Adaptation Measures for Sustainable Development of the Agricultural Potential of the Flood-Risk Zones of Ghareb Lowland, Morocco

R. Bourziza, W. El Khoumsi, I. Mghabbar, I. Rahou

***Abstract*—**The flood-risk zones called Merjas are lowlands that are flooded during the rainy season. Indeed, these depressed areas were reclaimed to dry them out in order to exploit their agricultural potential. Thus, farmers were able to start exploiting these drained lands. As the development of modern agriculture in Morocco progressed, farmers began to practice irrigated agriculture. In a context of vulnerability to floods and the need for optimal exploitation of the agricultural potential of the flood-risk zones, the question of how farmers are adapting to this context and the degree of exploitation of this potential arises. It is in these circumstances that this work was initiated, aiming at the characterization of irrigation practices in the flood-risk zones of the Ghareb lowland (Morocco). This characterization is based on two main axes: the characterization of irrigation techniques used, as well as the management of irrigation in these areas. In order to achieve our objective, two complementary approaches have been adopted; the first one is based on interviews with administrative agents and on farmer surveys, and the second one is based on field measurements of a few parameters, such as flow rate, pressure, uniformity coefficient of drippers and salinity. The results of this work led to conclude that the choice of the practiced crop (crop resistant to excess water in winter and vegetable crops during other seasons) and the availability and nature of water resources are the main criteria that determine the choice of the irrigation system. Even if irrigation management is imprecise, farmers are able to achieve agricultural yields that are comparable to those recorded in the entire irrigated perimeter. However, agricultural yields in these areas are still threatened by climate change, since these areas play the role of water retaining basins during floods by protecting the downstream areas, which can also damage the crops there instilled during the autumn. This work has also noted that the predominance of private pumping in flood-risk zones in the coastal zone creates a risk of marine intrusion, which risks endangering the groundwater table. Thus, this work enabled us to understand the functioning and the adaptation measures of these vulnerable zones for the sustainability of the Merjas and a better valorization of these marginalized lowlands.

***Keywords*—**Flood-risk zones, irrigation practices, climate change, adaptation measures.

I. Introduction

THE flood-risk zones, called Merjas in Morocco, are lowlands that are flooded during the rainy season. The Merjas according to [6] designates more especially the low regions likely to retain, temporarily or permanently, on a part of their surface, the water of run-off, of flood and of rain. Thus, the phenomenon of Merja responds to a double characteristic, topographical: it is a lowland, and hydrological: it is an extent of water more or less stagnant. Flood zones are defined in the Flood zones Conservation Strategy for Ontario [7] as water-saturated lands long enough to cause the formation of waterlogged soils (hydric) and the growth of plants that enjoy water (hydrophilic) or which tolerate water. Many flood zones are permanently flooded, while others are only periodically flooded in the spring or fall. The size of flood zones varies from very small to exceptionally large, covering hundreds of square kilometers. They are defined by [11] and [13] as areas of marsh, bog or water that can be natural or artificial, permanent or temporary, with static or flowing water and with a fresh, brackish or salty quality, including also areas of sea water whose depth at low tide does not exceed six meters. In addition, flood zones may incorporate coastal areas adjacent to flood zones and islands.

According to [12], inland flood zones cover at least 9.5 million km² (i.e. about 6.5% of the land area). They deliver a range of ecosystem services [3]. Reference [10] cited flood zones as essential for providing ecosystem services related to water, such as drinking water, water for agriculture and water quantity regulation (example of regulation of floods). In addition to their role in erosion control and sediment transport, flood zones also contribute to land formation and, consequently, to resilience to storms. In addition, they provide a wide range of water-dependent services, such as agricultural production, climate regulation, soil and sediment retention, storm and flood protection, and support services such as: soil formation and the nutrient cycle (nitrogen, phosphorus and carbon).

Flood zones provide a wide variety of products. The production of flood zones can also come from agriculture or livestock, for food and feed (pasture, rice, fruit, vegetables, watercress, logging, reeds ...). Depending on the regions of the world, these productions are integrated into subsistence or marketing economies. In any case, they participate in local development [2]. For example, seasonal flooding in the Waza-Logone flood area in Cameroon traditionally supported a large population of fishermen, sedentary farmers, and pastoralists, all of which rely on the reliable natural sequence of floods and recession [12]. In Mali, the lowlands cover an estimated 700 000 ha, including 300 000 ha in the southern part of the country.

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At the national and local levels, the lowlands make a significant contribution to food security and job creation, and thus to poverty reduction. For example, more than 11% of Paddy's national production and a large part of fruit, vegetables and tubers are produced in southern Mali. This shows the agricultural potential of the southern lowlands of Mali, despite the small area allocated to agriculture which is of the order of 50 000 ha against an area of 300 000 ha occupied by these lowlands [1]. Given their water potentials and fertile soils, lowlands have been at the center of any agricultural development policy in West Africa and Benin in particular. Lowland development projects are needed to "reduce food insecurity and diversify production for export or import substitution" [8].

The problem of agricultural development in these areas, vulnerable to flooding and the formation of the merjas, therefore arises essentially in terms of farm management installed in these areas. Thus, a reflection on the adopted irrigation practices must be carried out, through the characterization of the irrigation systems used in terms of mobilization, adduction and techniques used. All the more, these areas are characterized by the existence of an important aquifer system which contributes to the extension of private pumping irrigation which is accentuated with the technological development, making these areas more vulnerable. Despite the different scientific works carried out on the flood zones, several questions arise: How are farmers adapting to floods? What irrigation systems are used in these areas? How are they managed? It is in this context that this work was conducted, in order to understand the functioning and the adaptation of these vulnerable areas for sustainability merjas and a better valorization of these low marginal lands.

II. Materials and Methods

A. Presentation of Study Area

The study area is located in North-West of Morocco and it is one of the main agricultural regions of the country. The Ghareb lowland (Fig. 1) is a vast alluvial zone of low altitude, separated from the Atlantic Ocean by a string of dunes and interrupted by the Sebou River in the South. Located in the north-west of Morocco, the Ghareb lowland covers an area of about 616 000 ha. Its useful agricultural area is 388 000 ha, of which the uncultivated area is 228 000 ha [9]. It is composed of a coastal zone, continental borders and the central alluvial lowland of Sebou which is the main river in this area [9].

The climate in the Ghareb area is known for its wet winters and hot summers. It is a Mediterranean climate with an oceanic influence allowing the development of a wide range of crops [4]. Rainfall is characterized by an irregularity in time as well as space. The gradient of rainfall decreases from the west coast to the center of the lowland; in this sense there are three climatic regions: Coastal zones (West) with 530 mm, Central zones with 480 mm, Inland areas (East) with 400 mm of rainfall [4].

The Ghareb is composed of a varied range of soils, which can be grouped in four sets with varied agronomic vocation [4]. Flood zones or Merjas (the vernacular name used for flood zones) cover 15% of the surface of the lowland, their soils are very hydromorphic, these areas are very suitable for rice and forage crops. The lowland itself covers 40% of the area; it is covered with black soils (loamy soils) that are suitable for several crops, including cereals and vegetables. In the coastal zone, soils become sandier, allow greenhouse crops (banana, strawberry ...) and peanut culture. The areas of alluvial deposits (30%) are characterized by less clayey soils, they are very favorable to industrial crops (sugar cane, beets, sunflower ...). The Zrar zone (15%) is covered with very rich red soils and presents as a vast alluvial zone of low altitude, generally formed of quaternary deposits.

We will study five flood zones, two of them are in the coastal areas (Merja Sidi Med Ben Mansour and Merja Daoura) and the remaining three are in the central areas (Merja Sidi Ameur, Merja Jouad and Merja Tedjina).

B. Data Collection and Field Surveys

To deepen the reflection, a participatory approach made it possible to understand the issue and the impact of the floods on the practices, systems and techniques of irrigation adopted by the farmers of the zones of study. This analysis was maintained through field surveys. These surveys were conducted on a sample of 40 farms in the coastal flood zones and 46 farms in the central flood zones. The farms surveyed were chosen to be representative in terms of longitudinal and transverse transects of the flood zones in order to review the entire field of irrigation systems observed in the study area, the problems faced and the practices used to overcome them. There are no criteria for area or crops planted since the plots are generally small and the farmers grow the same crops and use the same management methods as those being considered.

A first survey form was developed to collect field data for the drip irrigation system, a second one for the aspersive system and a third one for the furrow system. These sheets aim at characterizing these different irrigation systems on two levels. The first one is the characterization of irrigation systems by focusing on the resource mobilization components, the water supply system and the distribution system. The second one is the characterization based on the aspects of the management of irrigation techniques specifically irrigation management and maintenance.

C. Field Measurements

This approach is based on measurements of hydraulic parameters characterizing the irrigation systems used in the flood zones of the study area, such as flow, pressure and well depth. This made it possible to have an idea about the level of the groundwater table which is the sole source of water irrigation, resulting in overexploitation of this source. This led to a reflection on the risk of marine intrusion on the coastal zone and the excessive use of fertilizers in the central zone, it was therefore necessary to calculate the salinity of the groundwater table in these areas. These measurements were carried out on different types of irrigation, and in different places to have more accurate and real data. A single constraint was encountered; the delay in irrigation which began at least in May following the late rains that caused a delay in the drying up of agricultural land in these flood zones.

Flow rate is one of the most important parameters in the characterization of an irrigation system. This parameter gives an idea about the pumped volume from the groundwater table and the volume consumed by the farmer. It was measured using an Ultraflux NT 214B FR1 flow meter. It is a flow meter of the MiniSonic family, specifically the MiniSonic P (Fig. 1), which uses the principle of measurement by transit time difference of ultrasonic waves and is associated with external probes that allow to give the volumetric flow and its direction.

Fig. 1 Flow measurement using the Minisonic p flow meter

To measure the flow rate, it is necessary to make two sensors interact along a path L and to measure the travel times. The time measurement, associated with the knowledge of the geometrical parameters (diameter/thickness/L ...) allows the calculation of the volumetric flow rate whatever the evolutions of the temperature or the pressure of the water.

Pressure measurement is performed to judge the proper functioning of a pressure irrigation system. This measurement was performed using a precision class manometer of 1.6 with a measurement range of 0-6 bar (Fig. 2). This manometer is used for pressure measurement for sprinkler and micro-irrigation to judge the functioning of the system. Regarding sprinkler irrigation, the pressure in the lateral connected to the sprinkler must be 3 bars. As for drip irrigation, the last end of the lateral must have a pressure of approximately 1 bar.

Fig. 2 Manometer to measure the pressure at the end of a drip lateral

The second parameter to judge the functioning of drip irrigation system is the test of uniformity. The lower the flow rates at the nominal operating value, the more the network is clogged. To measure the flow rate of drippers, we carried out the irrigation uniformity test according to the method of [5], using the principle of volume flow per unit of time.

Fig. 3 Measurement of the depth of drilling by piezometric probe

The depth of wells or borehole informs about the level of groundwater table and therefore the availability of a permanent source of water for irrigation. The sound and light sensors, also called hydrometric probes or piezometric probes, are one of the simplest systems to install (Fig. 3). It aims to measure the height of the water using a differential pressure sensor. The water level is calculated from the hydrostatic pressure. A ceramic sensor measures the height of the liquid above the sensor and converts these data into an optical electrical signal (light). These measures are intended to give an idea of the situation of the aquifer used by farmers for irrigation.

Fig. 4 Measurement of salinity by the conductivity meter

The objective of the groundwater salinity measurement is to identify the risk of degradation of the aquifer quality or the risk of marine intrusion due to intensive pumping. Salinity is measured through conductivity. This is achieved by the Hanna Instruments HI98304 DiST 4 conductivity meter (Fig. 4). It is tester of a long range electrolytic conductivity (EC). A simply switch the ON/OFF button and immerse the conductivity sensor in the solution to see the result on its LCD screen. After the measurement is noted, and in order to have values not influenced by the previous measurements, the same procedure is repeated but using a neutral solution.

III. Results and Discussions

A. Farm Rotation in Flood Areas

The farms in each zone differ in terms of crops and irrigation technique used which is conditioned by the land status and the field area. Different types of crops are practiced in the area. In the Ras Daoura flood zone, the dominance of cereals over sunflower crop is 47% compared to 32%, which is not the case with the flood zone of Sidi Med Ben Mansour. In the second zone, the dominance of the oleaginous sunflower crop is noted, with a percentage of 46% for winter rotations and 32% for late rotations. This is a catch-up crop, which means that it is generally used to make up for crop losses due to the floods, it is characterized by farmers as being water resistant. This is explained according to the farmers by excess of floods in the Sidi Med Ben Mansour Merja in comparison with those of Ras Daoura, because this one dries faster. With a percentage around 10% in autumn-winter and 14% in spring-summer, beans in both coastal Merjas are sown alone or in parallel with sunflower to maximize the cultivated area. For peanut, it is practiced with different percentages (8% in autumn-winter and 14% in spring-summer in the Merja Med Ben Mansour and 17% in the Merja Ras Daoura). This is due to the fact that it is sown in the composed soil (silt + sand) named mixed soil according to the farmers, and which originates from the shore of the merjas or texture modified by embankment of sand from the construction of the high speed rail line. The peanut crop usually replaces cereals after harvest. As for Med Ben Mansour Merja, and after the drying up of the flood zone of Ras Daoura, farmers practice vegetables such as squash, zucchini, cabbage, tomato, pepper and forage crops (Alexandria Clover and corn).

At the level of the Merja Sidi Ameur, the crops grown in Bour (non-irrigated land) are the cereals that are generally harvested around June. Therefore, farmers can grow other crops during the period from June to September, namely: melon, tomato, maize, artichoke, rice, Armenian cucumber, rice and zucchini. While at the level of the Merja Jouad, farmers tend to be content to practice sugar beet or Alexandria Clover; in interannual rotation with cereals; between October and May. At the level of the Tedjina Merja, cereals and Alexandria Clover are most practiced in interannual rotation. Farmers living there usually have small acreage farms; about 0.3 ha; and are part of existing town at Tedjina so they exploit their farmland in fodder and grain crops, which require a low investment cost.

Generally, non-tenant farmers practice rotations in order to preserve and restore soil fertility. However, tenant farmers tend to change farms every one to two years because soils lose their fertility. This represents a danger on the lands of the zone, in addition to the fertilizers used in extra to maximize the yield which causes a degradation of the quality of soils and groundwater table.

B. Farm Sizes in Flood Areas

The results presented in Fig. 6 show that in each of the flood zones it is noted that farms with an area of less than 5 ha represent more than half of the farms under study; this is due to the decrease in areas following inheritance. In these zones, these farms are generally exploited by their owners who live in the existing town in the Merjas. While at the level of the Merja Jouad, the farms are generally rented to farmers from town close to the Merja and who aim to practice forage crops. Because of land fragmentation, 74% of the land is in direct land use and only 26% of land is rented to nearby farmers.

At the level of the Sidi Ameur Merja, 52% of the farmers surveyed are tenants. The latter tend to rent agricultural land of large area ranging from 3 ha to 20 ha to take advantage of the low rental prices of the private estates of the state which represent 21% of all existing land status in this Merja.

C. Characterization of Irrigation Systems in Flood Areas

Fig. 5 Irrigation of sunflower by the method of pump

Farmers in the area use different irrigation systems for the same crop. The surveys have made it possible to distinguish four different systems used in irrigation, which are: sprinkler, drip, furrow and pump system (Fig. 5). The choice of a given system depends on the nature of the crops grown and the vegetative stage of the plants as well as the financial means.

According to the surveys of the Ben Mansour Merja, the sprinkler system is the most used (48%), for several reasons namely: to wet the soil and facilitate the tillage before the seed. In addition, to have the same size of the plants, it is necessary to irrigate at the beginning of the vegetative stage of certain crops such as sunflower; irrigate some crops throughout the cycle such as groundnuts. The second system used is the drip system. This is mainly due to: gain of time, effort and manpower; the need to use it for certain crops such as beans which are fragile to leaf burn by sprinkler system, also for its efficient use in the middle of the cycle and at the end of the vegetative stage of sunflower instead of sprinkler system. Certain farmers use furrow system in special cases such as: insufficient financial resources for the development of the farm; the use in the middle and late vegetative stage of sunflower after sprinkler; after the drying up of farms for vegetable crops. Even if the pump system is difficult to handle, it is still used by farmers for the irrigation of cereals and sunflower, especially in case of insufficient financial support due to the lack of state subsidies for the installation of drip irrigation. The farmers did not benefit from the subsidies due to the lack of a certificate of ownership to put it in the application file.

For the Ras Daoura flood zones and according to the surveys (Fig. 7), the drip system is the most dominant with 35% followed by sprinkler with 31%. This is for different reasons such as the saving of time and effort; the faster drying of the flood zone of Ras Daoura compared to Ben Mansour which requires additional irrigation; the orientation of young people towards new technologies.

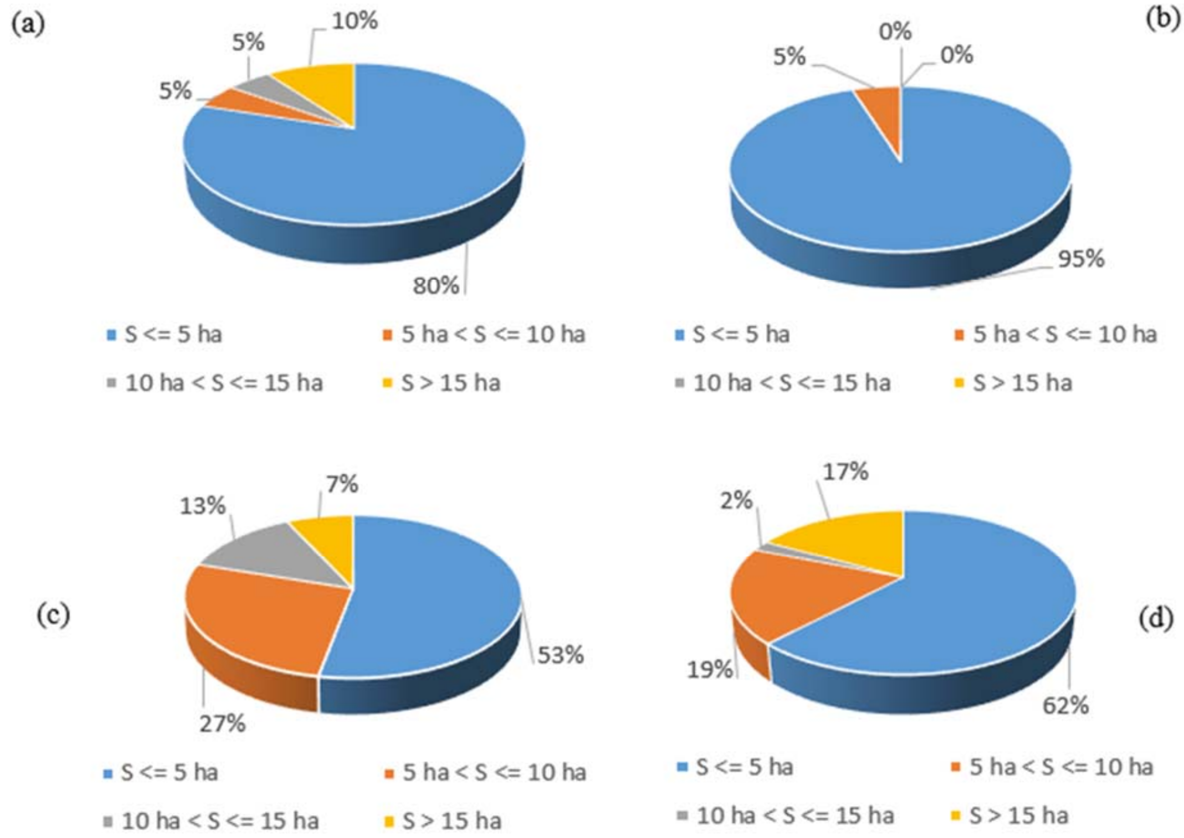

Fig. 7 Sizes of the farms surveyed in %: (a) Merja Ben Mansour; (b) Merja Ras Daoura; (c) Merja Jouad and Tedjina; (d) Merja Sidi Ameur

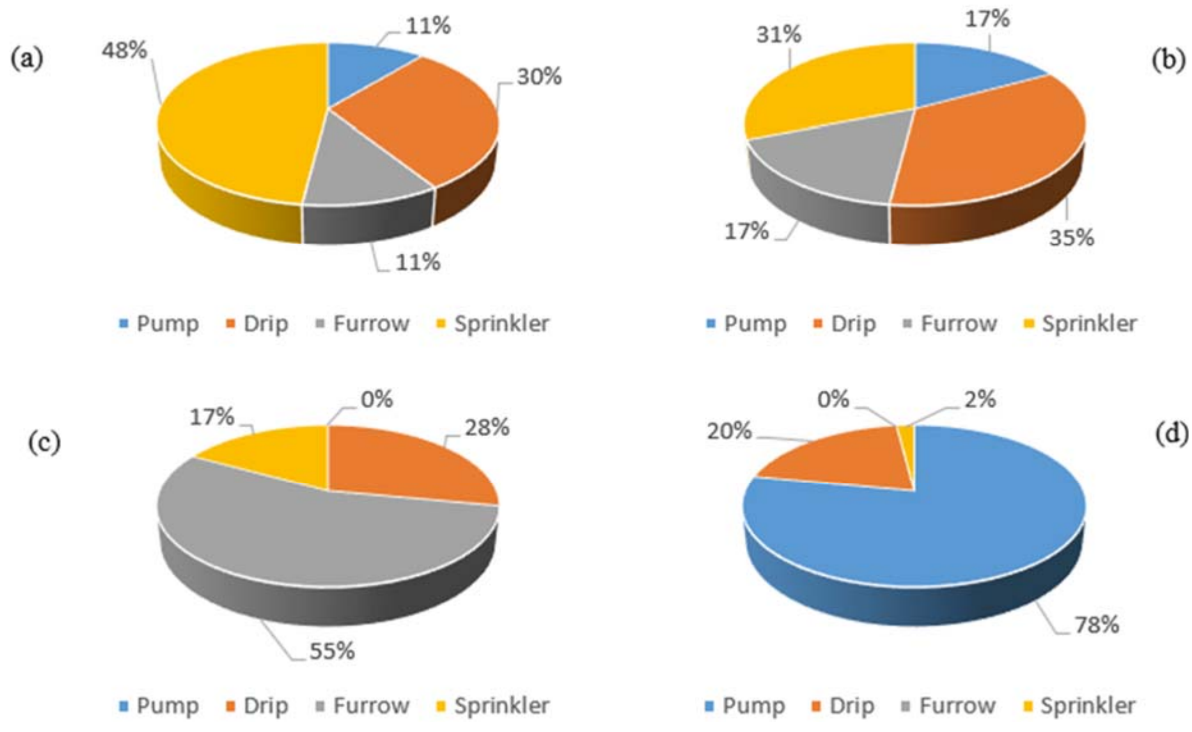

Fig. 8 Percentage distribution of irrigation systems used: (a) Merja Ben Mansour; (b) Merja Ras Daoura; (c) Merja Jouad and Tedjina; (d) Merja Sidi Ameur

It should be mentioned that at the level of the Merja of Tedjina, only furrow system exists. Regarding the Merja Jouad, the three irrigation systems are used but with furrow dominance. Farmers using drip system are farmers owning farms with large areas (greater than 8 ha), these farmers have benefited from subsidies granted by the state as part of the agricultural development fund to install the irrigation network. It is the same farmers who use sprinkler system using the same drip network already installed by removing the filters from the head station in case the pressure is not sufficient at the sprinklers. These farmers tend to use this technique because during the sugar beet irrigation period, they need to bring large doses of irrigation water over a short period of time, and thus the drip is considered inadequate since it provides low doses over a long period. Concerning the furrow system, several techniques of this system were noticed on the ground namely: the flood, the irrigation by planks or basins, the irrigation with lines and the irrigation by pump. At the Sidi Ameur Merja level, furrow irrigation is dominant with a utilization rate of 74%, while the use of basin irrigation and flood irrigation is 13% each. At the level of all the Merjas of Jouad and Tedjina, the only existing type is the irrigation by pump.

D. Water Sources

At the level of the coastal flood zones, all farmers without exception use wells and boreholes for the water mobilization from groundwater table. Their depths vary from 5 to 18 m depending on the location of the farms. Farmers on the right shore are looking for a better water quality, while farmers on the left shore do not have this problem.

About the Merjas of the central zone, at the level of the Merja Sidi Ameur, almost 60% of farmers have boreholes on their farms, the rest of the farmers pump water from Beht River and the other sanitation canals running through the Merja. It can be seen that at the level of the Merja Jouad, two water sources are used: the R'dom Canal and the boreholes, whereas at the level of the Tedjina Merja, the farmers pump the water from the wells. At the Sidi Ameur and Jouad zones, farmers have testified that surface water does not remain available during the dry season. After drying up irrigation water adduction channels, farmers pump water from Sebou River and use the existing canal network as an adduction network. According to the results, more than half of the boreholes at the Merja Sidi Ameur has depths between 70 and 90 m. While at the level of the Merja Jouad, the depths start from 90 m and can reach 130 m. It should be mentioned that at the level of the Merja Tedjina, and for lack of financial means, the wells made by the farmers have depths that do not exceed 20 m, whose water level reaches the surface. While at the Merjas of Sidi Ameur and Jouad, the water level in the boreholes varies between 15 and 30 m.

E. Water Quality

The salinity of the water is an important factor controlling the use of groundwater. The risk of plant wilt due to salinity becomes important as soon as the salinity exceeds 2 g/l. The salinity of the boreholes in the Sidi Ameur and Jouad flood zones is between 0.4 and 1.5 g/l. This is due to the fact that farmers pump from the deep aquifer of Ghareb which is known for its good quality. However, at the level of the flood zone of Tedjina, the farmers pump from the groundwater table which explains the salinity of the waters of the wells which is 4.6 g/l. This value conditions the use of this water in irrigation. In fact, farmers tend to reduce the frequency of irrigation so as not to burn the leaves of plants, especially the leaves of Alexandria Clover which is a widespread crop in this area. Other farmers tend to practice alfalfa which is a forage crop that is more resistant than Alexandria Clover to the salinity of irrigation water.

The waters of the Beht canals and the R'dom are of medium to poor quality. These channels receive the sanitation collected at the level of the equipped sectors such as the rice sector. These waters therefore contain phytosanitary substances and nutrients that farmers use in upstream sectors, which generates the risk of soil and groundwater pollution in these areas. In addition to this danger, water from these sources is turbid and loaded with suspended matter, which explains the fact that it is used by farmers using gravity, since it does not require the water filtration. In terms of salinity risk, the measurement of the salinity rate carried out on samples of the pumped water and sanitation channels respectively gave values between 0.77 g/l and 1.44 g/l which poses no restriction on the use of these waters for irrigation. These salinity values can be explained by the fact that the plants that exist at the level of the channels, for instance the reeds, feed on the diluted nutrients in the sanitation water, and so we are with a non-high level of salinity downstream, that is to say at the Merjas of the central zone.

The salinity of the water in the coastal flood zones depends on the depth of the wells and the location of the operation on both sides of the sewerage canal. This distance varies from 300 to 700 m. According to the results, the well water of the right shore is salty since with a salinity that varies from 1.45 to 5.55 g/l. Those of the left shore salinity varies between 1.22 and 2.59 g/l. Based on these results, the groundwater table in the right shore that is closest to the Atlantic Ocean is saltier, and farmers use deeper wells and boreholes than the left shore, looking for less salty water. This confirms the hypothesis of marine intrusion caused by private overexploitation of the aquifer. This pumping is encouraged by the cost which remains low especially since the gas cylinders used as energy are subsidized by the State.

F. Energy Sources

In terms of energy, there are three sources of energy used which are fuel, butane gas and electricity (Fig. 9). The energy consumption depends mainly on the hours of operation. More than 70% of farmers pump water for 12 hours a day, while the rest pump 24 hours a day. The last category usually has farms with large areas or crops requiring large volumes of water such as rice, hence the need to pump water day and night. The daily fuel consumption varies between 10 and 20 liters and can reach 60 liters in case the water is pumped 24h per day. It is noted from Fig. 9 that gas is the most used with a percentage of 45%, this can be explained according to farmers by its minimal charges especially with the subsidy granted by the State for gas.

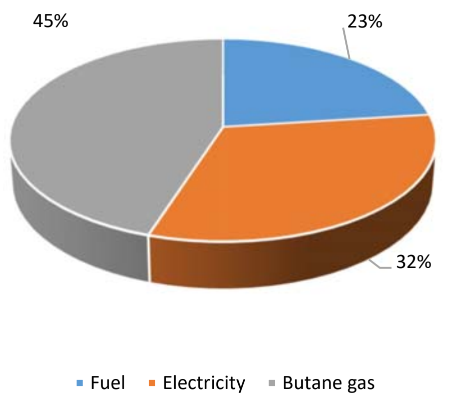

Fig. 9 Percentage of use of each energy source

G. Performance Analysis: Pressure Measures

The pressure measurement was carried out at ten drip-equipped farms. The values obtained vary between 0.2 and 0.4 bars at the level of the most disadvantaged positions. This shows that the pressures are not sufficient at these locations. Indeed, these farmers use identical laterals, however the measurement of flow rates drippers gave different values. These results can be explained by the fact that there are problems of clogging drippers as well as low pressures at the level of the laterals. The flow rate of the drippers in the case where the pressure is less than 2 mCE is between 0.3 and 0.4 l/h, while that of the drippers in the case where the pressure is greater than 2 mCE is between 0.8 and 1.1 l/h. This shows that even if farmers see that their networks are operating in a normal way, the reality is that these low pressures imply additional pumping costs, since these networks will need more time to ensure the proper watering of crops.

H. Performance Analysis: Uniformity Tests

The uniformity test was performed at the ten drip-equipped farms. The coefficient of uniformity varies between 58% and 93%, these networks therefore need permanent maintenance; by injection of acid; to solve the problems of clogging drippers. Farmers whose irrigation systems installed on their farms have uniformity coefficients of more than 80%, only maintain their networks once every 15 days or more by injecting acid. However, those whose irrigation networks installed on their farms have uniformity coefficients less than 80%, tend to maintain their networks once in 10 days or every day by injecting 1 liter of acid into the network.

I. Marketing and Prospect

Merjas lands are marginalized and fragile lands that are characterized by fertile soil that sows different crops with good yields. However, the floods that threaten the plots influence its yields. Farmers may lose all or part of the crop. Sometimes, they are forced to resettle the culture again which leads to continued loss of money. From the results presented in Table I, we see that the yields of the merjas are close to the average yields of the irrigated perimeter of Ghareb. It can be said that farmers in flood areas manage their agricultural land in a manner comparable to those outside flood areas. It should be noted that these yields are the returns of a good year without significant floods.

TABLE I
YIELD OF CROPS IN THE MERJAS COMPARED TO THE AVERAGE YIELDS OF GHAREB

	Crop	Yield per hectare (qx/ha)	Average Yield of Ghareb per hectare (qx/ha)
Merja of coastal zone	Sunflower	22.5	14
	Peanut	22.5	25
	Cereal	30	24
Merja of central zone	Rice	85	80
	Sugar beet	550	580
	Cereal	38	24
	Tomato	800	800

Forage crops, namely Alexandria clover and alfalfa, are used as fodder for livestock. Vegetable, namely melon, Armenian cucumber and zucchini are sold wholesale or after harvest or on the field for big farmers. Regarding small farmers, they sell their products to the weekly markets in the region as shown by [8]. The crops namely tomato and rice are sold to the factories of agro-food industry.

Some farmers are not moving towards the extension of their plots, because of floods that involve huge losses of money in terms of seed, energy source, fertilizer. They do not take into account the water factor, since they consider it available throughout the years even with a quality more or less minimal with a reddish color and a slightly high salinity. Other farmers are moving towards the intensification and extension of the plots because of the fertility of the soil they deem valid for a wide range of crop varieties (cereals, vegetable, arboriculture etc.) and even a space for livestock. This is the same thinking as tenants who tend to exploit new lands, they choose to make annual leases or two years following the decline in soil fertility after their cultivation.

Farmers change the irrigation technique in the case where they have to use a technique that is best suited to a certain crop namely the case of rice and sugar beet. Farmers want to use drip irrigation because it guarantees water productivity and saves energy and labor. As this is the most expensive irrigation technique, these farmers do not have enough money to install it. These farmers are either tenants or owners who bought their farmland by concession, which does not allow them to benefit from state subsidies.

J. Adaptation of Farmers

Flood water have several origins, namely intense rainfall, river discharge and dam releases. As well as the construction of the highway and the construction of the TGV line have aggravated the consequences, as they have created a sort of slope that favors the rushing of rainwater to the plots, even if they have created ponds for farmers to collect water. The duration of water stagnation within the plots varies according to the location of the plot, as shorelines dry out faster than the bottom, and depending on the precipitation rate, it usually starts in December-January until March or April. Farmers see that the only solution to minimize water stagnation is the digging of channels and drainage channels, to allow water to flow out of the plots.

In the event of flooding, farmers tend to act differently from one another, depending on their incomes, status and age. They look for other activities or sources of income as a form of adaptation such as livestock sales; looking for casual work (security, workers at other farmers, masonry, etc. ...); agriculture in other plots they own outside flood zones. After the drying up of their plots, as shown in [1], the farmers adapt and sow different crops as vegetables compatible with the period of drying such as beans, pepper, tomato, potato, squash and zucchini etc.

IV. Conclusion

Flood zone are fragile and marginalized areas, yet they represent a great agricultural potential that can be valued. Yields in these areas remain threatened by climatic conditions during the rainy season, which condition the period of practicability and drying up of the land. As a result, farmers resort to irrigation after drying of the merjas lands. The investment cost, the choice of crops and the availability of water (surface water) are the main criteria for the choice of irrigation technique. Thus, the irrigation systems used as they are practiced today are inefficient; they generate huge losses in water. This is likely to favor the intrusion of the salt wedge because of the overexploitation of the groundwater table. In order to make better use of these flood zones, further studies are needed, namely: a study on the role of flood zones in flood protection in downstream urban centers; an impact study of irrigation using mineral-laden water from developed sectors on soil quality. Additionally, a thorough investigation of the phenomena of sea intrusion in the study area is required, as is a reduction in the number of wells and boreholes drilled by farmers by restricting the number of wells allotted by a groundwater control commission. In order for these studies to be a step forward for future projects in the flood zones, they must consider farmers as a stakeholder whose participation is essential in order to succeed in any project aimed at developing these areas.

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