3 MULTIPLE USE OF IRRIGATION WATER IN NORTHERN MOROCCO

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Summary

The semi-arid Zaio region in North-eastern Morocco is one of the many parts of the country where water is stored for domestic purposes in subterranean tanks. A study was conducted to describe their importance, the different methods of storage and the multiple uses of the stored water. Though originally designed for the storage of rainwater, the tanks are now often filled with water from irrigation canals.

A full tank can provide water for a period of one week to more than two months, depending on the size, type of use and number of people in the household. The water is used for different purposes including drinking, cooking, bathing, washing utensils, sweeping the floor, laundry, sanitation, watering cattle, small scale brick making and home gardens. More than half of the users who drink the water, treat it with chlorine or crushed limestone. Users indicated an interest in simple and cheap treatment methods to improve the water quality. The tank water is the only source of water for sanitation and hygiene, thus bringing substantial health benefits to the households. Without the tanks, the water use per capita would be far below the minimum health requirements. Livestock, home gardens and small scale brick making also depend on water from the tanks and hence contribute substantially to local income.

The paper compares experiences in Zaio to other regions in Morocco, demonstrating how the multiple uses of stored irrigation water can contribute to improving rural livelihoods beyond the advantages of irrigation. It argues that investments in water resources development could be more cost-efficient if multipurpose systems were conceived, catering for both agricultural and domestic water needs.

3.1 Introduction

In many irrigation systems around the world, water from the canals is used for many other purposes in addition to agriculture (Ault 1981, Yoder 1983, van der Hoek *et al.* 1999). In the Zaio region in Northern Morocco, irrigation water plays a crucial role in fulfilling basic human needs for water. In the absence of good groundwater resources, people in rural Morocco have traditionally used covered subterranean or underground tanks to store rain or surface water for domestic purposes. These water storage facilities, locally known as *Jboub* (singular *Joub*)*,* are very common in the region of Zaio (Ambroggi 1996). The tanks are used across the irrigated area and in the nearby areas without irrigation. Traditionally designed for the collection and storage of rain water, nowadays the *Jboub* are usually filled with irrigation water from the large scale modern irrigation system of Basse Moulouya. The stored water is used for various purposes, such as watering livestock, laundry, brick making, as well as drinking and cooking, with or without treatment. In the Zebra irrigation system, no other surface water resources are available and the groundwater is deep and highly saline.

3.1.1 Study area

Morocco is located in North-West Africa, bordered by the Atlantic Ocean and the Mediterranean Sea. In the semi-arid and arid climate of Morocco, irrigation is vital for agriculture. Since the 1960s, 13 large dams of more than 150 Mm^3 storage capacity each have been constructed for irrigation, 8 of which also serve municipal water supply (Anonymous 1990). However, the development of rural water supply has received little attention as compared to urban water supply. In 1990 only 14% of the people living in rural areas of Morocco had access to drinking water from a public source (i.e. a functioning safe water supply within 100 m from the house). In the same year 23% of the population were reported to have private wells. Almost two thirds of the population depended on other supplies including rainwater collection and storage of surface water for their household needs (Moudden 1993, Benazzou 1994). In areas with deep and inaccessible groundwater, such as parts of the Tessaout Amont irrigation system, or with highly saline groundwater, such as in the Zebra irrigation system where this study was carried out, even fewer people have access to safe drinking water within a reasonable distance. The insufficient quality and quantity of water is among the major causes of mortality of children below four in rural Morocco (Zerrari 1993).

The present study was carried out in the region of Zaio, in the downstream part of the Moulouya river basin which covers 335,000 ha in the provinces of Nador and Berkane in the Northeast of Morocco. The area is bordered in the north by the Mediterranean sea, in the south by the Beni Znassen mountains, in the west by the Rif mountains and in the east by Algeria. The study covered both the Zebra irrigation system, part of the larger Basse Moulouya irrigation scheme, and the non-irrigated area of Hassi Berkane, both in the Zaio area.

The region of Zaio has a semi-arid Mediterranean climate with an average annual rainfall of 350 mm and a mean annual temperature of 18.2 °C. The main income generating activities of the rural population in the province of Nador are agriculture and cattle husbandry. Sheep and goats are by far the most important livestock, though dairy and poultry farming is practiced as well, especially in the irrigated areas.

Major crops in the Basse Moulouya irrigation scheme are barley, wheat, citrus, olives, fodder crops, grapes, sugar beet, and vegetables (Anonymous 1996). Because of limited water availability, there is a great variation between years and in periods of drought, priority is given to tree crops (El Kassimi *et al.* 1998). The balance between water resources and water demand is considered very fragile (Alloaouzi & Bouaam 1994). Irrigation, hydro power, domestic water supply and industry all depend highly on surface water, though an increasing number of agro wells pump groundwater for agricultural use. The Moulouya river constitutes the major source of surface water with an annual average runoff of 800 MCM. The discharge is regulated by two large reservoirs and since 1995, a pumping station downstream of the dams provides additional supply from return flows to small scale irrigation schemes.

The Zebra irrigation system is supplied by gravity force, which means that no pumps are used to get the water to the fields. The water is delivered in rotation through a system of lined elevated canals, which are all laid under a slope to get the water to the crops. Individual farmers usually receive water for their crops every 2-4 weeks, depending on the season and on water availability in the main dam. The farmers get billed annually for the water that they have actually received. The irrigation agency informs them when to expect “their” irrigation water and at which canal outlet. As a consequence of these water distribution practices, water flows (almost) continuously in the main canals, while the smaller lower order canals convey water in turns.

3.2 Methodology

In November 2000 and June-August 2001 field surveys were carried out in Zaio area. The first study had a more descriptive and qualitative character, while during the second study, some quantitative information was gathered as well. This paper is a synthesis of results from both studies.

In November 2000, informal interviews using a semi-structured questionnaire with open ended questions were held with farmers and other stakeholders, such as a water seller. A total of 45 ad-hoc selected households were visited of which 39 had water storage tanks, in villages in the Zebra area, equipped with a gravity-fed open canal irrigation system, and in Hassi Berkane, to the South, without irrigation. Five farmers were women, representative of the low number of women who own farms in the area. After a short introduction on the purpose of the visit and the objectives of the study, the semi-structured questionnaire was conducted to collect information on the reasons and purpose of the storage of water; the costs of the water itself, of its transport, storage and treatment; the various uses; treatment technique; duration of storage; problems and suggestions (if any) to improve water quality and availability as seen by the users. The questionnaire was administered often to more than one family member, allowing more women to contribute to the discussion. Some of the responders were concise whereas other took the opportunity to ask the team questions in return, about water pricing, water delivery and other problems such as the volume released at their fields. The participation of a representative from the local irrigation agency often inspired a discussion on larger water issues, leading to an open and fruitful dialogue for the farmers, who got some satisfying answers to their specific questions related to water allocation. In addition, meetings were held in Berkane and in Zaio town with irrigation authorities at local and regional level, with the president and six members of the local communal council, health authorities at the health center in Zaio town and the environmental hygiene officer at the municipality of Zaio.

In the period June – August 2001, more in-depth interviews were complemented by observations. Interviews were conducted with managers of the irrigation system at central level and for Zebra, with irrigating farmers, with users of Farhya and Sidi Othmane springs, with water users in 137 households randomly selected over the different sectors of the Zaio region, with farmers practicing intensive husbandry (cattle and poultry), and with the owners of a traditional and a modern brick factory, an olive oil factory and a tree nursery. Team members made daily observations during four days at three different sites of water collection by water sellers to estimate the quantity of water pumped out of the canal, as well as the number of cisterns filled from the canal daily. This was compared to water distribution records from the irrigation agency. Four households were selected in different sectors of the Zebra irrigated area, based on the type of water source used, for more detailed participatory observations. A female student from the region spent two to three days at each household, following every drop of water from the source to the final use with regard to timing, type of use, and user. Explanations and complementary information were obtained where needed through open discussions with the head or members of the household on water use patterns and rough estimates of quantities.

3.3 Results

3.3.1 Characteristics of water storage tanks

The *Jboub* in Zaio are water storage tanks with a long tradition, as the oldest participant in this survey recalled that they were commonly used well before the Spanish colonialism *i.e.* before 1912. In addition to these structures for domestic use, small impoundments called *Majn* store rain water for watering livestock. Most of the old *Jboub* were constructed before the modern irrigation system (Figure 1). These can be easily recognized by their design and construction material, usually stones and mud mixed with straw, while the recent ones are made of cement (Figure 2.). The *Jboub* are of very diverse shapes: triangular, rectangular, circular and squares, with horizontal, dome-shaped and semi-circular domes. They also showed a great variability in dimensions and subsequently in storage capacity as shown in Figure 3. The minimum capacity observed in the present survey was 5 m^3 and the highest capacity was 400 m^3. As shown in Figure 4 most of the *Jboub* are partly or entirely subterranean. To prevent access to children, some of the tanks are placed on top of the house. For these elevated *Jboub*, a motor pump is used to fill them and a network of pipelines brings the water into the household taps.

The random sample of households visited showed that 33 *Jboub* are individual and 6 are used by more than two households. The common ones are basically old *Jboub* built before the irrigation system was implemented. Some schools and mosques also have their own tanks, which are filled, equipped and maintained by the community.

3.3.2 Sources of water for storage tanks

The two large storage dams in the Moulouya river are the most important and reliable source of water in the entire region. For the population living nearby, the river is also an important source of water depending on the flow. Water from the river is pumped or drawn directly for different purposes including irrigation, drinking and domestic use. Three springs are the most important sources of drinking water for the population in the Zaio area, though the water is less suitable for cooking and bathing because of its hardness. People living within a 5 to 10 km distance from these springs fetch the water by donkey, mule carts, tractor or even scooters. Many farmers mention that they do not always have the means of transport available to collect drinking water in this manner. The alternative in these situations is water stored in *Jboub*. Relatively wealthy people fetch smaller quantities of water for drinking from the water supply system in the town of Zaio, or from the well in Hassi Berkane. These people often have a vehicle or tractor or can afford to pay the transportation fees.

Most of the *Jboub* are filled with canal water (34 out of 39), some of these in combination with river water (2) and rain (3). The other tanks were filled from rain (2), a well (1), a spring (1) and the river (1) only. The ones that are filled with rain water only are all outside the irrigation scheme. In the villages of Hassi Berkane, outside the irrigated area, people fetch water from a well or from the river, when it has a flow. The *Jboub* in the irrigated area were usually filled during the irrigation turn, with farmers using part of their private crop water allocation to fill their *Jboub*. They can also ask the irrigation agency to provide extra water for domestic purposes, for which the farmers pay the normal irrigation fee of 0.023 US$/$m^3$. In those cases, the water is usually conveyed from the irrigation canal via field canals, sometimes cement lined, to the *Jboub* in the village. Outside the irrigation season and in between turns, water is taken from the main canal that conveys water permanently to the municipal water treatment plant of Nador. This means that the water has to be taken out of the canals with buckets or pumps and transported to the Jboub. The distance for water transport ranges from 5 – 10 km for Jboub in the irrigated area, to over 15 km for those outside the irrigation scheme. With increasing distance, larger volume (4m^3 or more) water tanks on tractors or trucks are used for water transportation. As a result, a new profession has emerged: the water seller (Box 1.)

Figure 1. Age of *Jboub* in Zaio (n = 39).

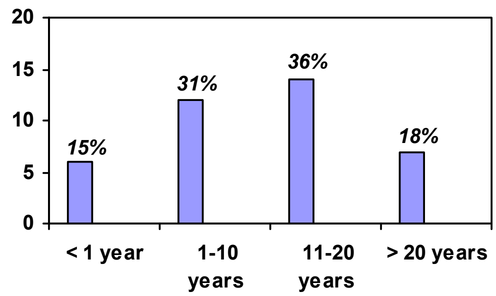


Figure 2 Material used to build *Jboub* (n = 39).

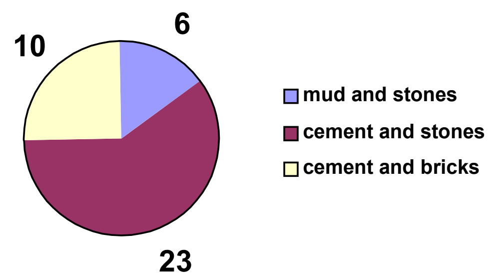


Figure 3. Capacity of *Jboub* in m^3 (n = 39).

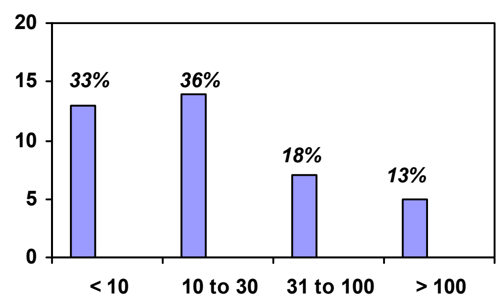
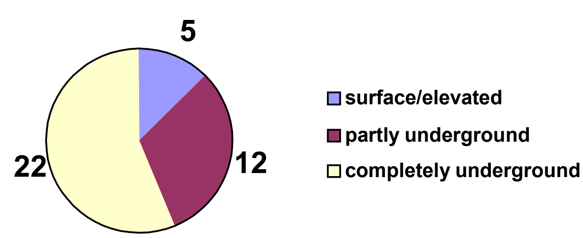


Figure 4. Types of *Jboub* found in Zebra and Hassi Berkane (n = 39)



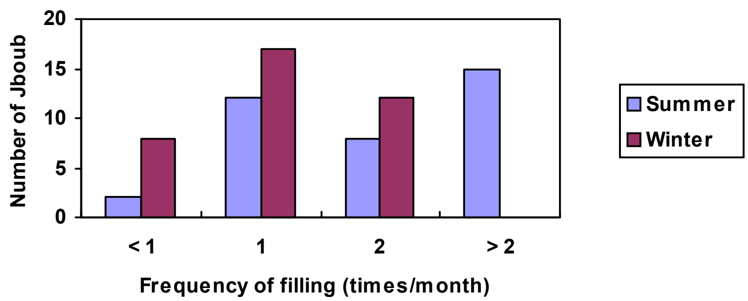
Depending on water availability, rainfall, water use and season, most *Jboub* are filled once to twice a month (Figure 5). If the stored water is used for irrigation of tree crops or watering of animals (cattle husbandry and poultry), water consumption is high and the tank has to be filled more frequently. According to the users, if the water were used for one specific task only, such as domestic use, the water in one tank would be sufficient for more than one month in summer and for longer in winter. In drought periods, such as in 1999-2000, people and livestock depend entirely on water in the *Jboub*, so the tanks get emptied more frequently and the duration of storage is shortened. As a result, the cost of transport increases and may double for the areas outside the irrigation scheme.

Box 1 A new profession in Zaio: the water seller

Since 1974 special permits are issued by the irrigation agency for water collection from canals for livestock and domestic purposes. Officially this water can only be used for agricultural purposes and the local health authorities have to give formal approval before the permit can be issued, stating that the water is not suitable for drinking. The maximum amount of water is specified in the permit, as well as time and place of water collection, usually between 7:00 and 13:00 hours and downstream of the intake for municipal water supply. In practice this is not always followed. More tanks per day are collected than stipulated, on more days per year.

In the year 2000, 49 farmers were authorized to fill tanks from canals, but only 13 of these actually paid the fees for the water. In reality more than 100 farmers and water sellers come and get water for their tanks regularly, on average twice monthly. Several people sell the water with a profit and approximately 30 manage to make a living from this, selling some 5 trucks a day, depending on the demand. Together these water sellers would use their engine or a separate pump to lift 200,000 to 250,000 m^3 of water out of the canals for the Zaio region annually. While the cost of irrigation water is some US$ 0.1 for a 4 m^3 tank, it is sold for US$ 3 at a distance of 1-2 km from the canal. With the distance, the market value increases and the price of one tank could go up to US$ 20 at more than 10 km away from the canal. In times of drought, the price may rise further and even double.

Figure 5. Monthly frequency of filling the *Jboub* in winter and summer (n = 37, excluding the rain-fed ones)



3.3.3 Water use from storage tanks

Water allocation and water use are influenced by the availability of water in the irrigation canal and in the *Jboub*. Some domestic activities such as laundry and washing utensils, seeds or wool are performed at the canal site whenever possible, as this is more convenient. Once stored in the tank, *Joub* water is considered more precious than canal water, although the quality is perceived as being the same. For allocation of the stored water when the canals are dry, some intra-household competition may take place and water has to be rationed. Usually the mother of the house determines the value of each activity and decides what gets priority.

The water from *Jboub* is used for many different purposes, but hardly ever for agricultural purposes such as the irrigation of home gardens. More than half of the tanks are used for one purpose only, such as domestic purposes (cooking, bathing, washing clothes, utensils and seeds, 9 *Jboub*) and watering livestock (8). Water from more than 40% (17) of the *Jboub* is used for several purposes. *Joub* water is also used in mosques for ablutions, which reflects the perception of people that irrigation water is “purifying and clean”. Many users indicated that they would use the stored water for drinking if its quality would be improved. Only one tank was used for drinking water only.

For the watering of livestock canal water is the almost exclusive source, directly or after storage in *Jboub*. This is reflected in the large number of cattle in the irrigated area, as opposed to goats and horses[1] dominating the non-irrigated area. As a result, farmers in the irrigated areas have higher income from their livestock in addition to benefiting from higher value crops. The irrigation water stored in the tanks is also used for small scale brick making, allowing farmer families to improve their homes without high investments.

[1] Horses plus donkeys and mules.

According to the respondents, an average family of 10 members in the non-irrigated area of Hassi Berkane (range 6 to 30 in this survey) would consume 4 m^3 within two months in winter. This represents a daily average consumption of 6-7 l per capita per day (lpcd). This is well below the subsistence level set by the World Health Organization at 30 lpcd. As in Zebra, irrigation scheme water from the canal provides more than half of the household needs, and here we estimate the daily consumption to be at least twice that of Hassi Berkane, but probably still below 15 lpcd.

3.3.4 Treatment of stored water

Before they are filled, *Jboub* are often flushed out to clean them and remove mud (25 out of 39). The users consider this measure necessary to keep the tank in good condition and to maintain water quality. Farmers who fill their *Jboub* from a small canal or from rain often use filters to prevent floating material from entering the tank. To reduce the frequency of cleaning, some farmers have built a small open de-silting basin that allows the sedimentation of small particles before water is conveyed for storage in the *Jboub*. If the *Jboub* are filled with water from trucks, the users request this water to be pumped from the canal early in the morning, to minimize the effects of upstream pollution.

At two-thirds of the visited *Jboub* (25 out of 39), the water is treated, mostly with commercial chlorine, though occasionally crushed limestone is used. Since the water is often used for several purposes, some users prefer to treat only the amount of water that is used for consumption, instead of treating all stored water in the *Jboub*. Some of the farmers use a cloth filter before water is used for drinking or cooking. Most of the *Jboub* users were aware that water should be treated, but expressed a strong need for information about the correct treatment dosage for drinking and cooking. It was observed that the treatment was often over-dosed. Usually a liter of commercial chlorine (12%) was used to treat the entire tank regardless to its volume, which often resulted in much more than the required 50 ml/m^3, while crushed limestone was hardly ever measured, providing concentrations far higher than the desirable 5 g/m^3 (Ministère de la Santé 1990).

3.3.5 Options for improvement of storage

The older generation of respondents appeared to be quite satisfied with the *Jboub* as a traditional way of water storage (Table 1). Three old farmers pointed out that the provision of water is not a real problem, as people are prepared to "travel to town twice a week to look after the television battery while filling the *Jboub* once a month costs the same". Younger farmers were more critical and accused the authorities of segregated development: "when the irrigation system was constructed in an area with deep groundwater of high salinity without any prior thinking about drinking water supply, they expected that every farmer would build his own tank to store irrigation water for drinking and other domestic use. So that is what we did and that is what we will probably be doing for many years!" Most respondents (20 out of 37) find the overall availability of water for *Jboub* insufficient, sometimes in combination with water quality.

Table 1. Problems restricting the use of stored canal water for non-irrigation purposes as identified by users of 37 *Jboub* (excluding the ones filled by rainwater).

Problem	No.
Water supply and availability	12
Cost	7
Quality	7
Quality and quantity	8
None	3
Total	**37**

interval between irrigation cycles and the fact that water allocated to irrigation has also to be used for drinking and domestic uses. This is more problematic in periods of drought when water may not be released in the canals for periods of more than one month.

Many respondents had suggestions on how to improve the *Jboub*, either by rehabilitating the structure or by treatment of the water (Table 2). They were interested in upgrading the structure, preferably with technical assistance (14 out of 37), though several users pointed out that this was only useful if water would be delivered to the *Jboub* more regularly. The respondents were most interested in appropriate technology to improve water quality, such as the construction of sand filters. Others emphasized that since the water was also used for other purposes such as laundry, treatment of drinking water only would be sufficient. They insisted on the need for information and training of the villagers in water treatment. In

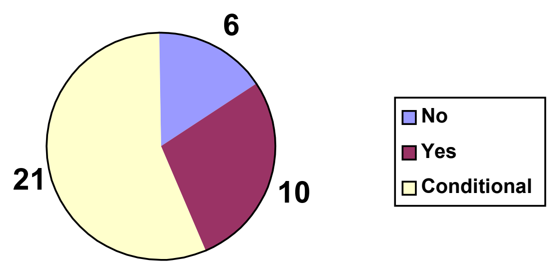
Hassi Berkane many farmers suggested that digging wells would be a durable solution but they recognized that this would be extremely expensive because of the very deep groundwater table.

Table 2. Suggestions for improvement of water storage, as formulated by users of *Jboub*.

Suggestions	No.
Upgrading of tank	14
Upgrading and more regular water deliveries	5
More regular water deliveries	2
Dig wells	5
Water treatment	4
None	7
Total	**37**

All respondents, who had suggestions for improvement, were willing to contribute to the cost of upgrading the *Jboub*, be it in manpower, material or financially (Figure 6). While a third of these (10) confirmed their unconditional willingness to pay, most of the others (21) only wanted to contribute under certain conditions. Many of these can be summarized as durable interventions that would indeed improve water quality. Five farmers mentioned affordability and three stated that they would pay if no recurrent investments were required. One farmer mentioned that he is willing to pay if the water treatment facility would be "like the one I saw in southern France where the farmers use solar panels to decontaminate water for drinking". The elected members of the community council were keen to be involved in upgrading of the existing *Jboub* but proposed that small-scale treatment facilities for irrigation water would be more sustainable, though extremely expensive.

Figure 6. Willingness of users to contribute to the improvement of water storage in *Jboub* (n = 37).



3.3.6 Other uses of irrigation water

Water in the Basse Moulouya irrigation scheme is officially allocated to other uses than irrigated agriculture. Figure 7 shows the amounts of water that were actually distributed for irrigation and other purposes in 2000. In the Zebra irrigation system on the left bank, some 600,000 – 1,000,000 m^3/month is allocated to the municipal water treatment plant of Nador city and less than 100,000 m^3/month goes to the water supply system of Zaio town (ONEP 1996). In addition, special water allocations are distributed to a sugar factory and six modern brick factories for the same (subsidized) price as irrigation water (Figure 8). The figures for 2000 show a somewhat distorted picture, as it was a dry year, in which crop water requirements could only be satisfied for 14% in the whole of Basse Moulouya (Zizi 2001). In periods of drought, certain crops do not receive any water for irrigation, while the releases for municipal water supply and industry continue as usual.

3.4 Discussion

The situation in Zaio is comparable to the one in the Haouz plain in central Morocco, where water storage tanks, there locally referred to as *metfia*, are filled with irrigation water and used for domestic purposes as well (Laamrani *et al.* 2000). But several differences can be observed. In Zaio the *Jboub* are mostly individually owned and used, probably because of the sparse habitations. A similar situation was found in the eastern part of the Haouz, where new and dispersed settlements prevailed. In the more traditional parts of the Haouz, most *metfia* were communal (Pascon 1977, Boelee *et al.* 1999). Another reason for the high proportion of privately owned tanks in Zaio is the better economic situation in this region. Especially people living in the Zebra irrigated area seem to be able to afford as much water as they need, even at high rates. This is comparable to other regions in Morocco (Benjelloun *et al.* 2002). Hence, most households have their own tank and do not need to share water from the *Jboub* with other families.

Figure 7. Actual monthly water distribution for irrigation and for other purposes in Zebra irrigation system in 2000 (large consumers only, individual water sellers are excluded).

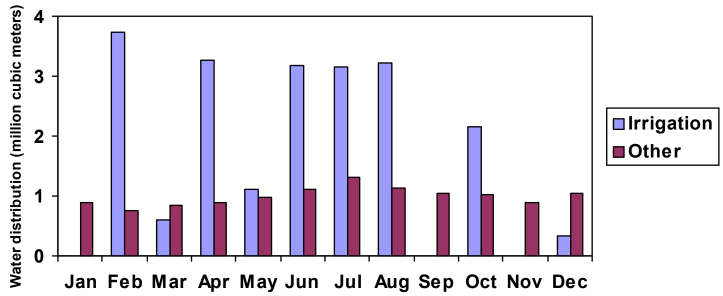
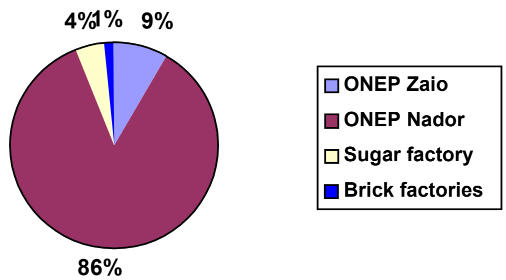


Figure 8. Total annual water distribution to other purposes in Zebra irrigation system in 2000 (excluding individual water sellers).



A more striking difference with the situation in the Haouz is that the farmers in Central Morocco raised water availability as the major problem faced by the users. In the present study in Zaio, many more users brought up water quality as the major issue. The users of *Jboub* in Northern Morocco, as well as the local community councils and the government agencies are willing to contribute to improvement of the storage and treatment facilities. Such a project, based on the felt needs of the community, would contribute to improve the availability of good quality water for domestic purposes and have a beneficial effect on the health of the rural population, if certain conditions are fulfilled (van der Hoek *et al.* 2001).

In the middle income country of Morocco, the lack of rural drinking water supplies has created a profitable opportunity for new jobs, the professional water sellers. These people can obtain a permit from the irrigation agency to pump water for livestock from the canals and transport this to the *Jboub* for storage. The farmers, water sellers, as well as local authorities, irrigation and health departments are all aware that the purpose of water storage is not necessarily what is officially delivered for. But no stakeholder is to be blamed for this equivocal situation. More equivocal is the situation, when seasonal workers employed by the Ministry of Health, who normally treat wells in the rural area, provide chlorine and limestone to the users of *Jboub*. This is an ambivalent position at the institutional level that no stakeholder has questioned.

In the study area of Zaio, with unsuitable or inaccessible groundwater, people depend on surface water for domestic purposes. The use of irrigation water as a major source by most of the rural inhabitants in Zebra and Hassi Berkane, and the users' concerns about water quality, raises questions on integrated water resources development. Increased water availability for domestic purposes, especially hygiene, is more important in the reduction of diarrhoeal diseases than improved quality (Esrey 1996, van der Hoek *et al.* 2002). Increased water allocations from the irrigation canal system for the *Jboub* would make more water available for domestic purposes and, by refreshing the stored water more frequently, also improve water quality. Alleviation of water scarcity and an increased availability of better quality water for domestic use can contribute to better health, improvement of rural livelihood and reduction of migration to urban areas.

3.5 Conclusions

The multiple uses of irrigation canal water in the region of Zaio have beneficial effects on rural livelihoods by contributing to health, reducing the cost of living or even providing additional income. The storage of canal water in *Jboub* allows for extended use of the water, at times when there is no flow in the irrigation canals and also outside the irrigated area. More detailed analysis is required to assess the exact benefits derived from the multiple uses of (stored) canal water, notably the increased potential for livestock and small scale productive activities.

3.6 Acknowledgements

The authors wish to thank the Office de Mise en Valeur Agricole du Moulouya (ORMVAM), in particular Mr. O. Laaydi of the irrigation department in Zaio and his colleagues in Berkane, for assisting in field arrangements and providing us freely with all information; the farmers and *Jboub* users in the Zaio region for their patience and confidence; Wim van der Hoek and Felix Amerasinghe for their comments on earlier versions of this manuscript.

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