Integrated water management and durability of landscape of public irrigated areas in Tunisia: cases of public irrigated areas of Chott-Meriem and Mornag.

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ISSN- 2350-0530(O), ISSN- 2394-3629(P)
IF: 4.321 (CosmosImpactFactor), 2.532 (I2OR)
InfoBase Index IBI Factor 3.86

INTERNATIONAL JOURNAL OF RESEARCH – GRANTHAALAYAH
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INTEGRATED WATER MANAGEMENT AND DURABILITY OF LANDSCAPE OF PUBLIC IRRIGATED AREAS IN TUNISIA: CASES OF PUBLIC IRRIGATED AREAS OF CHOTT-MARIEM AND MORNAG

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DOI: https://doi.org/10.5281/zenodo.260280

Abstract

An important part of the landscape of irrigated areas in Tunisia is the result of morphology, organization and operation of agricultural policies implemented since independence, aimed at optimizing the exploitation of the best soils and natural resources, particularly water and productive crop intensification. The sustainability of the landscape of public irrigated areas has a strong bonding with the resources of irrigation water and their states of management. The scarcity of irrigation water due to drought generates profound changes in many public irrigated areas as Chott-Mariem and Mornag, like standpoint operating (decrease of production) and land occupation (transformation of agricultural land to urban land). An investigation was carried out with farmers, leaders and policy makers, which the result was a range of measures and recommendations to promote sustainability of agricultural landscape.

Keywords: Integrated Water Management; Irrigation Water; Durability of Landscape; Public Irrigated Area of Chott-Mariem; Public Irrigated Area of Mornag.

Cite This Article: Abdelkarim Hamrita, Amira Boussetta, Rafael Mata Olmo, Mehdi Saqalli, Hichem Rejeb. (2017). "INTEGRATED WATER MANAGEMENT AND DURABILITY OF LANDSCAPE OF PUBLIC IRRIGATED AREAS IN TUNISIA: CASES OF PUBLIC IRRIGATED AREAS OF CHOTT-MARIEM AND MORNAG." *International Journal of Research - Granthaalayah*, 5(1), 73-89. https://doi.org/10.5281/zenodo.260280.

1. Introduction

Tunisia remains a semi-arid to arid country on ¾ of its territory. It is characterized by the scarcity of water resources and accentuated climate variability in space and time. Tunisia spreads over an area of 164 000 km² and is characterized by a Mediterranean climate, ranging from humid in the extreme north to the desert in the extreme south (average temperature 11,4°C in

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
IF: 4.321 (CosmosImpactFactor), 2.532 (I2OR)
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December and 29,3°C in July). The climate factor divides the country into three agro-climatic zones; the north with an average rainfall between 400 and 600 mm/year and is the forest-agricultural land (forest in the north-west and annual crops), the centre with rainfall between 200 and 400 mm/year with vocation agro-pastoral (course and planting) and finally the south who knows irregular rainfall (100-200 mm/year) and it is the pastoral space with oasis around water points. The definition of agro-climatic zones is dependent on the availability of water resources, which have been a central factor of the conditions of the Tunisian development. The country has a strong seasonal variability (temporal variability) of rainfall and the surface water is concentrated in the winter, but also an inter-annual variability of severe droughts. The potential conventional water resources for the country as a whole are estimated at 4,670 million m^3/year. Of these, an average of 2700 million m^3/year is surface water and 1970 million m3/year are underground water. The country also has an unbalance of spatial distribution of water resources between the well-watered north and the southern desert. Of the 36 billion m^3 of rainfall per year over the whole territory, 4855 million m^3 are potential resources which 2700 million m^3 of surface water and 2155 million m^3 of groundwater (about 35% fossil character or bit renewable). These resources are concentrated in the North (60% of the total, 80% of the surface water), especially in the basin of the Mejerda (Hamdane, 2012; Kochbati, 2009). The problem of resource development so fragmented is found not only in terms of the spatial and temporal variability, but also in terms of quality because the water available in Tunisia exceeds the health and agronomic internationals standards of salinity, then the country has water quality problems as well as the quantity and variability issues described above. Less than half of the country's resources have less than 1.5 g/l of salt, and therefore meet health and agronomic standards (Lebdi, 2005). Of this water with reasonable salinity levels, 72% is surface water, 20% deep groundwater, and scarcely 8% groundwater (Louati and Bucknall, 2010). Despite the difficult geo-climatic conditions of the country (the largest share of the Tunisian territory is located in semi-arid to arid zone), the temporal and spatial variability and water quality, Tunisia has always been involved with the know-how of his society for water resources management that are rich and varied dice the Roman aqueduct to the small *faskia* and *majel*, to build the identity of the Mediterranean landscape.

Table 1: Water resources in Tunisia for 6 successive years since 2007

Indicator	Unit	2007	2008	2009	2010	2011	2012
Rainfall	Million m^3/year	31680	21120	34080	21600	29280	18360
Surface water	Million m^3/year	2100	2100	2100	2100	2100	2100
Groundwater	Million m^3/year	2167	2167	2174	2167	2164	2164

Source: INS, 2012

2. Materials and Methods

The methodology is based on the intersection of bibliographic references and field data. The methodological approaches examine the representations of different agricultural actors of practices and water resources operating and management in the irrigated areas of Mornag and Chott-Mariem. These spaces induce specific representations from farmers and agricultural

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actors? How consider the impact of their practices on the availability and quality of water resources? The semi-structured interview as a method of collection of practices and associated representations permit an understanding of professional practices, but also to highlight the perceptions of the area and there resources. A dozen interviews were conducted with various actors of the public irrigated areas of Chott-Mariem and Mornag on the summer of 2016. The grid survey of farmers included more topics as water, irrigation techniques, methods of irrigation water management, the main threats of the farms and the solutions proposed by farmers. Another grid survey was also developed and proposed to the technical and institutional actors to understand the strategies and future irrigation water management projects in Tunisia and especially for irrigated agriculture sector of the two regions of studies.

3. Results and Discussions

3.1.Tunisian Integrated Water Management

Water resources in Tunisia are characterized by scarcity and a pronounced irregularity (Horcheni, 2007). The mobilization strategy of water in Tunisia dates back a long time and is manifested in the creation of ingenious structures of ancient civilizations, including *mgouds*, *meskat, foggaras*, *tanks*, *gallery*, *jessours,* watershed systems in the oasis… "fig.1". This phase can be considered the first phase of mobilization of water resources in Tunisia (Mekki, 2009).

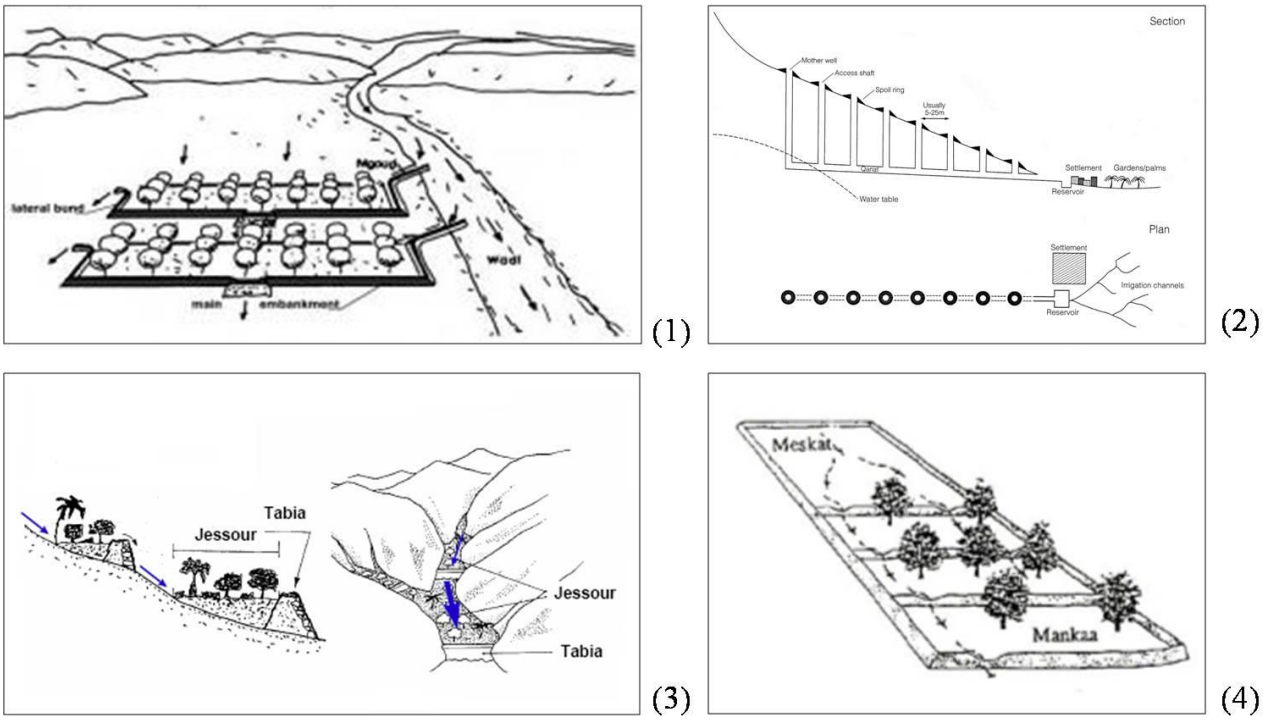

Figure 1: Some traditional structures of water mobilization in Tunisia.
(1) *mgouds*, (2) *foggaras*, (3) *jessours, (4) meskat.*

Tunisia has invested considerable amounts of resources to develop a complex and diverse water infrastructure (Horchani, 2007; Chebil, Frija and Abdelkafi, 2010). In fact, the government engages in extensive political debate and strategizing and has invested heavily in measuring,

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mobilizing, and managing resources as well as in getting the maximum value from each cubic meter of water used (Louati and Bucknall, 2010). At the same time, Tunisia has put in place systems and legislation to assure access to drinking water for the majority of the urban and rural population and to provide supplies for agricultural irrigation, as well as the industrial and tourism sectors. In face to the water demand increase, Tunisia has adapted the integrated management strategy (Seddik, 2015) and a significant efforts have been deployed all water resources using a variety of instruments: dams, collinear dams, collinear lakes, emission of sewage water, desalination, drills, surface wells, treatment of used water, recharging water tables, regional connection canals and locks (Nouira and al, 2014; Mekki, 2009; Horchani, 2007). The strategy has included agricultural water to encourage irrigated agriculture and to improve the farm's income (Chebil, Frija and Abdelkafi, 2010). Tunisia has taked advantage of his land and set up agricultural policies that aimed at optimizing the exploitation of the best soils and natural resources, particularly water and productive crop intensification (Ben Attia, 2015). The strategy has transformed the Tunisian land and more of traditional agricultural lands were converted into irrigated areas with an irrigated and intensive agriculture. This policy has increased the total area of irrigable land to 405 000 ha (225,000 ha public and 180,000 ha private) (Comete Engineering, 2007; FAO, 2009). The objective of this policy is to assure food security (Horchani, 2007), to improve the level of production, to improve the situation of certain farmers, to ensure economic integration in terms of transformation and to contribute competition of total agricultural production (Hamrita, Mata Olmo and Rejeb, 2016). Actually, irrigated area in Tunisia occupies only 8% of total agricultural surface but it generates 35% of the agricultural production value, 20% of exports and 27% of agricultural employment (Al Atiri, 2007).

Our two field studies were included in this policy:

- Coastal plains have been affected by these policies as olive coastal plains, for example, the plain of Sidi Bou Ali, the plain of Sahline and the plain of Chott-Mariem, our field of study "fig.2". The public irrigated area of Chott-Mariem, is known by olive vocations "photo.1", vegetable productions "photo.2" and other local productions dedicated by the character of 'early vegetables' (Rejeb, 2011). It corresponds to a landscape area unique by his character; peri-urban modern and intensive agriculture (Hamrita, Mata Olmo and Rejeb, 2016). The public irrigated area of Chott-Mariem is irrigated by the water of the dam of Nabhana in Kairouan region (center of the country) also which supplies the Sousse region with drinking water.

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InfoBase Index IBI Factor 3.86

Table 2: Landscape characteristics of public irrigated area of Chott-Mariem

Landsacpe area: public irrigated area of Chott-Mariem+photos	Structuring elements and general organization	Typical Landscape Components and Patterns
 Photo 1: General view of the public irrigated area of Chott-Mariem Photo A. Hamrita, 2015  Photo 2: Field vegetable farming. Photo A. Hamrita, 2015	• transition from monoculture to irrigated mixed farming • occupies the coastal plain of Chott-Mariem • characterized by a very low slope and leaned against the olive groves which form the olive forest of the hinterland • heterogeneity of small agricultural parcels • parcels in checkerboard organized by roads and cypress hedges • olive growing constitutes in most of the landscape area the main component of the cropping systems	• the olive tree is the characteristic feature of the landscape area • Dominant olive forest • early vegetables production in association with olives growing • small farms (less than 5 ha) and multi-localized • private property • cypress hedges • modern technique of irrigation technique with the water of the centre region (Dam of Nabhana) • some modern farms • horticulture farms (Ornamental plants and floriculture) • residential houses • several agricultural wastelands awaiting urbanization

- The Plain of Mornag "fig.3", located about 20 km southeast of the city of Tunis, extending from the Gulf of Tunis north to the hills of Khlédia south, an area of 200 km^2. Due to its proximity to the capital, this plain is a major agricultural center "photo.3". The waters of the shallow aquifer of the plain are generally subject to intense exploitation which resulted in a decrease in piezometry and increased salinity (Lassoued, 1995). Mornag irrigated areas cover a total area of 8667 ha of which 6487 ha public. They are irrigated by three water resources:
  - The Water table surface and secondarily the deep aquifer
  - The Water transfer channel of Mejereda to Cap Bon region
  - and previously treated waste water (this technique was arrested for water quality reasons and studies are underway to study the various artificial recharge of alternatives with or without the waste water treated)

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Initially only the first resource was available for irrigation plots scattered across the farms. In the late 80s a new perimeter was created to receive the waters of Medjerda and early 90s, a third perimeter was arranged to highlight the third resource (Mhiri, 1998).

Table 3: Landscape characteristics of public irrigated area of Mornag

Landsacpe area: public irrigated area of Mornag+photos	Structuring elements and general organization	Typical Landscape Components and Patterns
 Photo 3: General view of the public irrigated area of Mornag  Photo 4: Field vineyard farming Photo A.Boussetta, 2014	• Irrigated area known by its vineyards "photo.4", fruit trees including peach. • Construction Roads promotes chunking land. • Water resources limited but more abundant than Chott-Mariem, (multiple sources for irrigation water: Dams, surveys, well surfaces). • Unless than 40% are proprietors.	• Like all peripheral agricultural plains, the plain of Mornag has been influenced by a city bourgeoisie interested in the development of cereal production and a breeding essential to the needs of urban consumption. • This plain is particularly targeted because of its proximity to Tunis and its accessibility. • It is the richest plain of the region of Tunis. In 1881, she owned a large "ghaba" (forest) consisting of 321,000 feet of olive trees.

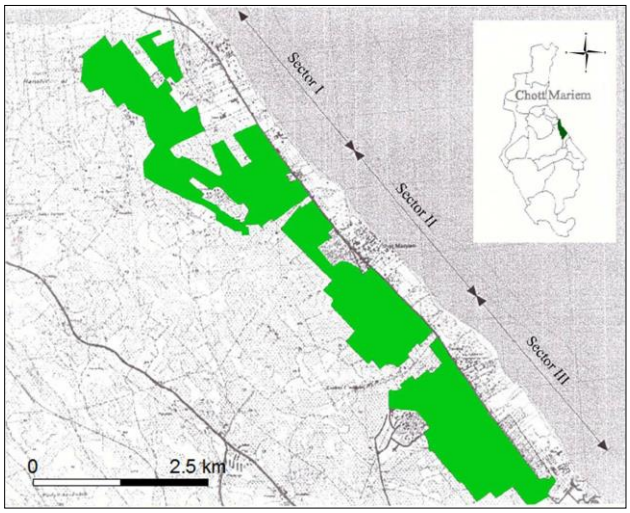

Figure 2: Geographic situation of the public irrigated area of Chott-Mariem
Source: Hamrita, 2016

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
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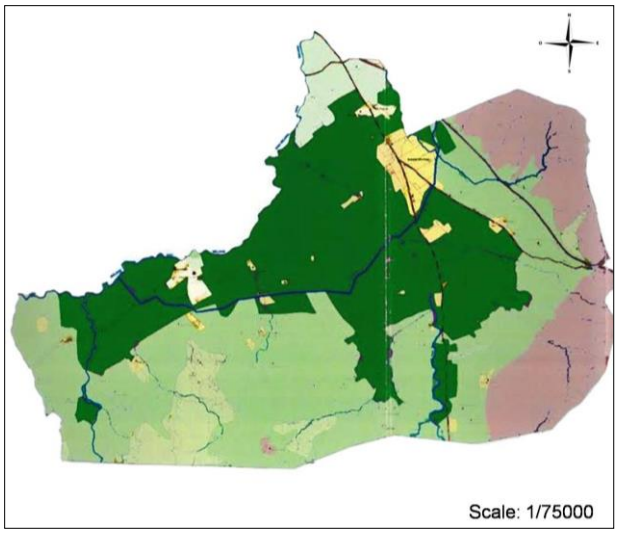

Figure 3: Geographic situation of the public irrigated area of Mornag
Source: Boussetta, 2016

Today, Tunisia is considered to be one of the countries in the Mediterranean basin least well-endowed with water resources in face of the increase of water demand, associated with the rapidly growing population and competition between industrial, domestic, touristic and agricultural sectors (Thabet, 2003). The potential volume of available water, 4,864 million m^3 per year, is less than 500 m^3 per inhabitant per year. This ratio will decline to 360 m^3 in 2030, when the population will have grown to approximately 13 million (Louati and Bucknall, 2010). The water becomes a limiting factor for economic development, also agriculture the first consumer of water, using 80% of the total water potential in the country. For this purpose and to overcome the water shortage, especially in the future, several measures and a strategic program of irrigation water management was established by the Tunisian State in order to improve the irrigation water use efficiency and to enhance the performance of the agricultural sector (Chebil, Frija and Abdelkafi, 2010). An addition to the regulations and legislations texts (Water Code) and the decentralized administration (ROAD), fore important reforms are established: (i) the modernization of collective irrigation systems management to encourage irrigated agriculture and to improve the farm's income (Chebil, Frija and Abdelkafi, 2010) by improving the role played by Agricultural Development Groups (ADG) and by promoting the participation of users in all management aspects, (ii) reformulating the water pricing system by introducing the cost recovery objective (Seddik, 2015), (iii) developing financial incentives to enhance the adoption of water saving technologies (Hamdane, 2008) at farm level and (iv) using of non-conventional water and artificial groundwater recharge.

3.1.1. Regulations and Legislations Texts

The Water Code in Tunisia is the essential text of water management, developed in 1975, when water resources were greater than demand. It focused on control, valuing of water resources, supply management, introducing new fundamental provisions concerning public water resources, conservation, polices of water sector, the rights and water uses, easements, permits and concessions, useful and harmful effects of water, user associations... (Mouri and Marlet, 2006). Tunisian water policy had been engaged toward an integrated approach (Omrani and Ouessar,

2012) and currently the text is being revised which basically integrated the management of demand and it considered these changes that the water sector known as the conservation of resources, the expansion of the optimal use, the equity of distribution, the management of climate extremes and the water storage strategy (Ministry of Agriculture, 2013).

3.1.2. Decentralized Administration

For fifteen years, the recent development has given an important role to the private sector and to the decentralization which the Offices of Agricultural Development (OAD) (in charge since 1972 of all irrigated areas of the country, the studies and necessary works of hydro-agricultural equipment in the new irrigated areas) have been replaced in 1989 by the Regional Offices of Agricultural Development (ROAD) in the Governorate (regional government) and attached to the central administration. For this purpose, the regional office is responsible for several missions as the application of laws and regulations, protection and development of forest resources, conservation and management of water and soil, conservation of natural resource, defense and protection of the environment, management of hydro-agricultural infrastructure, vulgarization and technical actions...

3.1.3. Participative Management of Irrigation Water

The politics of water in Tunisia has turned to the participative management and implication of users with the creation of Associations of Collective Interest (CIA) that have been converted to Agricultural Development Groups (ADG), an institutional change affecting the operation of Tunisian public irrigated areas (Mouri and Marlet, 2006). These groups have been created for the management of rural drinking water and supply systems, public irrigated areas and perhaps for management of groundwater in the future. The number of groups is around of 1327 on the end of 2012. These groups are concerned by the management systems (water sales, maintenance of systems, etc...). These are supported by the State which has set up a national strategy to promote associations since 1992 to develop the technical, financial and organizational capacities and to be a real partner in irrigated areas sustainable development (Omrani and Ouessar, 2012). These institutions are still dependent on the state that realize the maintenance, rehabilitation and modernization of hydraulic structures, encouragement, vulgarization and other capacity necessary to rationalize the exploitation of the water, balancing subsidies, control and evaluation (Al Atiri, 2004). Currently all of Agriculture Development Groups provide to cover the cost energy and his work teams but rarely the maintenance of networks of water irrigation than generating a loss of 15% during his distribution (INS and SONED, 2003). They suffer from many problems as (1) the level of instructions of voluntary members of the administration, (2) the complexity of projects with successive extensions and development of individual hydraulic connections (3) support on the free interventions of the administration, (4) absence of preventive maintenance of infrastructure and equipment, (5) the low cost of coverage of exploitation and maintenance and (6) the non-involvement of women in the management of water systems.

3.1.4. The Recourse to the Water Saving Equipment

The reform of the irrigated sector toward more efficient performance became evident (Omrani and Ouessar, 2012). The program of the rehabilitation phase aimed to rehabilitate the irrigation

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
IF: 4.321 (CosmosImpactFactor), 2.532 (I2OR)
InfoBase Index IBI Factor 3.86

facilities and to reinforce farmer's skills for more efficient water management mode (Seddik, 2009). Despite the fact that the implemented of this program already contributed positively to significant results in terms of irrigation water use efficiency (IWUE), some recent research studies (Chemak, 2010; Frija et al. 2009; Dhehibi et al. 2007; Albouchi et al., 2007) concerning the IWUE at farm level show that a large potential for improvement of the IWUE exists in Tunisia. The use of saving water equipment in irrigated areas has undergone a remarkable evolution, favored by the significant financial incentives of the State (Hamdane, 2008). The performance recorded in economy of water was attributed to the evolution of irrigated areas equipped with water saving equipment, indeed, 75% of irrigated areas are equipped with the new irrigation techniques in 2005 (localized irrigation, aspersion,...), against only 37% in 1995 "fig.4". The rate of installation of water saving equipment increased the total equipped area to 405,000 hectares in 2011 (Comet Engineering, 2007). However, it remains to improve the technical management and the control of these surfaces and available water resources.

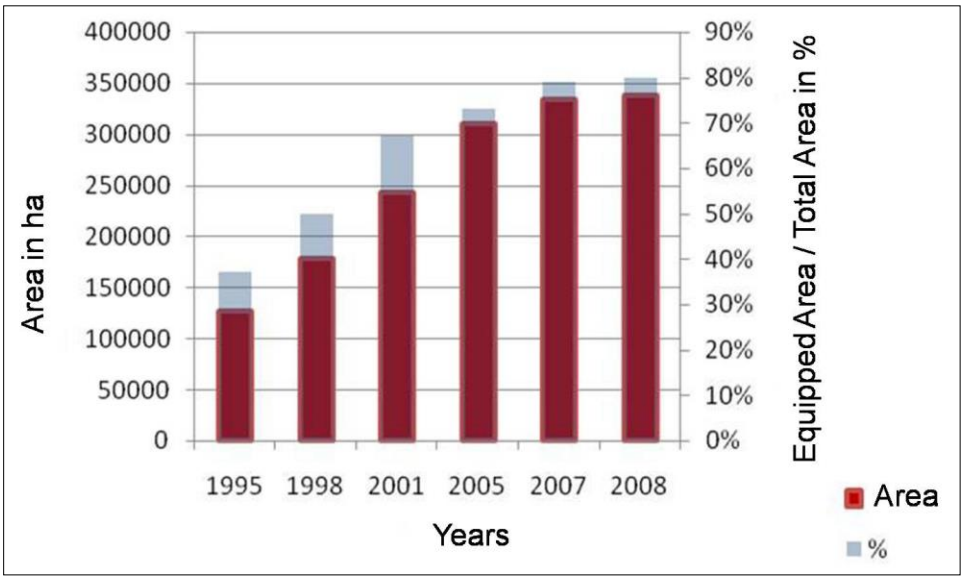

Figure 4: Tunisia irrigated area equipped with efficient on-farm irrigation systems (%)
Source: DGGREE- Ministry of Agriculture and Hydraulic Resources, 2007

3.1.5. The Use of Non-Conventional Water

In order to increasing the water potential in the country and to respond to growing demand in the irrigation and industrial sectors, Tunisia has engaged in studies and demonstration of the re-use of treated wastewater and the use of non-conventional water resources controlled by a strict legislation is being encouraged (Horchani, 2007) as part of the integrated management strategy and a viable option with the development of the treatment wastewater (water supply reliability and wastewater treatment station) (Omrani and Ouessar, 2012). The major reuse fields are the agriculture irrigation (30%), the golf course irrigation, landscape irrigation in urban areas and the aquifer recharge (Louati and Bucknall, 2010; Omrani and Ouessar, 2012). Tunisia aim to increase the use rate to 50% (450 million m^3 in 2030) as a national objective (Neubert and Benabdallah, 2003). The use of non-conventional resources is a solution of Tunisia in a situation of competition between the use sectors, an increasing commodity of resources and difficult climate conditions (Romagny, Guillaume, Ouezdou and Palluault, 2004). Despite the relevant

efforts consented into the development of the treated wastewater, a strong reluctance from the population that still persists. Participative approach (Scoullos, 2012) can be a solution to increase acceptance of wastewater extension and use to establish a new policy and a long-term strategy research strategy.

3.1.6. Recharging Subterranean Aquifers

Artificial groundwater recharge is an important component of the country's water management plan. Tunisia has a long experience in recharging subterranean aquifers from surface water resources during surplus periods to store the water for use during dry periods. The program consists to recharge zones where underground water resources are over exploited with excesses from zones where surface water resources are plentiful. The program also involves the construction of small dams of water retention and to favorite infiltration (Louati and Bucknall, 2010). Under the Hydromed program, researchers from IRD, in partnership with INRGREF (National Institute of Rural Engineering Research, Water and Forestry, Tunis), have studied the role of these small dams to recharge the groundwater. It thus appeared that the water seeps lakes to groundwater in a layer of sand located in the sediment deposits. This result will enable local authorities to choose suitable locations for dams intended to recharge the groundwater (Montoroi, 2001).

3.1.7. Economic Instruments

The water pricing is another element for the water resources management, which helped to encourage conservation and finance maintenance of hydraulic infrastructure. In 1991, a presidential decree outlined the water pricing policy related to the irrigated sector. It clarified the role of the stakeholders dealing with irrigation water management. The governmental development agencies as well as the farmers groups called GIC (groups of common interest) were called on to work closely together to establish water pricing and determine the mode of incomes collection, including the penalties rates in case defined rules are not respected. For this reason, three water pricing methods were recommended, as well as methods to collect the rates: (i) the volume pricing method, based on actual water consumption, (ii) the global price method based on the irrigated area and (iii) the binomial pricing method that covers two proportions: a fixed part and a variable part dependent on actual use. For irrigation water and according to the director of Agricultural Engineering, the price fixed for irrigation water is 0.11 DT/m^3 which does not correspond to the real cost estimated at 0.25 DT/m^3. The pricing of irrigation water has more impacts on the sustainability of irrigated production systems (Jeder, Sghaier and Louhichi, 2011). Progressive pricing (Horchani, 2007) added to an expensive cost of workers, energy and maintenance make it more difficult for farmers which can not to solve their credit problems. It is necessary to revise these prices in order to cover the cost of renewing the irrigation water connections and help farmers to solve the problems of equipments and water pipes. The "binomial pricing" already applied can solve these problems if all of farmers joined to this choice. This is a pricing that combine by a first fixed cost in dinars per hectare per year, paid regardless of the volume of water used and a second variable cost to be based on the volume used. The total is the global cost to pay per hectare. This pricing will create a background of money for the ROAD and hydraulic groups for maintenance of the distribution canalization (Seddik, 2013). According Thabet, Mahe and Surry (2005), this binomial pricing in terms of

equity has a negative effects on the welfare of rural households and only the "personalized binomial pricing" has generated positive impacts on the welfare of urban and rural households (Thabet, Mahé and Surry, 2005).

3.1.8. Demand Management and Integrated Planning

Conscious of the problem of scarcity and demand increases of water, Tunisia is engaged in formulating a strategy to more fully develop its water resources and to meet the demands of the various socio-economic sectors. The strategy focuses on demand management and integrated planning systems. The exploitation of conventional water resources in Tunisia is very advanced but the development of new resources as dams, recycling water and desalination… will be more complicated and costly and the better solution will be a balancing between supply and demand to ensure the rational management of irrigation water. Tunisian Integrated management of water, as studied in this paper show that is probably will be more necessary to rationalize the use of the water, to save water resources and to assure their long term availability.

3.2.Decrease of Supply of Irrigation Water and Impact on the Landscape of Chott-Mariem and Mornag Public Irrigated Areas

With the emergence of the modern areas characterized by a remarkable population growth and particularly socio-economic development diversified and oriented to new activities as industry, tourism and urban development in general, the Tunisian water capital (surface water, water deep, fossil groundwater) will be gradually restricted and unable to satisfy all of the new demand. This decrease in water supply recorded during the summer season generates discontent among farmers in particular, farmers of public irrigated area of Chott-Mariem and Mornag representing a part of the survey conducted for our research which covers the future of the landscape of the suburban agriculture areas in the big Tunisian towns, including Tunis and Sousse. By asking questions like: What techniques do you use for irrigation? What are the constraints and threats in the farm? What is your opinion about water management method adopted by the ADG..., the results obtained are that; the majority of farmers surveyed used the localized irrigation (drip) since it is the most economical technology for irrigation water, reduces the charges of water in farm and that the public authority accord incentives (40% to 60 %) to farmers who adopt the water saving techniques. The dissatisfaction of farmers is also recorded at the methods employed by the ADG for the management of irrigation water. They affirm that there is no real coordination between all of ADG between themselves and between farmers, particularly small farmers. They recorded an aging hydraulic drain and that the actions of renewal are modest despite the expensive price of irrigation water and financial resources of the ADG. For the irrigated agriculture, the main threat in farms is the decrease on the water supply and 100% of the farmers of Chott-Mariem said that this is the major constraint for the activity "fig.5". In Chott-Mariem, urban sprawl is the second problem. In the case of Mornag the problem of water is raised but at a lesser degree than urban sprawl "photo.4a". Reduced water supply and other problems like, the aging of water saving equipment's, the debts which are estimated for the sector of irrigation agriculture to 35 MTD in total (seddik, 2013), the water management, urban sprawl, tiredness of the soil, chemical residues… affects profoundly the operation of public irrigated areas and generates a regress of agricultural activity, a decrease in the agricultural area cultivated and the entry of several lands in a process of wasteland transformation which intensified by a unplanned urbanization classified

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
IF: 4.321 (CosmosImpactFactor), 2.532 (I2OR)
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as the second constraint to agricultural activity (45% of the farmers said that is the second constraint after the decrease of irrigation water) and the tourist speculation (Ben Attia, 2015) in the case of Chott-Mariem "photo.4b". Despite these threats, it is increasingly recognized that peri-urban agriculture can contribute to territorial development modes that are organized and accepted by the population thinks to the proximity factor, to the multifunctionality, since it offers goods and services (agricultural production, supplying cities with fresh produce, environmental quality, leisure and recreation, landscape…) and to the policy and public decisions concerning the preservation of landscape agriculture with a system of open spaces or peri-urban green infrastructures by planning instruments such as the various forms of protected zoning and territorial planning initiatives.

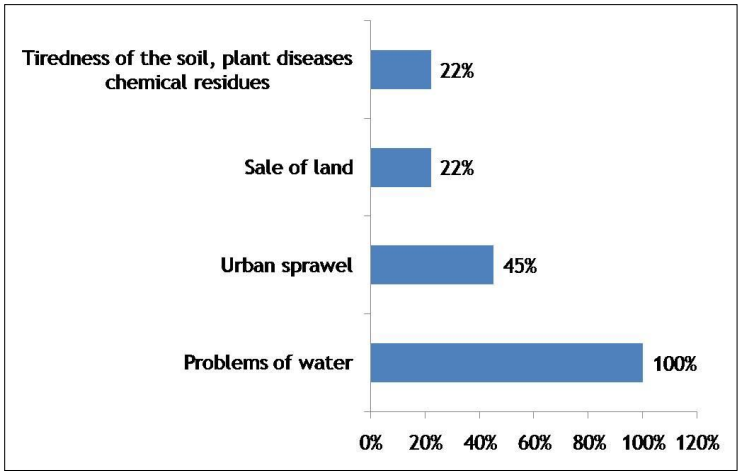

Figure 5: Histogram of the opinions of farmers on the constraints in farms
Source: Hamrita and Boussetta, 2016

We can summarize the landscape transformations in the public irrigated areas of Chott-Mariem and Mornag in three phases: (i) the first one corresponds to a traditional agricultural landscape (Houimli, 2008), (ii) a second phase corresponds to the passage of the traditional agriculture (monoculture) to modern and intensive agriculture and the last one (iii) is the entry of the public irrigated areas in a clearing process of unplanned urbanization. The Tunisian suburban agriculture is constantly changing and becoming more sensitive to the process of urban sprawl that affects all of agricultural land including the two irrigated areas under metropolitan influence of the capital Tunis for the public irrigated area of Mornag and under the influence of the tourism impact in the region of Sousse in the public irrigated area of Chott-Mariem. For various reasons as scarcity of water, farms in public irrigated areas can be found in four forms: (a) exploited farmland, (b) capitalized farmland, (c) short-term sharecropping in order to reallocate land for non-agricultural uses and (d) abandoned farmland (Jaouachi, 2016). So, Tunisian suburban agriculture is characterized by deep functional and spatial mutations due to the scarcity of irrigation water and also the urban pressure "fig.6".

ISSN- 2350-0530(O), ISSN- 2394-3629(P)
IF: 4.321 (CosmosImpactFactor), 2.532 (I2OR)
InfoBase Index IBI Factor 3.86


(a)

(b)

Photo 4: (a) Urban sprawl in the public irrigated area of Mornag and (b) the public irrigated area of Chott-Mariem. Source: Hamrita and Boussetta, 2015

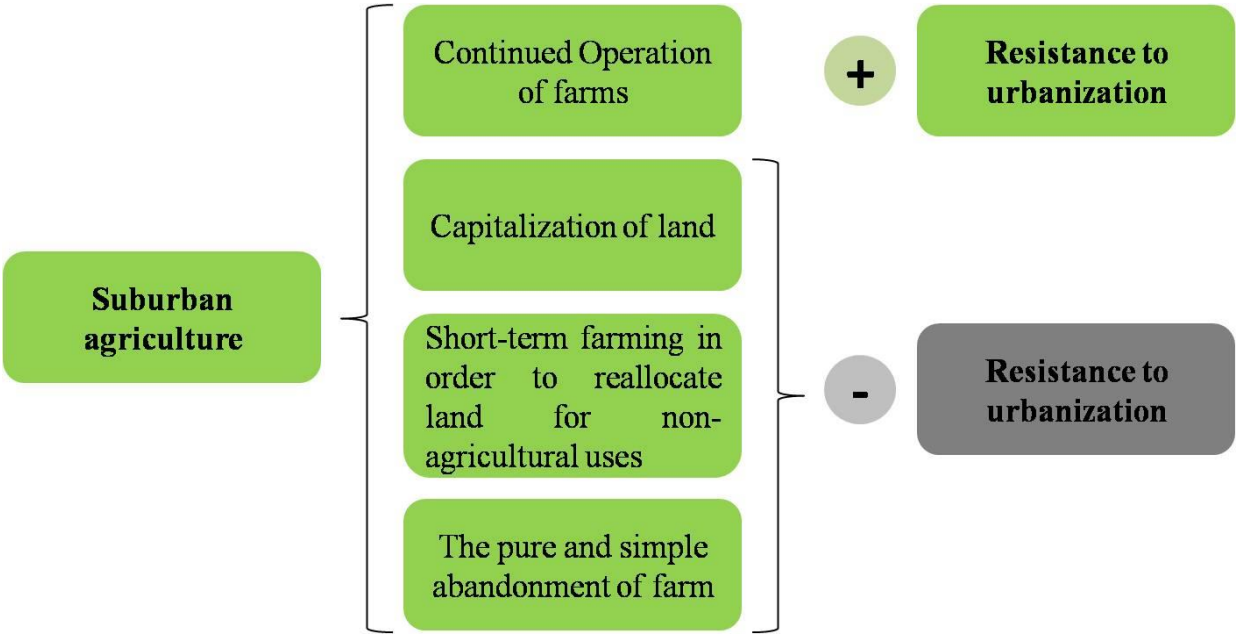

Figure 6: Process of transforming of suburban agricultural land in the public irrigated areas. Source: Hamrita, 2016

4. Conclusions & Recommendations

Classifying water as a national resource that everyone must preserve, protect, and use in lasting in 2001, is signal about the serious problem of water scarcity en Tunisia. This problem constitutes a severe constraint for economic and social development and can lead to decreases in living standards and the loss of productive systems (Horcheni, 2007). In order to manage the situation and to make suburban agriculture areas more active, the two types of respondents (farmers, technicians and decision makers) have proposed a number of solutions despite the high number of farmers who were pessimistic about the future of this suburban agriculture and that they offer nothing as solutions or they claim that it is the responsibility of the state to find effective solutions to all of problems. Among the proposed solutions is promoting the project of mobilization of water from north, establish a excess water storage strategy, provide a supplementary irrigation cycle during the summer season, the updating of laws and water code, develop new participative management tools for the water sector, develop new agricultural

cooperatives which brings together farms and farmers. Now, the management of water resources in Tunisia is very difficult and it will be more difficult in the future. The water policy in Tunisia is a balance between two conflicting factors; the limited water resources and increasing cost of storing and transferring additional of water resources and the growing demand for water (Louati and Bucknall, 2010). Tunisia is engaged in the implementation of integrated water resources management and has implemented a number of reforms to bring the basics and fundamentals of optimal, rational and sustainable water resources management, and whose most characteristic is the transition from supply management to demand management strategy aimed to reduce losses, protect the quality of water resources, optimize the socio-economic efforts and minimize environmental damage. Suburban agriculture in Tunisia has, over time, undergone a certain number of changes in their role in the city and the countryside and the important point is its multi-functionality (food production, environmental function, socio-cultural function, landscape…). It seems to us that it goes through a period of transaction (Vanier, 2005), where the antagonistic relationship leaves room for a complementarily relationship between the urban and the agricultural space and that a real integration of the suburban agriculture through a project of local and also regional governance must be born for a sustainable development of resources including water. This approach will affect all actors involved in water management as planners, civil society and different users; it will interest all aspects which organizes the water management namely:

- Environmental aspect: by the preservation of available water resources, strengthening the mobilization of water potential (infiltration, local and decentralized mobilization, development of non-conventional waters and integration of the environmental dimension into the water system;
- Social aspect: by maintaining the sustainability of financial access to water and the guarantee of quantity and quality of drinking water;
- Economic: by strengthening water conservation programs and development of water valorization programs;
- Institutional aspect: by improving the involvement of users in water management, strengthening the organizational groups (training, technical assistance...), redefining the concept of participatory management and cordoning between operators and users;
- Legal aspect: by a legal reforms and upgrading the water code.

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Acknowledgements

The authors would like to thank Professor Hichem Rejeb and Professor Rafael Mata Olmo for their constructive comments and suggestions that helped to improve the contents and the presentation of the paper. The authors would like to thank also all of the surveys for their enriching answers and the University of Sousse (Tunisia) and the Universidad Autonoma de Madrid (Spain) for the financial support.

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