

**DIAGNOSIS AND ANALYSIS OF THE FUNCTIONING OF THE  
REHABILITATED IRRIGATED AREA ZAAFRANA II (CENTRAL  
TUNISIA)**

**DIAGNOSTIC ET ANALYSE DE FONCTIONNEMENT DU  
PERIMETRE IRRIGUE REHABILITE ZAAFRANA II (TUNISIE  
CENTRALE)**

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**ABSTRACT:** Because of the reduced performance of public irrigated perimeters (PIP) in Tunisia, important rehabilitation projects have been established within the context of the national strategy for water saving. Particularly in Kairouan region (Central Tunisia), ranked first in the country in terms of land conducted by irrigation, 24 perimeters among 81 in the region have been rehabilitated. This study aims to the diagnosis and the analysis of the functioning of the irrigated perimeter Zaafrane II rehabilitated in 2005, in order to know whether the desired objectives have been met and then the perimeter has earned the state investment on one hand, and to identify the constraints, still encountered, to improve their performance, on the other hand. The study based on the analysis of various performance parameters (rate of use of water resources allocated to the perimeter, distribution network efficiency, rate of water saving equipment, agricultural intensification rate, crop water satisfaction rate, and agronomic efficiency) revealed that the hydraulic network regarding the equipment and the functioning plans isn't a constraint against the perimeter's development. The network efficiency estimated at 95% has provided a, relatively, notable reduction in the rate of water loss and has ensured a crop water satisfaction of about 85% with an agricultural intensification rate exceeding 80%. The rehabilitation has encouraged farmers to practice the pressurized irrigation systems. Especially for the drip irrigation, a good uniformity of water distribution has been proved, however, a tendency to the clogging of drippers has been shown; which requires a periodic inspection of the installation in order to ensure more benefit from this water saving technology.

**Keywords:** Performance indicators, hydraulic network, drip irrigation.

**RESUME :** Tenant compte des performances réduites des périmètres publics irrigués en Tunisie, d'importants projets de réhabilitation ont été établis, dans le cadre d'une stratégie nationale d'économie d'eau d'irrigation. Particulièrement, dans le gouvernorat de Kairouan (Tunisie Centrale), classée au premier rang en termes de terres conduites en irrigué, 24 périmètres, parmi 81 de la région, ont été réhabilités. La présente étude vise le diagnostic et l'analyse du fonctionnement du périmètre irrigué Zaafrana II créé en 1964 et réhabilité en 2005, en vue de connaître si les objectifs escomptés ont été atteints et s'il a mérité alors l'investissement de l'Etat d'une part, et d'identifier les contraintes auxquelles se heurte encore le périmètre, d'autre part. L'étude basée sur l'analyse de divers paramètres d'efficacité (taux d'utilisation des ressources hydriques allouées, efficacité de distribution, taux d'équipement en matériel d'économie d'eau, taux d'intensification agricole, taux de satisfaction des cultures et efficacité agronomique) a permis de dégager que le réseau hydraulique sur les plans équipement et fonctionnement n'est pas contraignant quant à la valorisation de ce périmètre. L'efficacité du réseau, estimée à 95%, a assuré une réduction relativement remarquable du taux des pertes d'eau et a permis d'assurer un taux de satisfaction des besoins en eau de l'ordre de 85% avec un taux d'intensification agricole moyen dépassant les 80%. La mise en valeur a encouragé les agriculteurs à s'orienter vers la pratique de l'irrigation sous pression. Spécialement au niveau du système goutte à goutte, une bonne uniformité de répartition de l'eau à la parcelle a été démontrée avec néanmoins une tendance de bouchage des goutteurs qui exige le contrôle périodique de l'installation afin de bénéficier davantage de cette technique économisatrice d'eau.

**Mots clés :** Indicateurs de performance, réseau hydraulique, irrigation localisée.

## INTRODUCTION

Water resources in Tunisia are scarce and agricultural demand has increased. As an indication, the agricultural sector is taking about 80% of mobilized resources which doesn't cease to increase (Gharbi 2007). In addition, high water losses caused by the poor state of collective irrigation networks, the adopted irrigation techniques, and the absence of the tradition of pressurized irrigation among a lot of farmers (Louati 2008) posed a serious problem and incite the government to establish a policy of modernization of public irrigated perimeters (PIP) through a national

strategy for water conservation. The latter aims to valuing water and rationalize its use in the agricultural sector (MARE-DGGRRE 2007). The policy's action plan focuses on the following points: i) the rehabilitation and modernization of the collective irrigation PIP ii) the promotion of various water-saving techniques inside parcels, and enhancement of water resources by a suitable choice of crops with high economic value and iii) the reinforcement of regional capabilities in saving water at the level of the applied research, of the popularization and management of irrigation systems, in order to provide better farmer's training (Al Atiri 2005).

Kairouan region (Central Tunisia) is considered among the regions with the biggest irrigated area in the country. Irrigated crop area estimated in 2005 at 63 370 ha presents 15.4% of the total irrigated area of the country and classes the region at the forefront in terms of land conducted under irrigation. 24 PIP (among 81 existing) were rehabilitated in Kairouan region in a perspective of rationalizing the use of water resources at the levels of collective irrigation and farm (field) networks.

At the collective network level, modernization focused on improving the mobilization and transport infrastructure, however, the lack of maintenance of hydraulic equipment may lead to weaken the expected network efficiency and lead to quite large water losses. At the field level, the State's undertaken actions mainly concerned the encouragement and the financial incentive for farmers (attractive subsidies between 40 and 60%) to the equipment of parcels by saving water systems (MA-DGGR 1996; Zayani et al., 2000). However, the farm irrigation efficiency doesn't depend exclusively on the adopted irrigation technique, but also on the state of the installation. Specifically, drip irrigation, considered promising in water scarcity condition (Tizaoui 2004), shows a strong trends to occlusion of distributors (drippers) over time which could lead in some cases to water waste and hydromorphic conditions such the case of some irrigated areas in Tunisia (Slatni et al., 2004; Slama et al., 2004). Clogging also causes a lack of uniformity of water application that affects growth and crop yield quality and quantity. Production losses may greatly exceed the cost of renewing the installation (Turcotte 2005).

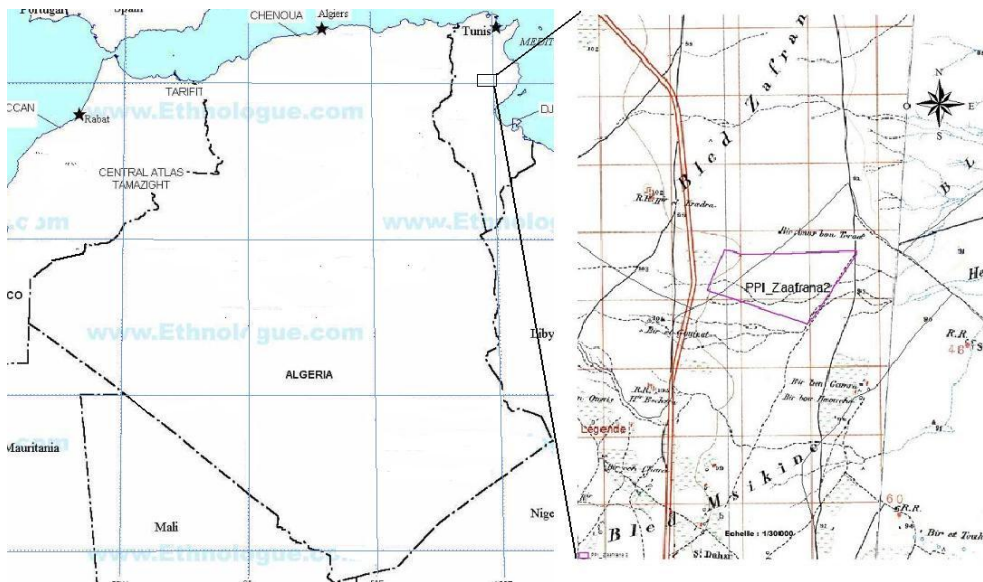
To follow up the modernization efforts and the applied water policies, the functioning diagnostics and the analysis of hydraulic and agronomic performances of rehabilitated PIP will allow to: i) specify whether the State's objectives of valorization and water saving have been achieved and ii) analyze the evolution of their state to identify deficiencies and problems in order to achieve better performances. This study focuses particularly on the public irrigated perimeter (PIP) Zaafrana II located in

Bouhajla zone (Kairouan region), built in 1964 and renovated in 2005. Based on a set of performance parameters, this work aims to conduct a diagnostic analysis of the perimeter concerning the exploitation of water resources and hydraulic infrastructure, the agricultural enhancement, the agronomic efficiency of irrigation water and the uniformity of water application in field.

## MATERIAL AND METHODS

### Study Area

The study area Zaafrana II, as part of Bouhajla zone in the region of Kairouan, is located 14 km, in a straight line, from the center of Bouhajla and has the following geographic coordinates: latitude  $35^{\circ} 40'$ , longitude  $10^{\circ} 05'$ , and altitude of 60 m (Figure 1).



**Fig. 1.** Location map of the study area

The perimeter covers an area of 145 ha, divided into 62 parcels exploited by 46 farmers. It is managed since its rehabilitation by an Agricultural Development Grouping (ADG) (BICHE 2005). Sizes of agricultural holdings in the irrigated are reported in Table 1, there are three types of exploitations.

The considered perimeter is implanted in the alluvial plain of Zeroud wadi characterized by calcareous alluvium of almost all the perimeter and alluvial limestone encrusted on glacia. The soil is split into two categories:

slightly developed alluvial soil in the plain, and Calcimagnesian brown calcareous soils on glaciais in southern perimeter.

**Table 1.** Farm sizes in the studied area

Area	Number of exploitations	Exploitation area, ha	Average area, ha	Percentage of the total area, %
$A \leq 1$ ha	15	12	0.8	8.3
$1 < A \leq 5$ ha	18	59	3.2	40.7
$A > 5$ ha	13	74	5.6	51
Total	46	145	3.1	100

This area belongs to the upper arid bioclimate with a moderated winter. It is a continental climate characterized by hot summer with an average maximum temperature of 37.1°C; in July and a cold winter with an average minimum of about 4.8°C; in January. The average annual precipitation is about 303 mm and is characterized by its inter-annual irregularity. For wind, the region is under the influence of two prevailing winds the Northwest in winter and the South East in summer with a warm wind of Saharan origin (Sirocco) whose average speed varies between 2 and 3 m/s. For the jelly, it is common, but not very frequent and began in December till March with an annual average of 3 to 4 days.

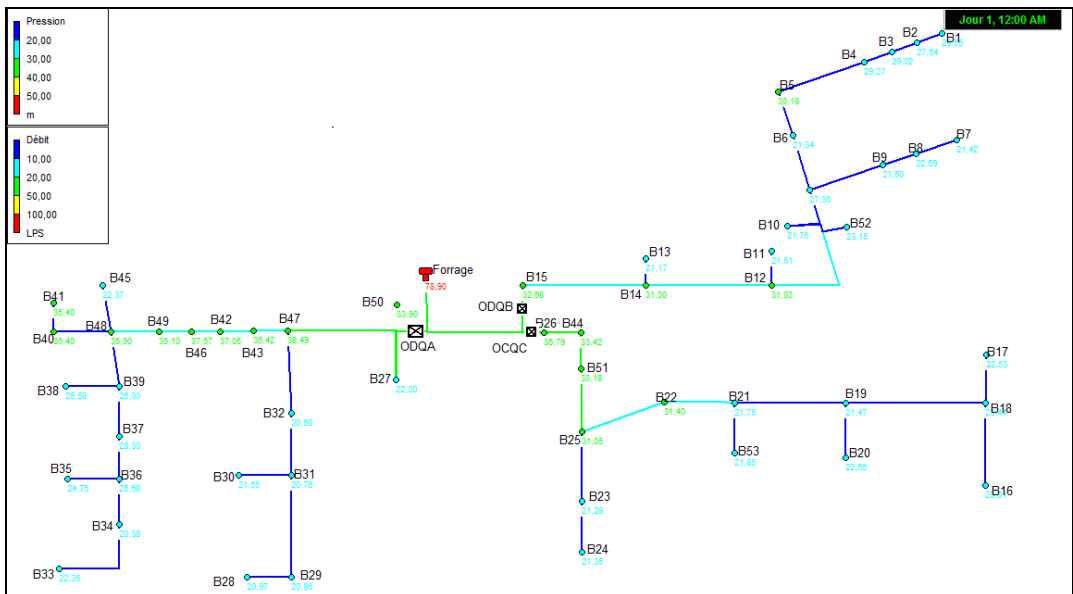
The practiced production system is based, mainly, on field crops (cereals and fodder) that occupy 85% of the area. The oil olive tree occupies 15% with a density of plantation of 50 feet per ha, the spacing is 14 m x 14 m. The crops are generally seasonal. Summer crops, belonging to the Solanaceae and Cucurbitaceae families, begin in April and finish in August, while winter crops such as cereals and fodder crops have a varied cultural calendar. Crop rotation is practiced by farmers is biennial or triennial.

### **Perimeter's water resources**

Irrigation water is taken from the drilling of Zaafrana II created in 1958 which exploits groundwater resources contained in the Quaternary plain of Zaafrana. Its discharge is 20 l/s and its chemical characterization shows relatively loaded water with a salinity of 2,7 g/l and a pH close to neutrality, 6,8.

### ***Irrigation network***

Starting from the drilling, the irrigation water distribution is ensured by a common core diameter of 200 mm and a length of 89 m feeding three sectors A, B and C with an area of 52; 51 and 42 ha, respectively, and passing through a regulating tank with a capacity of 10 m<sup>3</sup> (Figure 2). Distribution of water to three areas is on demand while the distribution within the sector is in turn. Area A is supplied by a flow rate of 7.2 l/s for 22 terminals irrigation, sector B with a flow of about 7 l/s for 17 terminals, and sector C by a flow of about 6 l/s for 13 terminals, so a total of 42 irrigation terminals.



**Fig. 2.** Irrigation network of the perimeter

**Field irrigation system**

The pressurized system is the most prevalent mode of irrigation in the perimeter. In fact, 57 ha are irrigated by drip irrigation method, 68 ha by sprinkler, while only 22 hectares are devoted to the improved gravity (surface) irrigation. The latter is adopted in the case of furrow irrigation. It consists on using pipes between plots to control water flow, improve the water distribution uniformity and reduce runoff in the head of the furrow.

**Diagnosis of resource exploitation and hydraulic infrastructure**

Diagnosis and analysis of functioning of the perimeter Zaafrana II were carried out relying on a survey accomplished among farmers and several

parameters as evaluation criteria related to i) the exploitation of available water resources and the implemented hydraulic infrastructure, ii) the agricultural development, iii) the socio-economic enhancement, and iv) the irrigation system in field. Given the importance of drip irrigation in terms of water savings and the considerable area occupied in the perimeter, the uniformity of distribution of water by this system was appreciated.

#### ***Rate of use of water resources***

The rate of use of allocated water resources ( $Ru$ ) is determined by the ratio of the pumped volume ( $Vp$ ) to the available water volume ( $Va$ ). The latter was calculated before and after rehabilitation, during the period 2002 - 2009, and assuming that the network operates 16 hours / day, 25 days / month and 10 months / year.

$$Ru (\%) = (Vp/Va) \times 100 \quad (1)$$

#### ***Water distribution efficiency***

The efficiency of water distribution ( $Ed$ ) is used to evaluate the rate of water loss through the ratio of the pumped ( $Vp$ ) and distributed water volumes ( $Vd$ ) in the perimeter. This parameter was determined during the period 2002 - 2009.

$$Ed (\%) = (Vd/Vp) \times 100 \quad (2)$$

#### ***Equipment rate of fields by water saving equipment***

The rate of water saving equipment ( $Re$ ) is defined by the percentage of the equipped area with water-saving equipment ( $Ae$ ) over the total area of the perimeter ( $A$ ).

$$Re (\%) = (Ae/A) \times 100 \quad (3)$$

### **Diagnosis of agricultural development**

#### ***Agricultural intensification rate***

The agricultural intensification rate ( $Ri$ ) expresses the ratio of the cultivated and irrigated area during a crop year ( $Ac$ ) to the irrigable area of the perimeter ( $Ai$ ):

$$Ri (\%) = (Ac/Ai) \times 100 \quad (4)$$

### ***Crop water satisfaction rate***

The satisfaction rate of crop water requirements ( $R_s$ ) is defined as the ratio of the distributed water volume ( $V_d$ ) to the theoretical volume of water required for the installed crops ( $V_{th}$ ).

$$R_s (\%) = (V_d/V_{th}) \times 100 \quad (5)$$

The net irrigation water requirements were calculated on the basis of the water balance (Doorenbos and Pruitt 1977). The reference evapotranspiration ( $ET_o$ ) was calculated using the software CROPWAT and Penman -Monteith Formula, given the theoretical basis of the latter which is derived from the balance of energetic flows at the surface canopy (Allen et al. 1994).

The gross water requirements have been defined by considering the overall efficiency of collective and farmer irrigation networks. The overall efficiency ( $E_g$ ) of the used irrigation system is 0.9 (0.95 x 0.95) for localized irrigation and 0.8 (0.95 x 0.85) for sprinkler system. Given that the irrigation system employed in the majority of perimeter is the sprinkling, the overall efficiency used was 0.8. For crops irrigated by the drip system, the gross water requirements have been reduced by 30% to reach a real need of about 70%.

### **Socio-economic diagnosis**

The social and economic diagnosis focused particularly on the agronomic efficiency of water irrigation ( $E_a$ ) for the overall crops during the period 2005-2009. This efficiency is also called productivity of water irrigation, is defined as the ratio of the average crop yield ( $Y$ ) to the amount of water consumed ( $C_w$ ) per cultivated hectare (Eq. 6).

$$E_a (kg/m^3) = Y/C_w \quad (6)$$

### **Water application uniformity**



Diagnosis of operating system (in field), focused on the measurement of emitter's water distribution installed in a plot occupying 4 ha divided into 10 sectors. The experimental plot has been chosen randomly. It is cultivated in chilli, with a cross-row spacing of 1.5 m and an inter-plant spacing of 0.5 m. The used emitters are integrated-type GR, delivering a flow rate of 4 l/h under a pressure of 1 bar. The uniformity of water distribution in the plot is judged from the uniformity test carried for each sector according to the protocol adopted by the CEMAGREF (2003). Then the uniformity coefficient (CU) based on the least irrigated quarter (Keller and Karmeli 1974) was determined for each sector, by applying relationships (7), (8) and (9). The higher the coefficient of uniformity (CU), better the distribution is (Table 2).

$$\bar{q} = \frac{\sum_{i=1}^{16} q_i}{16} \quad (7)$$

$$\bar{q}_{25} = \frac{\sum_{i=1}^4 q_{low}}{4} \quad (8)$$

$$Cu(\%) = 100 \times \frac{\bar{q}_{25}}{\bar{q}} \quad (9)$$

Where  $q_i$  : drip emitter flow rate;  $\bar{q}$  : average flow rate ;  $\bar{q}_{25}$  : average of the 25% lowest values of flow rate;  $q_{low}$  : lowest flow rates; and  $Cu$  : uniformity coefficient.

**Table 2.** Criteria for assessing the uniformity coefficient of emitters

Uniformity coefficient	Network operation
$Cu > 90\%$ ,	Network in good condition
$70\% < Cu < 90\%$	Network has to be cleaned
$Cu < 70\%$	Network clogged

The application of equation (10) was used to estimate variances between average flow rates and the nominal rates to assess the functioning of installed emitters.

$$E(\%) = 1 - \frac{\bar{q}}{q_n} \times 100 \quad (10)$$

Where  $q_n$  : nominal flow rate emitter.

## RESULTS AND DISCUSSION

### Survey results

The interviews with farmers exploiting the perimeter revealed that the majority of farmers is conscious and satisfied by the interest of the project. However, training and popularization insured by the government are considered insufficient due to lack of qualified personnel and available resources. In addition, the unsatisfactory level of technicality and low financial means of most of farmers make them unable to introduce new crops, and the water quality which is relatively loaded did not encourage farmers to undertake crops with high added value. Concerning bank loans, they are frustrated by the property status of several unregistered plots in the cadastral plan, which creates insurmountable obstacles for commissioning.

### Functioning of the irrigation network

#### *State of the hydraulic infrastructures*

The examination of the adopted water supply infrastructure (pumping station, tanks, etc.) at the appointed irrigated area Zaafrana II does not show apparent anomalies, except the storage tank that is in bad condition, mainly the presence of cracks and broken pipes.

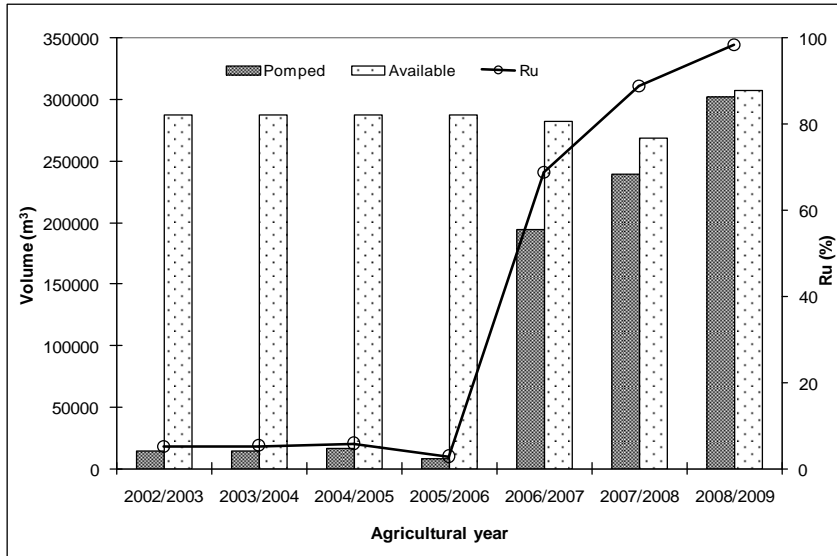
#### *Exploitation rates of allocated resources*

Figure 3 shows the rate of use of water allocated to the perimeter ( $Ru$ ) . The recorded results show that prior the rehabilitation, resources were largely underexploited with an average rate less than 5%. This rate, however, is found increased after rehabilitation to reach 69% in 2006/2007 and 98% in 2008/2009, confirming so that the perimeter has been well exploited.

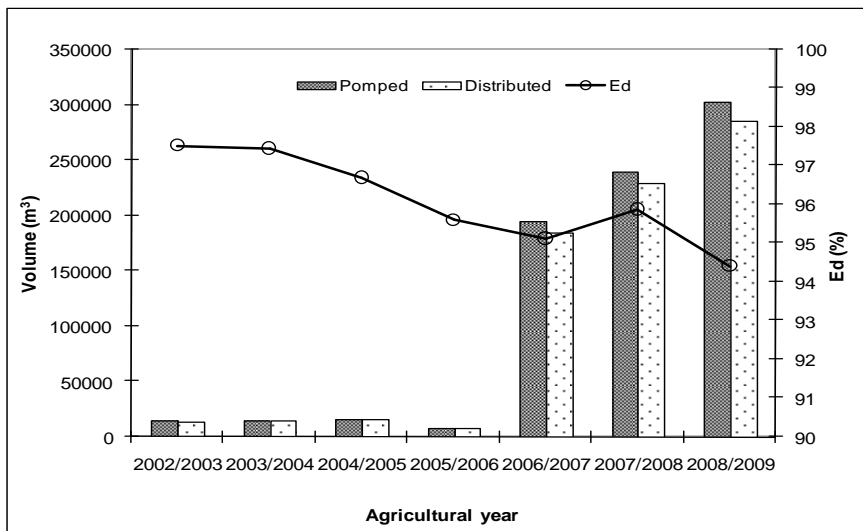
#### *Irrigation water efficiency*

The efficiency of the distribution network during the period 2002-2009 is presented in Figure 4. The latter shows a pre and post rehabilitation efficiency ranging between 94.4% and 97.5%. However, the good efficiency

observed before rehabilitation could be explained by the low flow rates being pumped and delivered as well as the absence of water counting systems. In any event, efficiency after rehabilitation is consistent with the desired objective (95% on average).



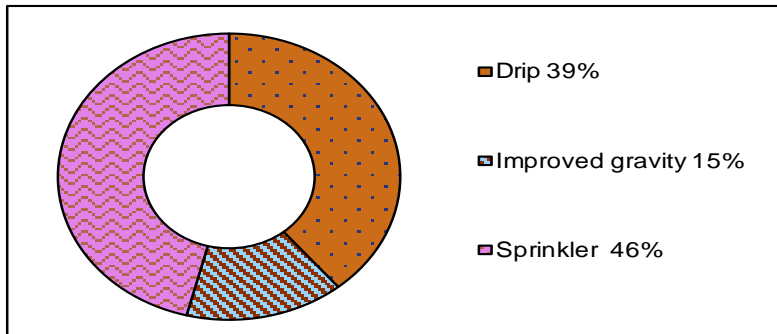
**Fig. 3.** Rate of use of water allocated to the perimeter



**Fig. 4.** Efficiency of the distribution network of the perimeter

**Rate of water saving equipment**

The percentage of irrigated area by various techniques met in the perimeter Zaafrana II is illustrated in Figure 5. It shows a high level of water saving equipment Re (85%), where 46% was for sprinkler and 39% for drip irrigation. This exceeds the desired objective (75%), which proves that the considered perimeter is well equipped. However, despite the rapid expansion, generated by the rehabilitation, of the irrigation drip system and despite the financial incentives granted by the State to encourage more farmers to adopt this technique, it was a much lower developed than sprinkling. In fact it is the sprinkling which always retains the first rank. This could be explained by the limited financial resources of most of the farmers, the lack of technicality and insufficient of supervision and popularization services.

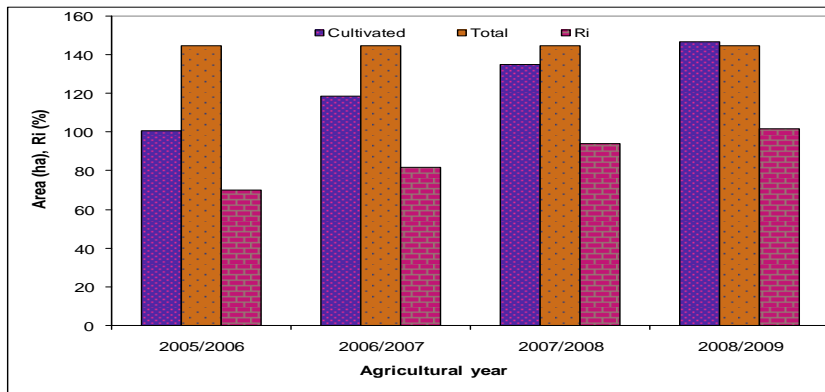


**Fig. 5.** Adopted irrigation techniques within the perimeter

## Development of the perimeter

### *Agricultural intensification rate*

The variation of the agricultural intensification rates ( $R_i$ ) of the perimeter since its rehabilitation is reflected in the Figure 6. At the beginning of the rehabilitation during the crop year 2005/2006, the exploitation of the perimeter was weak with a rate of 70%. Then, the rate has evolved linearly from one year to another to reach 102% during 2008/2009 and show a good exploitation of the perimeter.



**Fig. 6** Variation of the agricultural intensification rate

***Irrigation water requirements***

The gross irrigation water requirements are about 32 350.0 m<sup>3</sup>/ha, with a peak consumption of 6422.5 m<sup>3</sup>/ha, recorded in July and ETo of 1626.9 mm / year. The gross requirements per rotated hectare during the peak month are about 785 m<sup>3</sup>/ha, which corresponds to a continuous fictitious flow rate of 0.3 l/s/ha. Thus, the maximum area that can be irrigated during the peak months is about 67 ha, with a real irrigated area of 68 ha (33 ha of chilli, 22 ha of olive trees, 7 ha of watermelon and 6 ha of melon).

***Crop water satisfaction rate***

Table 3 shows the evolution of satisfaction rate of crops for the campaign 2008/2009. This table reveals the months of October, November and December present a rate exceeding 100%. While the minimum rate is displayed in April, it is about 15% and corresponds to a very low water volume delivered to the perimeter (12 389 m<sup>3</sup>), given the strong rain received during this month compared to the assessed needs of 84 400 m<sup>3</sup>. The average satisfaction rate is about 85%, it reflects a good use of water resources by farmers in the studied perimeter.

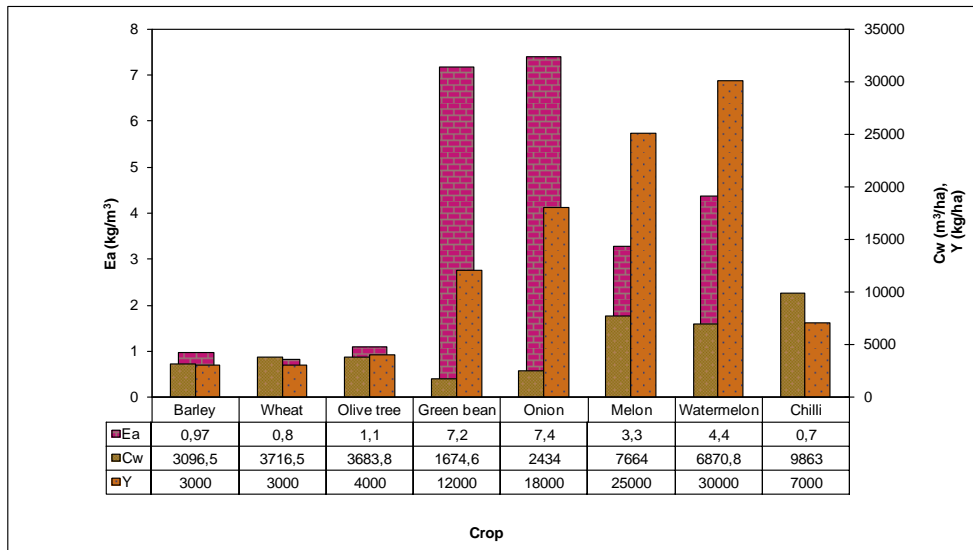
**Table 3.** Crop water satisfaction rates

Month	Vth, m <sup>3</sup>	Vd, m <sup>3</sup>	Rs, %
S	19901	14541	73.07
O	5802.5	11790	203.19
N	8718.3	15079	172.96
D	11730	28063	239.24
J	13803	10920	79.11

F	22274.2	10918	49.02
M	65593	37041	56.47
A	84400	12389	14.68
M	109573	24479	22.34
J	85081	33006	38.79
Jy	115490	37030	32.06
A	76782	40376	52.59

**Socioeconomic diagnosis**

The agronomic efficiency of water irrigation is obtained by using crop yields and volumes of water consumed for different crops within the perimeter during the period 2005-2009 (Figure 7).



**Fig. 7.** Productivity of irrigation water

As figure 7 shows, the highest values of coefficients Ea are those of onion ( $7.4 \text{ kg/m}^3$ ) and green bean ( $7.2 \text{ kg/m}^3$ ) consuming the lowest water quantity. In addition, watermelon and melon recorded the highest yields, but however, they aren't necessarily with the greatest productivities. Finally, it should be noted that the culture of chilli has shown the lowest productivity ( $0.7 \text{ kg/m}^3$ ); hence it is necessary to look for other high-value crops to replace this culture.

**Diagnostics functioning of localized irrigation system**

***Drippers flow rates***

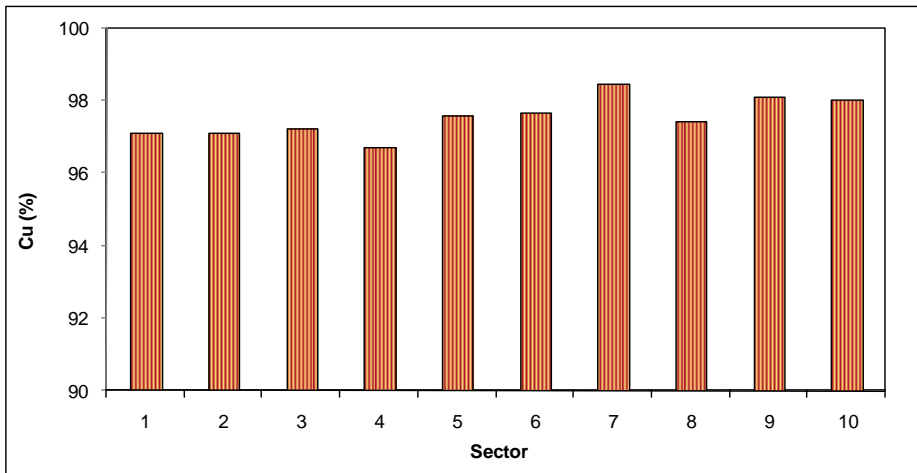
Table 4 provides the average; minimum and maximum rates resulted from the measurements made at the level of the 10-valves distributed within the experimental irrigated plot. The small variations in the rate flow reflect the proper water application. In fact for all valves, the average flow rate  $\bar{q}$  has varied between 3.80 and 4.04 l/h, the minimum (qmin) have ranged from 3.70 to 3.85 l/h and the maximum (qmax ) from 3.95 to 4.20 l/h.

**Table 4.** Mean and extreme values of measured flow rates by sector

Sector	1	2	3	4	5	6	7	8	9	10
$\bar{q}$ , l/h	4.04	4.00	3.98	4.02	3.90	3.90	3.89	3.85	3.84	3.80
q min, l/h	3.85	3.84	3.83	3.84	3.78	3.76	3.78	3.72	3.72	3.70
q max, l/h	4.20	4.20	4.20	4.20	4.10	3.97	3.96	3.96	3.96	3.95

***Uniformity distribution of water in field plot***

The uniformity coefficients obtained from 160 measurements are presented in Figure 8. This figure shows a very high coefficients  $C_u$  ranging from 96.7 to 98.5%. For an average flow of 3.92 l/h, the average uniformity coefficient is 97.6%, which shows a good homogeneity of water application in the plot. From this figure and referring to Table 2 for the classification of  $C_U$ , all coefficients are above 90% showing a good operating condition of the system and the absence of clogging problem at the time of the experiment.



**Fig. 8.** Variation of uniformity coefficients of water distribution

***Real and nominal dripper’s rates***

Table 5 shows the deviation of the average flow rates (actual) from the nominal flow rate (theoretical) drippers in each sector. According to this table, the average flows drippers ranging from 3.80 to 4.04 l/h are as follows: 20% of emitters provide flow rate higher than 4 l/h corresponding to a positive deviation from the nominal flow rate (eg due to their wear and tear) and 70% of drippers deliver between 3.80 and 3.98 l/h to give negative deviations (mostly due to impurities). The measured rates are considered good and almost consistent with the nominal flow (4 l/h) and the differences between the measured and nominal flow rate is low reaching a maximum of 5%, which confirms the good uniformity of the irrigation in the plot; ensured by the general good state of the network and the absence of clogging problem previously reported.

Table 5. Difference between real and nominal flow rates of drippers

Sector	1	2	3	4	5	6	7	8	9	10
$\bar{q}$ , l/h	4.04	4.00	3.98	4.02	3.90	3.90	3.89	3.85	3.84	3.80
E, %	-0.88	0.02	0.50	-0.42	2.41	2.61	2.80	3.81	4.08	5.02

**CONCLUSION**

The diagnosis and analysis of functioning of the perimeter Zaafrana II (Central Tunisia) based on various efficiency indicators at the level of the distribution network and the water quality distribution in the plot have



shown that hydraulic system is suitably equipped and operated with an efficiency of about 95%. The satisfaction rate of crop water requirements of crops of the perimeter ensured by network is estimated at 85%. The proper functioning of the network increased the intensification rate which exceeded 100% in 2008/2009 and to incite farmers to practice the water-saving techniques. The first rank is reserved to the sprinkling occupying 46% of the area of the perimeter, and the second is devoted to drip system occupying 39% of the area. The onion and bean crops need to be more practiced in the perimeter given their good conversion efficiency of irrigation water.

Concerning the diagnosis of drip irrigation in the plot, the uniformity coefficient was greater than 90% and the small differences between the measured flow and the flow rate; below 5% proves a good uniformity of water application; the good state of irrigation system and the absence of a malfunction in the plot during the experiment. However, 70% of drippers deliver a lower flow rate than the recommended, to highlight a trend towards plugging and the necessity to control installations in order to maintain the performance of the localized irrigation technique and ensure the materials longevity.

This study has proved that the perimeter has earned the state investment and rehabilitation of PIP will contribute to the rational and efficient use of water resources.

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