Intelligent Irrigation System for Low-cost Autonomous Water Control in Small-scale Agriculture

Deliverable D3.1b

Second report on smallholders common irrigation practices and irrigation techniques selection

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EXECUTIVE SUMMARY

Deliverable D3.1a was initially the first report presenting the common irrigation practices in Algeria and Morocco. It should be followed by D3.1b but we decided to merge both deliverables. Therefore, this is D3.1b.

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1. Introduction

1.1. Irrigation sector in Morocco

Water availability in Morocco is one of the main limiting factors for obtaining good yields. Although irrigated agriculture occupies only 15% of Morocco's cultivated area (about 1.5 million hectares), it contributes about 45% to 75% of agricultural exports, depending on the season. This contribution is greater during dry seasons when production in rainfed areas is severely affected (MAPMDREF, 2021).

In this context, the global objectives expected by the actors and managers in the irrigated perimeters are centered on increasing production, water management control and irrigation rationalization which constitute a challenge of agricultural policy. This is why Moroccan decision-makers and managers constantly encourage farmers to promote water saving through technical supervision and coaching, the granting of subsidies for irrigation equipment and the adoption laws governing water resources mobilization and rational use (Higher Council for Water and Climate, Law No. 36-15, 2016).

1.1.1. The great hydraulics (GH)

Most of the State's effort was initially devoted to large-scale irrigation, which benefited from more than half of the investments reserved for agriculture. Nine large perimeters have been created in the hydraulic basins of the country. Development in these perimeters has made notable progress.

Figure 1 - water channel in a great hydraulic in Morocco

Figure 2 - a panoramic view of a great hydraulic in Morocco

The rate of intensification has gradually increased and new guidelines are drawn up by the State to meet the requirements of efficient and sustainable irrigated agriculture). For a better valorization of agricultural production, the missions of the Agricultural Development Offices have been oriented towards the management of water and facilities, advice and professional organization.

1.1.2. Small and medium hydraulics (SMH)

Composed of a multitude of traditional perimeters, small and medium hydraulic designates traditional irrigated perimeters of small size (less than 100 ha), to medium size (3,000 ha to 5,000 ha). The PMH represents 35% of the national irrigable potential in a sustainable way, 484,000 ha and 300,000ha of seasonal irrigable area. The existence of small and medium hydraulic perimeters gives the SMH an important role in the regional socio-economic balance.

Figure 3 - Water canals in a small and medium hydraulic perimeter in Morocco

They are distributed throughout the national territory between mountains and plains, and between large irrigated areas and the Bour zone. The State's new approach for the development of SMH perimeters is based on the constitutive principles of territorialisation, integration and participation. Indeed, the size of the perimeters, low to medium, allows the implementation of local and participatory integrated development which combines the development of irrigation infrastructure, the intensification of agricultural production and the construction of socio-economic facilities. economic (Bekkari, 2009).

1.1.3. Private irrigation

In Morocco, the area of private irrigation represents 442,000 ha developed and managed by private investors (MAPM, 2013). In recent years, the State has been concerned with safeguarding certain areas where private irrigation is threatened by the overexploitation of groundwater resources.

Considered as an essential component of the irrigation potential in Morocco, private irrigation includes all irrigation schemes carried out by private initiative. It can thus cover a wide field of investment ranging from a simple well for the irrigation of less than one hectare to a modern development for the irrigation of several hundred

hectares. According to the study of the master plan for water development in the South Atlas basins, private pumping has experienced significant and uncontrolled development since the 1980s and serves as a supplement for water from the collective large hydraulic network or PMH (ABHOER, 2012). Thus, the uncontrolled evolution of this type of irrigation disrupts the assessment of the demand for irrigation water and the water balances of surface and groundwater resources (Lionboui et al., 2018).

1.1.4. Irrigation water rationalization and valorization programs

To meet the challenge of producing in a sustainable and competitive manner, Morocco's current agricultural strategy "Green Generation" encourages the rationalization and recovery of irrigation water. Thus, a proactive policy of generalization of water-saving irrigation techniques and agricultural water recovery has been adopted and implemented through four main programs: a) National Irrigation Water Saving Program (PNEEI): concerns the development of localized irrigation over a total area of 550,000 ha; b) Irrigation Extension Program (PEI) downstream of the dams: its scope of action is the creation of new irrigated areas and the strengthening of irrigation of existing areas over an area of 130,000 ha; c) Program for the rehabilitation and safeguarding of Small and Medium Hydraulic (PMH) perimeters: was set up to improve the efficiency of traditional irrigation infrastructure at the level of PMH perimeters; d) Program for the Promotion of Public-Private Partnership: strives to improve the technical, economic and financial conditions for the management of the irrigation water service, through the development of new irrigation projects in the framework of Public-Private Partnerships.

According to figures announced by the Ministry of Agriculture, Fisheries, Rural Development, Water and Forests, at the end of 2019, the implementation of these programs made it possible to carry out hydro-agricultural developments over an area nearly 800,000 ha (including 585,000 ha under localized irrigation, i.e. approximately 50% of the irrigated area at the national level) for the benefit of 235,000 farms and for an investment effort of nearly 36 billion MAD (1MAD≃0.095 Euro) .

1.2. Irrigation sector in Algeria

1.2.1. Climate and type of agriculture

In Algeria, 96% of the territory is subject to an arid to semi-arid climate (Table 1). Under these conditions, irrigation is essential to maintain agricultural productivity.

Table 1 - Types of Climate of Algerian regions

Régions Algériennes	% National Area	climateType
Tellian Region (North)	4	Mediterranean on coastline
Steppic Region (hights plateaux between Tellian and Saharian Atlas)	9	Semi-arid
Saharian Region (Sud)	87	Arid

The size farm distribution in Algeria shows that the total number of them is approximately 1 million (Table 2).Family farming dominates the sector, in fact a survey conducted by the Chamber of Agriculture of Mostaganem in 2010 showed that more than 70% of farms are managed by the family for at least three generations.

Table 2 - Size distribution of farms in Algeria

Farm size in ha	% of total number of farms	% of cultivated area
< 10	71	25
10 - 50	27	50
> 50	2	25

It is known that irrigation management in family farming is mostly based on traditional surface irrigation methods, which generate large water losses since the quantities applied are often very high compared to the net needs of the crops.

1.2.2. Evolution of irrigation practices

The use of surface irrigation techniques in Algeria has since 2012 represented 58% of surface irrigation practices, compared to 23% for sprinklers and 19% for micro-irrigation.However, the evolution of irrigation practices reported by the Ministry of Agriculture (Figure 4), shows that between 2001 and 2018, irrigation systems by sprinkler and drip are constantly increasing.

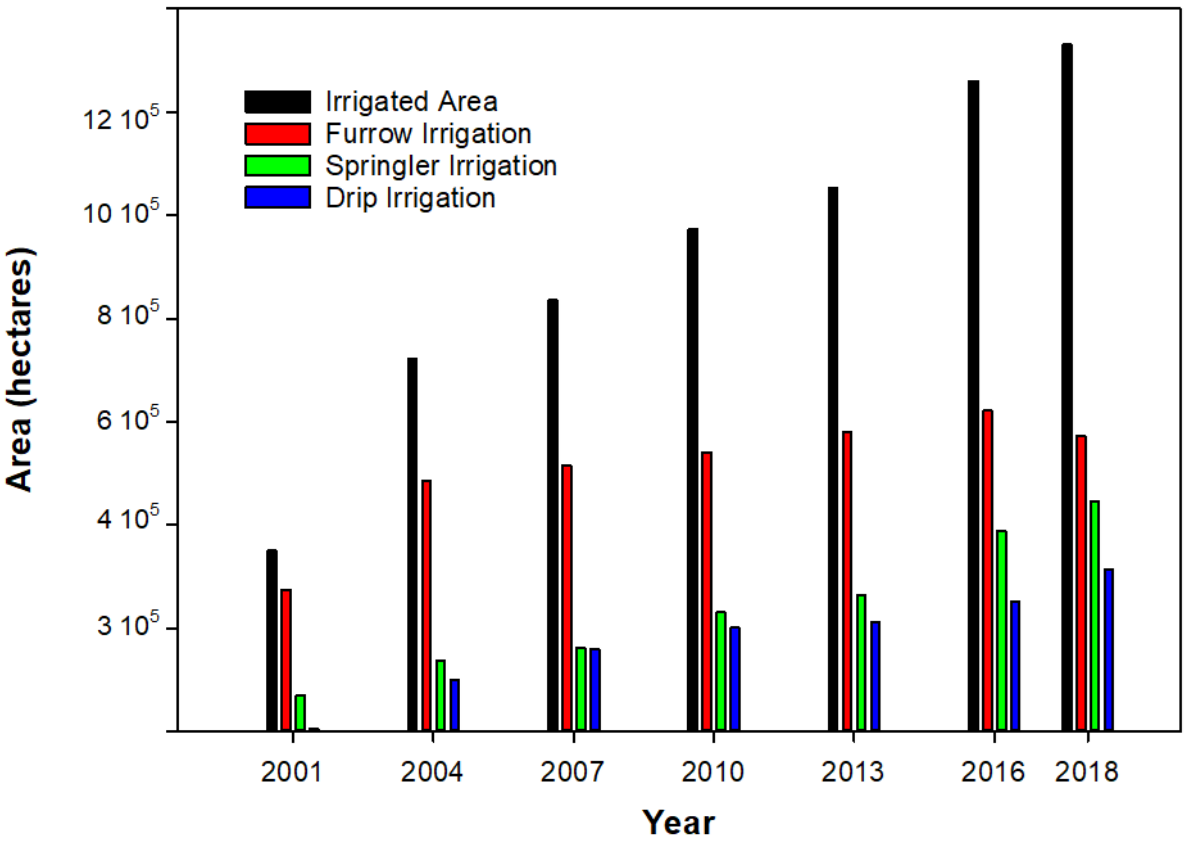

Figure 4 - Evolution of irrigated area by furrow, sprinkler and drip irrigation in Algeria (2001-2018)

2. Review of common irrigation techniques and practices in small-scale agriculture

2.1. In Morocco

2.1.1. irrigation techniques

Efforts made by the state and by farmers since the 1960s to develop irrigated agriculture have made it possible to reach one million irrigated hectares. In 2020, the irrigated area is 1,600,000 ha, or 18% of the total arable area and 21% of the cultivated area per year, or 38% of the total irrigated area at the national level. The irrigation programs cover 750,000 ha, 90% of which is intended for areas of less than 20 ha.

A main component of the current national agricultural strategy is the National Irrigation Water Saving Program (PNEEI) which consists of the reconversion of 610,000 ha by 2022 from flooding irrigation system and sprinkler irrigation to drip irrigation technique. In addition, subsidies of up to 100% have been applied to encourage farmers to adopt drip irrigation.

Morocco receives an annual average of about 29 billion m3 of rain, the hydraulic potential that can be mobilized, under current technical and economic conditions, is estimated at 68%,

55% of which comes from surface water and 14% from groundwater. Morocco currently has an important hydro-agricultural heritage and enjoys an important place internationally in terms of water management policy, particularly in agriculture.

In Morocco, there are three types of irrigation, namely: drip irrigation, sprinkler irrigation and Flooding irrigation.

Flooding irrigation

Flooding irrigation is the operation consisting of artificially bringing water to cultivated plants to increase their production, and allow their normal development in the event of a water deficit induced by a rainfall deficit, excessive drainage or drop in the water table, especially in arid areas, the flow of water is done according to the natural slope of the ground.

Figure 5 - A plot irrigated by flooding irrigation

Surface irrigation has more disadvantages than advantages:

Table 3- Advantages and disadvantages of flooding irrigation.

Advantages	Inconvenients
- low investment cost per plot for the farmer. - no external energy supply.	- Labor time for distribution and important monitoring; - Significant water loss (50%); - Requires flat ground or leveling; - low efficiency; - possible pollution by spillage.

Sprinkler irrigation

Sprinkler irrigation reproduces the natural phenomenon of rain, by controlling the intensity and height of precipitation, this technique requires medium to high pressure conditions (from 3 to 6 bars at the nozzle).

Figure 6- Plots irrigated by Sprinkler irrigation

At the level of the sprinkler, the centrepiece of the device, a nozzle creates a jet and directs it towards the spoon, the mobile arm is activated by the jet, the return spring causes the return of the mobile arm and thus ensures the rotation of the sprinkler.

Localized irrigation

Localized irrigation or micro-irrigation (Figure 4) consists of bringing water to a part of the soil only in small frequent doses. At the limit, the compensation of evapotranspiration takes place daily and water is supplied by distributors, which creates wet areas in the soil called “watering or humidification bulbs”.

Figure 7- A plot irrigated by drip irrigation

Several techniques are developed:

- localized irrigation by drippers: drip.
- localized irrigation by fixed perforated ramps.
- localized irrigation by diffusion (micro jet, micro diffuser).

Localized irrigation has more advantages than disadvantages, Table 3 illustrates the advantages and disadvantages of this type of irrigation.

Table 4- Advantages and disadvantages of Localized irrigation.

Advantages	Inconvenients
- Water saving 50 to 70% compared to gravity and 30% compared to sprinkling; - The reduction of pollution of the water table by fertilizers as well as a saving in fertilizers; - Facilitates the exploitation of very light soils filtering with strong percolation and heavy soils cracking in summer; - The possibility of exploiting land with irregular topography and configuration; - Easy access to the plots for carrying out the various farming operations; - The increase in yield of around 20 to 40%, and an improvement in product quality.	- The difficulty of managing localised irrigation, which requires high technicality; - The risk of rapid drying out of plants in the event of a spontaneous and prolonged stoppage of the supply of water; - The cost of installing irrigation equipment and materials is higher; - The risk of clogging or clogging of the distributor constituting major drawback of this system.

In Morocco, irrigated areas have played a decisive role, both at the local level and at the national regional level. However, with the effects of climate change felt, the irrigated production system is faced with concern for the sustainability of water resources as Morocco is currently classified as a water stressed country. Therefore, managers of irrigation systems must ensure that irrigation is optimal in irrigated areas to cope with water shortages especially for small farmers. Hence the importance of developing intelligent irrigation techniques adapted to the needs of the Moroccan farmer.

As a result, within the framework of the Intel-IrriS project, we opt to focus on drip irrigation techniques which would make it possible to support the national strategy of water conservation, the demand of farmers to improve the efficiency of the use of irrigation water and also work to contribute to increasing water productivity.

2.1.2. Links to irrigation techniques documents

https://hal.archives-ouvertes.fr/hal-02963118/document

https://www.agrimaroc.ma/les-differentes-techniques-d-irrigation/

https://www.agrimaroc.net/2018/07/09/techniques-deconomie-de-leau-dirrigation-a-la-parcelle-aspersion-et-localisee/

https://www.agrimaroc.ma/les-differentes-techniques-d-irrigation/

https://www.banquemondiale.org/fr/news/feature/2016/02/18/growing-morocco-s-agricultural-potential1

https://www.afdb.org/fileadmin/uploads/afdb/Documents/Project-and-Operations/Morocco%20-%20The%20National%20Irrigation%20WAater%20Saving%20Programme%20Support%20Project%20(PAPNEEI)%20EN_01.pdf

https://www.mamopanel.org/media/uploads/files/Water-wise_case_study_Morocco.pdf

2.1.3. Links to irrigation techniques videos:

https://www.youtube.com/watch?v=pG1Zd-IAyVI

https://www.youtube.com/watch?v=NbYUsK_XpKg

https://www.youtube.com/watch?v=Hanaf5ghti8

https://www.youtube.com/watch?v=I7PkTiBwlPQ

https://www.youtube.com/watch?v=BzPZ1qs9Tus

2.2. In Algeria

2.2.1. Irrigation techniques

Following our visits to several smallholders in the Oranese region, primarily in the first pilot farm located in Bousfer village (see Figure 1), we became aware of the common process of operation of the irrigation system most used by farmers, which is summarized in Figure 2.

Figure 8: The region of Bousfer located west of Oran city

This irrigation system is purely traditional in the sense that no technoolgy is employed. It is basically composed of a water basin with or without fish and a traditional irrigation mechanism. The water in this basin comes from groundwater, rain, seawater desalination or

purified water to supply the irrigation system, which includes controlled motors and tanks for injecting chemicals into the water for irrigation. The water produced after treatment is used for drip irrigation (with soil or suspended perforated pipe) depending on the type of crop.

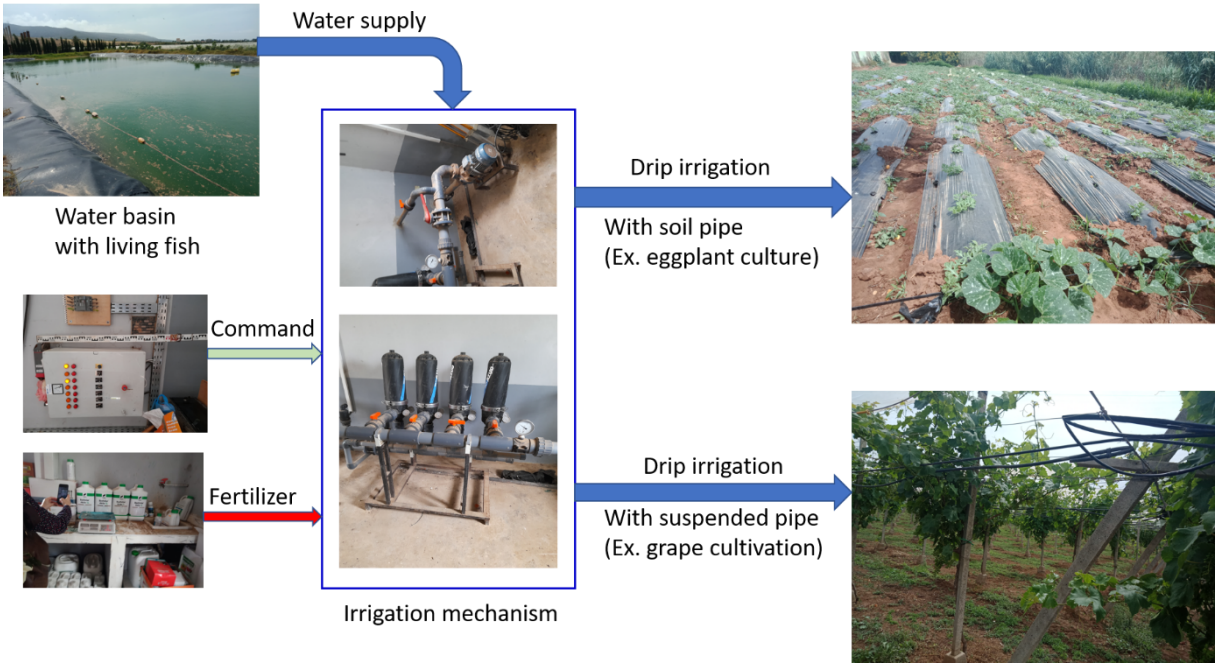

Figure 9- Common irrigation practices widely used in the city of Oran

Another practice used by few private farmers exists in the region, which have financial resources to practice proprietary modern irrigation technology initiatives. Indeed, the use of new information and communication technologies has become a mandatory requirement to increase production and reduce the cost in terms of natural resources such as water and energy. Algerian farmers are aware of the benefits of using new irrigation methods.

We took the example of a second pilot farm located in the region of Bousfer in Oran. We have seen the implementation of a farm monitoring system. As the vine cultivation is efficient with an irrigation system based on drip irrigation, perforated water pipes are placed on top of the vines (see figure 3).

Figure 10- Drip irrigation for vine crops

A pole is placed in the middle of the field equipped with the following sensors (see Figure 4):
- Temperature sensor.
- Humidity sensor.
- Wind speed sensor.
- Sunlight sensor.
- Soil moisture sensor (measures at different depths).
- A water meter is placed at the bottom of the pole.
- A solar panel

Figure 11- Farm monitoring node (sensors, microcontroller, GSM module)

All these sensors are connected to a microcontroller that has a GPRS/GSM (a chip from the private telecom operator *ooredoo* with an annual subscription) to connect to the Internet (see figure 5).

Figure 12- A microcontroller embedding a GPRS/GSM module

A station containing motors and barrels for injecting chemicals into the water (See Figure 2).
We can summarize the characteristics and limitations of this initiative as follows:
- Solar energy to power the monitoring system (sensors, microcontroller, as well as the GSM module).
- A mobile software application easy to use.
- Remote monitoring of the farm but the irrigation starting is manual.
- The irrigation process is not automated according to the water needs of the crop.
- A single sensor node for the entire agricultural field.
- Requirement of annual subscription of the *ooredoo* chip (10000 DA/year).
- High cost of equipment (sensors, ...).
- Collected data are stored in a server of the company owning the solution (limited access to the history).

2.2.2. Irrigation techniques Documents:

État des lieux du secteur de l'eau en Algérie (pseau.org)

Réseau de capteurs sans fil pour la surveillance de l'humidité du sol et des conditions météorologiques (asabe.org)

(21) (PDF) Tensiomètre avancé pour les mesures du potentiel des eaux de sol peu profondes ou profondes (researchgate.net)

2.2.3. Irrigation techniques videos:

Webinaire « Irrigation : concepts et état des lieux » - YouTube

Sondes d'humidité du sol: Utilité et comment les installer - YouTube

Pilotage Irrigation par sondes tensiométriques - YouTube

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[3] MAPM (2013). "Quel système d'information sur l'eau ?." Direction de l'irrigation, Rabat, Maroc.

[4] ABHOER (2012). Etude du Plan Directeur d'Aménagement Intégré des Ressources en Eau du Bassin de l'Oum Er Rbia et des bassins côtiers atlantiques. Ministère délégué auprès du Ministre de l'Energie, des Mines, de l'Eau et de l'Environnement-chargé de l'Eau, Rabat, Maroc.

[5] Lionboui, H., Benabdelouahab, T., Hasib, A., Elame, F., Boulli, A. (2018). Dynamic agro-economic modeling for sustainable water resources management in arid and semi-arid areas. In: Hussain, C.M. (Ed.), Handbook of Environmental Materials

Acronyms List

Acronym	Explanation
ABHOER	Oum Er Rbia Hydraulic Basin Agency
PNEEI	National Irrigation Water Saving Program

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