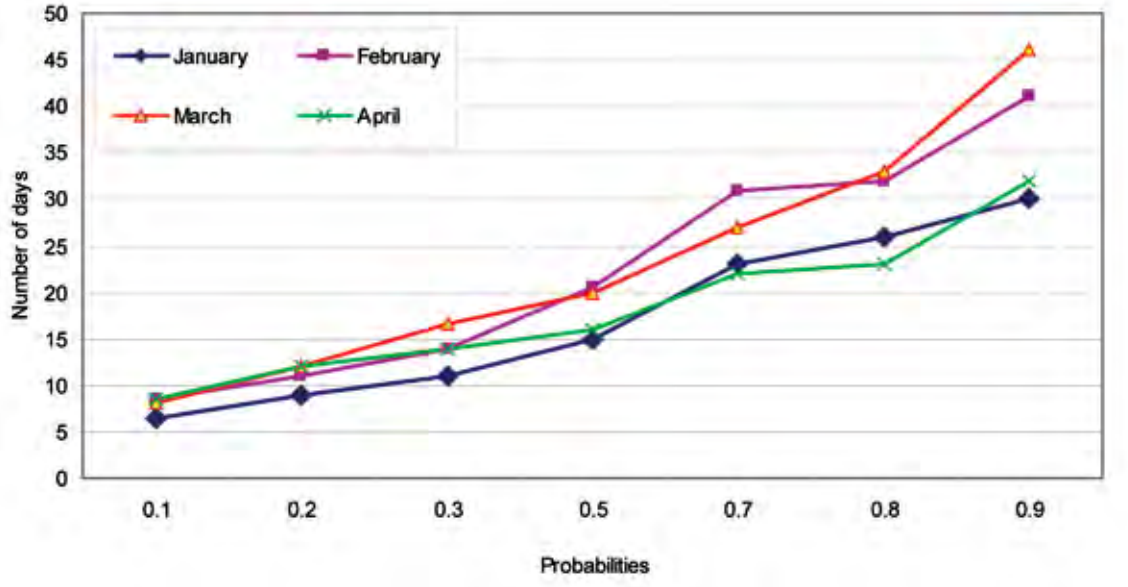

Figure 2.7: Length of drought periods at the end of the season in Tadla.

cropping season the level of this pollutant remains relatively low because a high proportion of the nitrates are leached by rainwater.

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 1,700 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 Tadla Irrigated Perimeter, Ahmed El Hansali dam built in 2001 across the Oum Rabia, which has a total capacity of 740 million m^3 of water, and Bin El Ouidane dam built in 1954 on the western Oued El Abid, which has a total capacity of 1500 million m^3. A constant decline in precipitation has significantly affected the water levels 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 consists of:
- Main canals: 200 km;
- Primary and secondary canals: 630 km;
- Tertiary canals: 1800 km;
- Collectors: 427 km;
- Drains: 416 km.

Groundwater resources comprise two aquifers: the unconfined upper aquifer and the deeper confined aquifer. Changes in the level of the water-table are monitored by the piezometric stations of ORMVAT (Tadla Regional Agricultural Development Agency, Office régional de mise en valeur agricole de Tadla) and the Oum Rabia Basin Agency. The water level is continually declining because of the pumping of water from wells and the low rainfall. From 1987–1993, and to a lesser extent from 1997–1999, there was a significant rise in the level of the water-table, especially in the Beni Moussa region. This re-charge was due to high rainfall and infiltration. This latter was due to inadequate irrigation management.

The procedure for programming irrigation is based mainly on the amount of water stored in the dams at the beginning of the growing season and on the estimates derived from monitoring 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 responsible for the organization of water distribution in the two zones (Beni Amir and Beni Moussa) of the perimeter. The way the water is distributed differs from one region to another. In Beni Amir, distribution is based on the area (hectares) and in Beni Moussa it is based on the importance of the crop (sugar beet, alfalfa). This poses two problems:

- The problem of adjustment between the crops' requirements and the basis of the system of water supply. This highlights the apparent contradiction between the rigidity of the distribution system and the new approach of giving farmers the freedom of choice in the crops they want to plant; and
- The problem of water availability at the beginning of the cropping season. This procedure affects 27,000 farmers and an irrigation network of 3000 km. The program for water distribution consists of a certain number of water turns (water rotation) among farmers for each growing season. This program is then sent to the Network Management District (NMD) for approval.

The irrigation calendar is based on:

- Crops that need to be irrigated;
- The 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/ha if the flow is 20 l/s (1/2 allowance).

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

- The planned crops and their water requirements in the irrigated zone of Beni Moussa; and

- The total area of the farm independent of the crops grown in the irrigated zone of Beni Amir.

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

Each official at the Center of Network Management compiles all the demands supplied by the '*aiguadiers*' under his authority; and then sends them to the NMD requesting a water release which is under the control of the National Electricity Office (NEO).

Copies of the irrigation programs are sent to the water distribution agent and to the water-gate guard, who are responsible for 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 deterioration of the irrigation network, some disturbance in the water distribution operation (water turn approach) can occur and make the farmers unhappy, especially the ones who are on the downstream side of the network.

Socioeconomic environment

It was difficult to obtain comprehensive demographic data for the Tadla Irrigated Perimeter. Consequently, only some information about the population, the transformation of agricultural products and the transport infrastructure is presented in this document.

Population

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

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

Agro-industrial infrastructure

The agro-industrial sector is well developed in the irrigated area. The number of agricultural product processing plants has increased significantly since independence. In fact, then the total industrial infrastructure consisted of only 3 cotton seed processing units. Now, it is more diversified and is composed, according to ORMVAT (2004), of:

- 3 sugar refineries with a total capacity of 14,400 t/day;
- 9 modern olive oil factories with a total capacity of 40,000 t/year;
- 496 traditional olive oil processing units 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/year;
- 1 freezer unit with a total capacity of 3,000 t/year; and
- Orange packing stations with a total capacity of 25,000 t/year.

2.1.1 Characteristics of the Tadla communities

Population

The two communities belong to the district of Fkih Ben Salah. The number of villages ('*douar*') is 17 in Ouled Zmam with a population of 31,595. There are only 13 in Bradia but with 36,530 inhabitants (Table 2.1).

Table 2.1: Demographic data.

Data	Bradia	Ouled Zmam
Population	36,530	31,595
Number of villages	13	17
Number of farmers	6415	2998
Number of households	5478	6204

Source: ORMVAT (2003).

The data of the 1996 general census of agriculture, show that there are 8 villages in Ouled Zmam and 21 in Bradia (RGA, 1996). This information can be considered definitive as the census is an official document, even although the data supplied by ORMVAT (2003) suggests that these numbers are 17 and 13 for the two communities, respectively. These differences can be explained by the definition of the term 'village' used in the two publications. The total rural population of the two communities is estimated at 9,967 in Ouled Zmam (Table 2.2) and 33,732 in Bradia (Table 2.3).

Table 2.2: 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 El Hejjaj	226	24
Total	**9967**	**1355**

Source: RGA (1996).

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 is 74% of the total area. Small farms represent only 36% in Ouled Zmam but 73% in Bradia. This structural difference between the two communities explains the difference in the way the farmers chose their farming techniques and crops.

Table 2.3: 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: RGA (1996).

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 has developed in Beni Amir, where the number of milk cows and livestock organizations is very high for this region.

Extension services

The two communities rely on the Tadla regional extension services (ORMVAT) for technical advice on agricultural production. There are many cooperatives and farmers' associations each having different objectives such as sugar beet processing, milk collection, irrigation management, trade in cereals and livestock. For milk collection alone, there are 11 cooperatives in Bradia and 9 in Ouled Zmam.

2.2 Site selection

Bradia and Ouled Zmam sites were selected because they are representative of the Tadla region in terms of water resources and agricultural production systems. In fact, the source of irrigation water was the major criterion used in the selection process. At Bradia, water comes mainly from the irrigation network (surface water). While at Ouled Zmam, the majority of farmers use groundwater in addition to surface water. As far as agricultural production systems are concerned, the main crops grown in the region are cereals, sugar beet, alfalfa and citrus trees, and these are present at the selected sites.

Two participatory workshops were held to select relevant communities, one in Ouled Zmam and the other in Bradia. Their main objectives were 1) to ensure a minimum level of participation by the community by raising awareness of the project and its major objective, which is the efficient use of water in supplemental irrigation, and 2) to improve the interaction of researchers with community members and partners such as the Chamber of Agriculture, local authorities, farmers' associations, cooperatives, etc.

The specific objectives of the workshops can be summarized as:

- to explain to the local community the major 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, potentials, and constraints according to the perception of its members; and
- to identify community members that are willing to host project field trials.

Participatory methods were used in the workshops. Interactive and flexible approaches were followed, and top priority was given to visualization as a stimulus to the communication and capitalization of the information. Different tools were used to reach these objectives – Venn and flux diagrams in the plenary sessions and agricultural activities, constraints and potentials during group work.

Before organizing the workshops, the project team made many visits to ORMVAT and contacts with local and provincial institutions were established to prepare for the meetings. With the aid of local authorities and ORMVAT staff, potential farmers (35 in Ouled Zmam and 50 in Bradia) to attend the event were identified. For efficiency and to ensure that the objectives of the workshop were achieved, 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 and consecutive participatory community workshops were organized on 12 and 13 April 2004.

Each workshop had two sessions; one plenary meeting with all participants and the second small thematic group meetings. The first session focused on the presentation, by farmers, of a 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 that was meant for exchange of information and the discussion of problems by small groups, focused on the following topics:

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

2.3 Outputs of the participatory workshops

2.3.1 Community of Ouled Zmam

Analysis of actors and fluxes

The importance of fluxes and relationships between the community and its environment is illustrated in Figure 2.8. Four institutions have the highest degree of relationship

with the community. These are ORMVAT, sugar refineries, milk cooperatives, and the agricultural bank. Among them, ORMVAT is of the greatest importance because it allocates water, ensures maintenance of the irrigation network and provides technical assistance to the farmers. Other ORMVAT services are provided in collaboration with cooperatives and associations.

During the meetings, community members raised problems that they had with ORMVAT. These problems can be summarized as:

- Water price has increased.
- Little technical advice to farmers and less maintenance of the irrigation network.
- ORMVAT is no longer involved in commercial negotiations with the sugar refineries, which have become more powerful than the producers and impose their own rules.

Farmers' relations with the main partner institutions in the region were also discussed during the workshop and the results ranked ORMVAT as the main partner. The nature of these relations is summarized in Table 2.4.

The sugar refineries are ranked number two, in terms of services offered to the community. These institutions have a monopoly of the marketing of raw sugar beet. They give cash advances on production to ensure that the crop is planted. These advances and loans are paid back by farmers at the end of the growing season at high rates of interest.

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 community partner is the milk cooperative. This cooperative collects and purchases milk from its members at a variable price. It also offers payment facilities, provides feed and health (medical) coverage up to 25%. This last service is particularly appreciated by the cooperative members. However, all farmers think that the price of milk remains very low because of the lack of other milk companies in the region. Central Dairy dominates the milk market. This situation does not encourage the development of milk production and valorization.

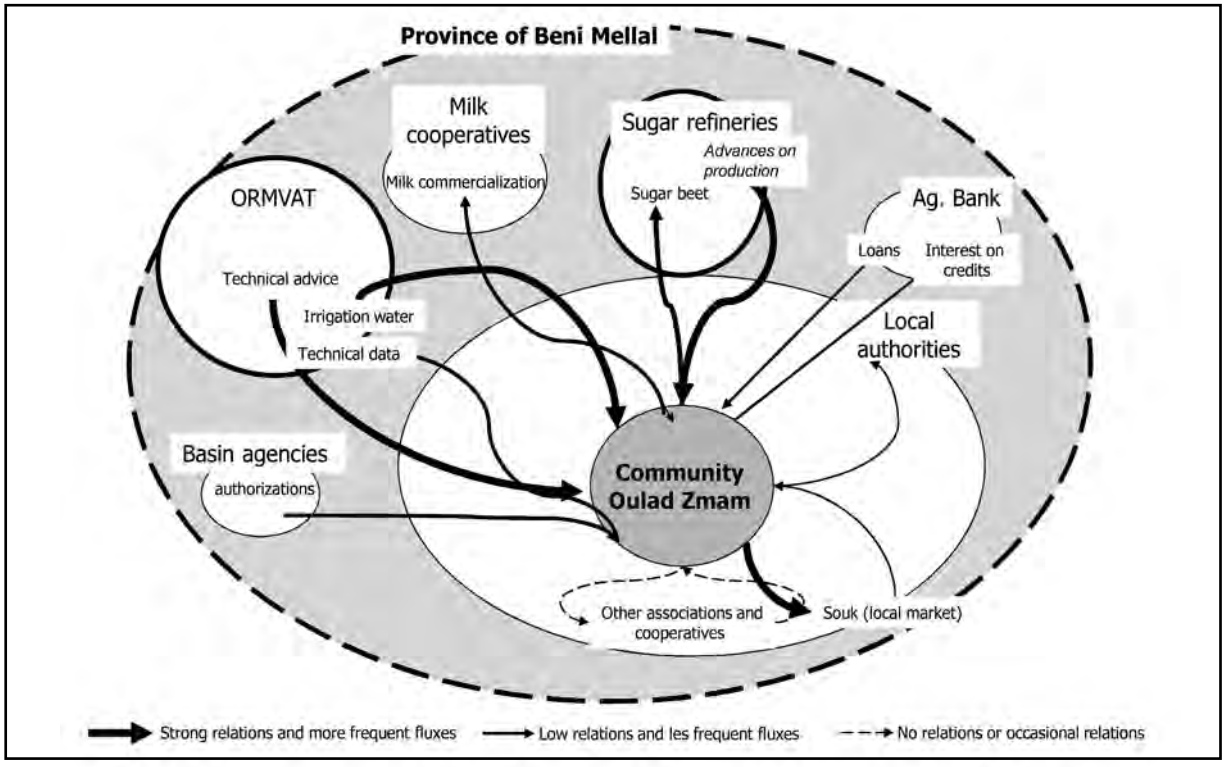

Figure 2.8: Fluxes and relations between the community of Ouled Zmam and its environment.

Table 2.4: 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) Analysis of water and soil Artificial insemination through cooperatives	Payment for irrigation water Payment for soil analysis Provision of information through surveys Organization into cooperatives to facilitate ORMVAT interventions Contribution to the success of ORMVAT programs	ORMVAT is no longer involved in commercial negotiations ORMVAT is no longer involved in the program of yellow nightshade weed control ORMVAT is unable to maintain the irrigation network because of the lack of financial and human resources Irrigation water allocated is not sufficient Lack of extension staff
Sugar factories	Give cash advances to acquire inputs (seeds, pesticides, fertilizers) Loans Provides sugar beet pulp	Provision of the raw product (sugar beet) Payment of advances on inputs Reimbursement of loans Payment of the price of sugar beet pulp	Problems with the determination of sugar content by the refinery (underestimated) Interest on loans is high Absence of a role for the Association of Sugar Beet Producers of Tadla, even if producers pay the membership fee Role of the producers in the evaluation of product quality Elimination of the financial contribution of the refinery in the 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 fee	Price for 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 for taking out loans Requirement for the mortgage operation (complex operation) Non-generalization of exemption from reimbursement of loans under drought conditions as it is in rainfed agriculture High rate of interest High cost of suing of debtors

The agricultural bank is an institution that is also important in the region. Provision of short, medium, and long-term loans is the main service provided by the bank. However, the complexity of the procedures and the absence of a mortgage do not encourage the farmers to deal with the bank.

Finally, we noted 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 also decides how much surface water is allocated to the irrigation network. According to farmers, the agency does not, unfortunately, take into account the specificity of the regions when it determines the amount of water allocated;
- The local authority that is involved in the coordination and follow-up of agricultural activities. This institution also plays an important role in ensuring security and in delivering administrative certificates; and
- Private companies that supply agricultural inputs such as pesticides and fertilizers, on a local or regional level.

Other institutions were mentioned by farmers; but they are not important to them. They include research institutions, the Livestock Producers' Association of Tadla, certified seed company, and others. It was noted 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 products. According to farmers, the association is supposed to protect their interests by ensuring that the quantity of sugar beet delivered is correctly determined by the refinery.

Results from the irrigation focus group

Water resources and management

There are two sources of water in the Ouled Zmam community – surface (dam) and underground (aquifer) water – and three combinations of irrigation water:

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

The irrigation network is judged to be very old and requires rehabilitation. There is a shortage of water downstream of the network because of the deterioration of the system. This problem is also related to the surface irrigation system used in this region. Some tertiary canals do not encourage the introduction of new and high-water demanding cash crops (freedom of choice of crops). Also the 'water turn' procedure (water distribution in rotation among farmers) makes it difficult for irrigation scheduling of different crops.

The most dominant irrigation technique (Photo 2.1) is '*robta*' (flooding surface irrigation of small basins).

This technique (photo 2.1) is very old; but has been modified by reducing the dimensions and increasing the number of basins. This

Photo 2.1. Traditional technique of surface irrigation.

increase is due to the degradation of soil leveling. It is a technique that is well adapted to local systems of crop production. The disadvantages of '*robta*' are the high cost of labor, water losses, reduction in the cropped area because of irrigation furrows (water channels), and high duration of irrigation. Farmers continue to use '*robta*' because they have not tried any other more efficient techniques in this region. Moreover, farmers lack the confidence to invest in new systems like drip irrigation in which salinity problems can cause deterioration of the irrigation materials.

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 organizations

Even if farmers' associations exist, they are not functional because of ineffective management and lack of members. According to the farmers, the status of these associations is not clear. Moreover, there is no aid from the State as was previously agreed with the associations of water users in agriculture. These associations, which are supposed to be involved in water management, only play a role in the negotiation of irrigation programs and planning. The number of members does not exceed 10% of farmers in the community.

With regard to agricultural product marketing, individual farmers sell their products immediately after harvest. This behavior highlights the farmers' risk of falling into debt. In this situation, it is difficult for farmers to develop an appropriate marketing strategy. For example, milk prices remain very low and vary tremendously from year to year and within a year.

Crop management

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

In Ouled Zmam, the dominant soils are iso-humus (2/3), 1 to 2 m deep and calcixerolls (1/3). The problem of salinity in both water and soils is becoming worse. 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.

Deep summer plowing in some situations and offset disking and drilling are the usual techniques used in the cereal/cereal rotation. However, the choice of techniques and tools for soil preparation is influenced by the preceding crop. When sugar beet is the preceding crop, one offset disking is sufficient. Superphosphate is incorporated in the soil during preparation in the autumn at the rate of 150–200 kg/ha. Urea is broadcast once at the tillering stage at the 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 chemical weed control. Some farmers apply the 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 (bread) wheat varieties. The rotations used are wheat/alfalfa and wheat/sugar beet.

Technical management of sugar beet depends a lot on the income (wealth) of the farmer. Nevertheless, adaptive management is well known to most farmers. The most common problems are those related to nematodes and weeds. The number of irrigations in one cropping season varies from 11 to 14.

Production is only moderate compared to the potential of the region. In the case of cereals, actual yields are divided into three groups according to the techniques used: 5,000–6,000, 3,500 and 1,800–2,500 kg/ha. Average yields are between 3,000 and 7,000 kg/ha, depending on farm size and rainfall conditions. For sugar content, polarization varies from 10 to 19. The levels declared by the refinery often show large discrepancies even for harvests from the same plot.

2.3.2 Community of Bradia

Analysis of actors and fluxes

In general, the fluxes seen in Oulad Zmam are the same as those observed in the Bradia community. Only the order of the ranking of the four institutions changed. As with the Ouled Zmam community, ORMVAT is the main institution with the highest level of interaction with the Bradia community. Farmers ranked their relationship with the agricultural bank in second place, followed by the milk cooperatives and finally the sugar beet factory (Figure 2.9).

The services offered by these institutions remain the same. Services and problems related to different institutions are presented in Table 2.5.

Results of group discussion

Water resources and management

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 use varies from one area to another. Some regions have good quality water.
- Around 90% of wells are traditional.
- Optimal water application depends on the condition of the soil surface. Soil leveling allows uniform water distribution across the field. Unfortunately, the use of this technique (leveling) that saves 40% of applied water is only seen with the 5% of farmers who own a tractor.

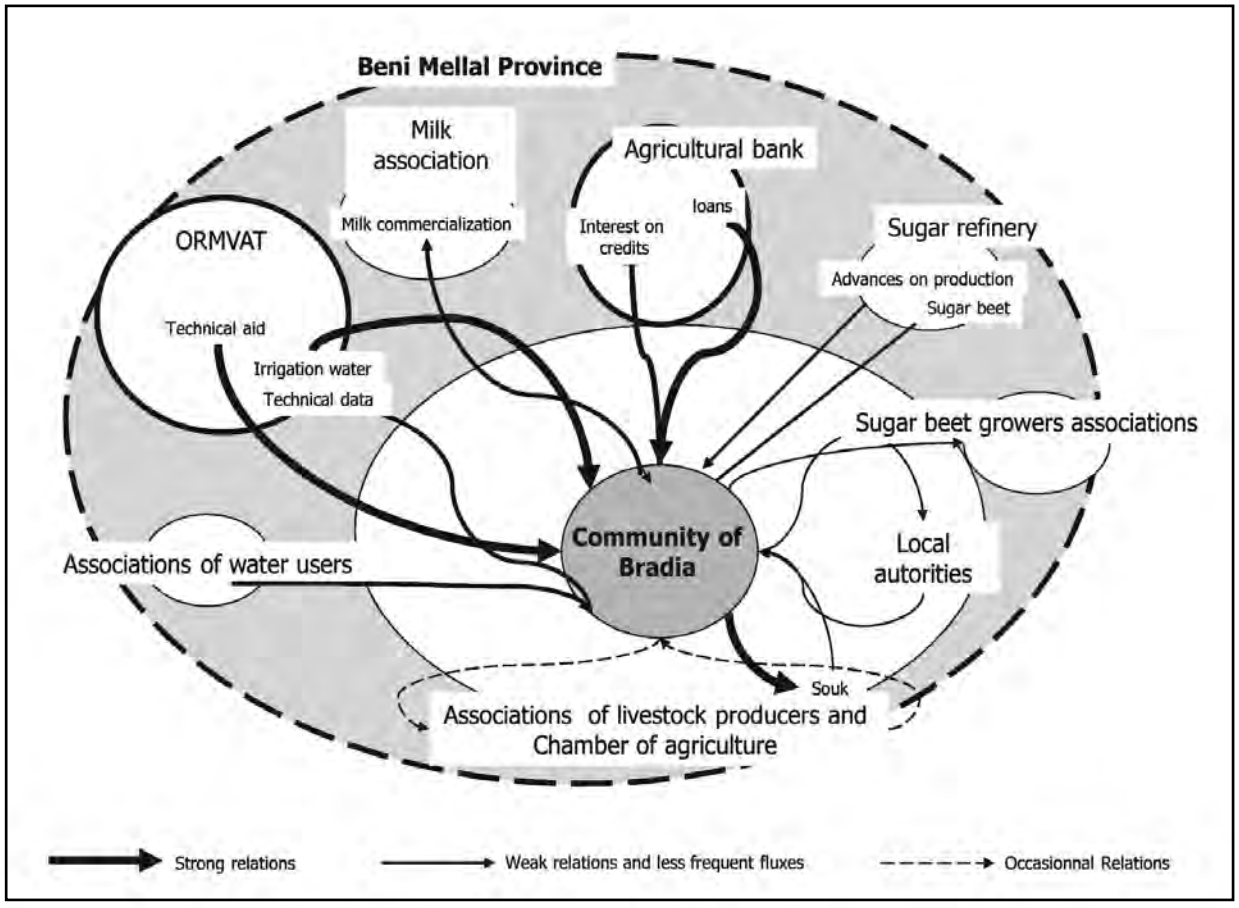

Figure 2.9: Fluxes and relations between the community of Bradia and its environment.

Table 2.5: 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 analysis	Water dues Payment of costs of soil analysis Provision of information through surveys	Reduction in 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 for irrigation water are not well adapted (February after planting of crops). Farmers suggest that payment take into account the level of crop production. Lack of action on network 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 of choice of crops)
Sugar factories	Marketing of sugar beet Financing of inputs for sugar beet by credit advances Credit	Provision of sugar beet	Ambiguity in the relationship between the community and the sugar refinery. There is a problem with sugar quality and sugar beet quantity determination Absence of the role of the association No change in price 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 interest	Credit is not granted to individuals but to cooperatives Complexity of the procedures for granting credits Rates of interest are high. The amount of annual credit is not enough for small farmers

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

- 98% of farmers continue to use '*robta*';
- Only 1% of farmers practice drip irrigation and irrigation by siphons. Improving '*robta*' depends on the farmer's financial means, since it requires laser leveling that costs 3000 dirhams/ha (around US$300) which is considered high by farmers for the maintenance of canals;
- The alternative to '*robta*' is drip irrigation; but not many farmers can afford this technique (the equipment is expensive);
- Irrigation water delivery depends on the system of 'water 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 for saving water; but they are worried about the cost of these technologies. Farmers are more interested in the output than in resource saving.

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 negotiations with ORMVAT on irrigation canal maintenance and irrigation water release. Some associations even contribute to canal maintenance and repair.

Crop management

Around 40% of farmers resort to deep plowing followed by 2 to 3 offset diskings. The remaining 60% use offset disking only. The average level of fertilizers applied is estimated at 200 kg/ha. Most farmers broadcast seed 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 conditions vary from 3000 to 4500 kg/ha. The dominant rotation is cereal/cereal (70% of cases).

For some farmers who obtain low cereal yields (1000–3000 kg/ha), livestock, olive and alfalfa production provide other means of livelihood. Among the 16 farmers (participants), only 2 grew sugar beet in 2003/04. Farmers avoided this crop because of nematode attacks, 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.

2.4 Conclusions and recommendations

From these workshops and an analysis of project documentation, we can conclude that possibilities for the improvement of water use do 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 illustrated by the following points:

1. **Water cost**: This problem is linked to improvements that could be made by the introduction of new crops that use water more efficiently, adapted irrigation techniques and incentives in terms of agricultural policies.
2. **Decision-making in water management at the canal level**: At present, ORMVAT is responsible for deciding when and how much irrigation water is to be released. This situation does not facilitate the use of irrigation techniques such as deficit irrigation, supplemental irrigation and drip irrigation. These new alternatives (to surface irrigation) can only be used when it is possible to own small basins and when communities have the right to participate in decisions regarding water release from the dams, taking into account their needs and climatic conditions.
3. **Investment in new technologies**, such as drip irrigation, is considered very expensive by most farmers. In fact, the high cost of drip irrigation equipment and the low level of subsidy to acquire it do not encourage farmers to use this technology. Therefore, incentives to shift from surface irrigation to drip irrigation are necessary.
4. **Lack of knowledge of irrigation techniques**: Most farmers, except the bigger ones, use traditional surface irrigation ('*robta*') that wastes huge quantities of water and reduces the land available for use by crops. An improved surface irrigation technique (using land leveling) has been developed, and if used by farmers, can improve water-use

efficiency. In addition to this technique, farmers need to adopt other cultural practices including new crops and varieties.

5. **Organizational aspects**: Many organizations (cooperatives, associations) exist in the chosen communities; however, they remain ineffective. Only dairy cooperatives seem to be successful.

   A new approach to the integrated management of natural resources, especially water, needs to be developed to involve the community more closely in irrigation water management in order to improve water productivity.

2.5 References

ORMVAT (Office régional de mise en valeur agricole de Tadla). 2003. Rapport monographique de l'ORMVAT. Fkih Ben Salah, Morocco

ORMVAT (Office régional de mise en valeur agricole de Tadla). 2004. Rapport du conseil d'administration de l'ORMVAT. Fkih Ben Salah, Morocco

RGA. 1996. Recensement générale agricole. Ministère de l'Agriculture, Rabat, Morocco.

RGPH. 2004. Recensement général de la population et l'habitat. Haut-Commissariat au Plan, Rabat, Morocco.