MINARET

NETWORKING FOR THE FUTURE

WATER BASELINE TUNISIA

Sweden Sverige

FUTURE PIONEERS Empowering Communities

IUCN

NERC National Energy Research Center

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List of Acronyms

ADB: African Development Bank

AEP: Drinking Water Supply

AFD: French Development Agency

AI: Association of Collective Interest

ANPE: National Agency for the Protection of the Environment

APAL: Coastal Protection and Development Agency

API: Industrial Promotion Agency

APIA: International Exhibition of Agricultural, Investment and Technology

AREF: Arab Renewable Energies Framework

AREMS: Association of Research and Studies of the Memory of Sousse

AWF: African Water Facility

BPEH: Office of Planning and Hydraulic Balances

BOD5: Biochemical Oxygen Demand 5 days: a water quality parameter. BOD5 measures the quantity of biodegradable organic matter contained in water. This parameter is expressed as the milligrams of oxygen needed to break down the organic matter contained in a liter of water over five days.

CITET: The Tunis International Center for Environmental Technologies

CNE: National Water Council

CRDA: Regional Commissariat for Agricultural Development

COD: Chemical Oxygen Demand: a water quality parameter, i.e. the total measurement of all chemicals in the water that can be oxidized.

DEM: Digital Elevation Model

DGACTA: General Administration of Planning and Conservation of Agricultural Lands

DGBGTH: General Administration of Dams and Large Hydraulic Works

DGEQV: General Administration for Environment and Quality of Life

DGGR: General Administration of Rural Engineering

DGGREE: General Administration of Rural Engineering and Water Exploitation

DGPA: General Administration of Agricultural Production

DGRE: General administration of Water Resources

DHMPE: Environmental Direction of Hygiene and Environmental Protection

DHU: Urban Hydraulic Directorate

DPH: Public Hydraulic Domain

EPNA: No Administrative Public Establishment

EUT: Treated Wastewater

FTDES: Tunisian Forum for Economic and Social Rights

GDA: Agricultural Development Groups

GEORE: Optimal management of water resources

GIC: Collective Interest Groups

GIS: Geographic Information System

GIZ: Gesellschaft für Internationale Zusammenarbeit

GTZ: Gesellschaft für Technische Zusammenarbeit

IAA: Agro-Food Industry

INS: National Institute of Statistics

IWRM: Integrated Water Resources Management

JDN: « Le Journal du Net » (Internet Journal)

Km3: Billion m3

MARHP: Ministry of Agriculture, Water Resources and Fisheries

MEDL: Ministry of the Environment and Local Development

MEH: Ministry of Equipment and Habitat

MENA: Middle East and North Africa

MES: Matière en Suspension: Total Suspended Solids (TSS): the dry-weight of particles trapped by a filter. It is a water quality parameter used for example to assess the quality of wastewater after treatment in a wastewater treatment plant.

Mm3: Million m3

MSP: Ministry of Public Health

ONAGRI: National Observatory of Agriculture

ONAS: National office of Sanitation

ONG: Non-Governmental Organization

OTEDD: Tunisian Observatory on Environment and Sustainable Development

PIB: Gross domestic product

PISEAU: Integral Part of the Water Sector Investment Program

PNB: Gross national product

RANDET: Tunisian Association for Nature and Development

REACT: Association of Research in Action

RSH: Hydraulic Surveys office

SECADENORD: Northern Channel and Water Supply Corporation

SIDA: Swedish International Development Agency

SINEAU: National Water Information System

SMAG: Guaranteed Minimum Agricultural Wage per day

SMIG: Guaranteed Minimum Wage per hour

SONEDE: National Society for the Exploitation and Distribution of Water

SQL: Structured Query Language

SRTM: Shuttle Radar Topography Mission

STEP: Wastewater Treatment Plant

UN : United Nations

WB: World Bank

WREP: Water Resources Efficiency Project

2C2D: Tunisian Association Climate Change and Sustainable Development

1. INTRODUCTION

1.1. The MINARET project (MENA Region Initiative as a model of NEXUS Approach and Renewable Energy Technologies)

Many countries in the Middle-Eastern North Africa Region (MENA Region), including Jordan, Lebanon and Tunisia are facing several challenges, putting huge pressures on available energy, water and food resources. Existing water supplies can hardly meet the growing demand for irrigation and municipal water usage; and thus, the region must import most of its food.

To face these challenges and to tackle poverty, unemployment, and the growing demand for energy, water and food, these countries need to act quickly and respond to the different needs of their populations and economy. Improving energy efficiency, using renewable energy technologies and reducing water consumption for food production are the most cost-effective solutions that can be swiftly implemented. These solutions, which focus on the *nexus* of energy, water and food, have a great impact on the countries' economic growth and prosperity, while reducing poverty and improving livelihood opportunities of its people.

Based on case studies in three countries (Jordan, Lebanon, Tunisia), the MINARET project aims to identify such solutions that can support these countries' transition into affordable, sustainable and secure energy and water systems, while also leading to increased food security. The projectaims to offer a framework for a coherent and inclusive regional strategy to support local authorities, municipalities, private sector and civil society in promoting renewable energy and energy efficiency, clean water accessibility and food security as well as executing relevant pilots.

The overall goal of the MINARET project is to strengthen regional cooperation within the MENA region through implementing the NEXUS approach integrating renewable energy technologies at the municipality's level to mitigate climate change impacts and combat poverty. More specific objectives include: building the municipalities' resilience to climate change; strengthening institutional capacities; promoting inter-municipal regional cooperation; reinforcing the role of women, youth, and marginalized groups; and developing a MENA dialogue knowledge platform.

The NEXUS approachis considered an effective and integrated approach that starts from the clear interactions that exist between water, food, and energy, to improve human well-being, reduce poverty and increase sustainable development. It aims to balance different uses of these ecosystem resources through identifying potential synergies between different sectors and/or related interest groups.

The first component of the MINARET project is set up to be a first step towards determining these synergies, through identifying baselines on energy and water consumption (related to agriculture), GHG emissions, and renewable energy use. This is done for a set of pilot areas in three countries (Jordan, Lebanon, Tunisia), presenting different socio-economic characteristics and reflecting the variety of challenges that the involved actors face. Given that agriculture accounts for 70 % of total global freshwater withdrawals, the water baseline data collection is merged with the collection of agricultural baseline data in one report.

The current report therefore, reflects the water/agriculture baseline for the Tunesianpilot area, and should as such be understood as one part of a tripartite first component of the MINARET project, which also includes similar baseline studies for Jordan and Lebanon.

1.2. Scope of Baseline

The overall scope of the current report is to identify the baseline information on the water and agriculture situation at the municipality level in the pilot area. For the water sector, this includes analysis of: (1) the geographical, demographical, economic, social, and governance situation of the country and case study, (2) the policies and regulations for the water sector at municipal and national levels to identify the main water needs, (3) the institutional and governance structure of the water sector at municipal and national levels, (4) the water supply and demand profile and components at municipal and regional levels, (5) capacity assessment for the involved decision makers and stakeholders at local level. For the agricultural sector, this entails brief analysis of the agricultural situation the municipal level and national level.

The analyses are targeted to identify the main needs for both sectors to support municipalities in meeting development challenges in accordance with international standards (such as the Sustainable Development Goals). Based on this, potential interventions in the field of water governance and policy dialogue are identified for the pilot area as an outcome of this study.

For implementation of the MINARET project in Tunisia, the municipality of Monastir was selected due to the great challenges it faces in water supply as a leading tourist and university city in the country. The city depends entirely on external water resources for both drinking and irrigation water. This is further exasperated by high urbanization that increases pollution and the pressure on natural resources in the area.

1.3. Structure

After this introduction, Chapter 2 describes the methodology that was used in general for this paper and the data collection methods to take stock of the water and agricultural situation in the case study area. Chapter 3 structures background information on Tunisia including demographic, socio-economic and climatic situations, the existing policies related to the water and agriculture sectors, as well as the current water and agricultural situations. Chapter 4 presents the collected data for the case study area. Chapter 5 discusses the results and links them back to the objectives. Chapter 6 closes the report with conclusions and proposed interventions.

1.4. Project Team

The team involved in the preparation of this report was a multidisciplinary team (academic and civil society) composed by Mr. Habib SMIDA (Water and Geomatic expert (GIS, Remote sensing and database), PhD and associate professor in the University of Sfax (Tunisia), and Mrs. Hayet BACCOUCHE (Master degree in water management and active member in civil society of Monastir), and two assistants who conducted field surveys, data collection and data entry: Mr. Dhaker Sakka (member of Local NGO with very good knowledge in agricultural activities), and Mr. Jihed Saad (field assistant for collecting data from local administration).

The report was developed in collaboration with the "Notre Grand Bleu" association in Monastir, the municipality of Monastir and other regional public bodies in the city of Monastir (SONEDE, ONAS, CRDA,

API, APIA, INS …) and civil society in the region. The information was collected from these national and regional institutions.

2. METHODOLOGY

2.1. Data Collection Tools, Protocols and Methods

The preparation of this report is based essentially on a multi-source and multi-topic database. The data collection and processing phase accounted for more than 80% of the work time. The development of the database was subdivided into three phases:

- Data Collection
- Data processing and data correction
- Interpretation and discussion of the results

Data was collected on several socio-economic sectors in the municipality of Monastir and at the national level of Tunisia focusing on the current and historical status of water resources and socio-economic activities.

The data collection by the investigators was structured as follows:

- Field surveys with citizen farmers, regional organizations (STEG SONEDE, ONAS, CRDA, API, and APIA), civil society and direct field observations (quality of seawater and beaches, emissaries in South, Central and North Sea). Surveys were conducted with farmers and citizens on the use of water, the condition and operation of surface wells.
- Data provided by the administration through the regional directorates involved in the water sector (the municipality of Monastir, SONEDE, ONAS, APAL, ANPE, CRDA, API, APIA, INS, etc.).
- Consultations of existing documents through a bibliographic study including data in the form of statistical tables and summary reports of previous studies in the field of water in the Monastir region and Tunisia.
- Satellite imagery (Landsat, Sentinel, and SRTM) was used for the compilation of land use maps and maps of socio-economic activities. Shuttle Radar Topography Mission (SRTM) data were used to develop topographic coverage (DEM file: Digital Elevation Model), watersheds and hydrographical network.
- Extraction of data from the agricultural map (Shape file data): these were digitized data in vector file. They cover several themes: administrative boundaries, the location of wells and boreholes, vegetation, watersheds, etc.

These data (from statistical tables, inventory sheets, existing reports, etc.) were used as input in graphs and interactive digital thematic maps. They were organized in a database platform (Microsoft Access, Excel), a geographic information system (GIS), and image processing. As such, selection of the desired information in the form of spatial and semantic queries could be done.

Before the interpretation of the data collected, a series of meetings were held with the managers and staff of the directorates and organizations involved in the project (ONAS, CRDA, SONEDE, STEG INS, municipality, etc.). The objective of these meetings was to verify the data and discuss their quality.

2.2. Data Categories

The types of data collected for this report included:

- Geographic data (location, topography, climate)
- Demographic data (population, density and spatio-temporal evolution of the population)
- Surface water resources data (evolution of reserves and exploitation of dams, transfer of water),
- Groundwater (resources and exploitation of groundwater, quality (salinity) and evolution of underground reserves
- Data on the supply of drinking water (in Tunisia, then the municipality of Monastir)
- Socio-economic data
- Agricultural data (evolution of animal production, plant production, fishing, and water consumption, irrigated perimeters, etc.)
- Industry data (type of industry and water consumption)
- Tourism (changes in the number of hotels, housing capacity, water consumption)
- House and accommodation data in Monastir (number, evolution, quality ...)
- Education data (enrolment ratio, changes in the number of pupils, students, teachers, and school and university infrastructure)
- Health data (public, private, infrastructure development, medical and paramedical staff ...)
- Social data (social advancement, unemployment rate, population participation rate)

2.3. Data Quality

Data collection was done by skilled people who were able to assess the quality and reliability of the information.

The quality of data used in this work is variable. Part of the data can be considered as reliable and correct, especially those provided by SONEDE, ONAS, and STEP. These data include direct measurements of flows, consumption of number of subscribers.

Also, the data from the NSI are generally of good quality (collected from the other public bodies cited above), but also contain data that are relatively acceptable (e.g., those based on the census through samples of surveys that do not always represent the reality of society).

The field survey data are based on specific questions asked by the investigators, on consumption, subscribers and methods of supply. The statistical data and the evolution of consumption and production parameters found in the existing reports are sometimes contradictory and especially when they concern several authors who treat the same information.

> Example - Value of Tunisia's total water resources: Based on the inventory of existing documents, it was found that the estimated annual average input values are slightly different (eg DGRE (2014) give 4,880km3/year, SONEDE (2015) gives 4.7km3/Year, the African Development Bank Group (2016) gives 4,766 km3/year, and the DGRE (2017) gives 4,875 km3 / year). Thus, it can be assumed that Tunisia's total water resources are around 4.8 km3/year, divided into 2.7 km3/year surface water and 2.1 km3/year underground water.

2.4. Limitation of the Collected Data

In the work plan defined by MINARET, it had been assumed that all data would be available after the first meetings and discussions, which were carried out with the officials in Monastir in April 2017. However, during the data collection, it became clear that some data were absent, which led to amending the initial structure of the report based on the available data.

A large amount of data are only available at national or regional level (governorate or delegation), and not at the communal level of the municipality of Monastir. In order to obtain specific data for the municipality of Monastir, a series of meetings and discussions were held with the regional authorities in Monastir (SONEDE, ONAS, CRDA, API, INS, APIA, Municipality) which resulted in a specific database for the municipality of Monastir.

3. BACKGROUND

3.1. Tunisia's Context

3.1.1. Geography and Population

Tunisia is the northernmost country of the African continent, containing the northernmost point of the African continent, Cape Angela or Ras Ange. It is separated from Europe by 140 km at the level of the Sicilian Canal and attached to the Maghreb of which it is the smallest state.

Tunisia extends between latitudes 31° and 37° north and between longitudes 8° and 11° east and is more stretched on the north-south axis than on the east-west axis. The country has a surface area of 163,610 km², and is bordered to the West by Algeria (965 km of common border), to the South-East by Libya (459 km) and to the North and East by The Mediterranean Sea (1,148 km of coastline).

The geography of Tunisia is characterized by regional contrasts. Tunisia has a varied relief, consisting of a northern and western mountainous part, which is an extension of the Atlas range, a flat eastern part and a desert southern part (**see Figure 1**).

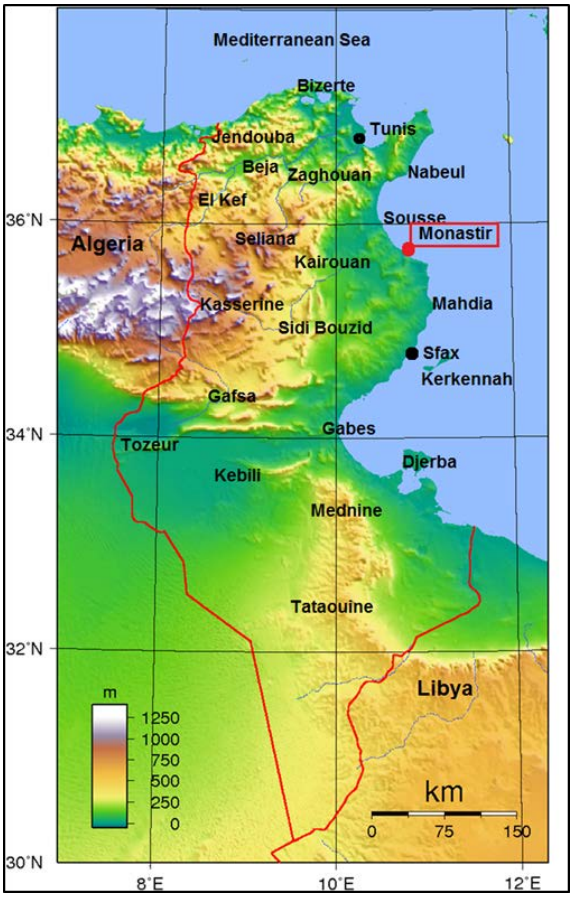


Figure 1: Topographic Map of Tunisia (Digital Elevation Model)

According to the 2014 census, the Tunisian population is 10,982,754 inhabitants, increasing to 11,134,588 in 2016 (INS, 2016) (**see Figure 2**). The Tunisian territory is unequally populated and socio-economically developed according to an interior-littoral (west-east) gradient (**see Figure 3**). The 13 coastal governorates contain 65.3% of the total population with a high population density (140 inhabitants/km2 compared to 65.6 inhabitants/km² nationally).

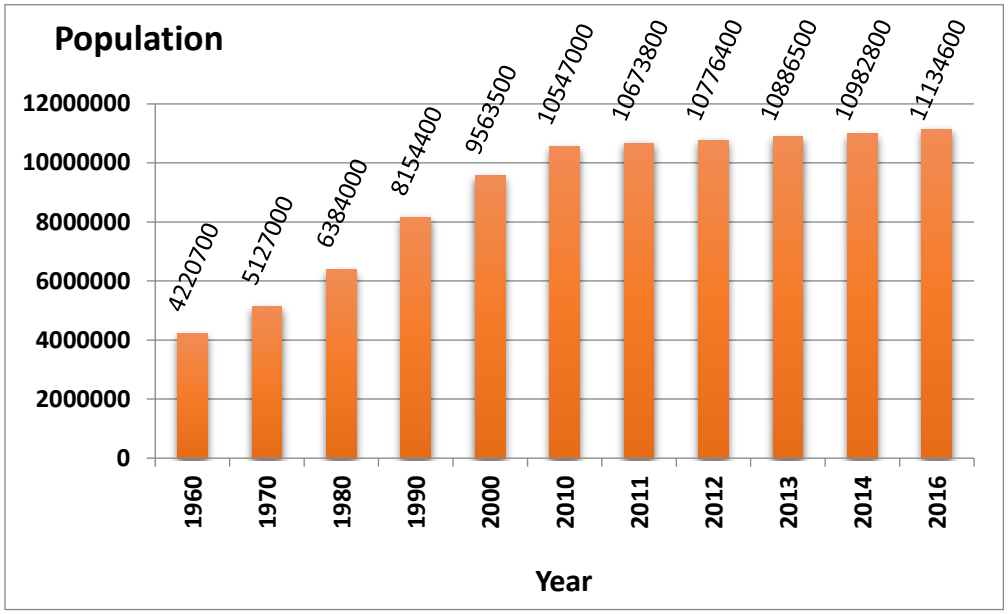


Figure 2: Evolution of the Tunisian population between 1960 and 2016 (INS, 2016)

Tunisia was urbanized at 65.6% in 2007 with an annual urbanization rate of 3.6%. The urban network is located on the eastern coastline, between the Bizerte and Gabes regions, via Tunis, Cape Bon, Sahel and Sfax (center-east of the country), which have the most important infrastructure and economic activities and concentrate more than 80% of the urban population. Based on the 2014 census, the main municipalities are classified by population in the graph below (INS, 2014) (**see Figure 4**).

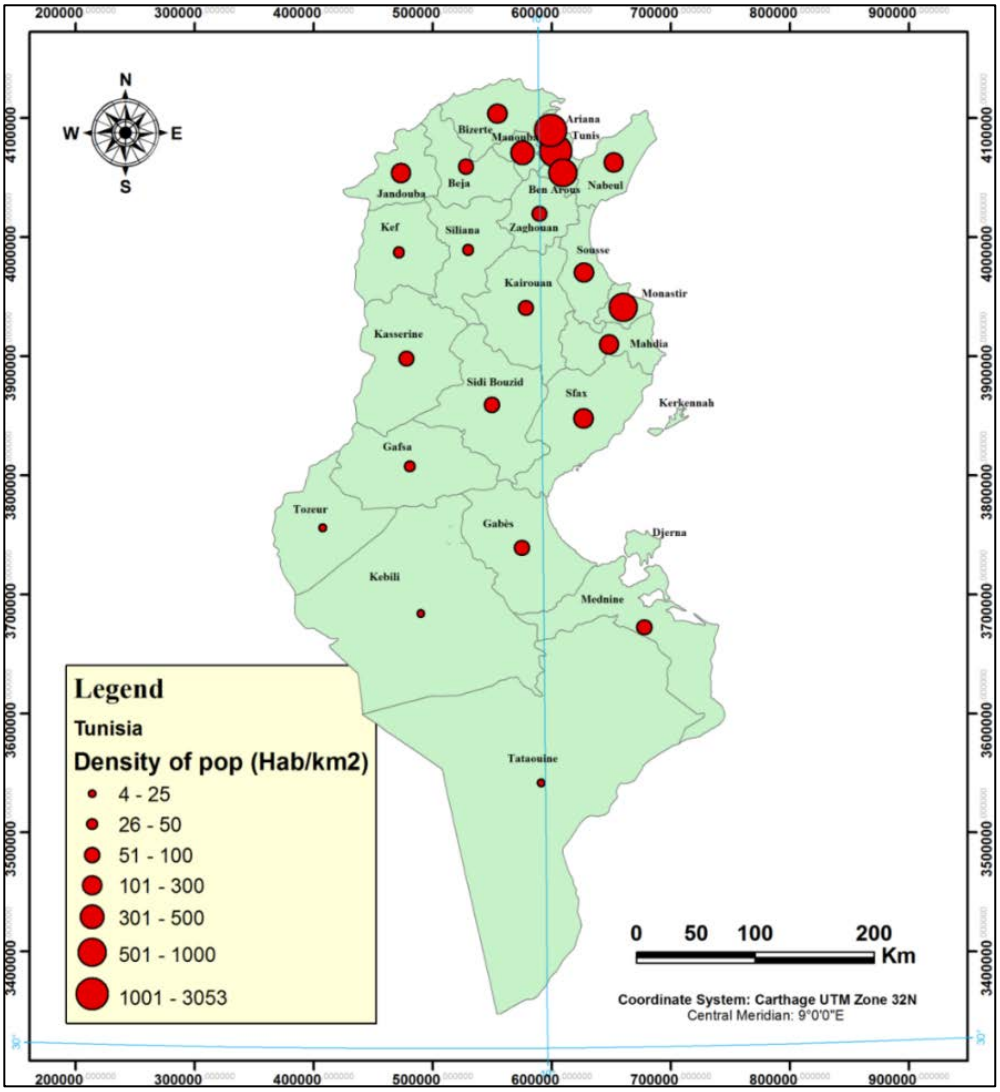


Figure 3: Tunisian population density on 2014 (INS, 2014)

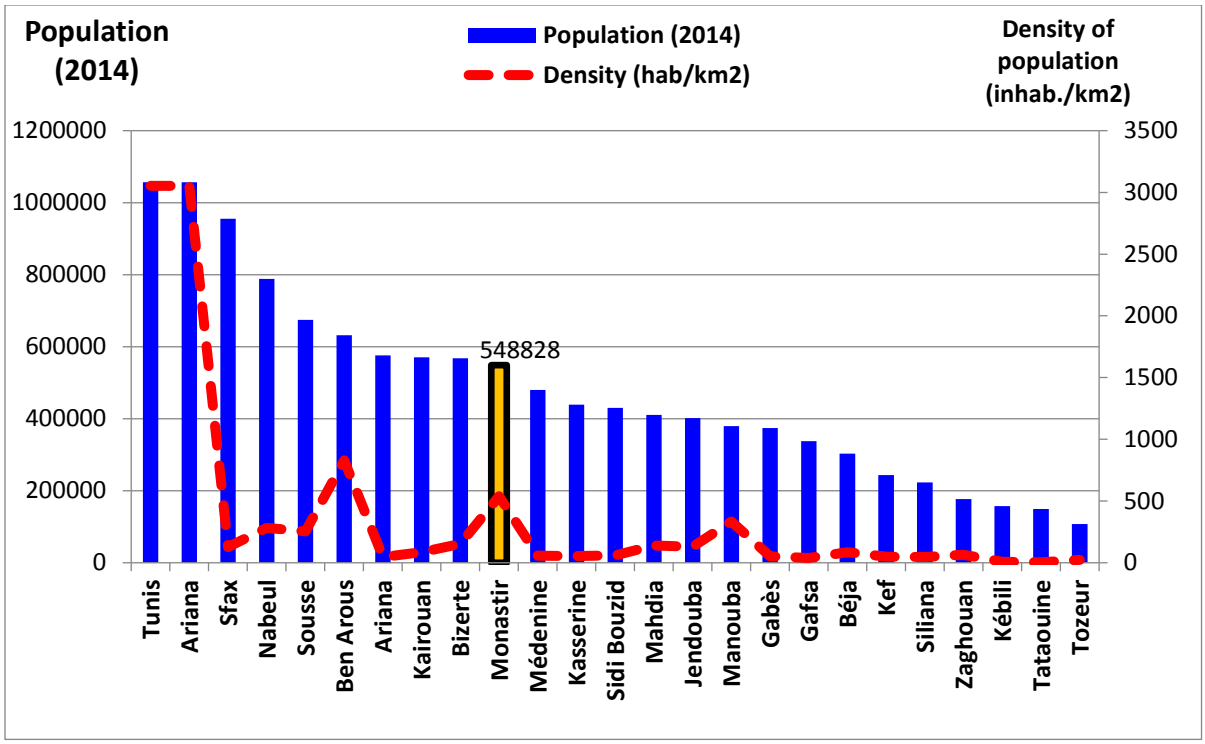


Figure 4: Demographic weight of the different governorates of Tunisia (INS, 2014)

Tunisia consists of 350 municipalities as counted by the National Institute of Statistics (INS, 2016). Most are assimilated to cities, that can be considered agglomerations polarizing around functions of administration, services or industry. The first hundred municipalities constitute 52% of the country's population and 80% of the urban population. The municipality of de Monastir occupies ranks number 15 with a population of 93,306 inhabitants (INS, 2014).

3.1.2. Climate

The climate of Tunisia varies greatly from region to region. It is Mediterranean in the north and along the coasts, semi-arid in the interior and arid in the south. National average temperatures amount to 12°C in December and 30°C in July (Sethom and Kassab, 1981). Annual rainfall decreases from north to south and from east to west (**see Figure 5 in chapter 3.3.1**).

3.1.3. Economy

According to the World Bank (2012), the average monthly income per inhabitant in Tunisia is USD 346 and USD4,150 per inhabitant per year. This average increased slightly between 2004 and 2012, but is less than the global average (**see Figure 5**).

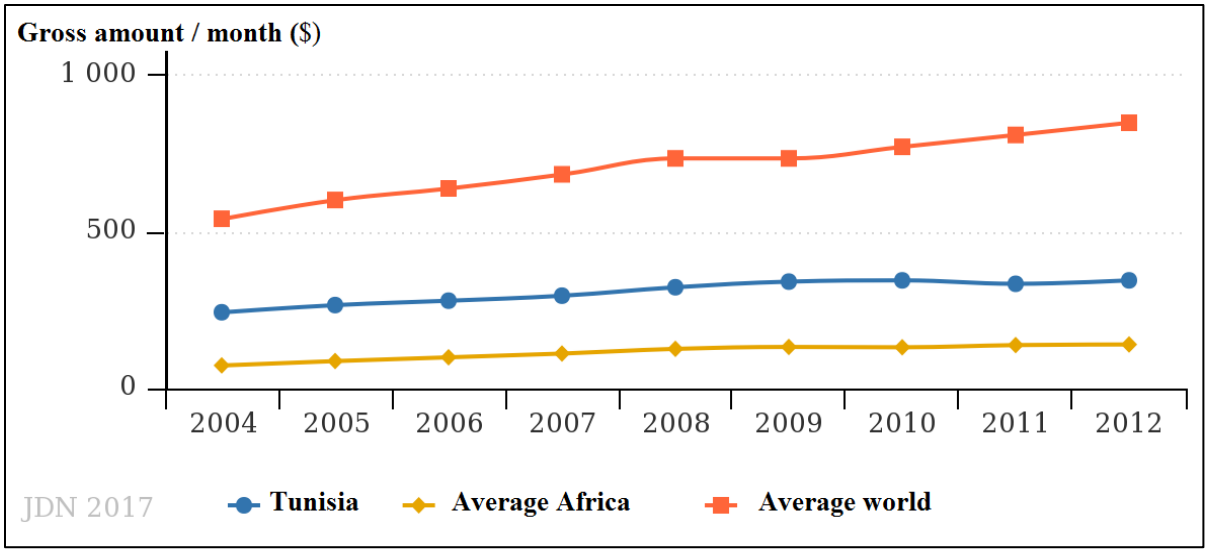


Figure 5 Evolution of the average monthly income per person between 2004 and 2012 in Tunisia, Africa and the world

Between 1990 and 2015, the guaranteed minimum wage per hour (SMIG) changed from 0.6 to 1.5 TND/hour (USD 0.25 to 0.625), for the 48-hour working week, and from 0.7 to 1.6 TND/hour for the 40-hour working week plan (INS, 2016). The Guaranteed Minimum Agricultural Wage per day (SMAG) fluctuated between 3.5 and 12.3 TND/day (**see Figures 6, 7**)

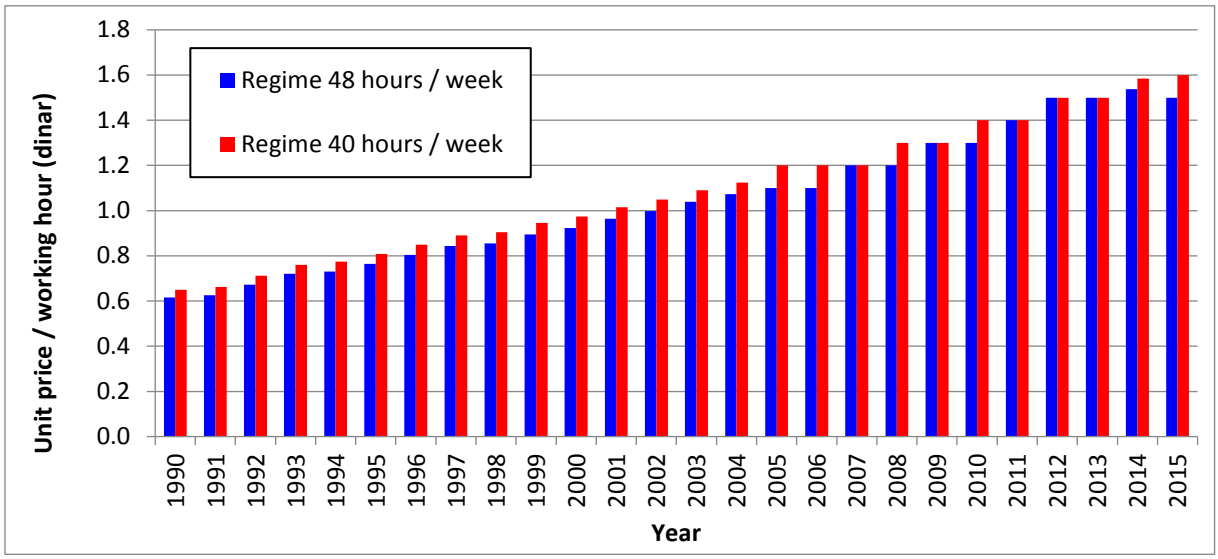


Figure 6 Evolution of inter-professional guaranteed minimum wage per hour (SMIG) in Tunisia

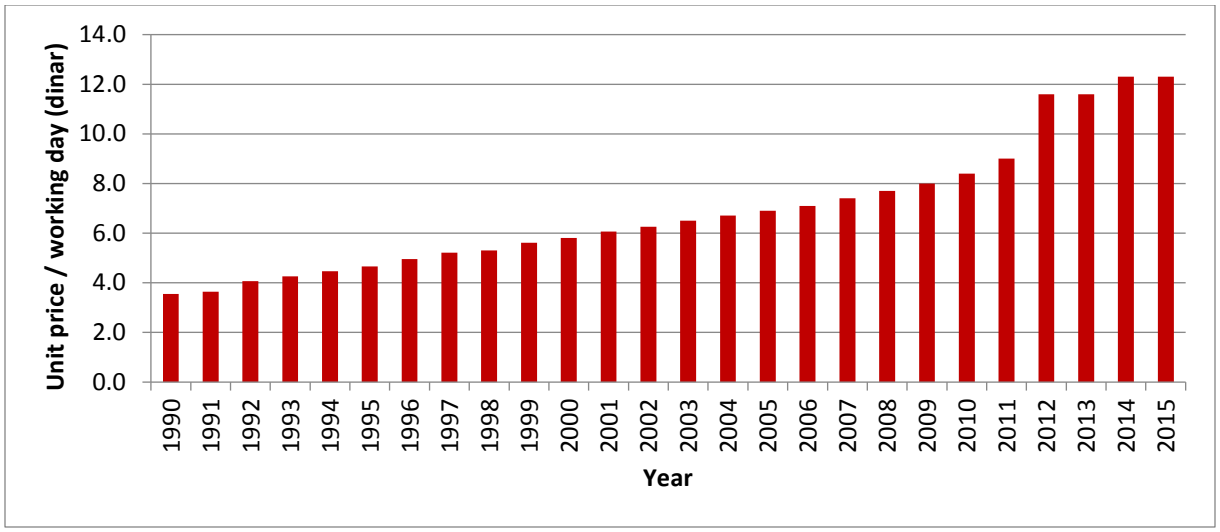


Figure 7 Evolution of Guaranteed Minimum Agricultural Wage per day (SMAG) in Tunisia (INS, 2016)

3.2. Political and Legal Situation in Tunisia

Tunisia, officially the republic of Tunisia, is a representative democracy and a republic with a president serving as head of state, prime minister as head of government, a unicameral parliament, and a civil law court system. The new Constitution of Tunisia, adopted 26 January 2014, guarantees rights for women and states that the President's religion "shall be Islam". In October 2014 Tunisia held its first elections under the new constitution following the Arab Spring.

In accordance with the new Constitution of 2014, Tunisia is engaged in a process of **decentralization** (Article 14) which gives local authorities more autonomy and a leading role in the economic and social development of their territories (Articles 131- 142). A draft of Local Government Code has been prepared. It would introduce a new institutional and administrative organization by enshrining the principle of free administration announced in the Constitution. It promotes local administration and management for a better public service, and grants the local level, the appropriate scale to think and build new development frameworks, the means to assume this role, in order to better meet the needs of citizens (Turki and Verdeil, 2013).

At the regional level, the regional council examines all matters concerning the governorate in the economic, social and cultural fields. In this context, it is responsible in particular for:

- The elaboration of regional development plans;
- Provide advice on the programs and projects that the State or public institutions intend to carry out in the governorates;
- Arrange the various regional development programs and ensure their realization;
- Coordination between regional programs and national programs of interest to the governorate, as well as the programs of the municipalities of the governorate;
- Develop co-operation between municipalities and ensure the implementation of joint projects between them ".

In each governorate, there is a regional administration for each department. The regional administrations are located in the capital city of the governorate. The directors of these formal bodies represent the associated ministry at the local and regional levels.

At the local level, within the governorates, the communes do not have important powers. Article 36 of Organic Law n° 75-33 of May 14, 1975 relative to the communes stipulates that: "the municipal council regulates by its deliberations the affairs of the municipality:

- It examines and approves the municipal budget;
- It sets, within the limits of the resources of the municipality and the means at its disposal,
- It defines, in accordance with the national development plan, the various actions to be undertaken with a view to assisting the development of the locality;
- It shall be consulted beforehand on any project to be carried out by the State or any other public authority or body in the territory of the municipality ".

Informal groups and organizations - in addition to the formal structures- are civil society associations and various organizations (social funds, financial and service companies) involved in local decision-making in socio-economic areas, e.g. CRDA, the SONEDE in the field of water and agriculture, and ANPE, APAL, ONAS in the field of environment.

3.3. Water Situation

The water sector in this report includes information on water resources and wastewater generated in Tunisia in general and in the pilot area in specific, and how it affects water resource quality.

The total potential of mobilized water resources in Tunisia is 4.8 km^3/year, of which 4.6 km^3/year. This is low compared to other similar countries (in climate) such as Morocco (29 km^3/year), Algeria (17 km3/year) and Egypt (58 km3/year). Most of these water resources are internal and renewable (Besbes, 2013). 2.7 km3 (55%) consists of surface water and 2.1 km3 (45%) come from underground water tables. With a water availability of 480 m^3/year/inhabitant (2015), the country is below the water stress threshold (set at 500 m^3/year/inhabitant) (SONEDE, 2016).

3.3.1. Precipitation

Rainfall is marked by a very important spatial and temporal variability, it decreases from north to south and from east to west with an average annual rainfall of 1590 mm (at Ain Draham in the north-west) to 90 mm (at Kebili in the south-west). Regional coefficients of variation gradually increase from north to south from 20% to 50% while being stronger in the East than in the West (Sethom and Kassab, 1981) (**see Figure 8**).

The north receiving the largest quantities of precipitation supplies 82% of the country's water resources. The center with the Sebkhet Sidi El Hani located in the Sahel region, and the south are characterized by aridity and endoreism. They provide only 12% and 6% of the resources, despite occupying 62% of the country's surface area.

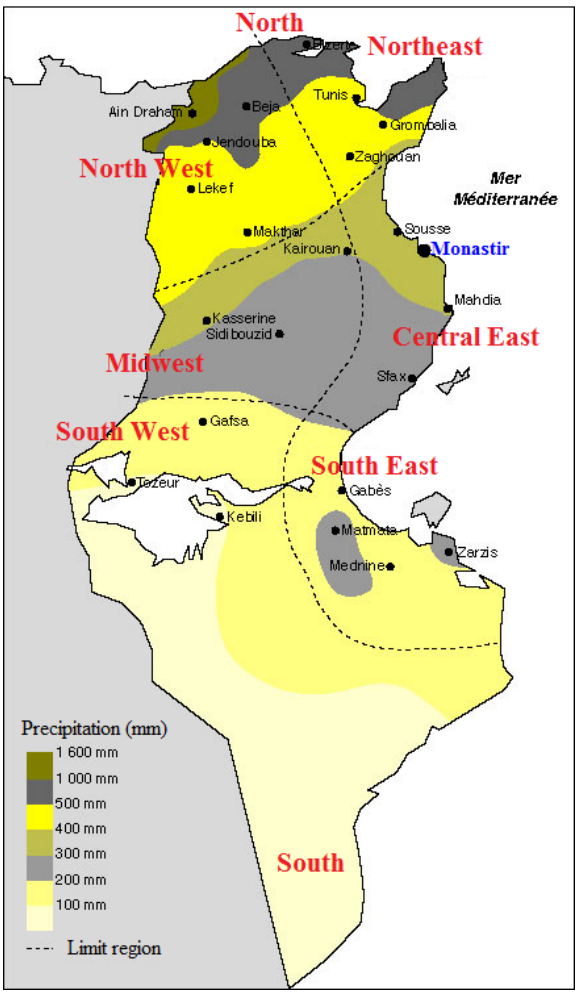


Figure 8 Map of the average annual precipitation of Tunisia

3.3.2. Rivers

The hydrographical network is characterized by an increasing density from south to north and from east to west, with Medjerdah as the country's main river with an average annual intake of 1 billion m^3/year. Most surface water is supplied by the northern basins, with an average annual contribution of 2,7 km^3. (1km^3 = 1 billion m^3) (**see Figure 9**).

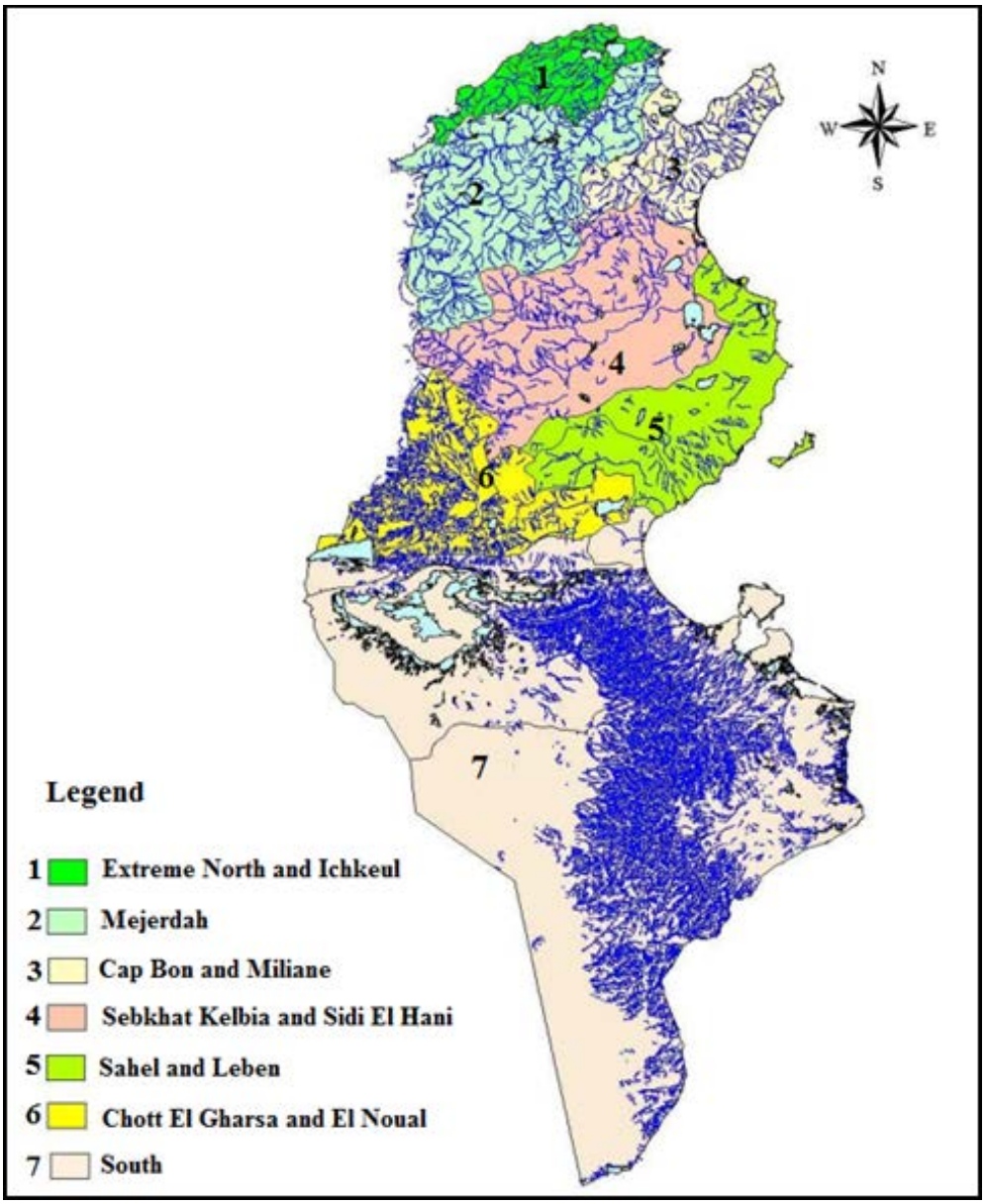


Figure 9 Hydrological map of Tunisia (hydrographical network and watershed).

3.3.3. Groundwater

Groundwater resources are estimated at 2125 Mm^3 of which 745 Mm^3 come from groundwater and 1380 Mm^3 from deep water, 650 Mm^3 of which are non-renewable.

The center and the south of the country, despite being arid, contain most of the underground resources (69% in total). They are characterized by an important potential of underground water resources harbored by large deep and weakly renewable aquifer systems. These have enabled the area of the oases to double over 30 years,

from 15,000 to 36,000 hectares of irrigated land (MARHP, 2015).Groundwater resources are estimated at 2, 1 km³/year (**see Figure 10**).

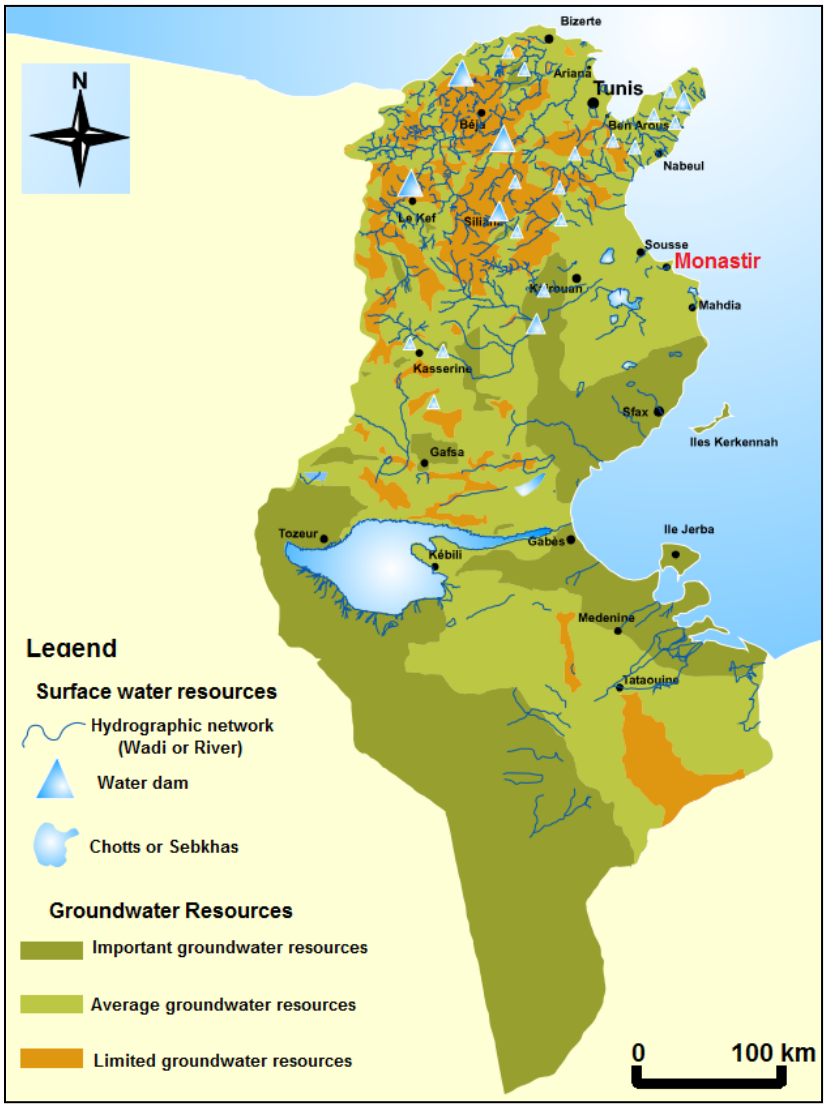


Figure 10 Map of Tunisia's underground water resources

3.3.4. Water Demand and Supply

Water use

In Tunisia, 83% of water resources are used by agriculture, and 17% is used for drinking water. The drinking water fraction is subdivided into 11% for domestic use, 5% for industry and 1% for tourism (**see Figure 11**).

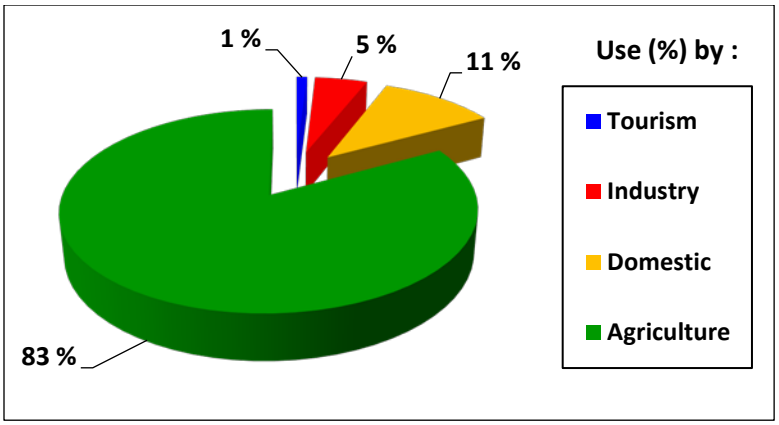


Figure 11 Distribution of water demand per sector in Tunisia

The consumption of drinking water in Tunisia is about 450 million m³, through 2,720,000 subscribers. 75% of this volume is used for domestic purposes through 95% of subscribers. The remainder is used in other sectors (industry, tourism, and others) (**see Figure 12 and 13**).

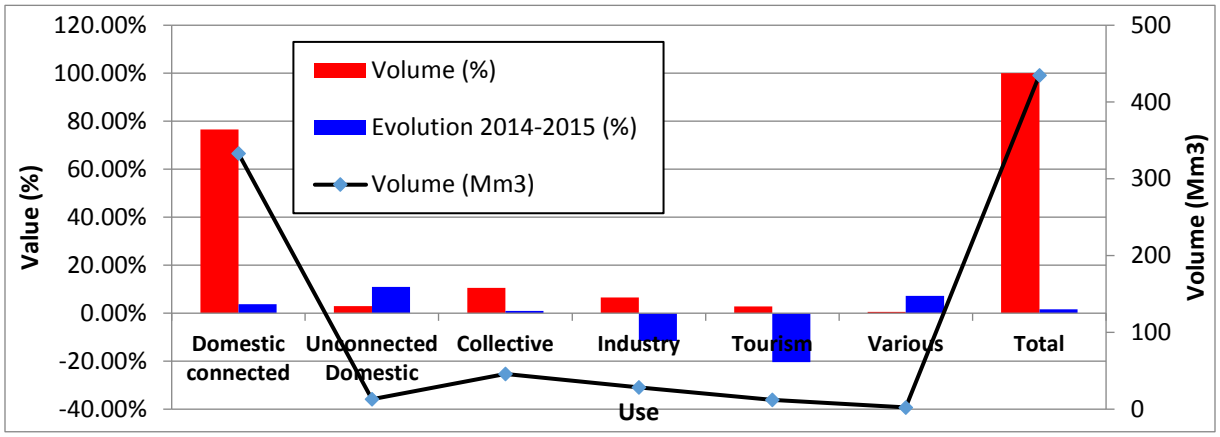


Figure 12 Distribution of the volume of consumed and billed drinking water and their rates of change between 2014 and 2015 in Tunisia

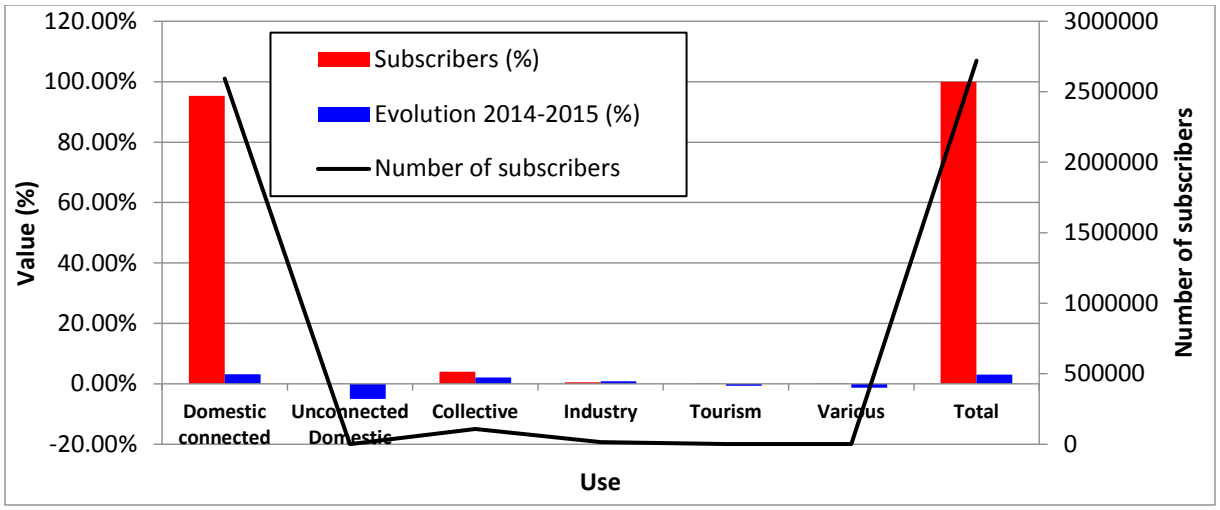


Figure 13 The number of subscribers and their rates of change between 2014 and 2015 in Tunisia.

Drinking water and sanitation in Tunisia

Tunisia's drinking water and sanitation policy has enabled the country to achieve the highest rate of access to water supply and sanitation in the countries of North Africa and the Middle East, through its infrastructure policy (**see Table 1**). 96% of urban residents and 52% of the rural population have access to improved sanitation (ONAS, 2015). At the end of 2006, access to drinking water was almost universal in Tunisia, close to 100% in urban areas and 90% in rural areas. Tunisia also offers good quality drinking water throughout the year (SONEDE, 2016).

Table 1 Connection rate on drinking water and sanitation networks in Tunisia (SONEDE, 2016)

		Urban areas (64% of the population)	Rural areas (36% of the population)	Total
Water	Improved Source of Drinking Water	99 %	82 %	93 %
	Housing Connections rate	94 %	38 %	74 %
Sanitation	Improved sanitation	96 %	65 %	85 %
	Sewers	75 %	4 %	49 %

Water tariff for different uses

The tariffs for drinking water and the sanitation fees are defined by SONEDE. Between 2014 and 2015, SONEDE maintained the same tariff system adopted in 2014. This system consists of seven quarterly consumption tranches and a gap of 7.7 times between the highest tariff and the lowest tariff. The tariffs per quarter of quarterly consumption are presented below (**see Figure 14**).

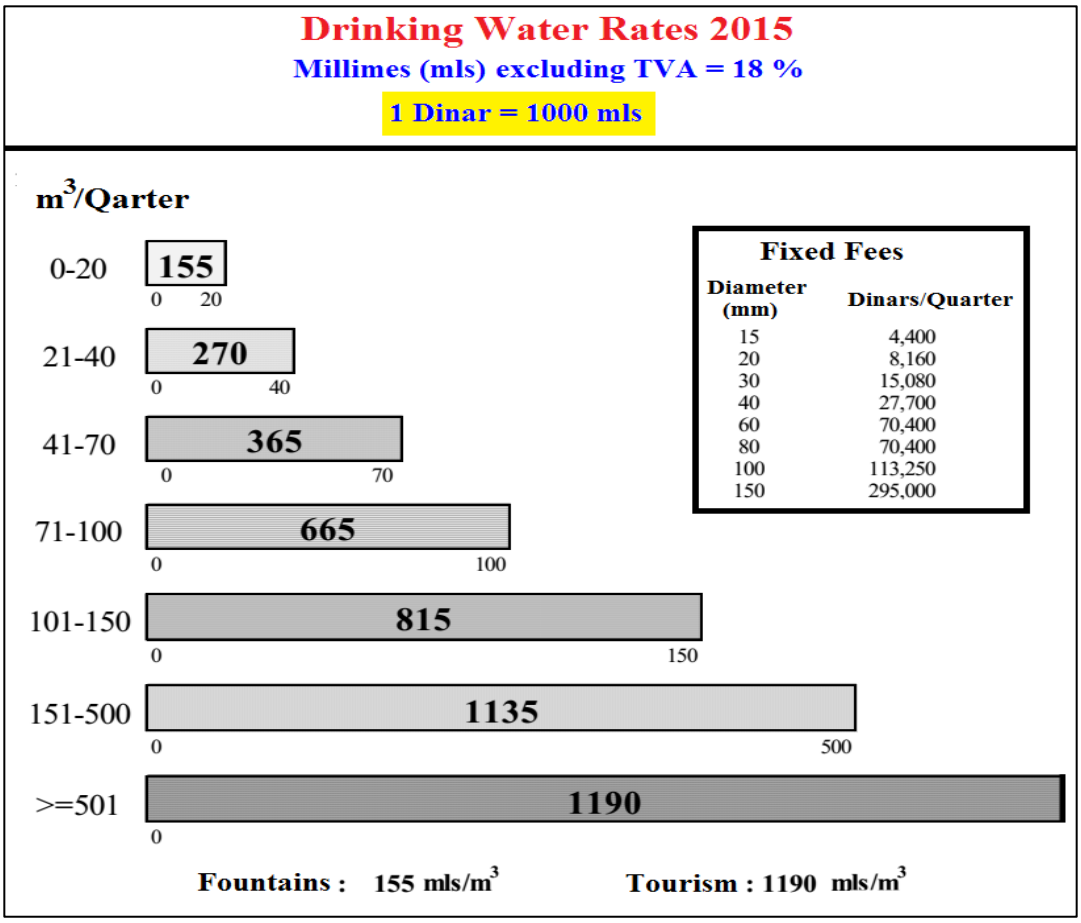


Figure 14 Tariffs for drinking water in Tunisia in 2015 (SONEDE, 2016).

In 2017, SONEDE increased drinking water consumption tariffs, as a result of the increase in network maintenance costs, the cost of mobilizing and transferring water to subscribers. The new increase in 2017 is proportional to consumption (**see Figure 15**).

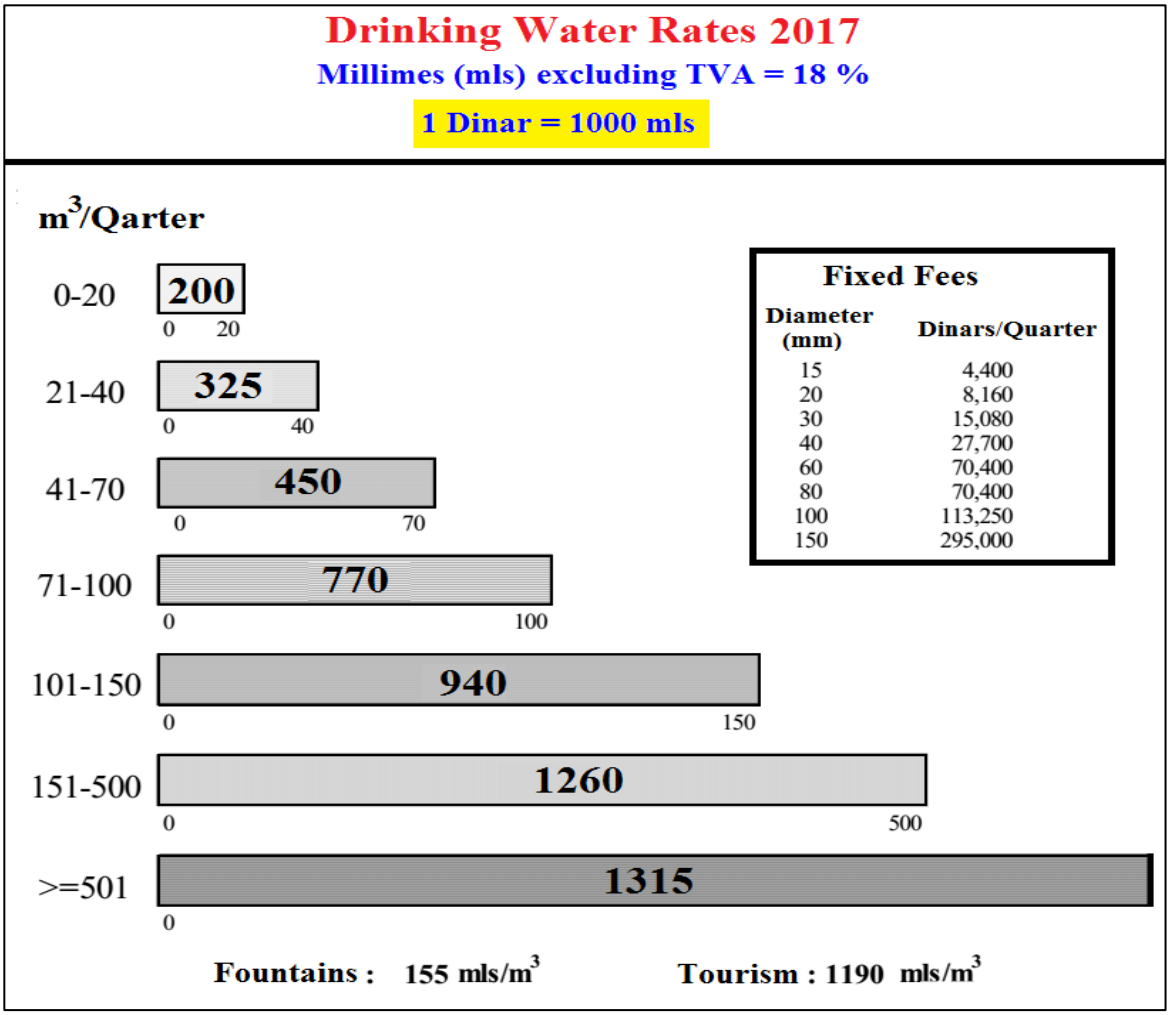


Figure 15 Tariffs for drinking water in Tunisia in 2017 (SONEDE, 2016).

3.3.5. Wastewater

The average rate of connection to the sewerage network is 90.3% in 2016. Faced with the situation of water scarcity in Tunisia, SONEDE has increased the tariffs of consumption of drinking water and sanitation several times after the revolution of January 14, 2011. In January 2015, ONAS revised its tariffs while maintaining the binomial tariff system which allows the subscriber to benefit from a maximum of two tariffs. **Figure 16** below illustrates the latest ONAS pricing scheme and how it is applied.

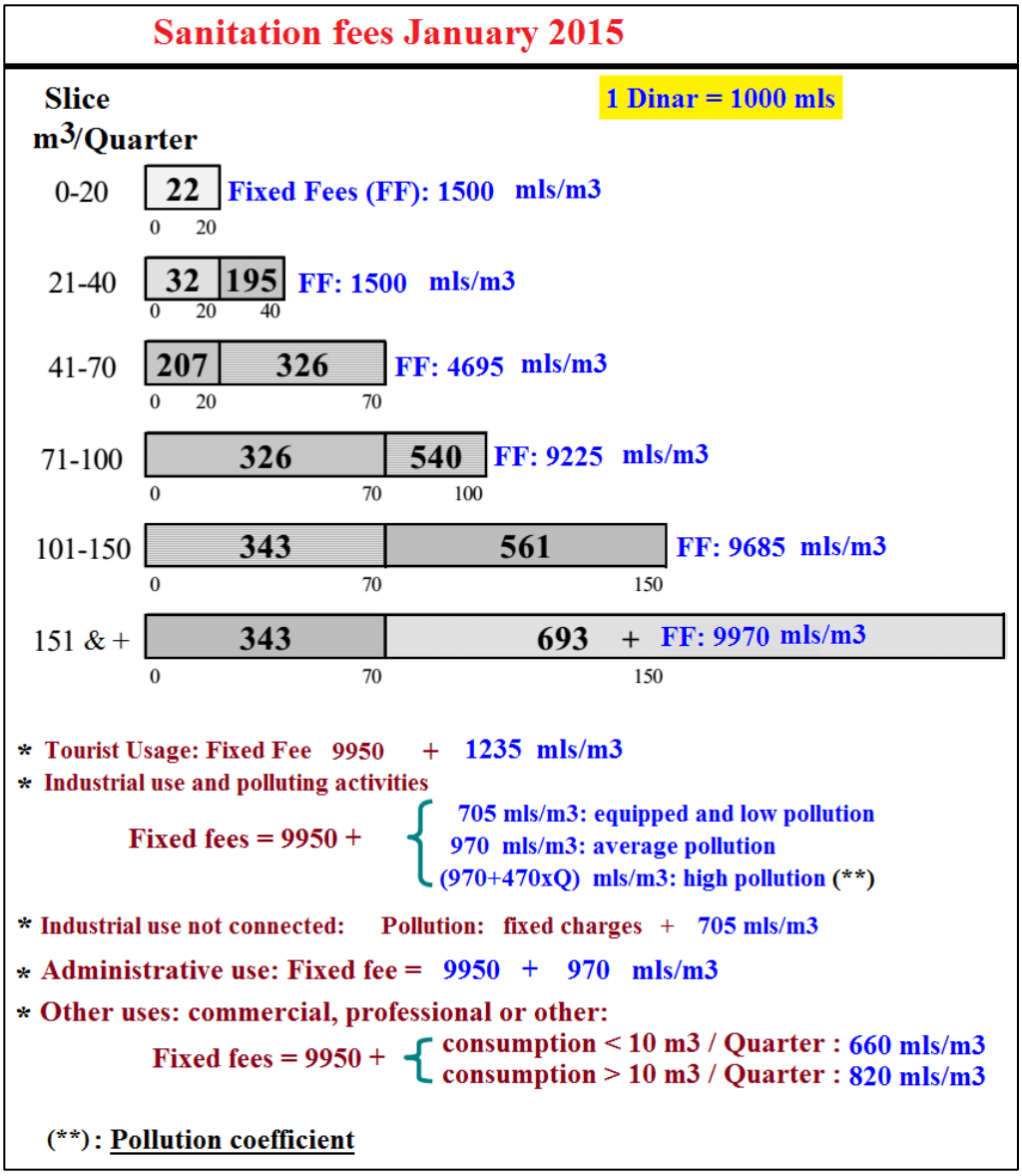


Figure 16 Sanitation tariffs in Tunisia (SONEDE, 2016)

3.3.6. Challenges

Water scarcity

The Tunisian population exceeds 11 million, with an average population density of around 66 inhabitants/km² and an urbanization rate of 66%. This population has only 4.8 billion m³ of water resources, resulting in a ratio of 480 m³/inhabitant/year. This rate is very low compared to the minimum level of hydraulic comfort which is 1,700 m³/inhabitant/year (Hamza, 2014). The Tunisian ratio is even below the poverty line and the water scarcity threshold (Hamza, 2014) (**see Figure 17**).

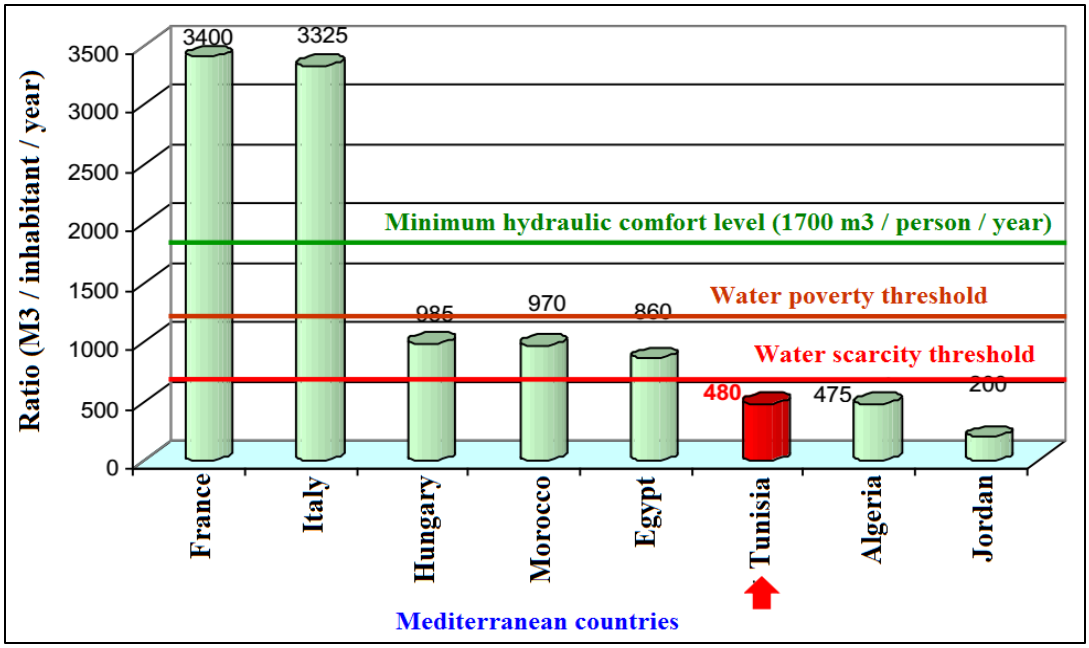


Figure 17 Ratio in m3 / inhab / year of some Mediterranean countries (Hamza, 2014)

Geographical disparity between water availability and consumption

Based on the available data on the presence of water resources and consumption, it can be concluded that there is ageographical disparity in water availability (both quantity and quality)and the population distribution in Tunisia (**see Figure 18**). The coastal regions with a high population, such as the Monastir case, are poor in water, while the low-population regions of the north-west of the center and south of the country present more than 70% of the water resources mobilized. The north is rich in surface water, a result of heavy rainfall that exceeds 1000mm/year, while the southern and central regions contain large groundwater reserves. The typical case is the Sahel region of Tunisia, and in particular the Monastir region, where water resources are low and of poor quality, whereas the population is very dense. Based on the scenarios and the estimates on the mobilization of water resources up to the year 2020 by SONEDE, also including the climate context, compared with the population estimates for the same period by the INS, it is expected that Tunisia will continue to face this situation of scarcity of water if the Tunisian government does not seek other water supply methods.

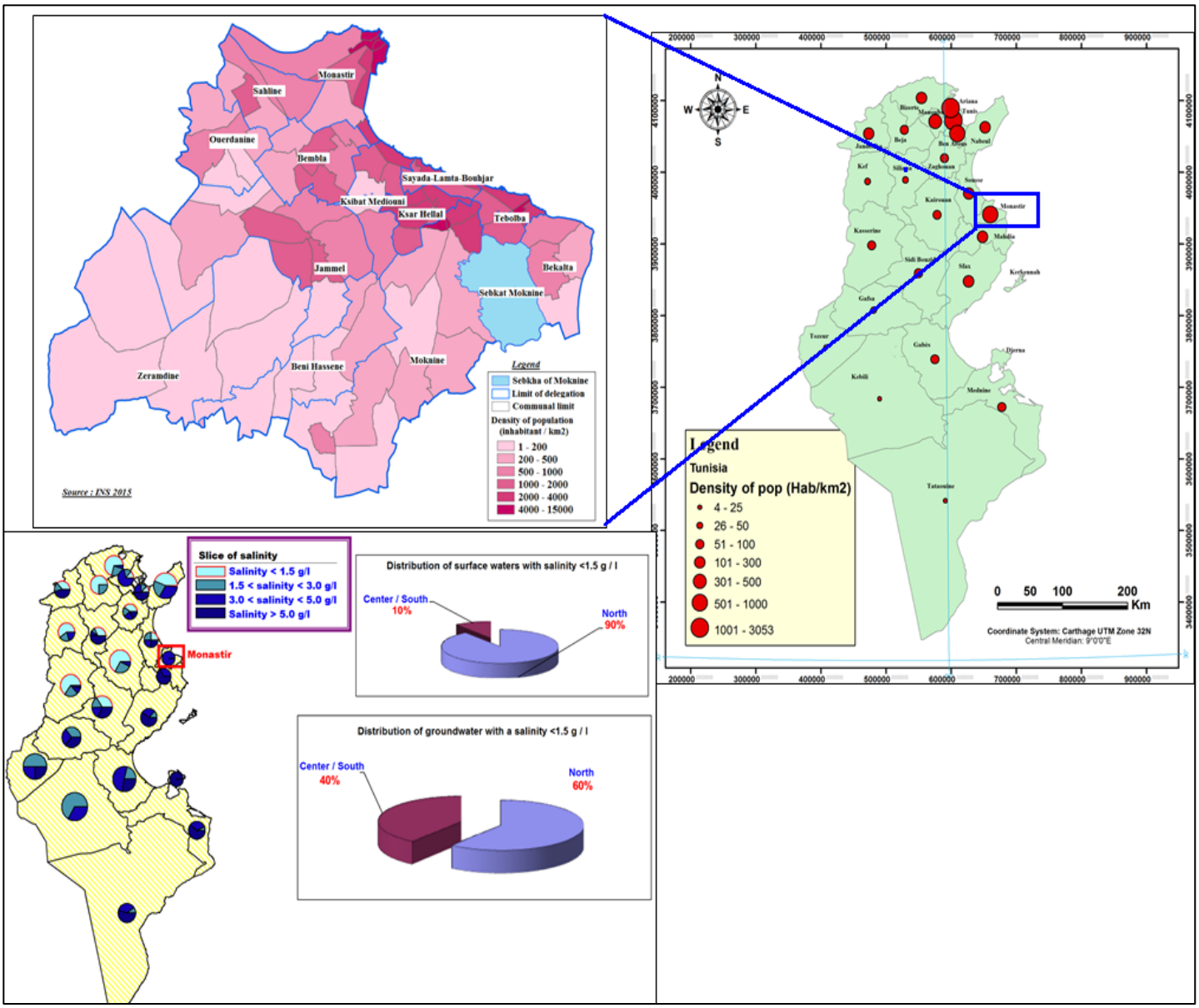


Figure 18 Relationship between the availability of water resources and the population in Monastir and Tunisia (2014).

Institutional inertia

The governance of the sector, based on a strong centralization of responsibilities and decision-making power, also shows its limits. The institutional inertia remains strong and the urgency of the reforms is not a feeling that is clearly shared by the Tunisian authorities. Despite the democratic transition, lack of government stability has prevented the development of a strategic vision of water policies, while strong social pressures have led to crisis rather than preventive management of the sector.

The national water strategy is now based on the economics of conventional resources and the mobilization of non-conventional resources such as desalination of seawater and the use of treated wastewater. The easiest

and least costly resources were used, and solutions for transferring water resources from north to south have shown their limits. Future extensions will require more investment, more complex studies and more advanced technology.

Obstacles to private sector participation

The current situation of post-revolutionary reconstruction offers a unique opportunity to also reflect on the water governance framework and on the role that private sector participation (PSP) can play in the development of the water sector. Due to the recasting of the legislative framework and the ongoing reflections on the country's new economic development models, a reflection on the strategy of the water sector with regard to PSP and the institutional and regulatory needs it entails is needed before the relevant choices are made.

However, the involvement of the private sector will require a change of administrative culture and modalities of water supply and sanitation services of the country. It cannot happen without the strengthening of the financial and decision-making autonomy of incumbent operators, the development of mechanisms for transparency, the integrity of the budgetary process and the optimization of public spending. Some services regulation functions must also be re-examined in logic of efficiency in the implementation of existing tools, systematization of procedures and greater customer orientation. The authorities must also work to strengthen the financial viability of the sector.

Water Quality

The quality of water resources in Tunisia is average. Only data on salinity were available; no data were available for other water quality parameters. This salinity is relatively high, with some regional variation (**see Figure 19**). Only 52% of water resources have a salinity of less than 1.5 g/l. The distribution of the salinity of water resources is marked by a great regional disparity: 86% of the good quality water resources are located in the north of the country (SONEDE, 2016).

For surface water, 30% have a salinity of more than 1.5 g/l and 70% have a salinity of less than 1.5 g/l, of which 10% is located in the south and in the center, and 90% in the north (the large dams of Tunisia). As for groundwater, 33% has a salinity of more than 3 g/l, 42% has a salinity of between 1.5 and 3 g/l and 25% has a salinity of less than 1.5 g/l. The latter is distributed for 40% in the south and center, and for 60% in the northern aquifers. As for the region of the case study, the Monastir region, average water salinity is generally between 3 g/l and 5 g/l. It varies from 1 to 7 g/l in the phreatic aquifers and from 1 to 6 g/l in the deep aquifers (Helali, 2015).

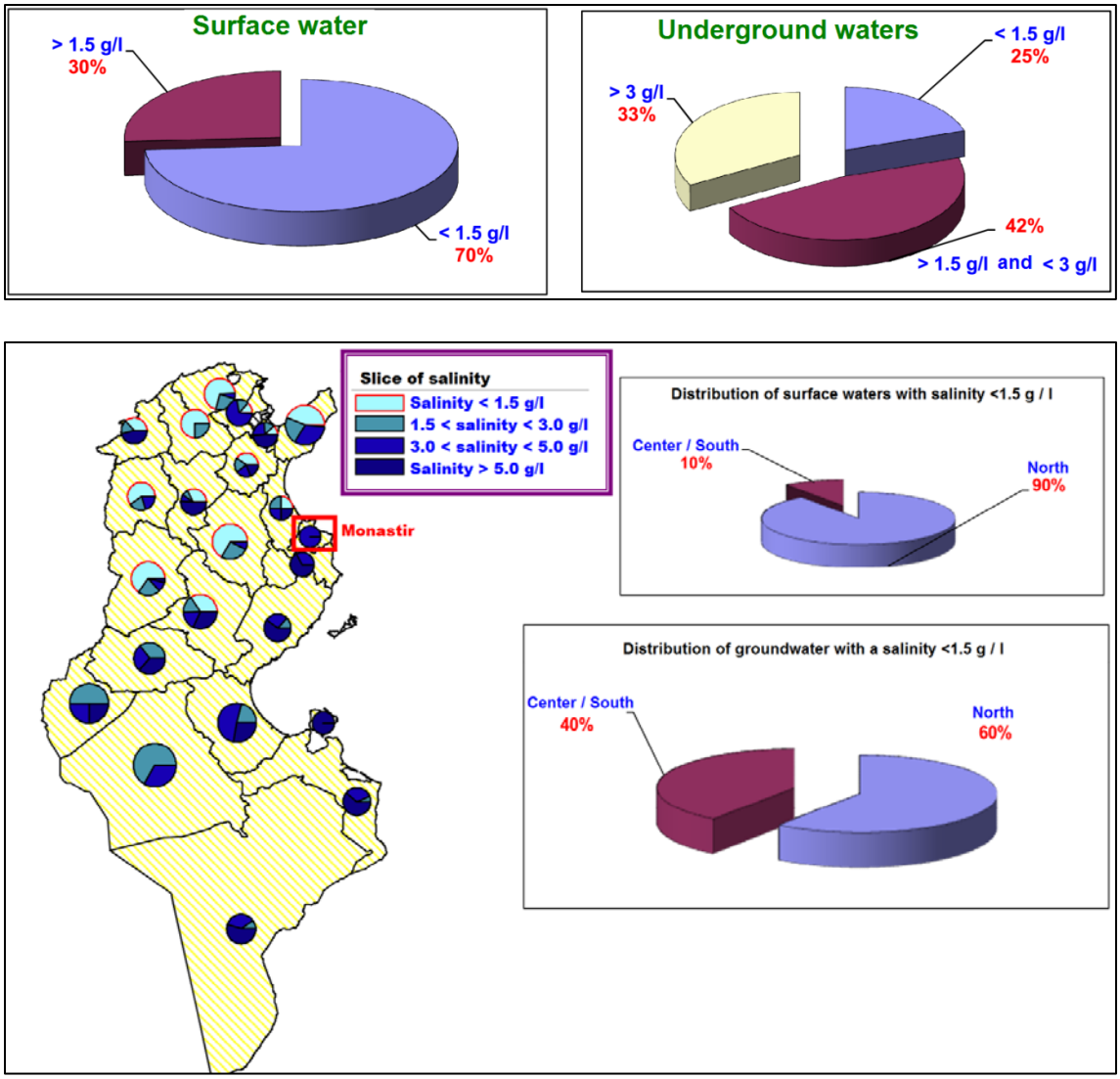


Figure 19 Geographical distribution of water resources quality in Tunisia (Helali, 2015)

3.3.7. Water Governance

Policies and Strategies

Given the difficult hydraulic environment, Tunisia has embarked on a policy of mobilizing resources in the short and long term to satisfy its needs from this vital source, since the 1970s, and especially in the early 1990s. This policy is also linked to an agricultural policy, given the close relationship between water and agriculture., Tunisia has developed strategies for the mobilization of water resources, which have enabled mobilization of more than 90% of the potential of mobilizable resources towards the end of 2012, through the construction of 34 dams (capacity greater than 5 Mm^3), 234 hill dams (capacity from 1 to 5 Mm^3), 800 hill lakes (capacity of less than 1 Mm^3) and more than 100 thousand wells and water wells equipped (with the implementation of the structures built in the meantime, the mobilization rate would be around 95% in 2015 (Hamza, 2014)).

The water policy in Tunisia has passed through three phases (Hamza, 2009 and 2014):

- The 1st phase can be considered as the period when mobilization of water resources happened through traditional means such as underground or surface reservoirs.
- The 2nd phase in the 20th century: the objective was to mobilize 85% of the water resources potential (PRE) through boreholes and piezometers, improvement and development of networks of measurement and monitoring of water resources, construction of 21 dams, 203 hillside dams and 580 hillside lakes.
- The 3rd phase starting at the beginning of the 21st century: it comprises (i) medium-term strategy (2030) and (ii) long-term strategy (Water-2050 Project), which emerged from the idea that the approach followed had its limits and that the transition to water management was necessary, based on the concept of Integrated Water Resources Management (IWRM).

Three water strategies were defined:

- First strategy (1990-2000): defined supply growth as a priority, resulting in the realization of:
    - 21 large dams to mobilize 1927 Mm3
    - 203 dams and 1000 hilly lakes to mobilize 273 Mm3
    - 1150 deep boreholes to mobilize 1127 Mm3.
    - 105,000 surface wells to mobilize 740 Mm3

  These achievements have mobilized 4.067 billion m3 of water, representing a mobilization rate of 87.5% at the end of 2004 compared to 60% in 1990.

- Second strategy (2001-2011): this was a complementary strategy for the mobilization of water resources, aiming to mobilize 90% of the water resource potential, increase irrigated areas to 405,000 hectares, reach 97% rural drinking water supply and improve the quality of water supply, with drinking water in urban areas to less than 1.5 g/l salinity. It resulted in:
    - The construction of 11 large dams and 50 hill dams
    - Interconnection between large dams (balancing water stocks in water works, improving drinking water quality and ensuring water supply to the capital city (Tunis) and major coastal cities (Sousse, Monastir, Mahdia and Sfax) in times of drought).

- Third strategy: medium-term 2030 and long-term 2050 (African Water Facility, 2016)
  The Water Sector Medium Term Strategy 2030 includes:
    - The establishment of an evaluative legal base: Water Code – see below (in progress)
    - The use of nonconventional waters (440Mm3)
    - Desalination of brackish waters and seawater (49Mm3)
    - Artificial recharge of the aquifers (200Mm3)

The Water Code

The basic legal instrument for water management in Tunisia is the Water Code[1] promulgated in 1975 (Law No. 75-16 of 31 March 1975 and amended several times). Many of the provisions of this Code need to be taken up and take the challenged into account faced by the water sector, in particular resource conservation, fair distribution, the need for effective user participation, management of climate extremes and the increased need for information and training, etc.

A draft of a new Water Code that considers all the challenges was submitted to the government in 2014. Among the main innovations of the new Water Code are:

- The introduction of the artificial hydraulic public domain concept and its organization;
- Integration of quantitative and qualitative control points of water resources with DPH;
- The production of scientific information for decision-making and monitoring;
- Management of extreme events (floods and drought);
- Participation of civil society and regional and local councils in decision-making;
- Encouraging the use of unconventional waters;
- Encouraging public-private partnerships;
- The creation of a multidisciplinary law enforcement committee in difficult situations such as illegal connections and unauthorized drilling.

Public services at national level

In Tunisia, the public hydraulic domain (DPH) is managed by the Ministry of Agriculture, Water Resources and Fisheries (MARHP). The latter is assisted by two committees (MARHP, 2011):

- The National Water Council (CNE) whose role is advisory
- The DPH Commission

In accordance with the provisions of Decree No. 2001-420 of 13 February 2001, the organization of the MARHP is as follows:

- The Minister
- The Secretary of State for Fisheries
- The Cabinet
- The Secretary General
- The General Inspection
- Common Services:
- Technical Services:
- Regional Services: includes CRDA, SONEDE, RSH and SECADENORD

[1] Check http://www.semide.tn/bas/Legislation.pdf

SONEDE, the CRDA and ONAS are the main bodies responsible for the water sector. SONEDE manages drinking water, CRDA manages irrigation water, and ONAS manages and treats wastewater.

In the MARHP, four specialized administrations are involved in the management of the public hydraulic domain (DPH) (Decree No. 420-2001 of 13 February 2001):

- The General administration of Water Resources (DG / RE)
- The General administration of Rural Engineering and Water Exploitation (DG / GREE)
- The General administration of Dams and Large Hydraulic Works (DG / BGTH)
- The General administration for the Development and Conservation of Agricultural Lands (DG / ACTA)

Three other ministries are involved in the water sector:

- The Ministry of the Environment and Local Development (MEDL): It intervenes through the DGEQV, ONAS, ANPE and CITET.
- The Ministry of Equipment and Habitat (MEH)
- The Ministry of Public Health (MSP)

Public services at regional level

At regional level, the MARHP is represented by a Regional Commissariat for Agricultural Development (CRDA) in each governorate. It is responsible for the national agricultural policy at the level of the governorate.

Under the supervision of the MARHP, other regional autonomous public institutions have a very important role in the management of water:

- The National Society for the Exploitation and Distribution of Water (SONEDE): responsible for exploiting and distributing drinking water in towns (municipalities) and villages (rural zones).
- The Northern Channel and Water Supply Corporation (SECADENORD): responsible for a major part of the water supply system in the North and Central of Tunisia.
- The Hydraulic Surveys office (RSH): responsible for public and other drilling programs.

Private Sector Participation

The State can relieve itself of the more technical tasks to concentrate on the fundamental role of regulator. Related to this, following main recommendations were made:

The decentralization of the management of hydraulic structures, the management of important structures (dams, transfer systems, etc.) could be undertaken by specialized public companies or organizations.

Private operators can take charge of the realization and management of minor works and equipment.

SONEDE entrusts to private companies the civil works and the supply of capital goods and others. The studies are either entrusted to consulting firms or carried out by SONEDE staff. Private connections are mainly entrusted to private operators (78.4% in 2015 (SONEDE, 2015)).

For over ten years, ONAS was interested in the private sector participation in operating the sanitation activities. In total, the private sector operates 16 STEPs, 133 pumping stations and 3,400 km of network (ONAS, 2015).

3.4. Agriculture

3.4.1. General Figures

Agriculture in Tunisia is a very important economic sector. It generates between 8.5% and 12% of the GDP (plus fishing (1%) and the agro-food industry (2%)), and accounts for 15% of employment (MARHP, 2015).The agricultural sector provides employment for about 22% of the labor force and regulates the export balance of payments at 11% of the goods. Employment in agriculture has declined since the 1960s (which accounted for 46% of the population), but female employment has remained substantial. In 2009, women represented 34% of the agricultural labor force (INS, 2014).

Agricultural land covers an area of about 10 million hectares divided into 5 million hectares of cultivated land (used for field crops and arboriculture), 4 million hectares for pasture and 1 million hectares of forests. The largest part of cultivable land is privately owned and operated by 516,000 farmers. Areas equipped for irrigation occupy 420,000 hectares (MARHP, 2015). Although it represents only 8% of the usable agricultural area, this irrigated sector contributes to 35% of the total agricultural value (INS, 2014**). (See Table 2)**

Table 2 Land use area distribution in Tunisia (Lucchesi & Kong, 2009 and Saidi & all, 2010)

Area	Water areas	Cultivated areas	Urban areas	forests	Untapped land
163 610 km^2	5 %	32 %	0,5 %	12 %	50,5 %

As for the 5 million hectares of cultivated land (Lucchesi & Kong, 2009 and Saidi & all, 2010), 1.6 million are cultivated for cereals (mostly durum wheat in the Medjerda valley), 1.6 million for the cultivation of olive trees (mainly in the region of the Tunisian Sahel and the governorate of Sfax) (**see Figure 20**). In the undeveloped land, the desert occupies between 33% and 40% of the land depending on the aridity (generally the area south of the 100mm isohyet) or landscape characteristics (brought back to the Big Eastern Erg).

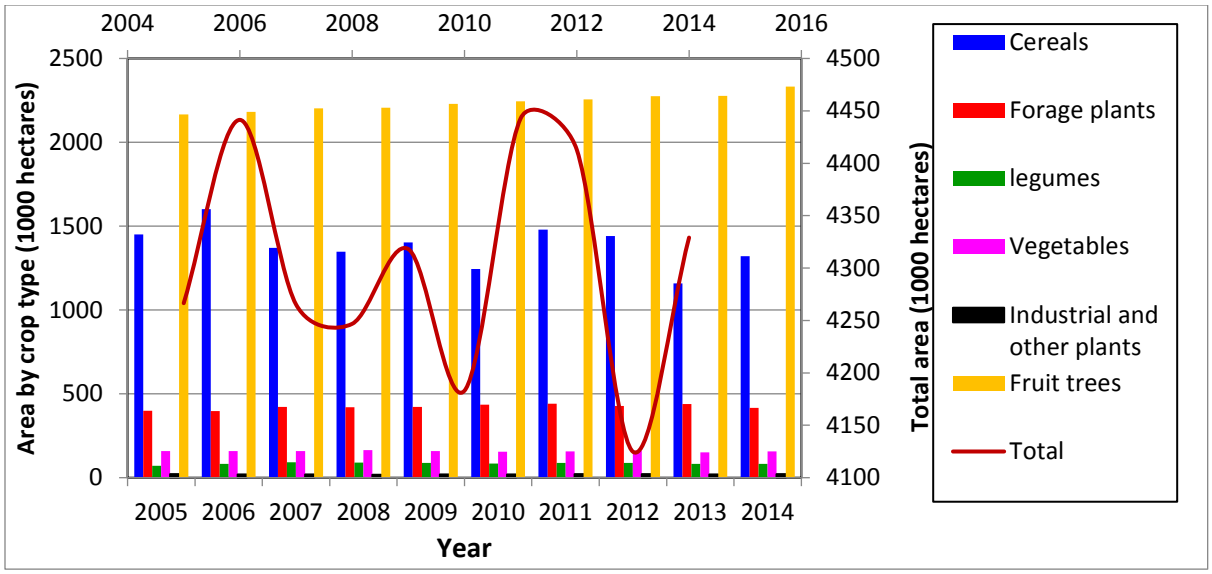


Figure 20 Distribution of agricultural land area (MARHP, 2015)

3.4.2. Agricultural Production

The main agricultural products in Tunisia are cereals (wheat and barley), olives, dates and citrus fruits, and sheep for the livestock sector (**see Figure 21**). The olive sector and palm grove dates are largely export oriented.

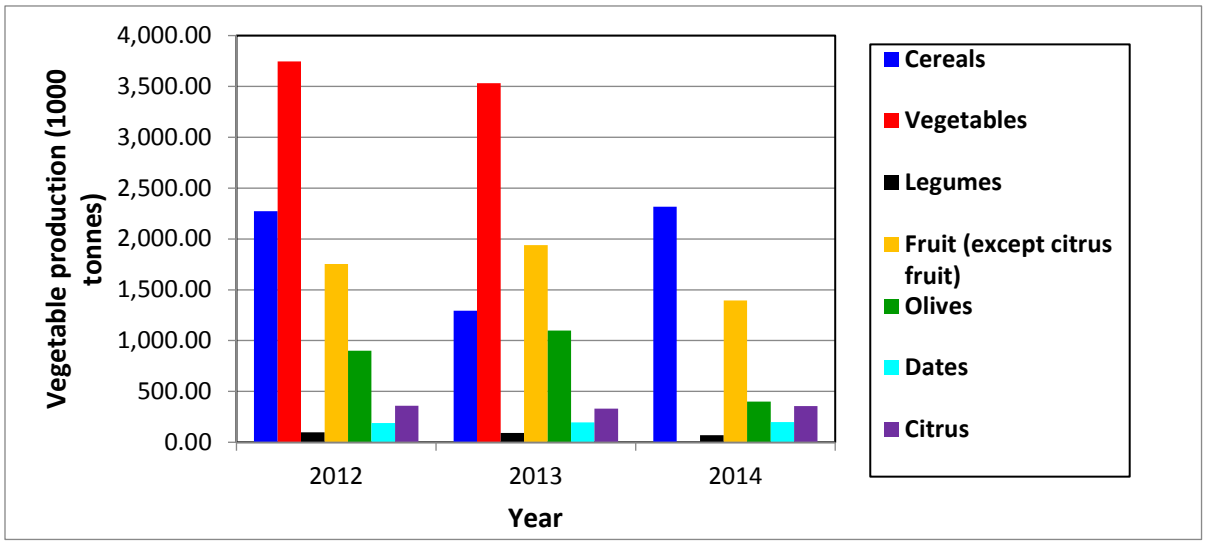


Figure 21 Agricultural production in Tunisia (MARHP, 2015)

3.4.3. Irrigation

In 2030, the overall water demand in Tunesia is expected to exceed its supply (MARH, 1998). To overcome water shortages, several measures should be taken to improve the agricultural sector which currently consumes more than 80% of the total water supply in Tunesia. Improving irrigation is therefore key in conserving water within the agricultural sector.

Irrigated areas in Tunisia occupy only 8% of the total agricultural area, but generate 35% of the agricultural production value, 20% of exports in agriculture and 27 % of agricultural employment (Al Atiri R., 2007). During the 1970s and 1980s, the Tunisian government has tried to invest considerable amounts of resources aimed to encourage irrigated agriculture, develop water system infrastructure and irrigated public perimeters (IPP). In fact, between 1971-1990, public investment in water systems comprised of 40% of the total investment in agriculture (Sghaier, 1995).

The increase of water demand, associated with the rapidly growing population and competition between industrial, domestic, touristic and agricultural sectors, therefore amplifies the need for better resource management in regards to improving the agricultural sector (Thabet, 2003).

3.4.4. Agro-Industry

The agro-food industry is of strategic importance for the development of the economic and social fabric of Tunisia. In fact, agriculture and the agro-food industry combined are the main contributors to Tunisia's national wealth, accounting for almost 15.7% of the GDP. The sector also employs nearly 18.5% of the country's population, and accounts for 9.7% of the total export value.

The agro-food sector has benefitted from strong political support since the 1990's by creating five year plans aimed at benefiting agricultural and industrial development. Market liberalization in the late 1980s, combined with aid funds for agricultural production, development and export have contributed to ongoing ag-growth. This has therefore improved cereal, livestock and oil product availability and ensured food independence for Tunesia. The Tunisian agro-food sector also benefits from an attractive development framework, in particular for foreign companies setting up business in the country. The country occupies a strategic position as a gateway to Europe, enabling it to establish direct links with Africa and the Middle East.

3.4.5. Import and Export

Agricultural production has grown faster than the population, thereby improving the country's food supply. As a result, export earnings have increased and the rate of import coverage by exports has improved (MARHP, 2011).

3.4.6. Livestock

Livestock represents 40% of the agricultural sector value and therefore over 4% of the country's GDP in 2009, rising steadily since 1990 with an annual growth rate of 4.1%. This growth is due to the combined increase in poultry and dairy production. The livestock sector, which is heavily supported by the government for example; animal care costs, national milk collection and production plants are funded by the state has satisfied total domestic demand and exports to neighboring countries.

3.4.7. Policies and legislation

Policies and Strategies

The foundations of agricultural policy in Tunisia is mainly based on two types of interventions: intervention on prices and interventions on production structures. The Tunisian agricultural development model has enabled significant advancement, such as the significant increase in production and the improvement of agricultural and food supplies. However, the development process showed signs of fragility and the international crisis of 2007-2008 that shook the markets for agricultural and food products served to reveal the structural limitations of the model.

Agricultural policy in Tunisia is characterized by:

- The construction of a reasoned argument
- The strategic axes of the 11th and 12th plan updated and articulated among themselves
- Enhanced coherence between agricultural policy and other public policies
- Controlled insertion in the global economy

Three main categories of strategic orientations have been identified:

- Improving the institutional framework and coordination of actors
- Improving the provision of public services
- Optimizing the integration of Tunisia into the international economy

The Agricultural Development Groups (GDA)

In Tunisia, the Agricultural Development Groups (GDAs) are democratically legitimized local structures. They include landowners and users and are tasked by the state with the management of certain natural resources. They have an important role because natural resources, such as water, forests and pastures, are subject to heavy overexploitation, which, aggravated by the effects of climate change, threatens to cause irreversible damage (Aude-Annabelle, 2010).

The GDAs are integrated into a management system for water resources, forests and pastures. They have become more democratic structures in which all segments of the population, including women, participate and represent the interests of all. The specific objective of the support is to improve in a sustainable way the sound management of drinking water supply (AEP) systems by the GDA.

4. Collected Data on the Case Study Area

4.1. The Pilot Area

The city of Monastir is the capital of the Monastir governorate, which is part of the Tunisian Sahel region. It is bordered by the governorates of Sousse to the north, Mahdia to the south, and the Mediterranean Sea to the east, with a coast that stretches for 35 km. Administratively, the governorate of Monastir is divided into 13 delegations, 31 municipalities and 77 imadas (agglomerations) (**see Figure 22**). The delegation of Monastir is subdivided into two municipalities: the municipality of Khniss and the municipality of Monastir (Monastir city) (**see Figure 23**). The latter represents the study area of this study.

Monastir city is a peninsula surrounded by the Mediterranean Sea on three sides and forming, towards the south, the Gulf of Monastir, which extends to the Cape of Ras Dimass. It offers diverse landscapes, including sandy and rocky beaches and a cliff extending for nearly six km. The topography is monotonous and does not exceed 200m throughout the governorate (hills of Zeramdine-Beni Hassene). In the municipality of Monastir, the topography varies between 0m and 50m in the cliff of Monastir (**see Figure 24**).

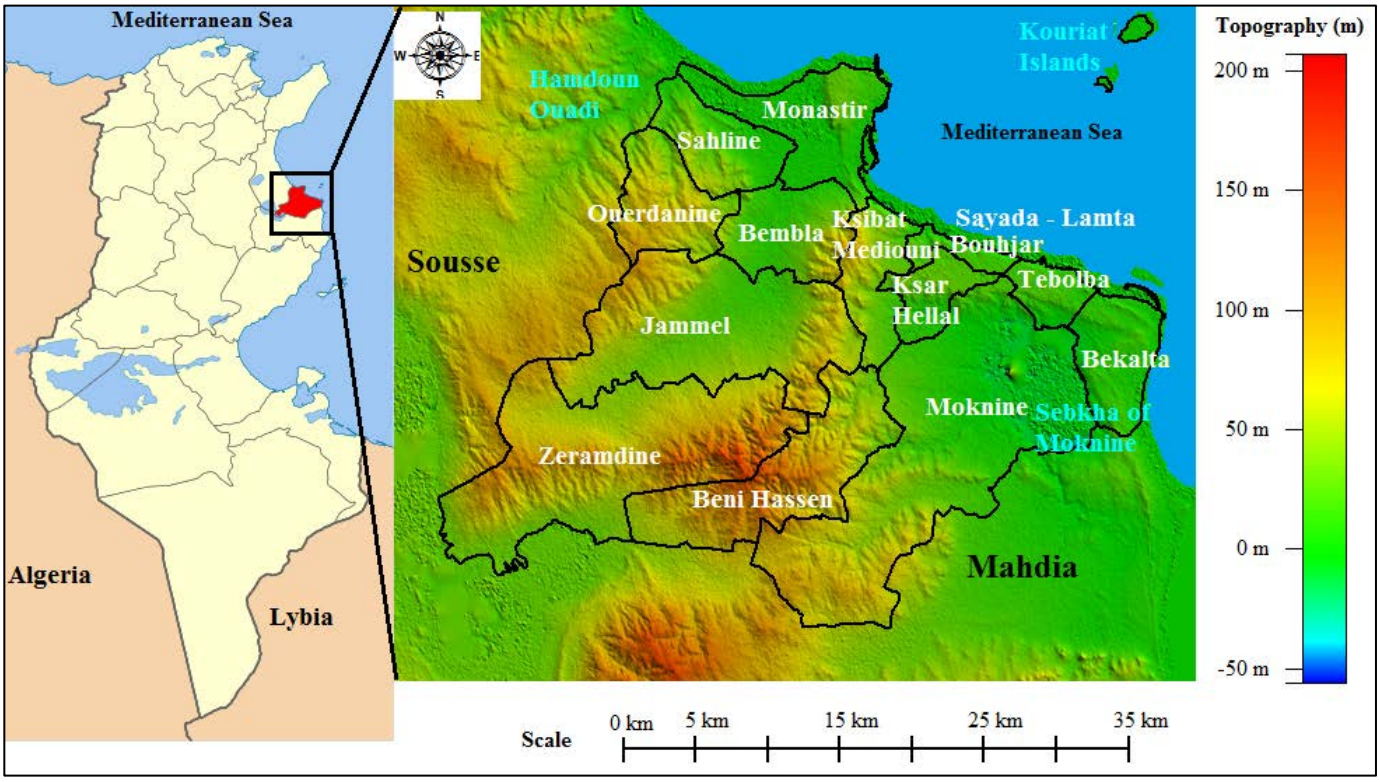


Figure 22 Location map of Monastir governorate: Topography (DEM) and limits of the 13 delegations

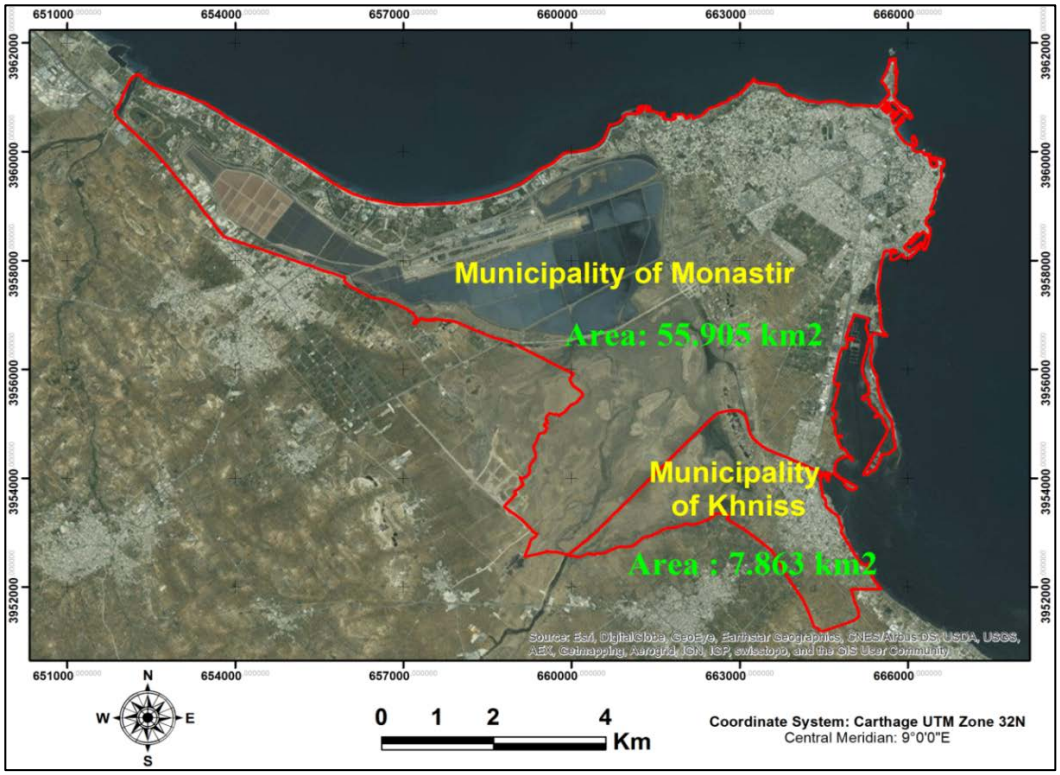


Figure 23 Delimitation of the Municipalities of Monastir and Khniss

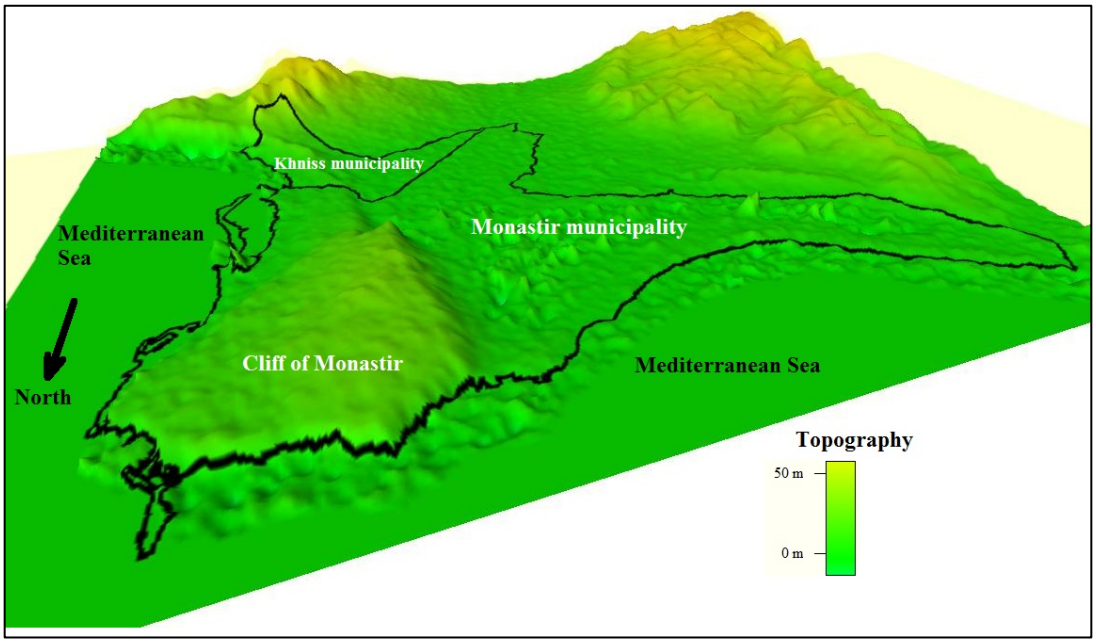


Figure 24: 3D DEM of Monastir municipality (SRTM Image), showing the Cliff of Monastir

The governorate of Monastir is drained by three major watersheds: Zeramdine Beni Hassene (Sebkhet Sidi El Heni), Sebkh Moknine and Jammel-Monastit (Oued El Meleh), of which the municipality of Monastir is a part (**see Figure 25**). The hydrographic network is relatively dense in the governorate, but it is almost absent in the municipality of Monastir, caused by the flat topography of the city of Monastir and the extension of the urban area (**see Figure 26**).

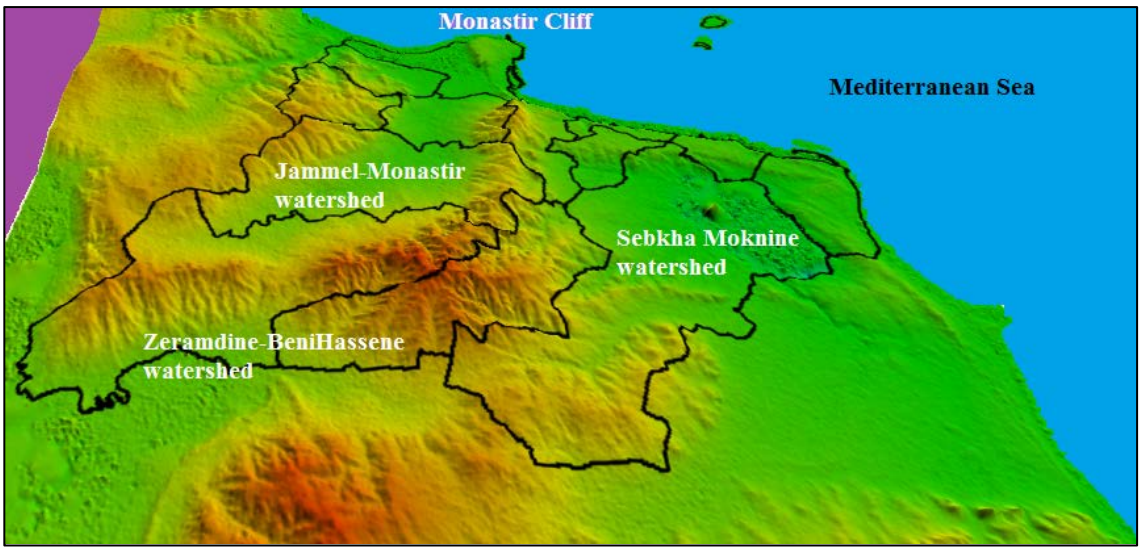


Figure 25: 3D Topographic map (DEM) Showing the watersheds in Governorate of Monastir

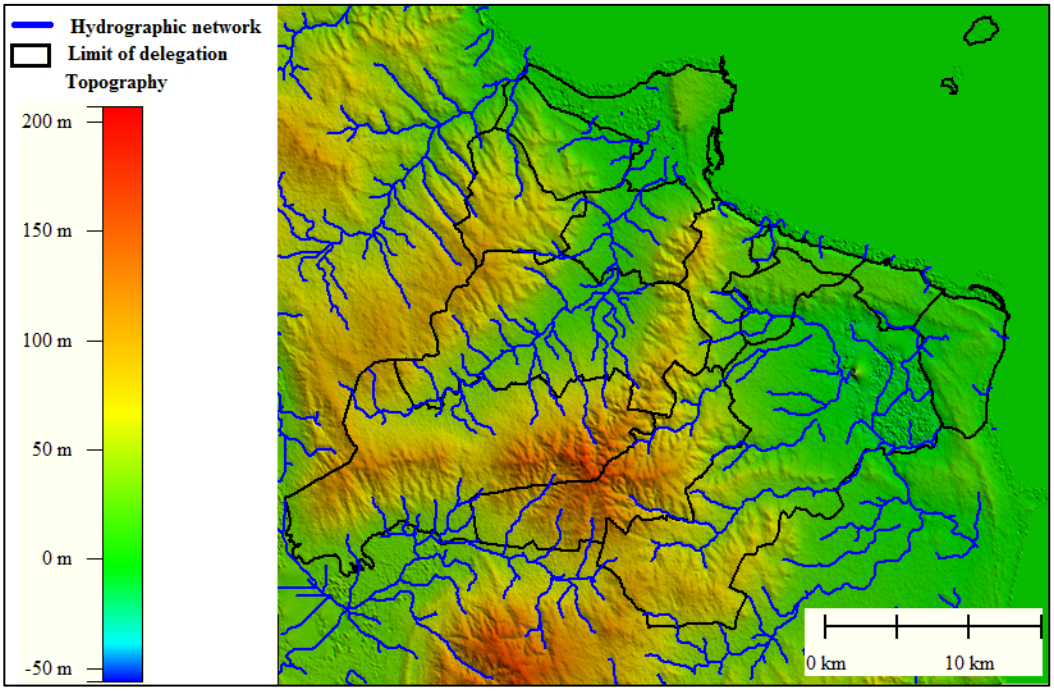


Figure 26 Hydrographical network in the Monastir governorate

The climate of Monastir city is Mediterranean, semi-arid. Average precipitation ranges from 5mm in July to 45mm in January with an annual average of 330mm. Average temperatures vary between 12°C in winter and 25°C in summer. The annual average is 18.1°C. (**see Figure 27**)

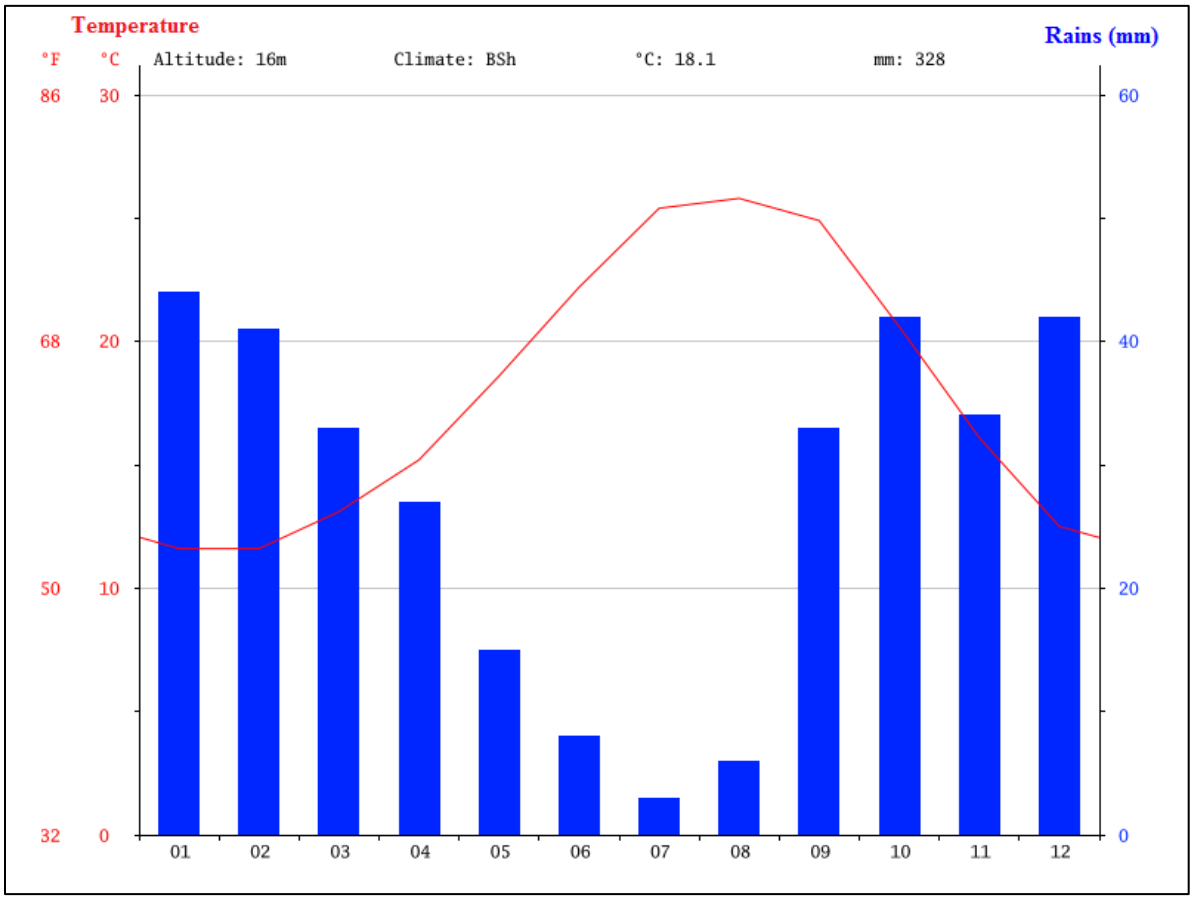


Figure 27 Monthly averages of temperature and precipitation in Monastir.

The Municipality of Monastir has a 100% urbanized population. The rural environment has been absent since the 1970s, despite the presence of a rural landscape in the form of agricultural land (olive fields, irrigated perimeters and forest). This is related to the degree of development that has characterized the entire region of the Tunisian Sahel since the Bourguibiste period. Thus, it can be said that the population and the community in Monastir is relatively homogeneous.

The municipality of Monastir is composed of 4 communal areas. It contains 50 hotels, divided into three tourist areas (Skanes, Dkhila and Marina-Monastir) and an international airport next to the tourist area of Skanes. It has the first therapeutic center of care with sea water in Africa.

Monastir is also a university city with the majority of university specialties within the University of Monastir (Sciences, Engineering, Medicine, Biotechnology, Pharmacy, Research Laboratories ...). The Science Palace in the city center is the venue for conferences throughout the year. Monastir is a cultural city, with cultural activities throughout the year (Ribat Al Monastir, Palace of sciences, youth centers, the old Medina ...). Monastir has several beaches stretching over 12km (Skanes, Mradda, Karraia, Dkhila, cliff beach ...), hills,

plains, mountains and the huge coastal cliff of Monastir. This Falaise has been rehabilitated and refurbished by the municipality of Monastir with an investment cost of 10 million Tunisian Dinars. The aim of this project was to connect the Dkhila tourist area with the downtown area.

Monastir is not an industrial city, but it has small businesses, divided into three industrial zones. Monastir also features two indoor sports halls and an Olympic stadium. It contains two irrigated perimeters (Al Omrane and Sidi Nasar) and a coastal forest, at the level of the cliff of Monastir.

4.2. Demographic Information

The governorate of Monastir

The governorate of Monastir, with an area of about 1,019 km² and a population of 562,600 inhabitants (in 2016), has an average population density of 549.4 inhabitants/km². This density varies considerably between the delegations and the communes, with less than 200 inhabitant/km² in the regions of Zeramdine and Ben Hassene, up to 15,000 inhabitants/km² in the city of Monastir.

The distribution of the population amongst the delegations (**see Figures 28-29**) shows that the delegation of Monastir (Municipalities of Monastir and Khniss) has the highest value with 104,500 inhabitants, with 93,300 inhabitants for the Municipality of Monastir (1,670 inhab/km²) and 11,200 inhabitants for the Municipality of Khniss (1,435 inhab/km²) (**see Figure 30**).

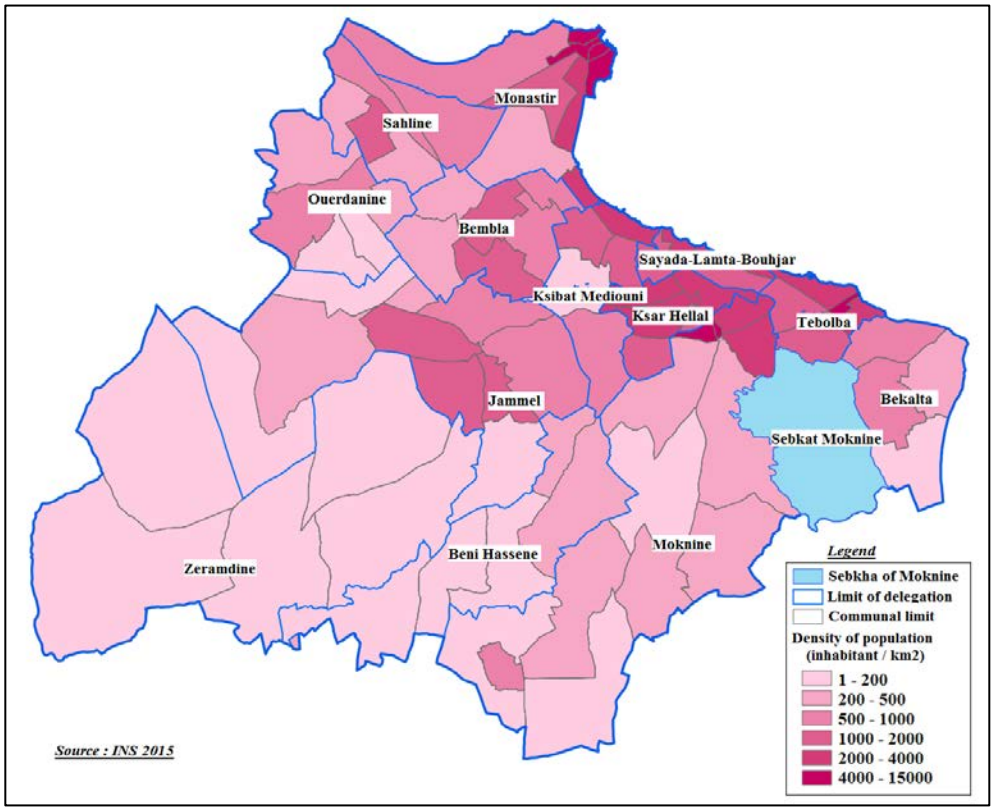


Figure 28 Population density map of Monastir Governorate

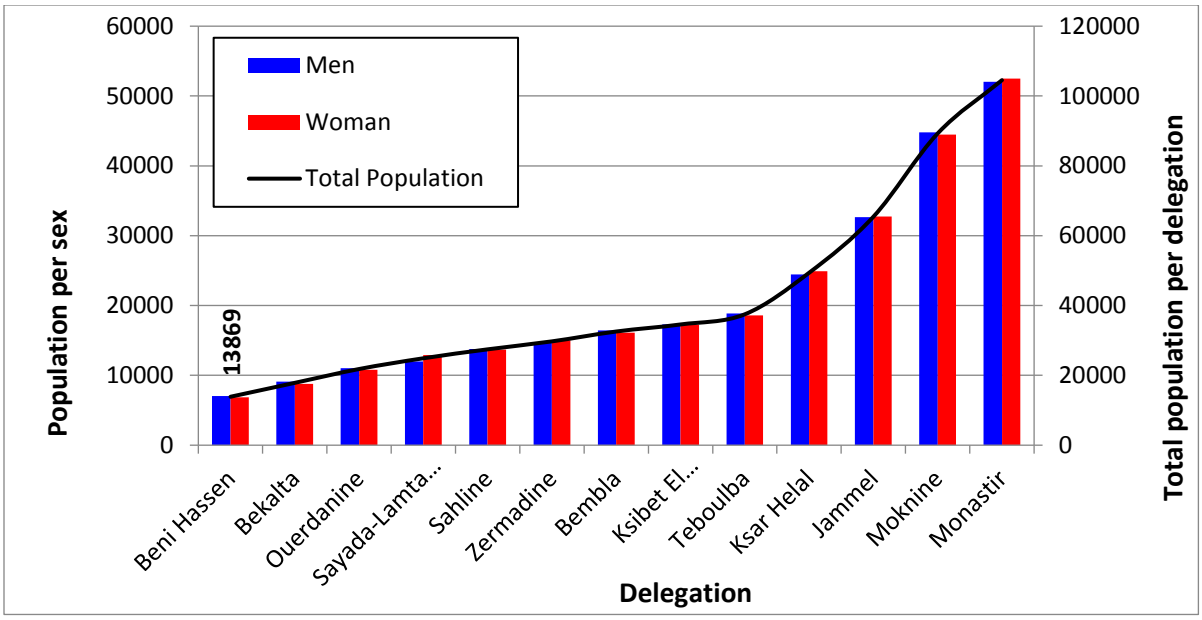


Figure 29 Distribution of the population in the delegations in the governorate of Monastir

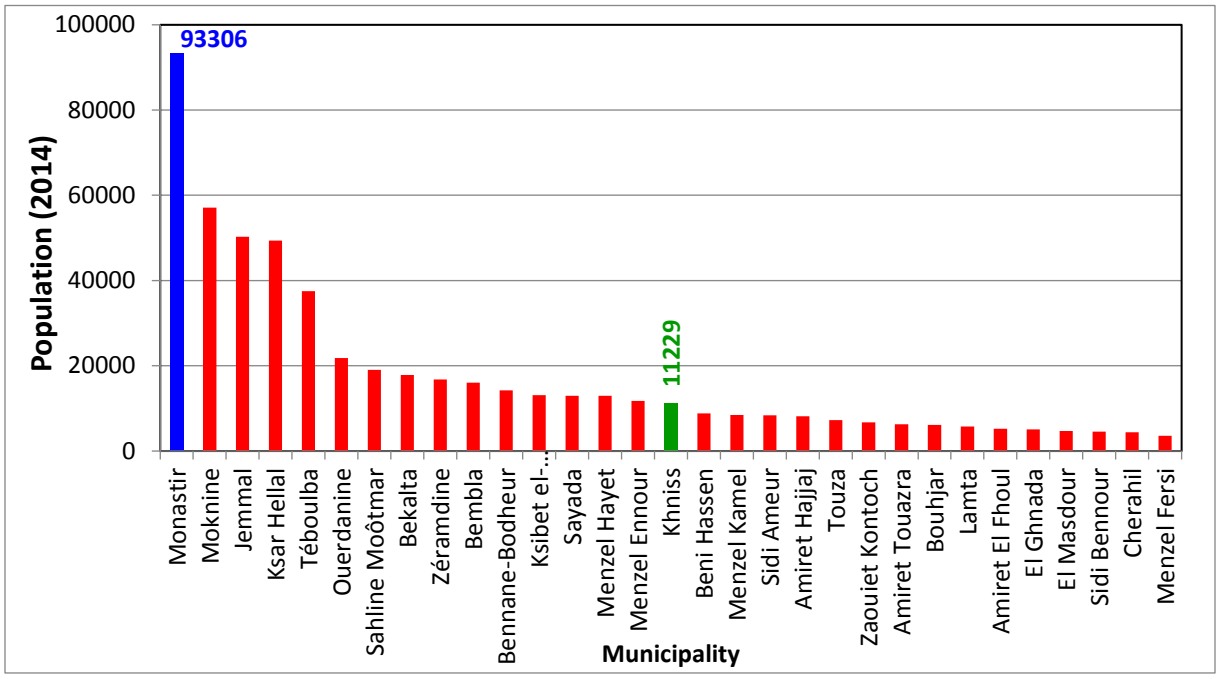


Figure 30 Distribution of the population according to the municipalities of Monastir Governorate

The municipality of Monastir

The municipality of Monastir covers an area of 55.905 km2 and has a population of around 96,000 inhabitants in 2016. The population recently increased from 84,500 inhabitants in 2010 to 96,000 inhabitants in 2016 (**see Figure 31**).

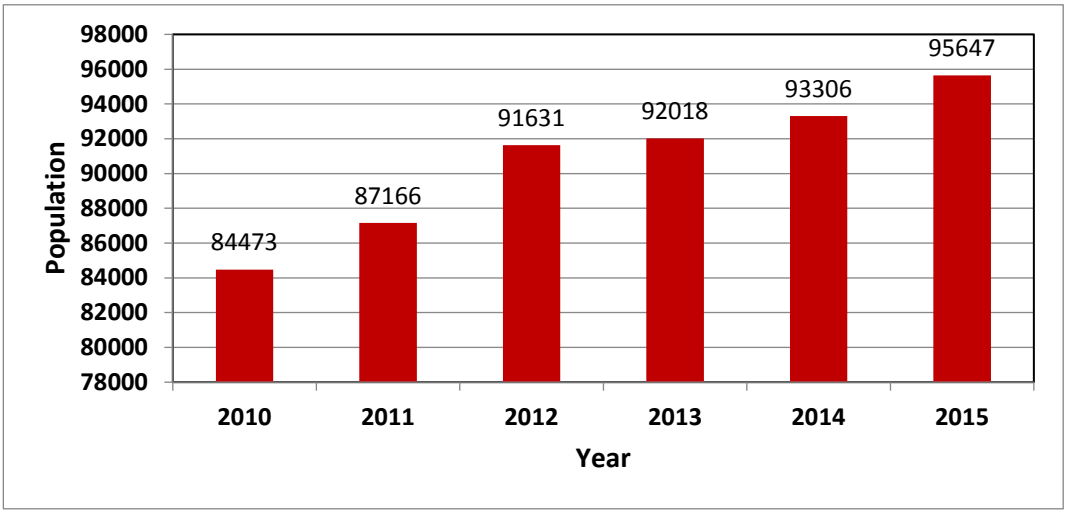


Figure 31: Evolution of the population between 2010 and 2015 in the municipality of Monastir

The population of the municipality of Monastir shows a spatiotemporal variability, with an increase to 250,000 inhabitants in summer (tourist season). Within the municipality, the population of the 4 districts varies; Skanes and Helia around 30,000 inhabitants, and Medina1 and Medina2 around 15,000 inhabitants (**see Figure 32**).

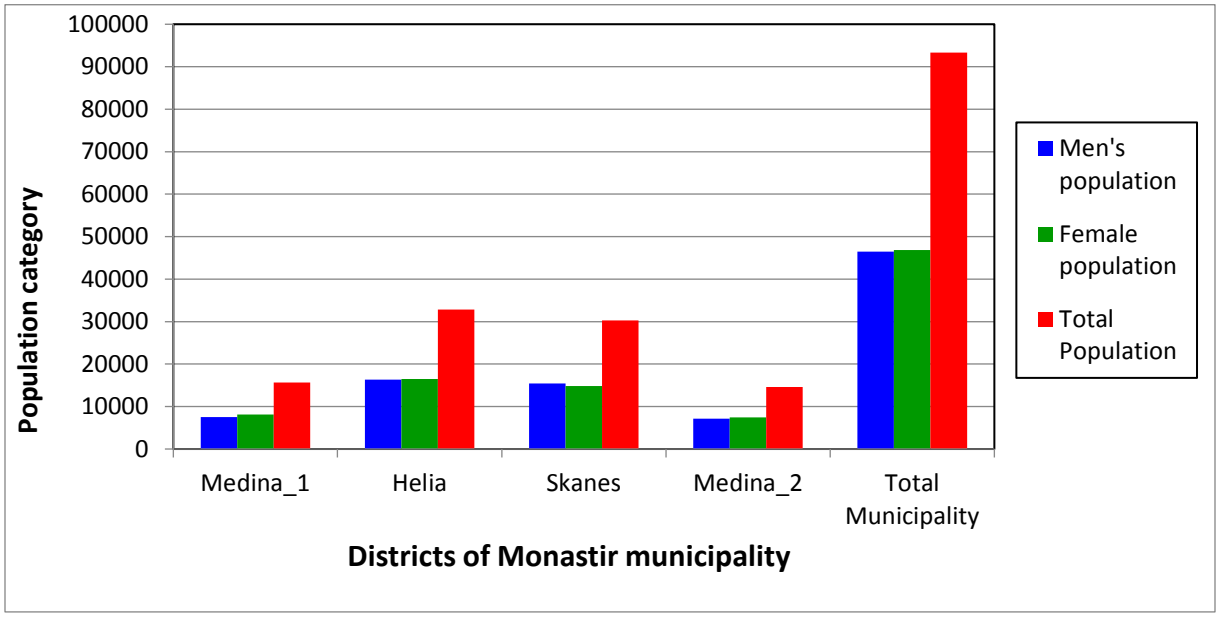


Figure 32 Spatial distribution of the population by district in the municipality of Monastir

Male and female population are equally divided (**see Figure 33**).

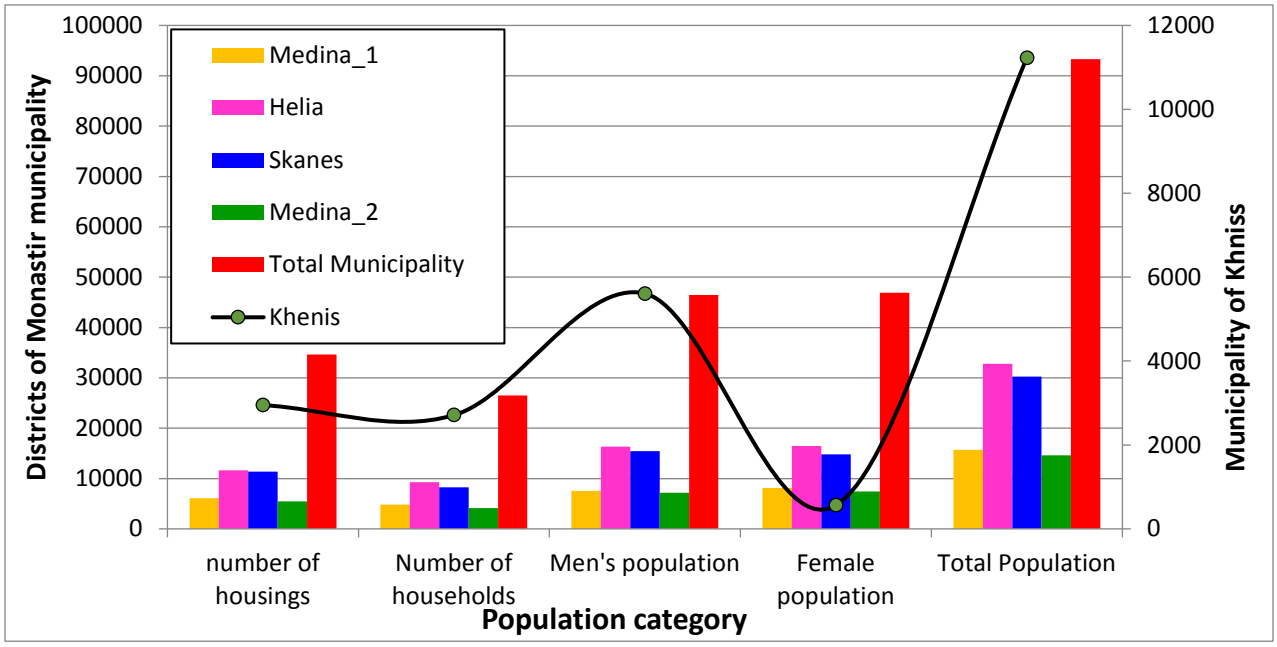


Figure 33 Comparison of population, households and housing between the municipalities of Monastir and Khniss

4.2.1. Communities Distribution and Characteristics

Social Organization

With the exception of the capital of Tunis, Monastir is the only governorate and the only city (municipality) in Tunisia, where the population is 100% urban. The population in Monastir is relatively young. More than 50% of the population is between 20 and 40 years of age (**see Figure 34**).

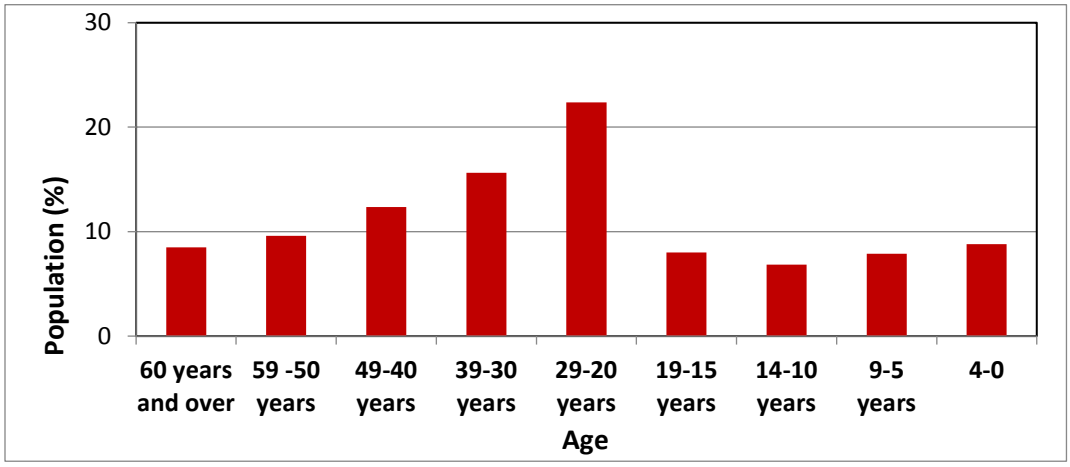


Figure 34 Distribution of population by age group in Monastir municipality

The standard of living is very acceptable in Monastir, based on the main indicators of living conditions of households throughout the governorate (**see Figure 35**). These show that the drinking water supply rate and the electrification rate are 100%, the connection rate to the drinking water system is 99.4% and the connection rate to the ONAS sewage network is 85.4% (**see Table 3**). The main socio-economic indicators show very favorable living conditions in most the municipality of Monastir and therefore a highly-civilized population.

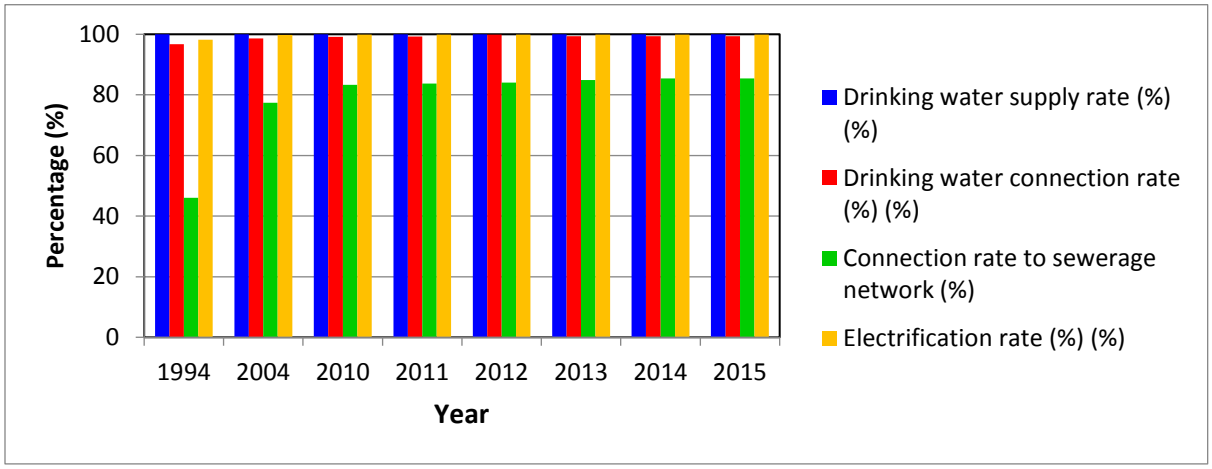


Figure 35 Evolution of the main indicators of household living conditions

Table 3 Distribution of households by source of drinking water (municipality of Monastir 2014)

Water Supply (%)					
Far more than 1 km from the nearest water source linked to SONEDE or GR	Uncontrolled source	Other private or public source	Public source or association	Water tap	**Number of households**
0	0	0,1	0	99,99	29 178

Schooling rate in Monastir is very high, with excellent school and university infrastructure available, including 27 primary schools, 20 secondary schools and 10 faculties and colleges. The number of students is 20,000 in the public sector and 3,000 in the private sector.

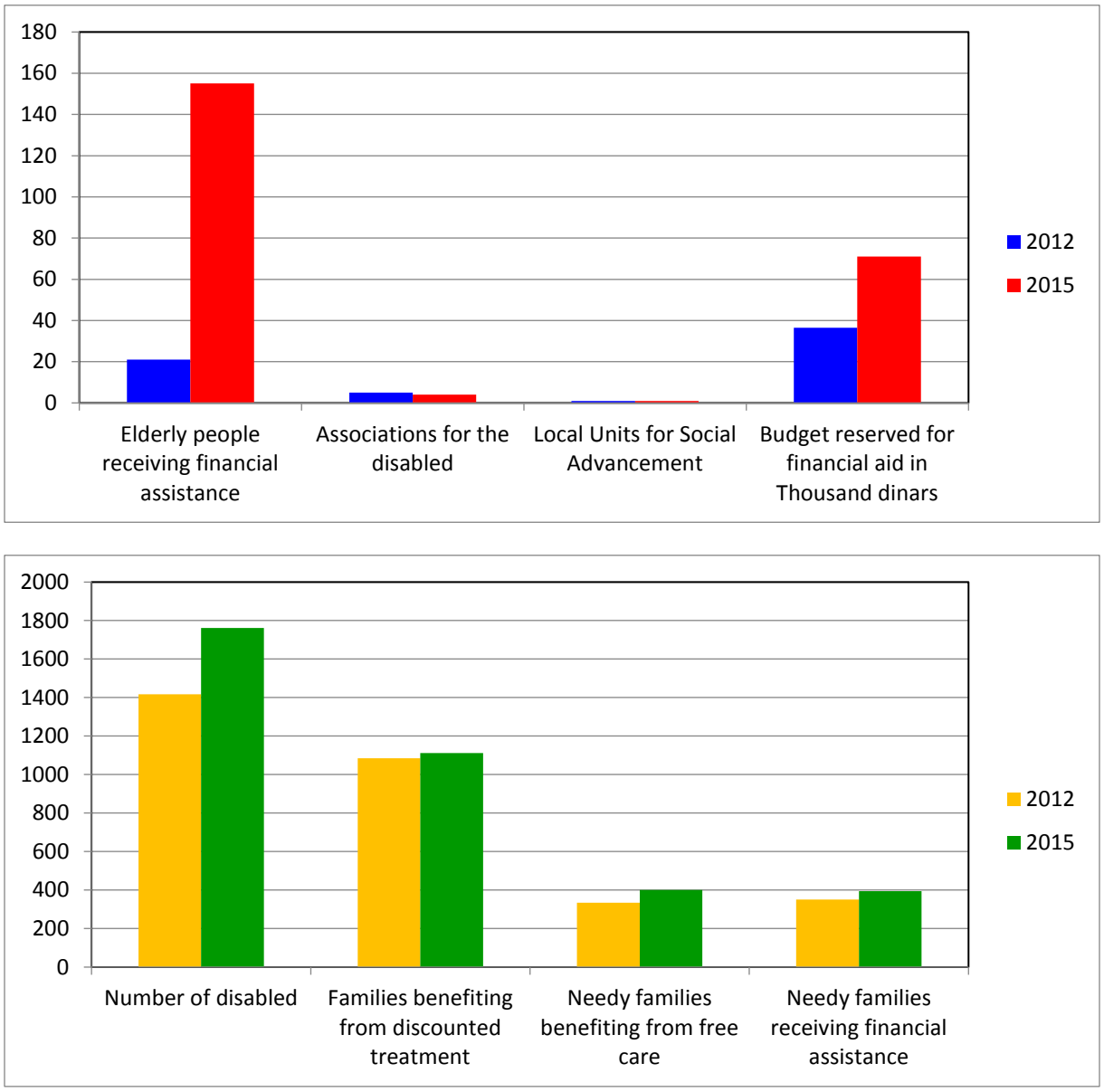


Figure 36 Evolution of the indicators of social promotion in the municipality of Monastir (2012-2015)

The health care sector is also very developed either in the public or private sector. There is a university hospital with the majority of medical specialties. The number of doctors is 51 general practitioners and 300 specialists in 2015. The cultural, and youth and children sectors occupy an advanced position in Monastir. There are four youth houses with 1,142 members, 33 civilian sports associations with 3,600 members, two public libraries and a house of culture.

Economic Organization

As indicated above, the Municipality of Monastir represents a 100% urbanized city. The urban density is very high in relation to the total area of the Municipality. There is a very varied urban fabric formed by multi-story buildings, villas, hotels, businesses, service and trade premises.

The municipality has an industrial zone formed by 56 small businesses. The tourist aspect of the city has led to avoidance of large heavy industries. The industrial fabric in Monastir results in employment of 4867 employers, spread over several types of industries, essentially textile and clothing, leather and footwear (**see Figure 37 and Table 4**).

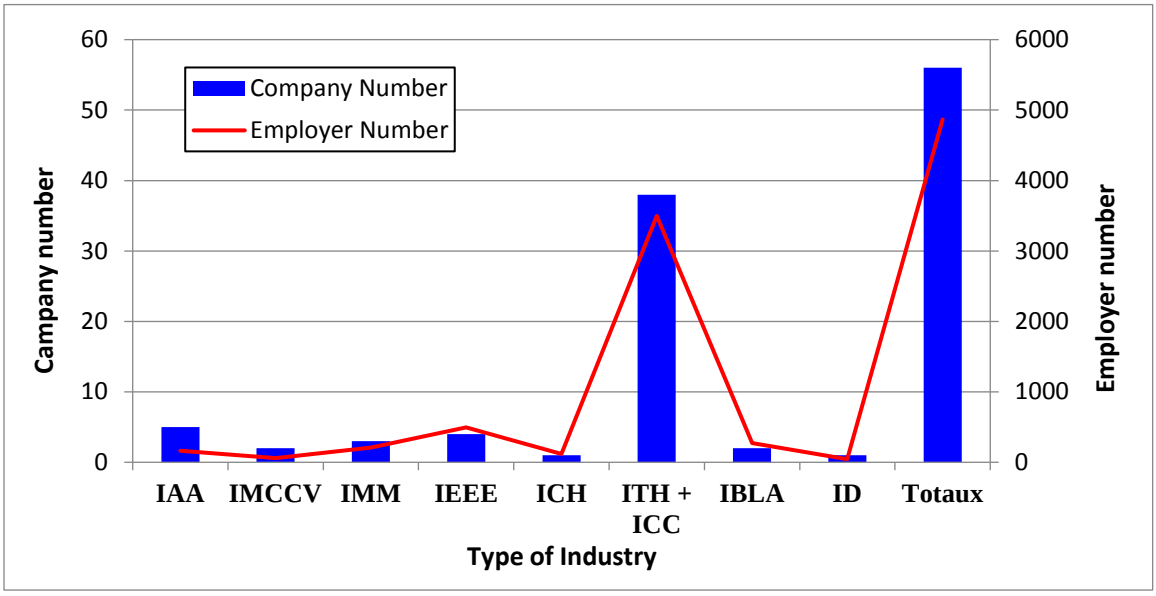


Figure 37 Distribution of enterprises employing more than 10 people in the municipality of Monastir (May 2017)

Table 4 Businesses and type of industry in the municipality of Monastir (May 2017)(*) ***IAA, IMCCV, IMM, IEEE, ICH, ITH, IBLA, ICC and ID are French abbreviations of industry types***

Type of Industry (*)	Company Number	Employer Number
Food industry **(IAA)**	5	162
Building Materials, Ceramics and Glass Industries **(IMCCV)**	2	61
Mechanical and metallurgical industries **(IMM)**	3	211
Electrical, Electronic and Household Appliances Industries **(IEEE)**	4	497
Chemical Industries **(ICH)**	1	120
Textile and Clothing Industries **(ITH)**	38	3497
Wood, cork and furniture industries **(IBLA)**	2	275
Leather and Footwear Industries **(ICC)**	1	44
Different Industries **(ID)**	56	4867

The municipality of Monastir also contains two tourist areas (Skanes and Marina-Monastir), containing 45 hotels, of which 38 are classified, and with an accommodation capacity of around 23 300 (**see Figure 38**). The hinterland of the city of Monastir is occupied by irrigated perimeters and a forest of olive trees.

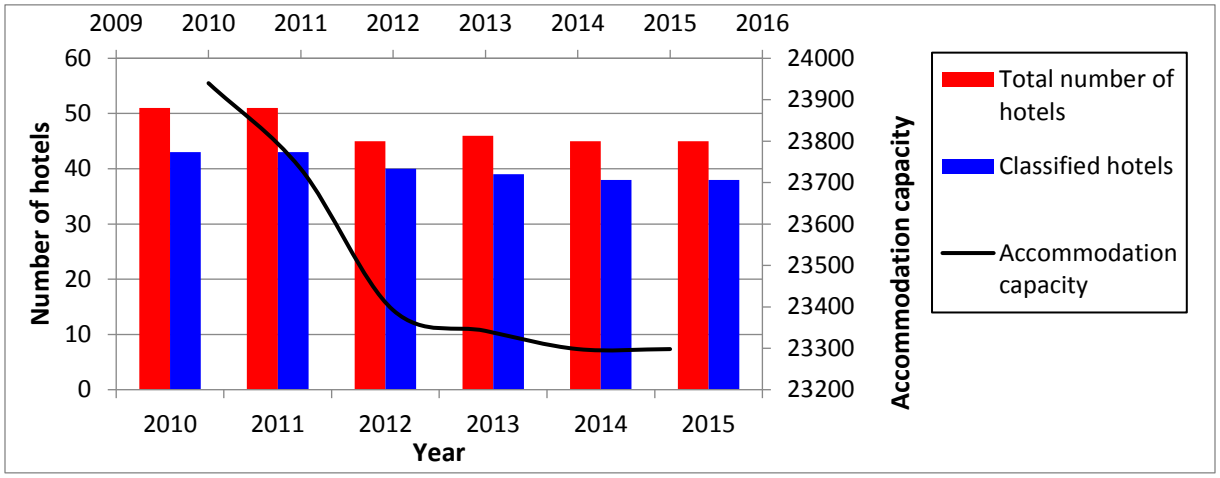


Figure 38 Evolution of the number of hotel units and the accommodation capacity in the Monastir municipality (2010-2015)

The governorate of Monastir has an activity rate of 37.20%, ranking amongst the highest of all Tunisian governorates (**see Figure 39**).

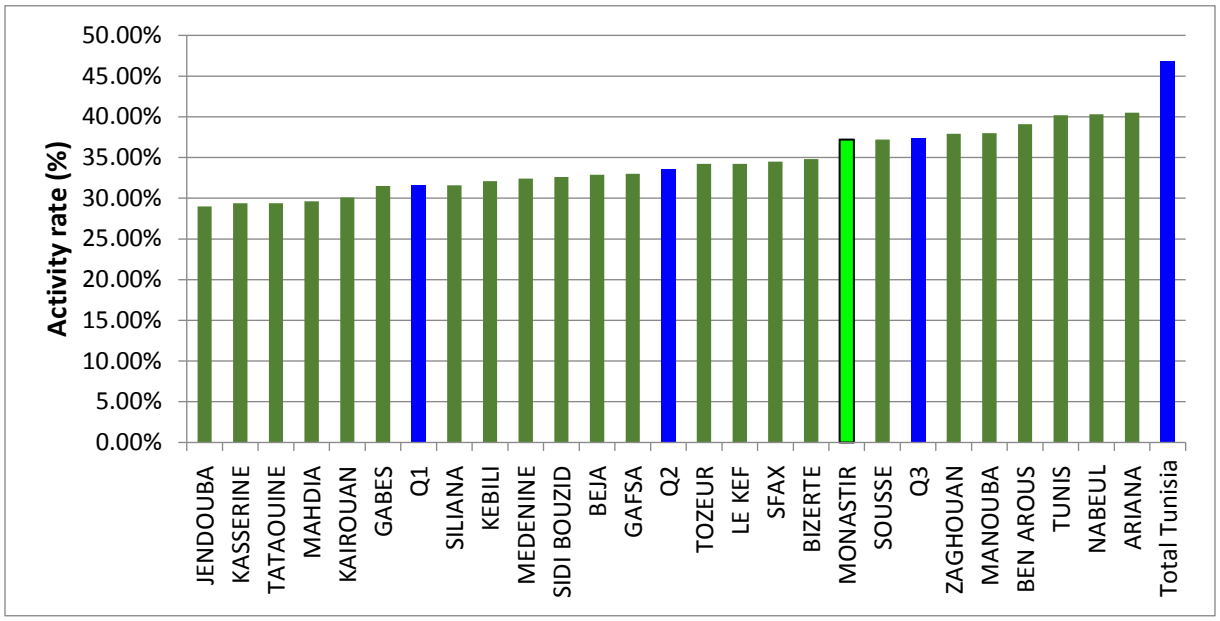


Figure 39 Distribution of activity rate (%) in Tunisia (INS, 2014)

In the municipality of Monastir, the activity rate is 50.35%, 39.1% for men and 60.9% for women. The unemployment rate is 9.94%, 13.19% for men and 7.83% for women. The working population in Monastir is around 80,000 inhabitants (**see Figure 40**).

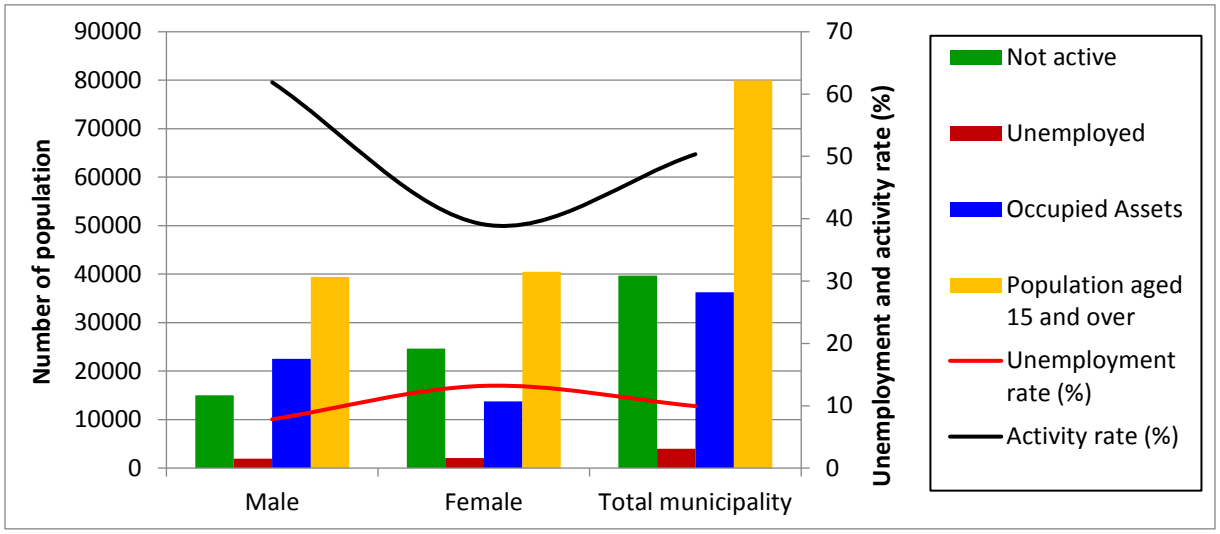


Figure 40 Distribution of activity/unemployment rate (%) and the labor force (aged 15 and over) in the municipality of Monastir

Between 2009 and 2014, 4,000 people of the working population migrated from Monastir municipality. There are many reasons for leaving. Migration can be linked either to study (13%), accompaniment of the family (24%), marriage (23%), seeking better living conditions (13%), and employment (22%) (**see Figure 41**).

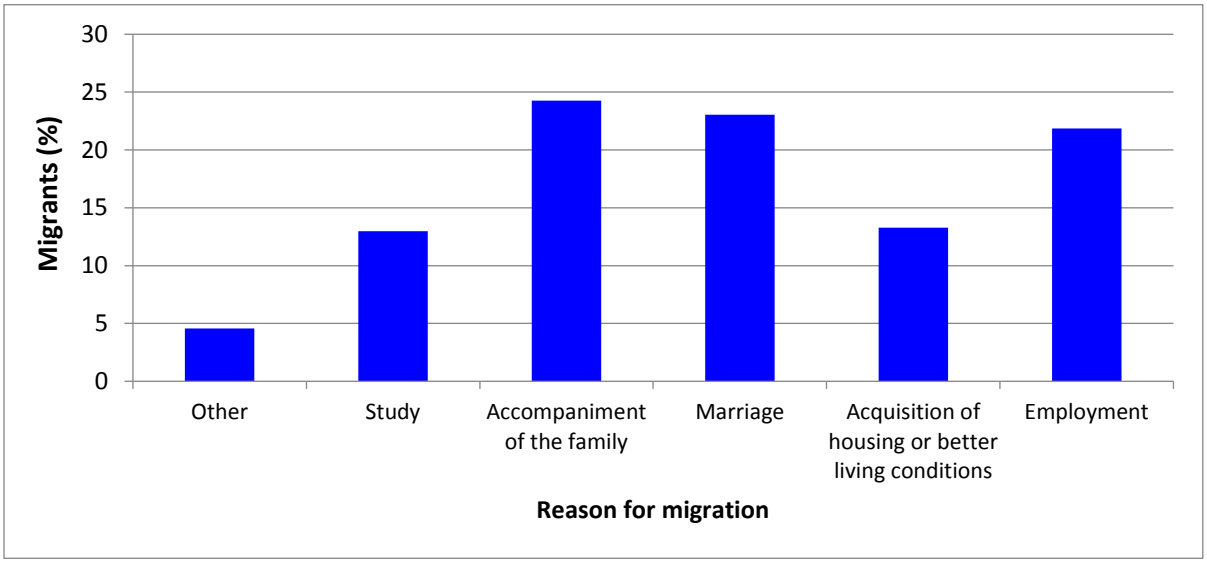


Figure 41 Distribution of migrants from the municipality of Monastir based on reasons for leaving, between 2009 and 2014

4.2.2. General Information about Household

Housing units

At the national level, 3289.9 thousand housing units were counted in 2014 compared with 2500.8 thousand in the 2004 census. This means that over the last decade, an average annual net increase of 78,900 units was observed, compared to 63,500 in the decade 1994-2004, 55,700 between 1984-1994, and 32,400 between 1975-1984. This demonstrates that over the years the housing stock has followed a steady upward trend.

At the regional level, the governorate of Monastir has 133,595 households and 164,687 housing units (INS, 2014) (**see Figure 42**). The distribution of these figures is not homogeneous for the entire governorate. The delegations of Monastir (37,500 housing and 29,000 households) and Moknine (23,000 housing and 19,800 households) had the highest values, while the delegations of Beni Hassene, Bekalta and Ouardanine, the number of housing and households does not exceed 5,000.

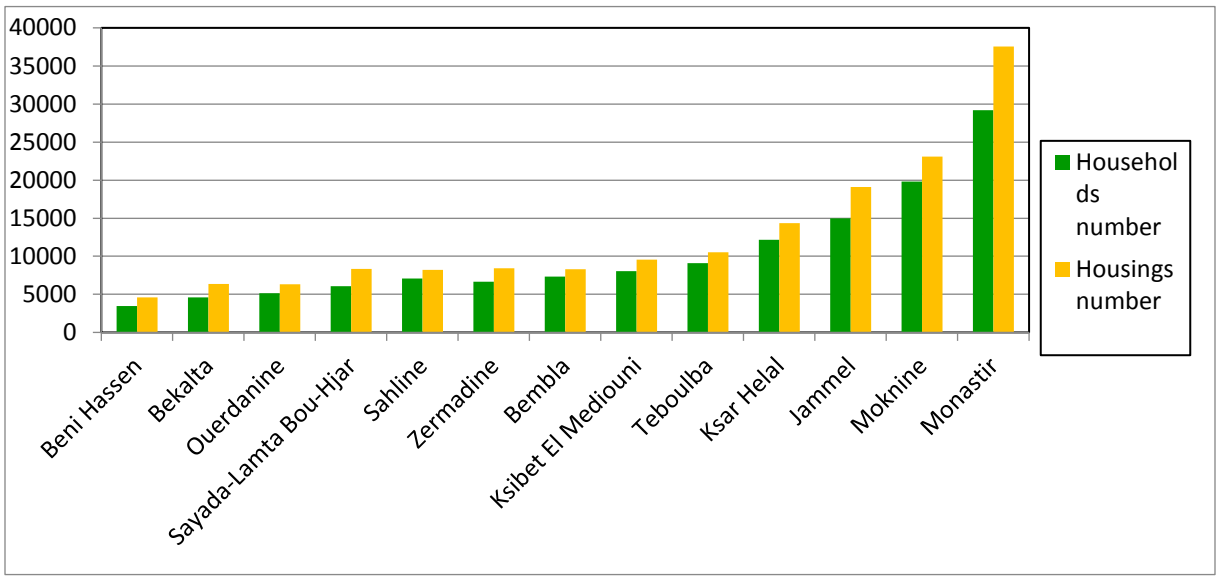


Figure 42 Distribution of households and housing at the level of the delegations of the Governorate of Monastir.

The municipality of Monastir has 34,600 dwellings and 26,500 households, distributed almost homogeneously between three districts: Medina, Skanes and Helia (**see Figure 43**).

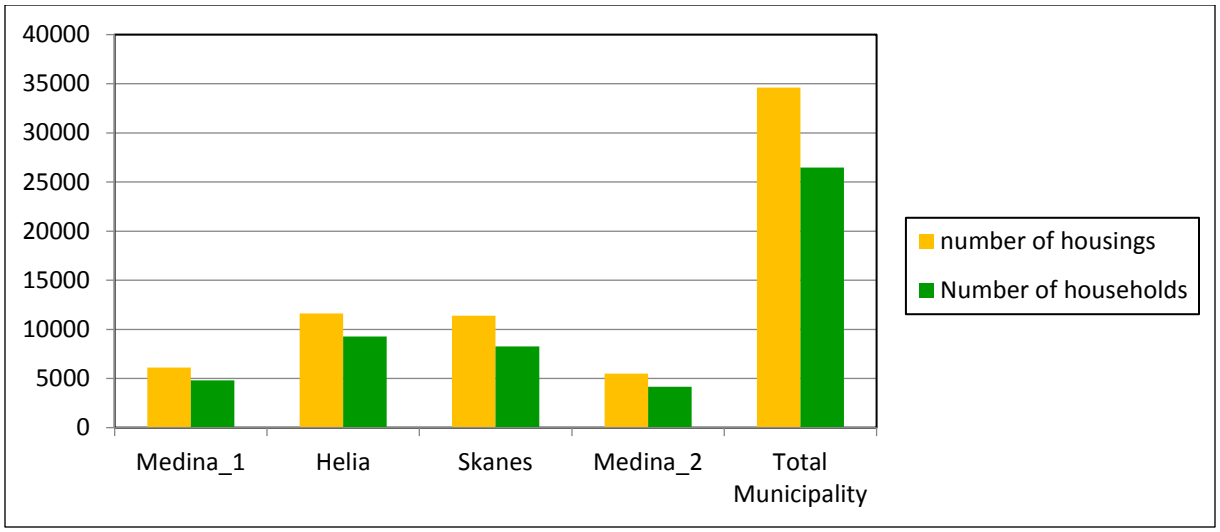


Figure 43 Distribution of households and housing at the level of the districst in the municipality of Monastir.

Households

In the municipality of Monastir, households vary in size from one to seven persons per family (**see Figure 44**). Households with 4 to 5 members (usually both parents and 2 to 3 children) are the most frequent in Monastir, accounting for 42% of families in Monastir. Households formed by 2 to 3 persons represent 15% of families. Large families (households of 6 to 7 people) do not exceed 10 to 15% each. One-person households account for 7%.

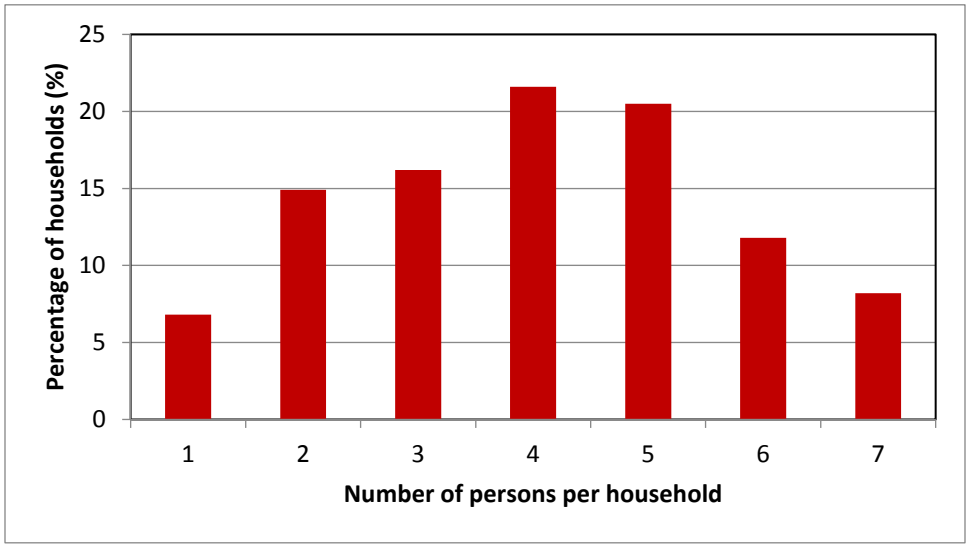


Figure 44 Distribution of households by size (i.e. the number of persons per family) in % in the municipality of Monastir

Regarding the residence of households in the municipality of Monastir, more than 50% of the families are owners of their households and almost 40% are tenants of housing (do not own a house or are not original

from the city of Monastir) (**see Figure 45**). 65% of the house owners built their homes on land they acquired. 15% of owners bought houses directly and 25% acquired dwellings in various forms (**see Figure 46**).

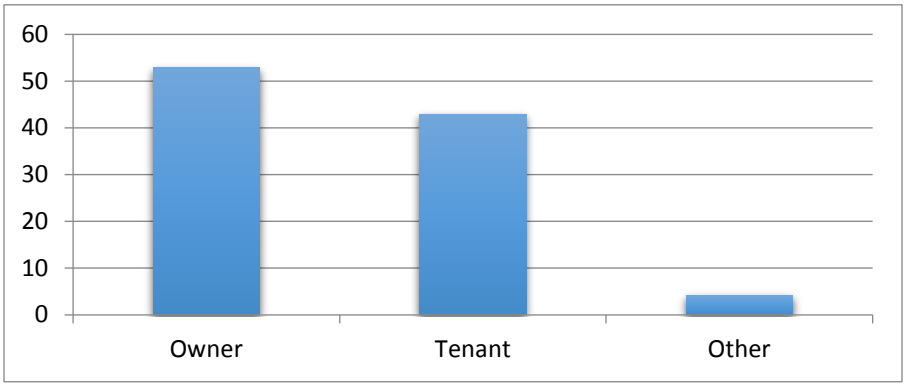


Figure 45 Tenure of housing in the municipality of Monastir (%)

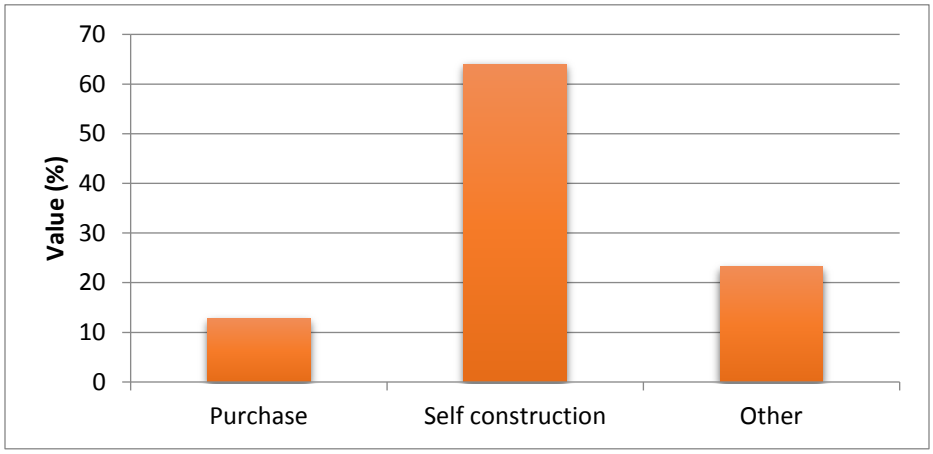


Figure 46 Ownership of housing (for owners) in the municipality of Monastir (%)

The type of accommodations in Monastir vary a lot: 8% are villas or duplexes, often with a small garden (12%), 22% are apartments in buildings and/or studios (living room + bedroom + kitchen + bathroom), and more than half (57%) are semi-detached houses (**see Figure 47**).

The number of rooms per unit range from 1 to 5, and sometimes more. 42% of the dwellings have 3 rooms, 25% have 4 rooms, 20% have 2 rooms, 4% have a single room (studio) whereas almost 7% have 5 or more rooms (**see Figure 48**).

The surface area of housing in Monastir is highly variable. 42% of the dwellings have an area between 50 and 100m2, 33% have an area between 100 and 150m2; 8% have an area between 150 and 200m2; 9% have an area less than 50m2 and 7% have an area that exceeds 200m2 (**see Figure 49**).

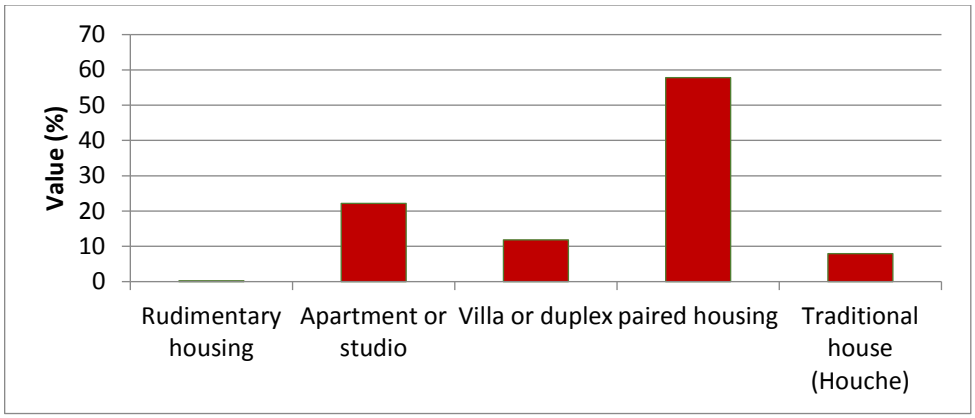


Figure 47 Distribution of housing by type in the municipality of Monastir (%)

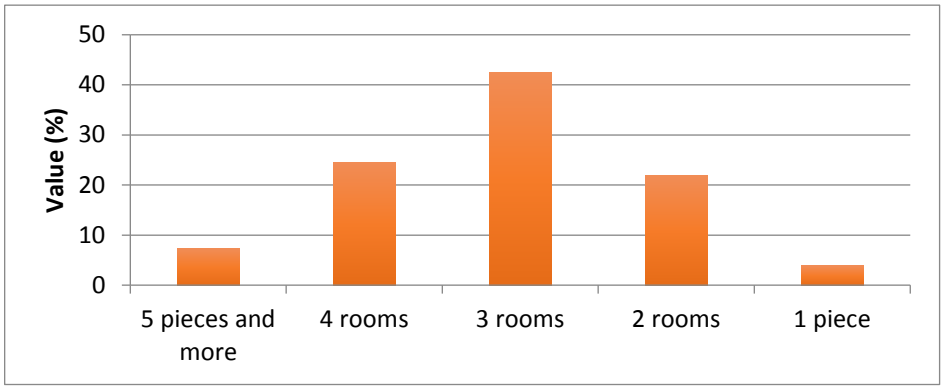


Figure 48 Distribution of housing based on the number of rooms in the municipality of Monastir (%)

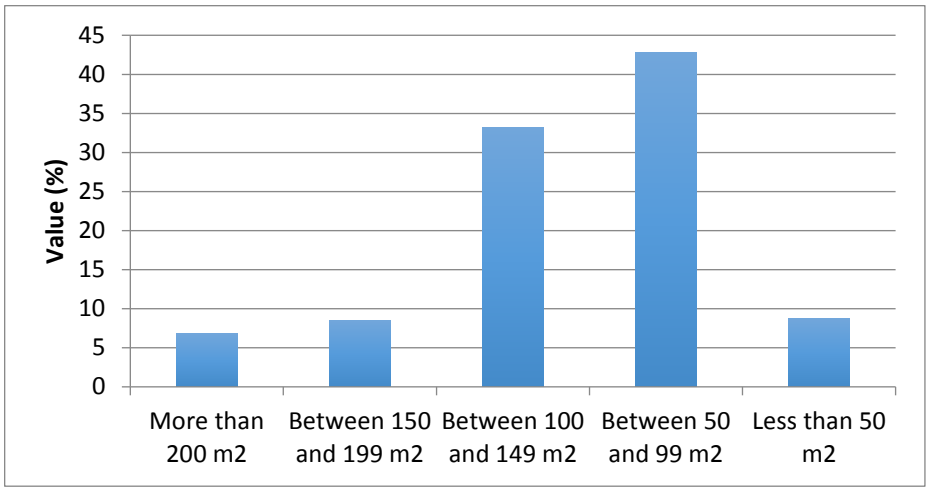


Figure 49 Distribution of housing based on covered surface area (m2) in the municipality of Monastir (%)

4.3. Water specific information

4.3.1. Water Governance

Water resources in the municipality of Monastir are managed by the regional directorates of ONAS, the CRDA and the SONEDE (district of Monastir) in the governorate of Monastir. Drinking water (domestic, industry and tourism) is managed by SONEDE, irrigation water is managed jointly by the CRDA and SONEDE and the wastewater is managed by ONAS.

4.3.2. Supply and demand

Water supply in the governorate of Monastir

The Monastir governorate is supplied by waters coming from the North, transported via the Medjerdah-Cap Bon pipeline and the Nebhana dam (intended for domestic use), the waters of the Kairouan deep aquifer system (intended for agricultural use), and from limited local resources (**see below in section 4.3.3**). However, this supply does not meet demand (domestic, agricultural, tourist, industrial, etc.), causing a deficit that comes with many problems. The demand is still growing due to population growth which increased by almost 25% between 2004 and 2014 [INS, 2015], as well as to the economic development. The hydraulic management and the political strategy for the mobilization and transfer of water resources are insufficient in the Monastir zone, especially as this region is also increasingly experiencing effects from climate variability. As such, the preservation of water resources (quantity and quality) in the Monastir region, through the improvement and development of technical adaptation to climate change and increasing demand becomes imperative.

Drinking water supply in the municipality of Monastir

The rate of connection to the SONEDE network in the municipality of Monastir is 98.2%, through 95,235 subscribers (district of Monastir). The drinking water supply is provided by the north and center dams of the country and 5 deep wells. The total length of the network is about 1,156 km. The drinking water is stored in 32 semi-buried tanks with a capacity of 3,2150 m^3 each (**see Figures 50 and 51**).

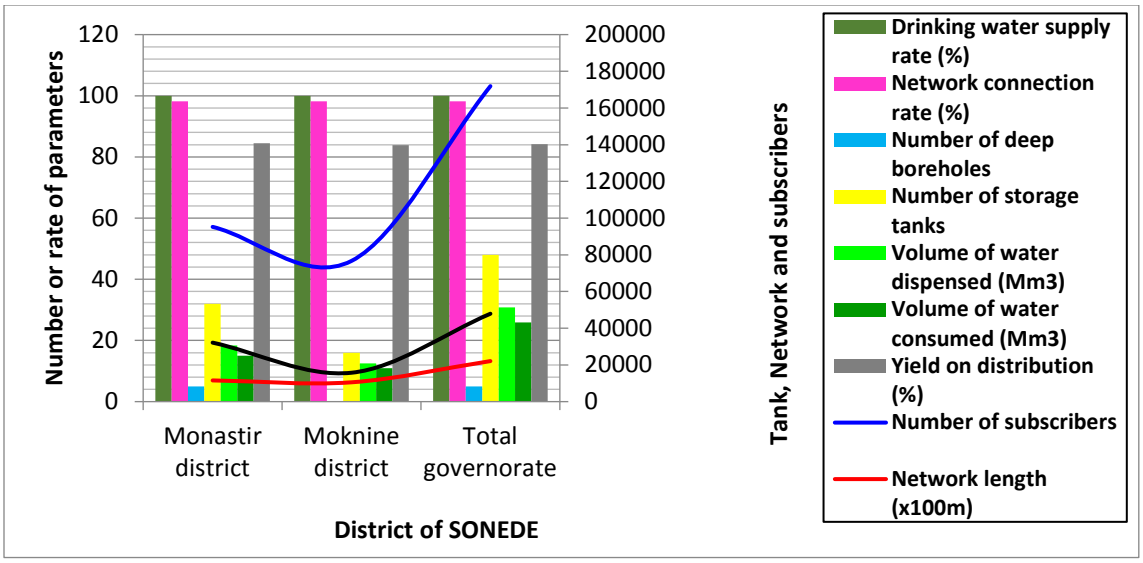


Figure 50 Drinking water supply characteristics in the SONEDE districts of Monastir (2016)

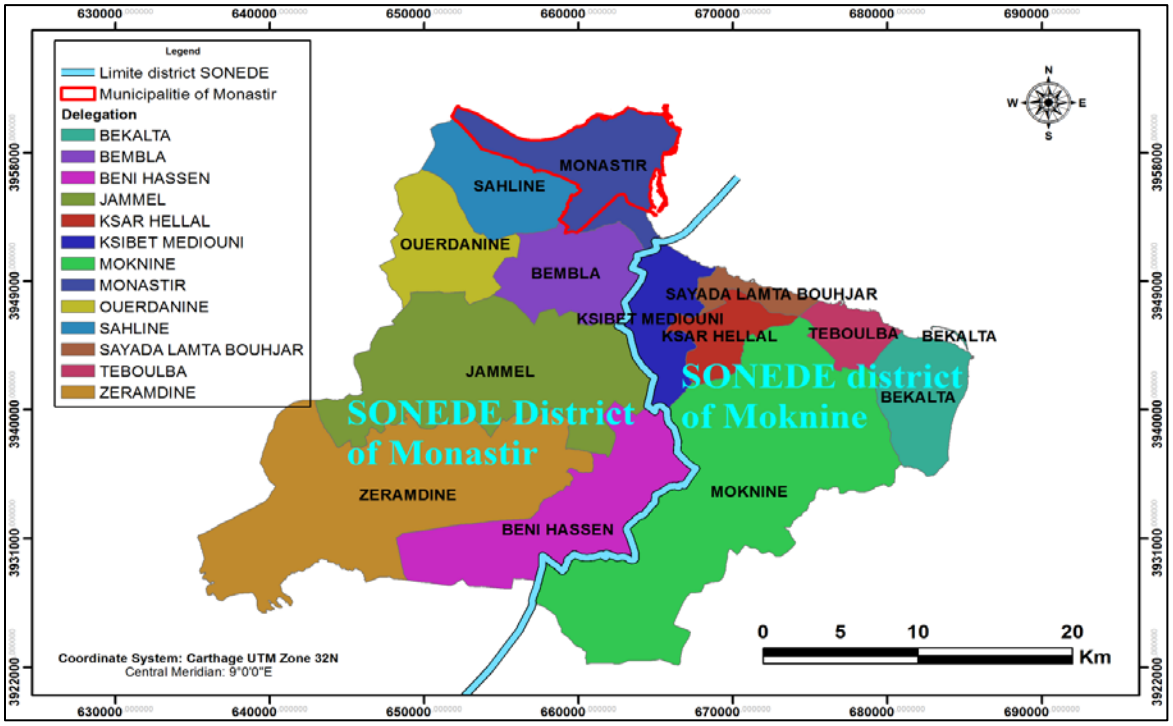


Figure 51 Limit of SONEDE districts in Monastir governorate

Amongst the various agglomerations that are fed by the SONEDE district of Monastir, the municipality of Monastir is consuming most drinking water.

Irrigation water supply in municipality of Monastir

In the municipality of Monastir there are two irrigated perimeters (El Omrane and Sidi Nassar). Water supply of irrigated perimeters in the governorate of Monastir has three origins:

- the Nebhana dam: represents 2,721 hectares, of which 2,592 hectares are irrigable;
- deep wells (deep aquifers): represent 1,536 hectares, of which 1,423 hectares are irrigable;
- surface wells (groundwater): represent 1,993 hectares, of which 1,766 hectares are irrigable.

4.3.3. Available water resources

The city of Monastir is devoid of local water resources and the groundwater resources are low and of poor quality. It is fed either by other delegations from the governorate of Monastir or from the other governorates. The deep aquifer is absent and the phreatic aquifer is very salty. Per the map of the water tables of the governorate of Monastir, the municipality of Monastir is located on two phreatic aquifers: the water table of Sebkha and that of Monastir (**see Figure 52**). The first is located under a marshy zone formed by the lagoon of Sahline-Monastir, so it is weakly accessible and very salty. The second one has salinity between 2 and 7 g/l and under the urban area of Monastir.

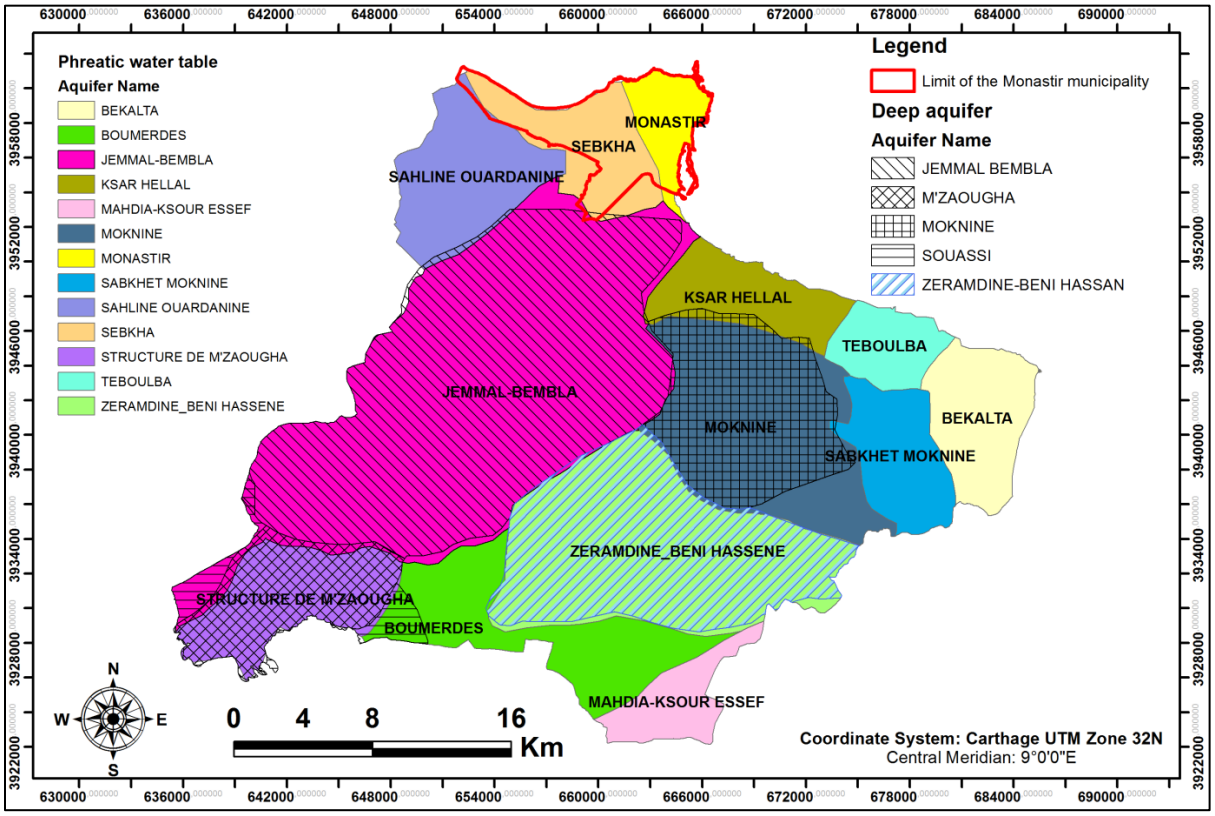


Figure 52 Phreatic and deep aquifers in the governorate of Monastir.

Intra-governorate water resources

The limited conventional water resources in the governorate of Monastir consist of 13Mm³ of surface water and 16.83Mm³ of groundwater. The groundwater is spread over 9 hydrogeological basins and exploited through 50 deep boreholes with a depth ranging from 100m up to 400m. Groundwater is distributed in 9.9Mm³ in the phreatic aquifer and 7Mm³ in the deep-water table (**see Figures 53 and 54**). These waters have a salinity which varies between 1 g/l and 7 g/l.

Of the 7Mm³ of deep water, 4.88 Mm³ can be used for irrigation, thanks to the high salinity. 3.76Mm³ of these are distributed in the governorate of Monastir and 1.06Mm3 in the governorate of Mahdia. A small amount of mediocre waters is used by SONEDE for drinking water (0.8Mm³). 0.06Mm³ are used by the industrial zone of Mahdia (**see Figure 55).**

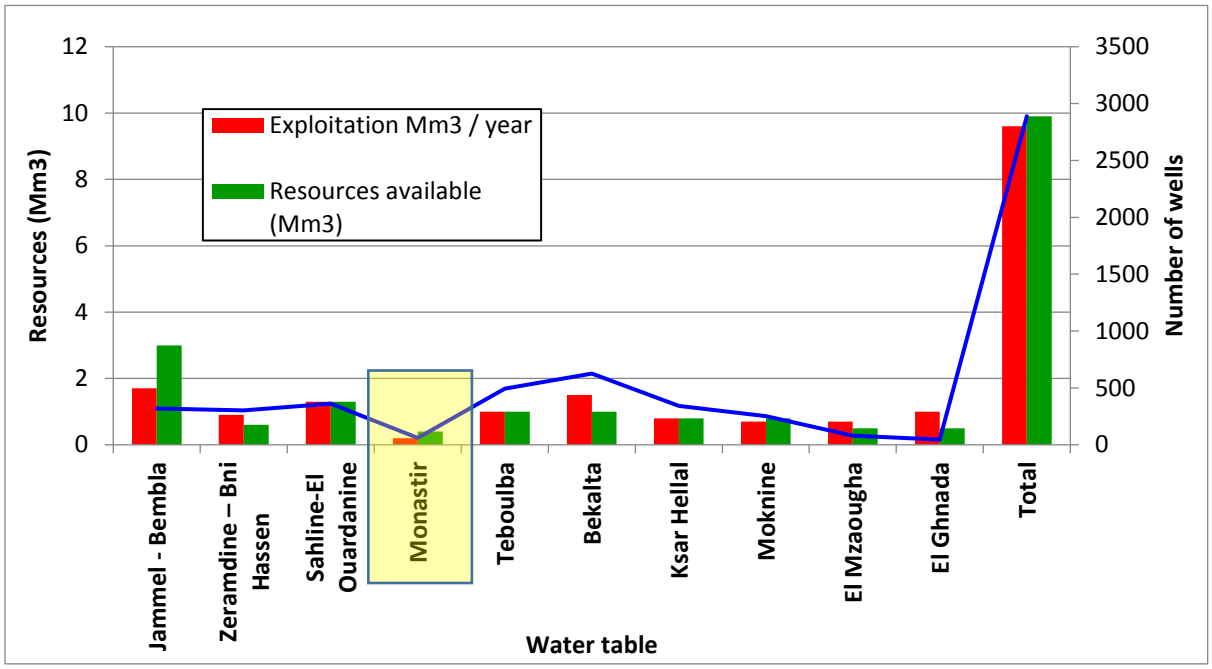


Figure 53 Distribution of available water resources, exploitation and number of wells in Monastir Governorate's phreatic aquifers (2015)

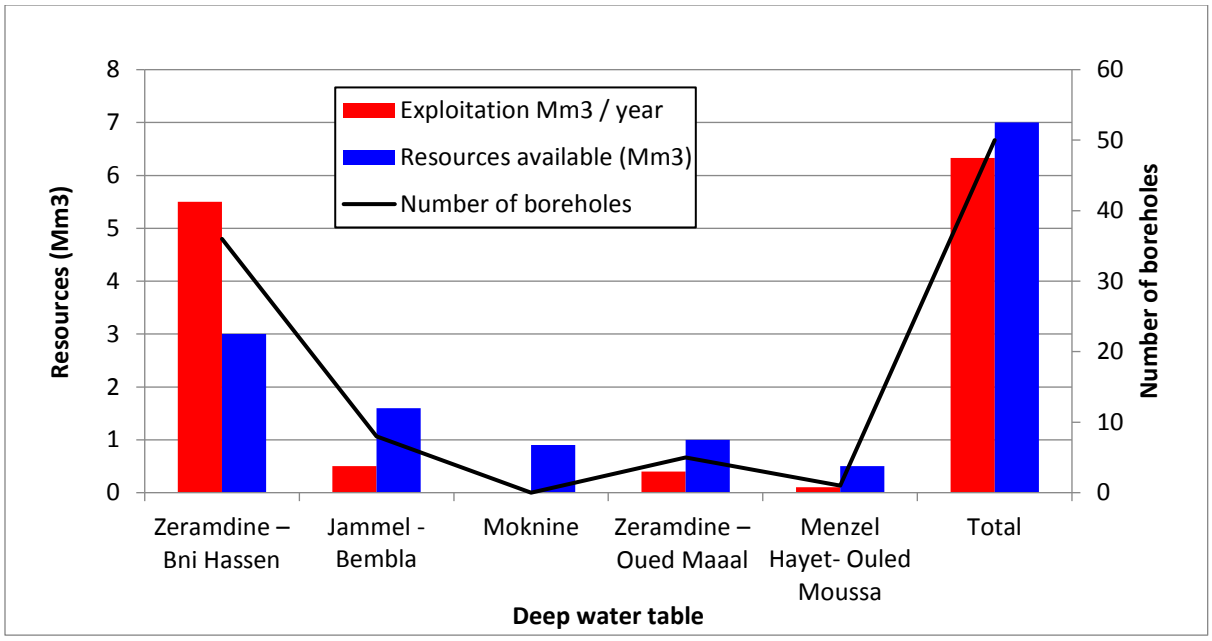


Figure 54 Distribution of available water resources, exploitation and number of boreholes in Monastir Governorate's deep aquifers (2015)

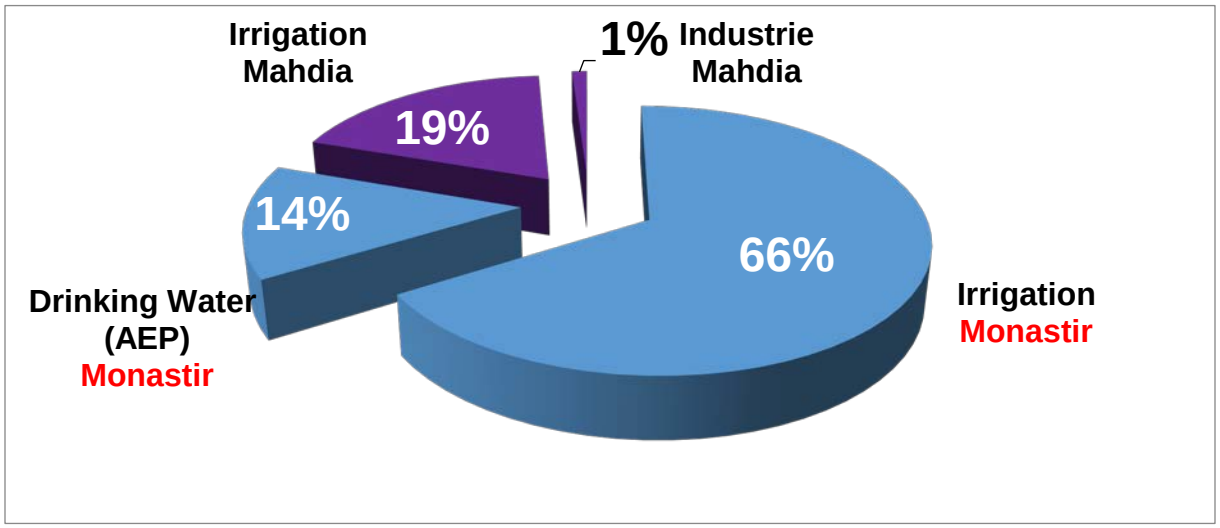


Figure 55 Distribution of Deep Groundwater by Use in Monastir Governorate

The exploitation of groundwater in Monastir has increased from 8.2 Mm3 in 2010 to 9.6 Mm3 in 2015, with exploitable reserves amounting to 9.9 Mm3 (**see Figures 56 and 57).** The number of surface wells is reduced with 50% (from 4,849 in 2010 to 2,889 in 2015). This is mainly due to the degradation of resources (salinization) due to the depletion of the water table caused by overexploitation and the drought that characterizes Tunisia.

The typical example is the Monastir aquifer at the level of the Monastir municipal area, where the number of wells is reduced from 167 wells in 2010 to 60 surface wells in 2015. This aquifer is very salty (2-7 g/l). The Sebkha water table is not listed because it is not exploited.

For deep aquifers, exploitation decreased slightly (0.5Mm3) between 2010 and 2015, despite the increase in the number of boreholes in the same period which evolved from 46 in 2010 to 50 boreholes in 2015 (**see Figures 58 and 59**). This can be related to the significant drawdown of the piezometric level of aquifers. The most exploited aquifer of the deep system is the Zeramdine-Beni Hassen aquifer (80% of the exploitation) through 36 deep boreholes.

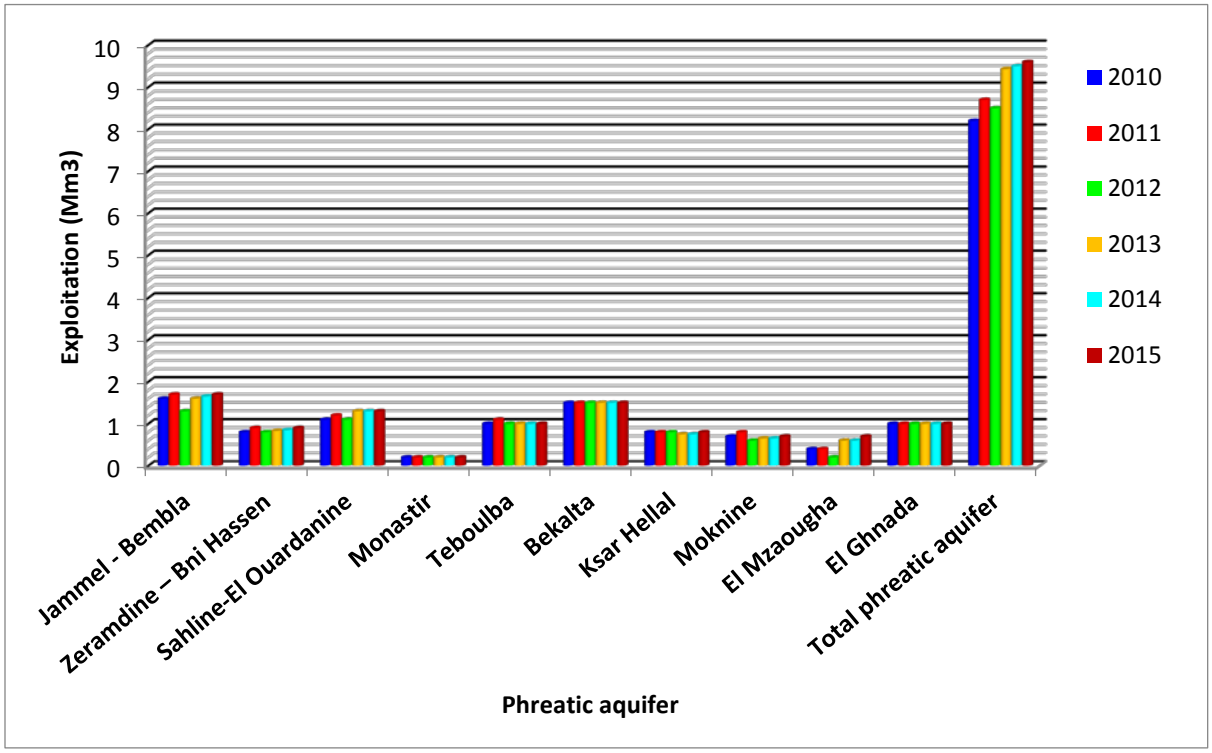


Figure 56 Evolution of exploitation of the phreatic aquifers in the governorate of Monastir (2010-2015).

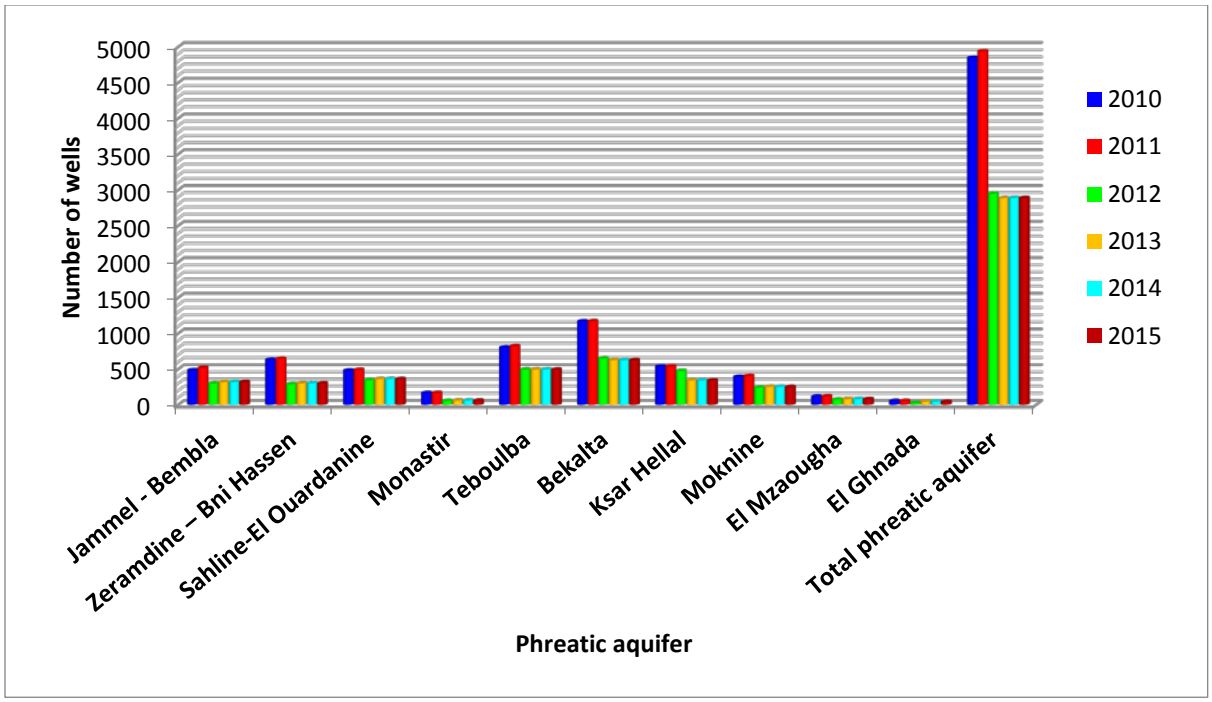


Figure 57Evolution of the number of surface wells of the phreatic aquifers in the governorate of Monastir (2010-2015).

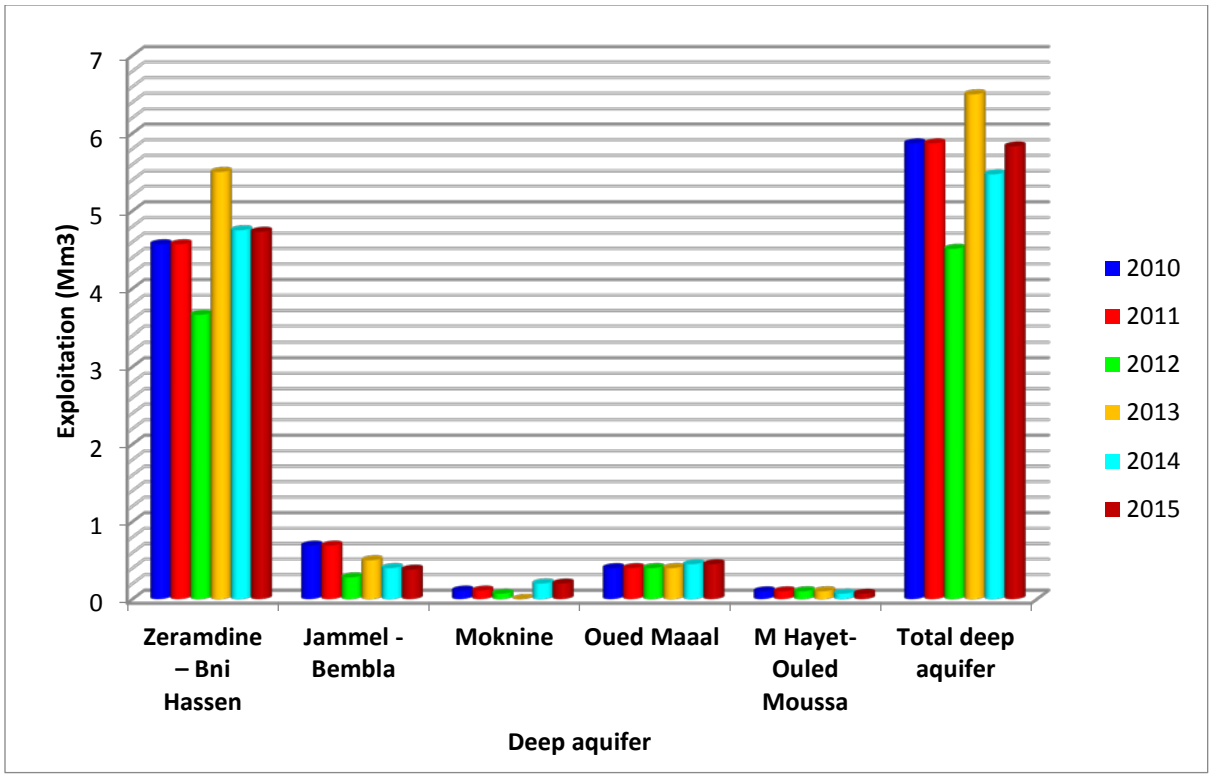


Figure 58 Evolution of exploitation of the deep aquifers in the governorate of Monastir (2010-2015).

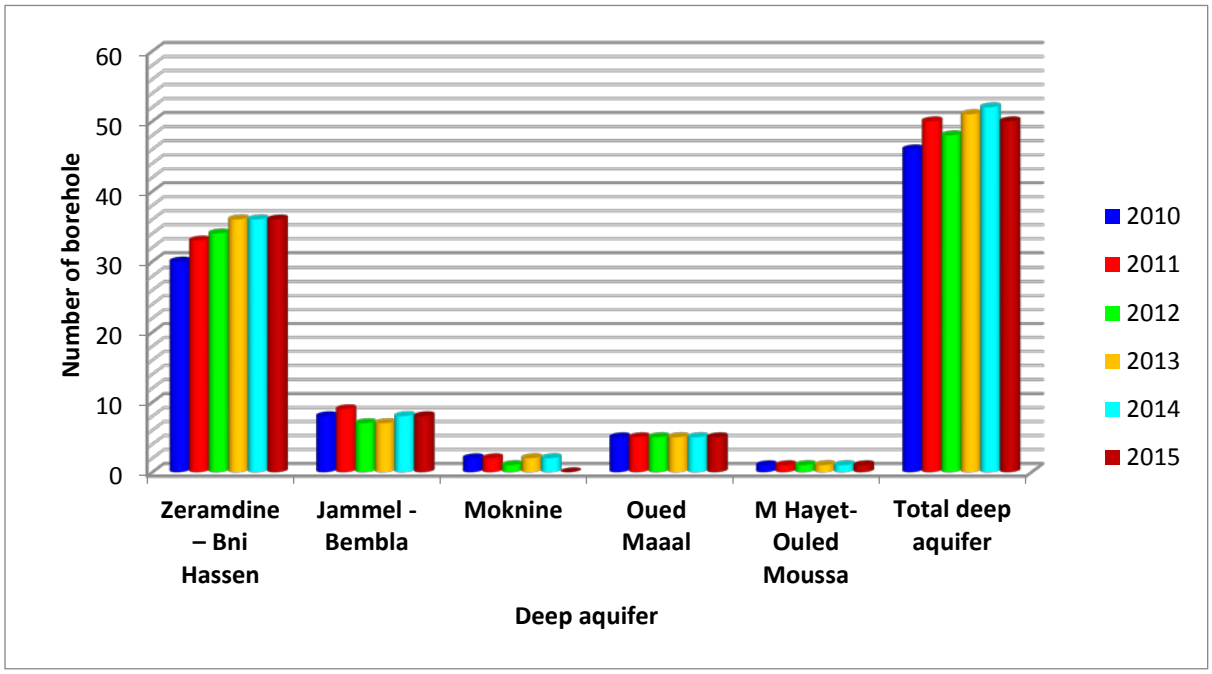


Figure 59 Evolution of the number of boreholes (deep aquifers) in the governorate of Monastir (2010-2015).

As for the unconventional water resources, there are 8 sewage treatment plants in the governorate of Monastir, managed by ONAS. These stations provide 6Mm³ of the treated water (with a secondary

treatment), of which 2.5Mm³ are used in the irrigation of golf courses (tourist area), municipal green areas, hotel gardens and irrigated perimeters.

Water reserves in dams

There are also water reserves available in the dams and slicks that feed the region of Monastir (**see Figure 60**). The main dams, which provide more than half of the water needs, are in the north of Tunisia. The first two dams in Tunisia (Sidi Salem and Sidi el Barrak) together provide 25% of the surface water that can be mobilized. These include the Masri, Sidi Salem, Sejnane and Joumine dams (in the north of the country) and the Nabhana, El Houareb (center). The reserves of water available in these reservoirs have been continuously low for several years, due to the succession of periods of drought that characterize Tunisia whereas the exploitation of these reserves continuously increases.

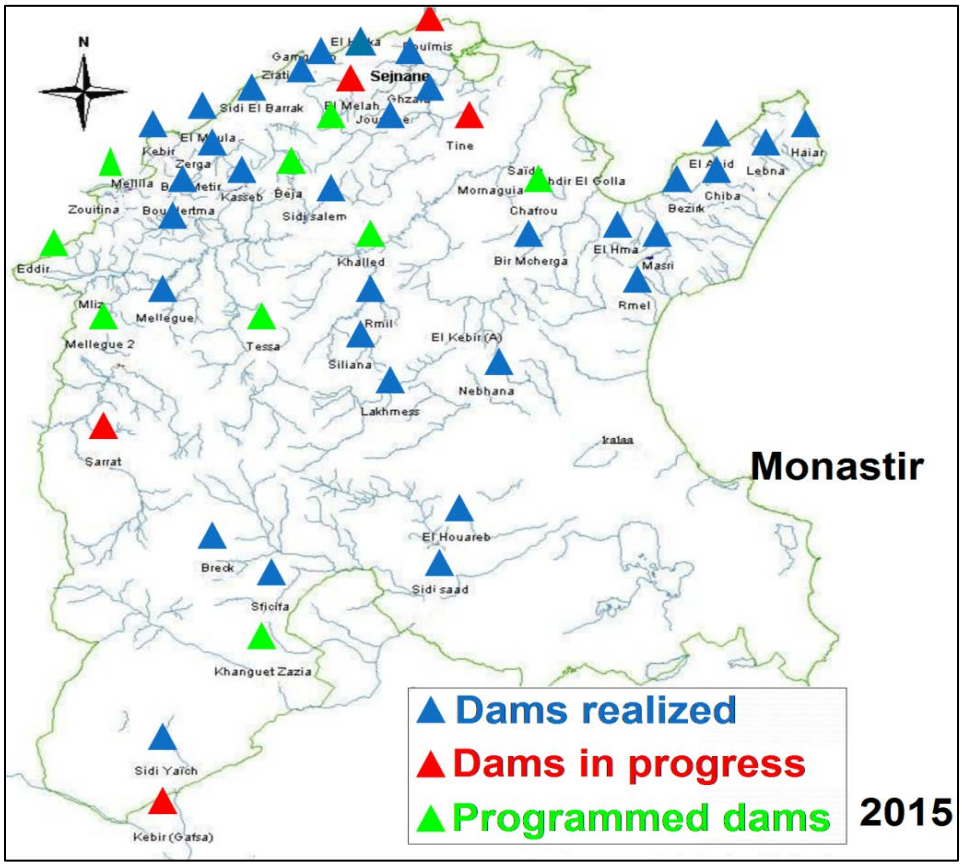


Figure 60 Location map of dams in Tunisia (MARHP, 2015)

Extra-governorate water resources

Given the development of living standards in the city of Monastir, the resources do not meet the water needs. Therefore, a large part of the demand is supplied by transfer of water from the north and the center (Masri,

Sidi Salem, Sejnane, Joumine and Nebhana dams) for drinking water, and from the Kairouan governorate (center of the country) for ground water used for irrigation (**see Figure 62**).The rate of water transfer from north and central to the Sahel region in general and the Monastir region in particular has increased considerably since the 1979s (**see Figure 61**).

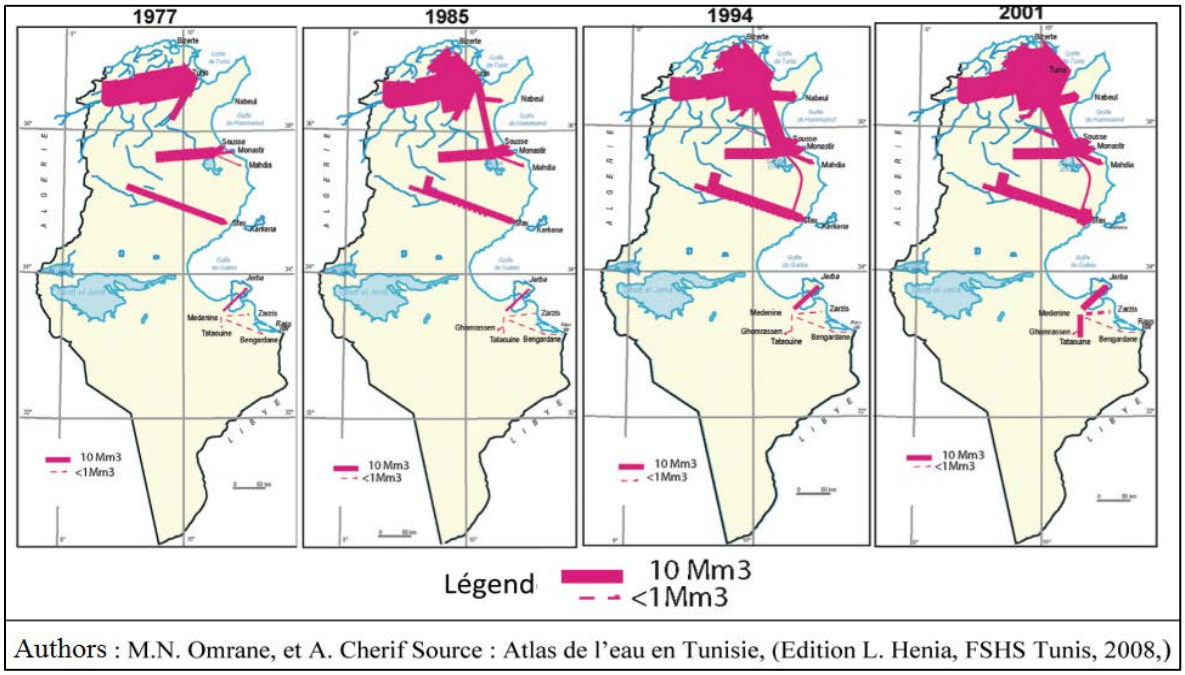


Figure 61 Evolution of water volumes transferred in Tunisia (1977 – 2001)

Figure 62 Major Transfers and water supply in Tunisia

4.3.4. Water Quality

The salinity of the Monastir water table groundwater varies between 3 g/l and 7.5 g/l for most of the existing wells and drilling borehole (**see Figure 63**).

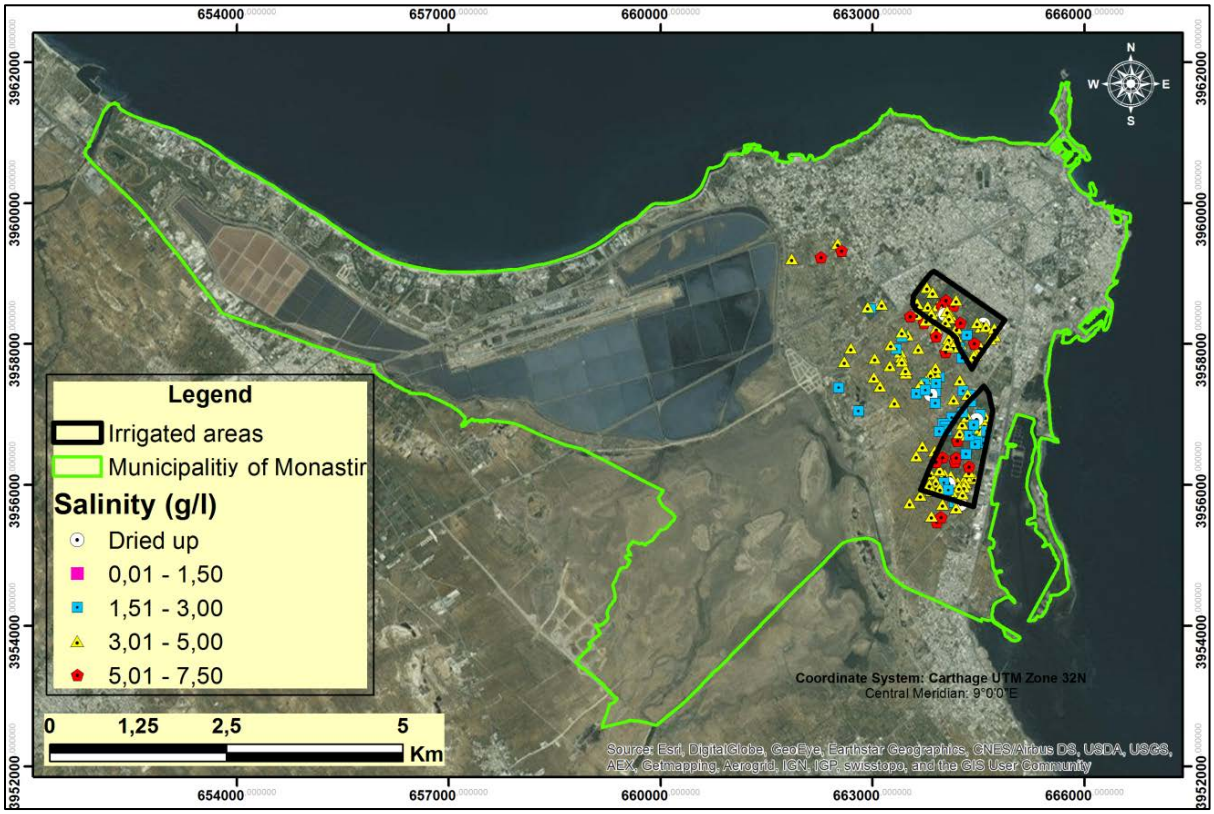


Figure 63 Salinity of water in the phreatic groundwater of Monastir

4.3.5. Water Supply Technical Facilities

Tanks

The drinking water is stored by SONEDE in semi-buried tanks. The SONEDE district Monastir has four tanks, two of which have a capacity of 5,000m³ each, and the other two each have a capacity of 800m³. The pipes are of several types and several dimensions:

- Cast iron, with diameters: 60mm; 80mm; 100mm; 125mm; 150mm; 200mm; 250mm and 300mm.
- Concrete, with diameters: 300mm; 400mm; 500mm and 600mm.
- A. cement, with diameters: 60mm; 80mm; 100mm; 150mm; 200mm; 250mm; 300mm; 400mm and 500mm.
- PF, with diameters: 63mm; 75mm; 90mm; 110mm; 125mm; 160mm; 200mm and 310mm.

Groundwater exploitation

The groundwater in Monastir is exploited through the surface wells for phreatic aquifer and through the boreholes for deep aquifers. As indicated before, there is no deep-water table in the municipality of Monastir, and the groundwater is supplied through two phreatic water tables, the Sebkha and the Monastir water tables. The first is unexploited because it is inaccessible, as it is located in a marshy area and full of water (Sebkha and saline of Sahline). The Monastir water table is exploited by citizens and farmers (on a private basis) through 160 wells, of which 60 are equipped with diesel motor pumps, and 9 with electric motor pumps and the rest are not equipped (without motor pumps). Of these 160 wells, 10 wells are abandoned and 130 unused due to the high salinity of the water table. Only 20 wells are currently in operation (in the irrigation area).

Wastewater evacuation systems

The Frina wastewater treatment plant receives wastewater from the entire municipal area of the city of Monastir, through a sewerage network of 279 km and a connection rate of 96% (in 2016). The pipes used have diameters ranging from 250mm to 800mm of PVC, AC (steel) and BA (reinforced concrete).

4.3.6. Wastewater Treatment

In the governorate of Monastir there are 8 sewage treatment plants, managed by ONAS. These stations annually provide 6Mm^3 of treated wastewater (with secondary treatment), of which 2.5Mm^3 are used in the irrigation of golf courses (tourist area), municipal green areas, hotel gardens and irrigated perimeters. The mud is used by farmers as chemical fertilizers after drying.

Table 5 Indicators of sanitation in the governorate of Monastir (Source: http://www.onas.nat.tn)

Monastir Governorate	Data 2016
Total population:	576 000
Urban population:	576 000
The communes in charge:	22 of 31 : Monastir, Khenis, Bembla-Mnara, Menzel Ennour, Masdour, Menzel Harb, Ksibet Mediouni, Bennane-Boudher, Moknine, Teboulba, Bekalta, Sayada, Lamta, Bouhjar, Ksar Hellal, Jammel, Zeramdine, Beni-Hassan, Zaouiet-Kountoch, Ouardanine, Sahline-Moâtmar, Sidi amer-Masjed issa.Touza
Population in Supported Cities:	513 000
Connected population:	473 000
Connection rate:	92.2 %
Length of the network:	1304 km
Number of hydraulic works:	8 sewage treatment plants, 57 pumping stations
Volume of water collected per year:	13.21 millions de m3
Volume of water treated per year:	13.21 millions de m3
Private sector participation	
Network operated (km):	0
Rate of participation:	0,00%

In the municipality of Monastir, there were three waste water treatment plants (WWTP), of which only one is still functional, the Frina WWTP since 1995. It covers 5 hectares and contains 8 basins with a capacity of

13,220 m3 each. The WWTP receives drainage water from the ONAS network for the municipalities of Monastir, Khniss, Bembla- El Manara and EL Masdour-Menzel Harb, in quantities that exceed the capacity of the plant. The treatment is of the secondary type with a "prolonged aeration" and then "fine bubbles". The analyses of the effluents carried out by the Frina station show the following characteristics: COD = 110 mg / l; BOD5 = 29 mg / l; and MES = 30 mg / l.

The treated effluents are discharged into the sea through a sea outfall that runs 1200m (700m underground and 500m under water in the sea.) This length does not allow waste to be thrown offshore, but they remain stagnant in the ejection zone which is a confined environment, a small golf with no sea currents. This adds to the already deteriorated status of the coastal environment, which is becoming catastrophic. In addition to this, the coastal zone of the municipality of Monastir is limited by two large wadis, O. Hamdoun in the North and O. Khniss in the south. These two wadis are the seat of more types of uncontrolled liquids and solid waste. As such, it can be said that the Frina wastewater treatment plant, near the industrial zone, is a source of pollution dangerous for the sea and the coast (**see Figure 64**).

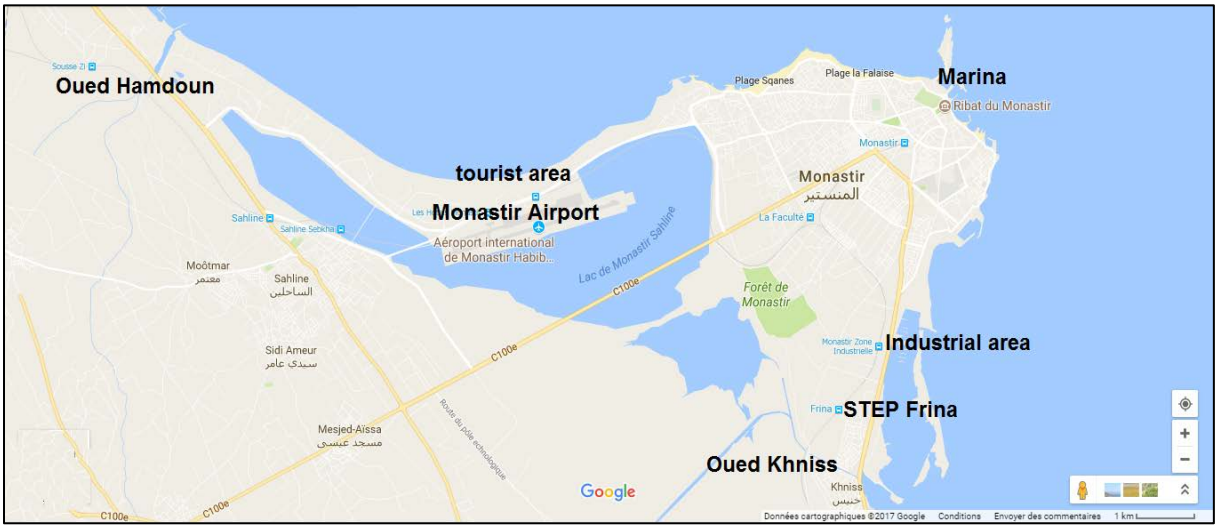


Figure 64 Map of the main sources of coastal pollution in the municipality of Monastir.

The configuration of the Bay of Monastir used to be an advantage favoring the presence of fish flows who could deposit their eggs and let them develop serenely far from large waves. Due to pollution, the Bay of Monastir has become an anaerobic medium favorable to the formation of bacteria, with already significant release of bad odors (**see Figures 65, 66, 67**).

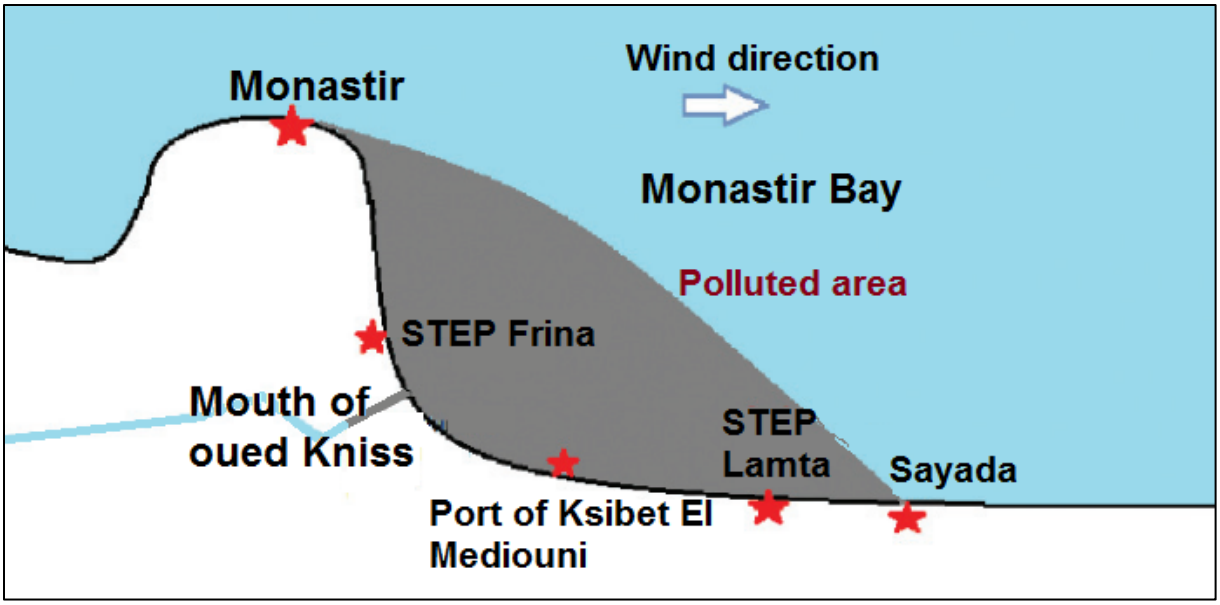


Figure 65 Diagram of the Bay of Monastir, showing a natural vulnerable configuration to pollution

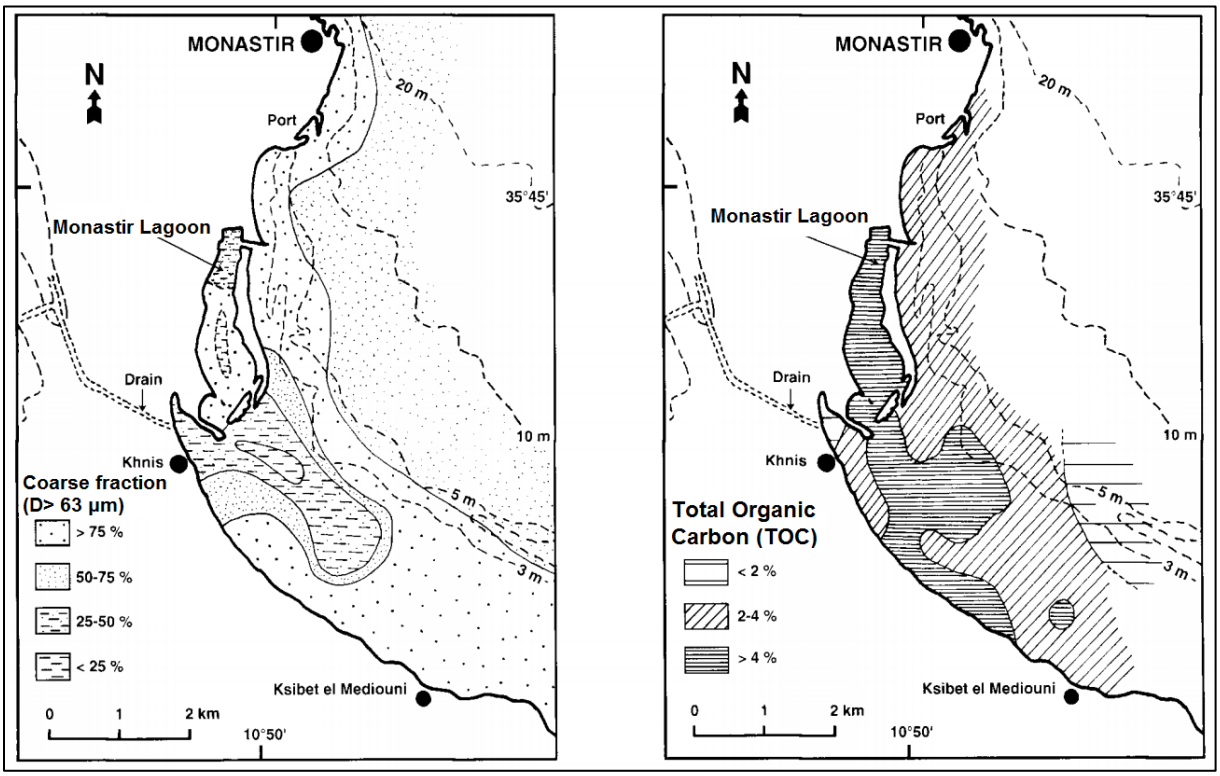


Figure 66 Distribution of the percentage of sand fraction (f> 63 ± \ m) and total organic carbon (TOC) in % content in surface sediments.

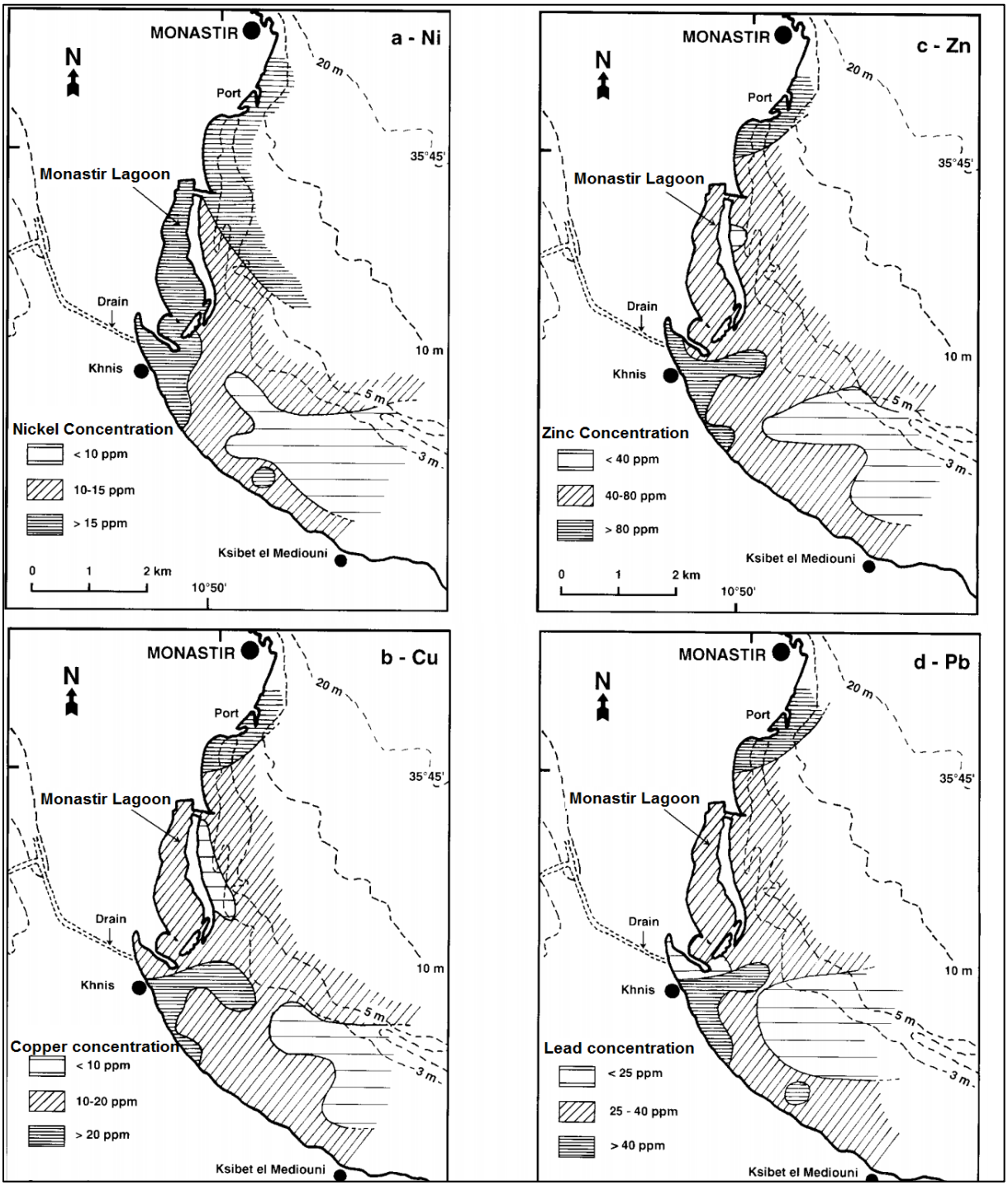


Figure 67 Distribution of Ni, Cu, Zn and Pb in surface sediments

4.4. Agriculture

Agriculture situation in Monastir municipality area are studied basing on data collected from survey with farmers and from direct interview with the heads of the agricultural sector at the level of Monastir.

4.4.1. Natural Resources

Soils in the municipality of Monastir

The pastoral lands, the Sebkha and the Salinas are occupied by holomorphic soils. The land on the coast consists of brown mineral soils (lithosols/regosols). The agricultural land and the urban area are dominated by the presence of subarid brown isohumic soils that are known for their lightweight, balanced texture, permeability, organic matter and deep limestone accumulation. They are very fertile and are exploited for arboriculture and for the development of irrigated perimeters.

Based on the soil map, land use map and hydrological map (watersheds and hydrographical network), it can be concluded that the erosion rate is low. There are several reasons for this. On the one hand the hydrographical network is very poor except for the neighbouring wadis: Oued Hamdoun and Oued Khniss, which delimits the municipality of Monastir. On the other hand, the majority of the land is occupied by urban perimeters and hydromorphic and holomorphic zones (saline and sebkhas).

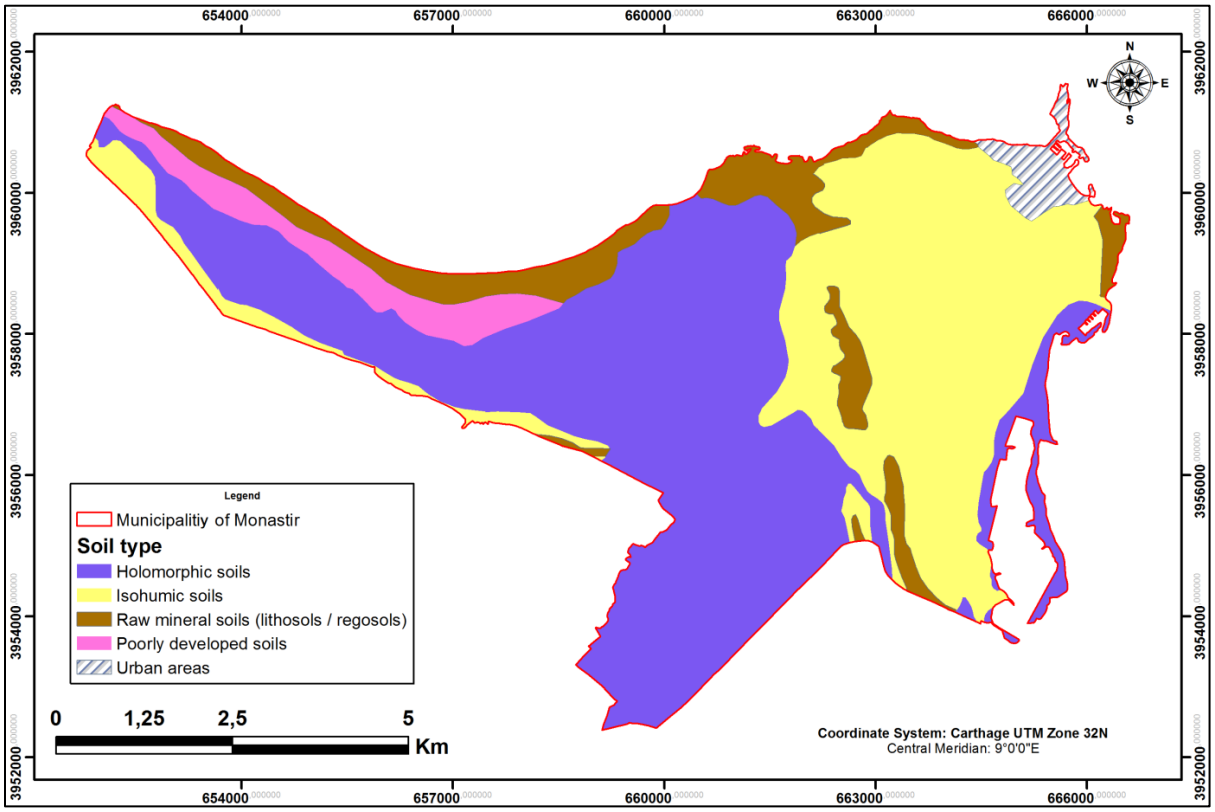


Figure 68 Soil map of the municipality of Monastir

Land use

A large part of the lands in the municipality of Monastir is not used, because of the holomorphic character of their soils due to salinization: more than half of the land is occupied by lagoons (Sebkha, Salinas and trails). The Salinas occupy 944 ha, Sebkha 7 ha, and water surfaces 101 ha. The urban area occupies almost 1/3 of the area of the municipality (1,720 ha). Agricultural land does not exceed 1/4 of the total area of the municipality (860 ha), and is occupied either by olive fields or by irrigated areas. The agricultural land is generally subdivided into relatively small parcels that do not exceed 5 hectares. Large facilities occupy 327 ha. On the north coast of the city of Monastir, a forest is set up along the cliff of Monastir on an area of 20 ha (**see Figures 69, 70, and 71**).

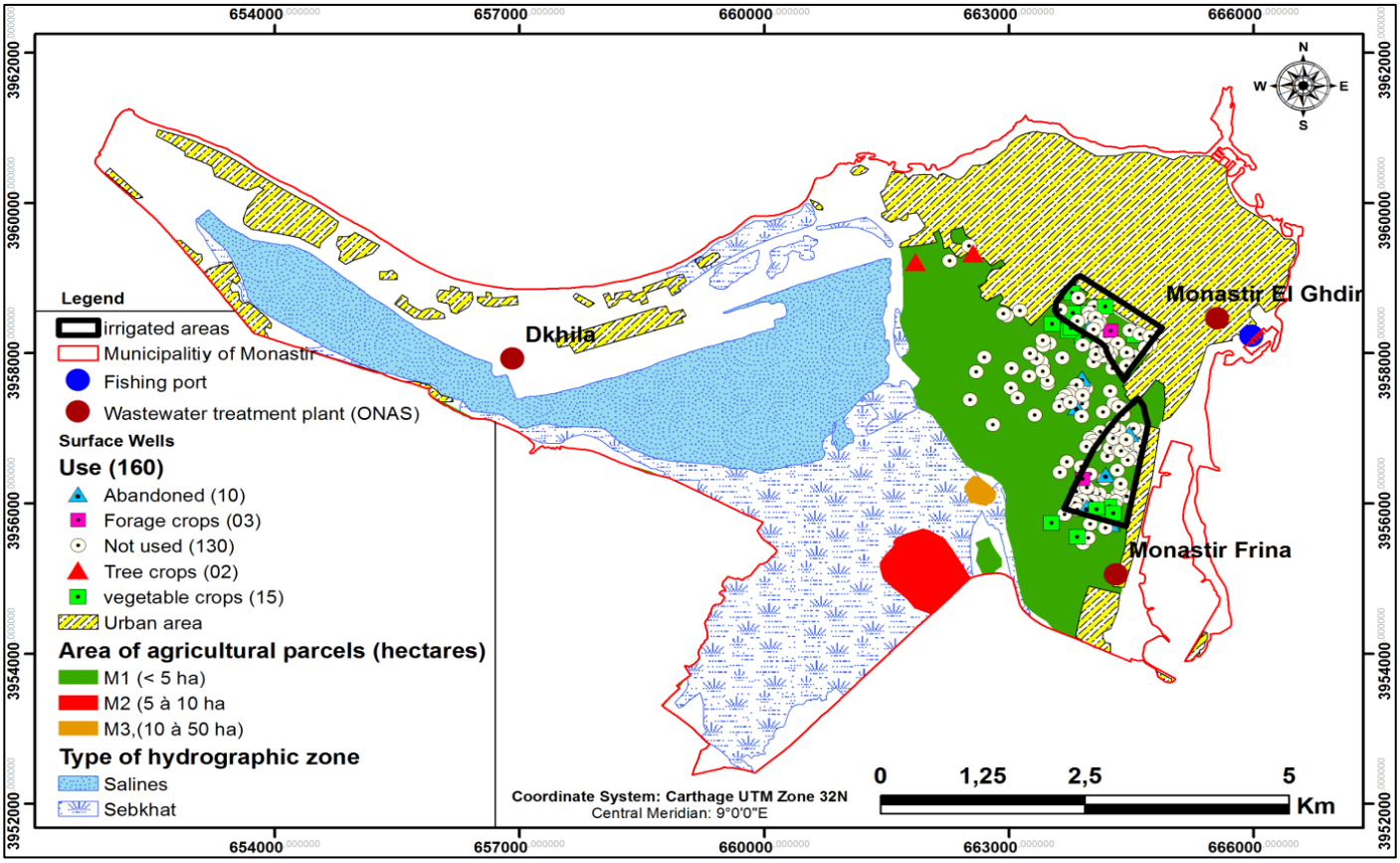


Figure 69 Global distribution of land use in Monastir

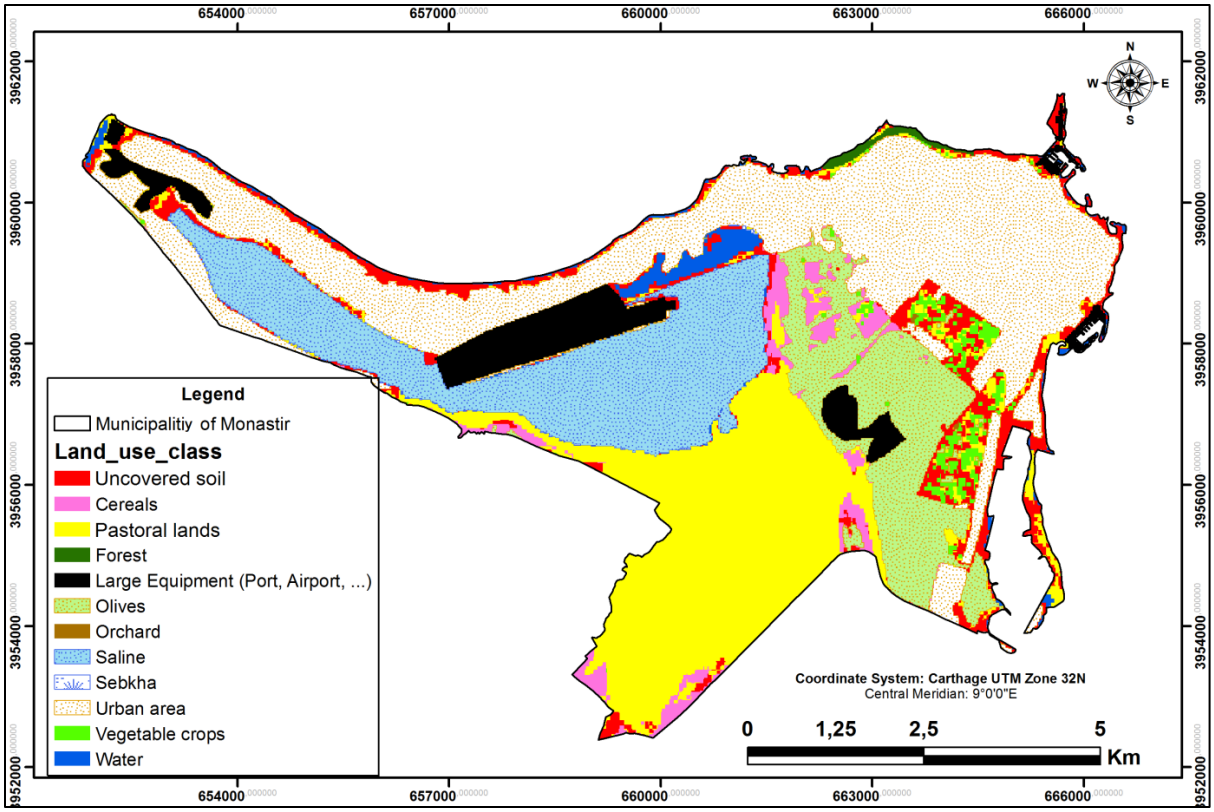


Figure 70 Agricultural land use of the municipality of Monastir

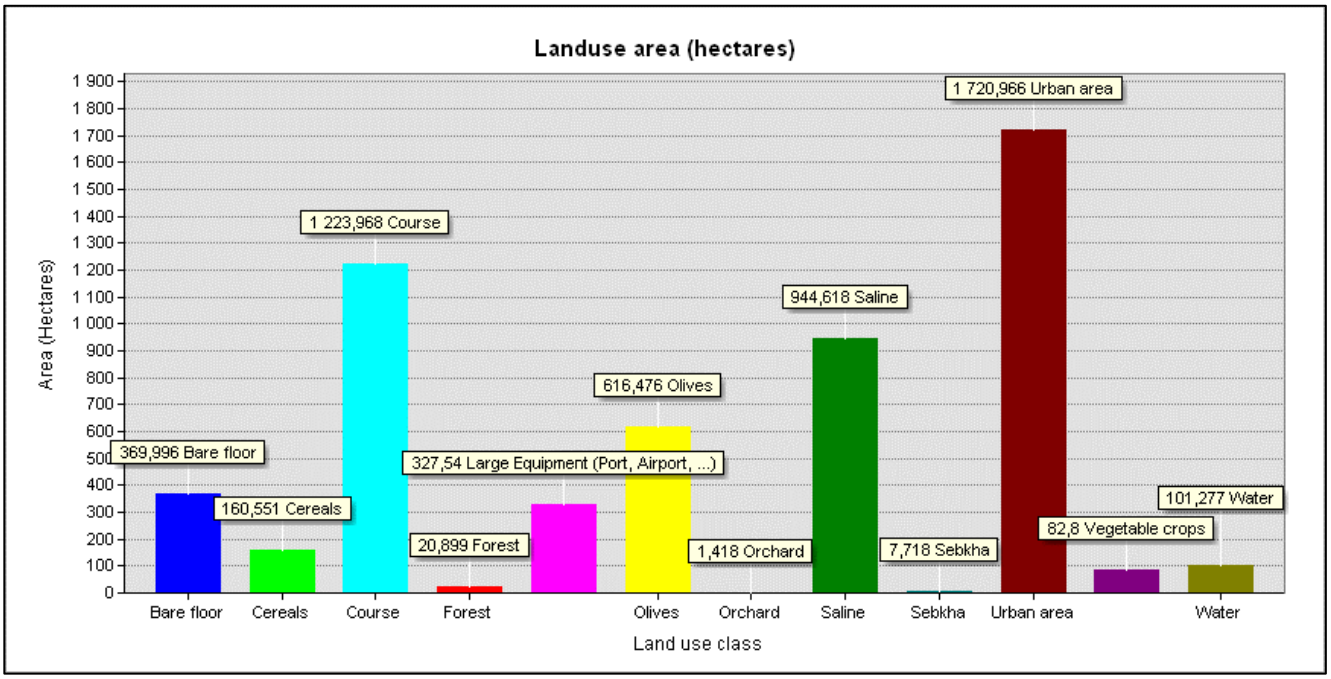


Figure 71 Distribution of land use by area in the municipality of Monastir

Agricultural land in the municipality of Monastir, despite being a small portion of the total area, is largely non-arable land. In 2015, only 764 hectares are cultivated compared to 4,276 hectares that are not cultivated. From 2010 to 2015, these areas decreased from 1,606 ha to 764 ha. This is mainly related to the availability and quality of water resources in the region (**see Figure 72**).

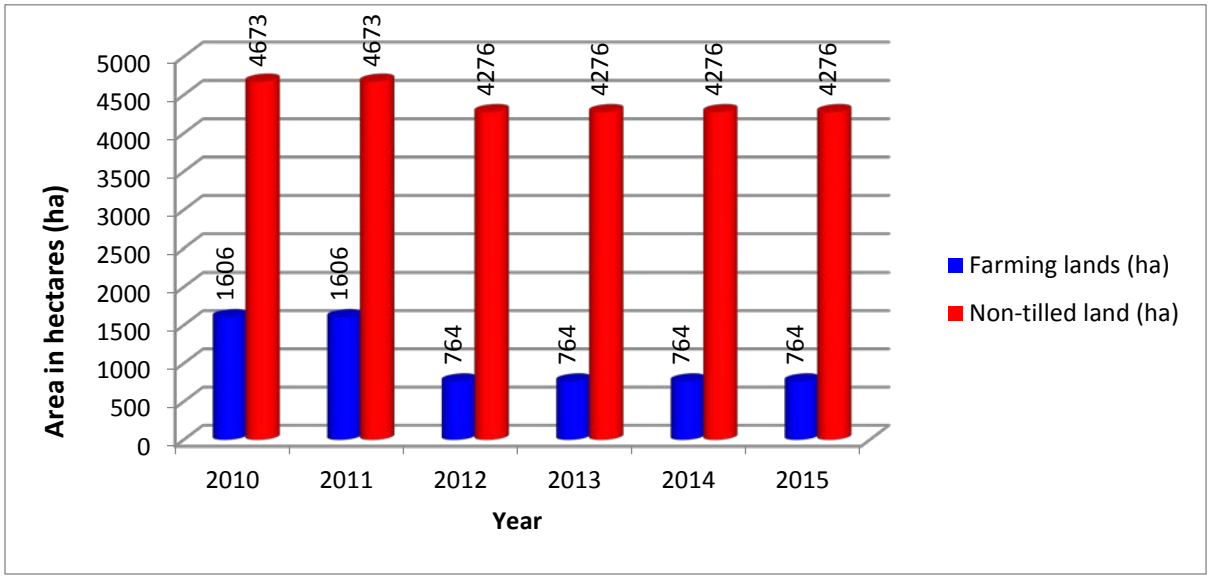


Figure 72 Evolution of the area of agricultural land that is cultivated versus non-cultivated in the Monastir municipality

4.4.2. Livestock, Animal and Forest resources

Animal production is relatively diversified, through cattle, sheep, goat, poultry, beekeeping and rabbit farms. Sheep are the dominant species, with 2,350 productive females in 2015 against cattle with 280 productive females (**see Figures 73 and 74**).

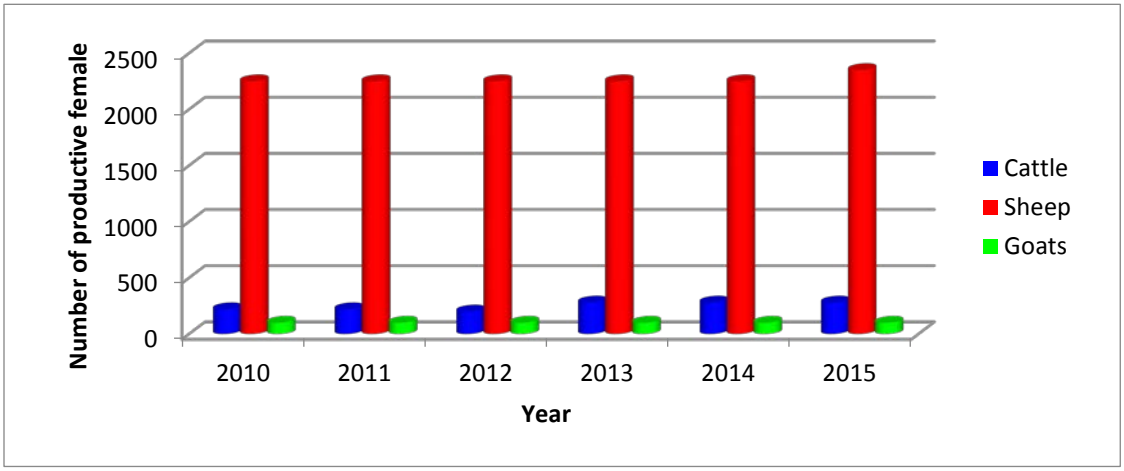


Figure 73 Evolution of livestock

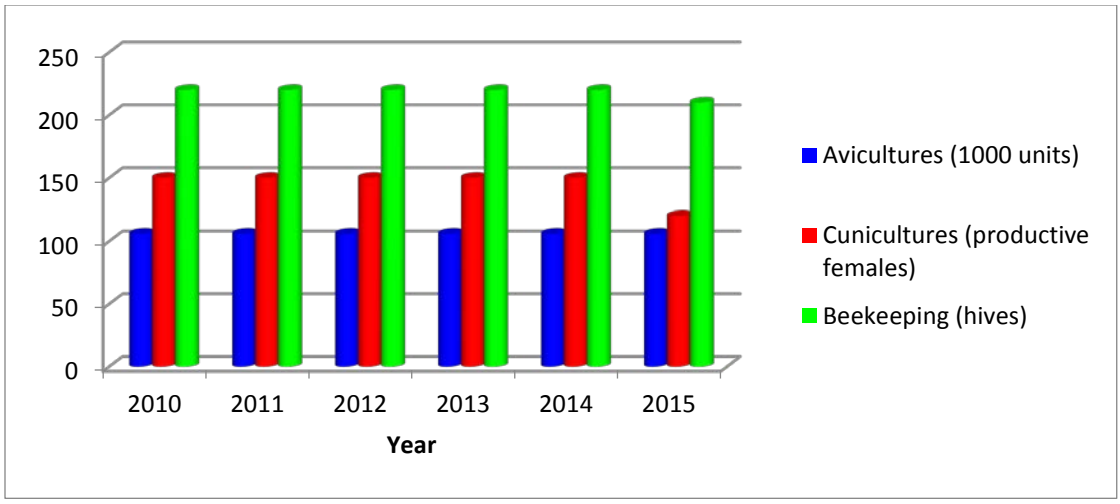


Figure 74: Evolution of small livestock

Meat production is based mainly on white meat (poultry) with 425 tonnes, compared with 99 tonnes for red meat in 2015. Production is almost constant between 2010 and 2015 (**see Figure 75**).

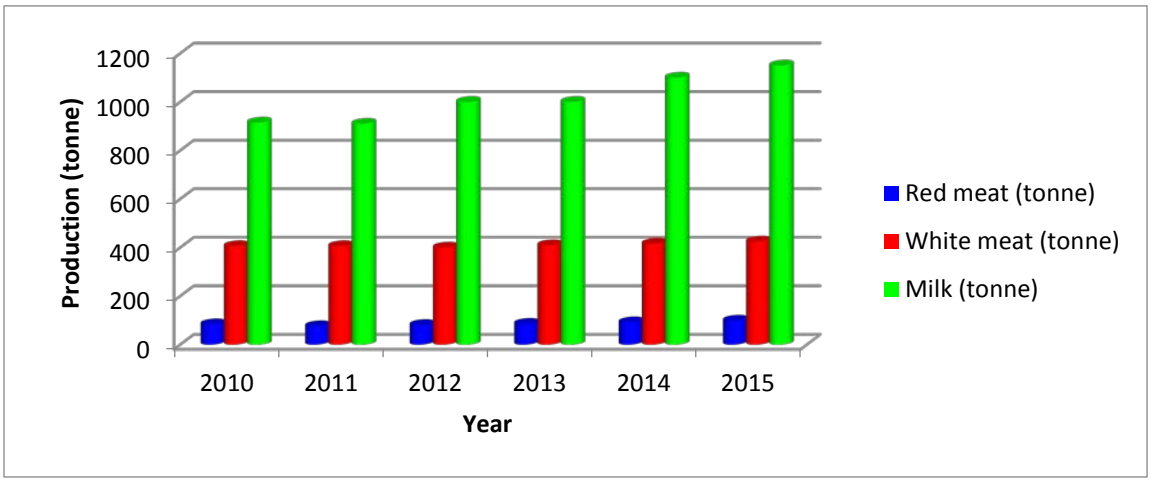


Figure 75 Evolution of meat production

4.4.3. Cultivated Crops

Plant crop production in the municipality of Monastir is based mainly on market gardening (i.e. vegetables to be sold on the market), which recorded a production of 4,432 tons in 2015. In contrast, tree production does not exceed 236 tons (2015) and fodder 57 tons. Production is almost stable between 2010 and 2015, with the exception of 2012, with 5,300 tons.

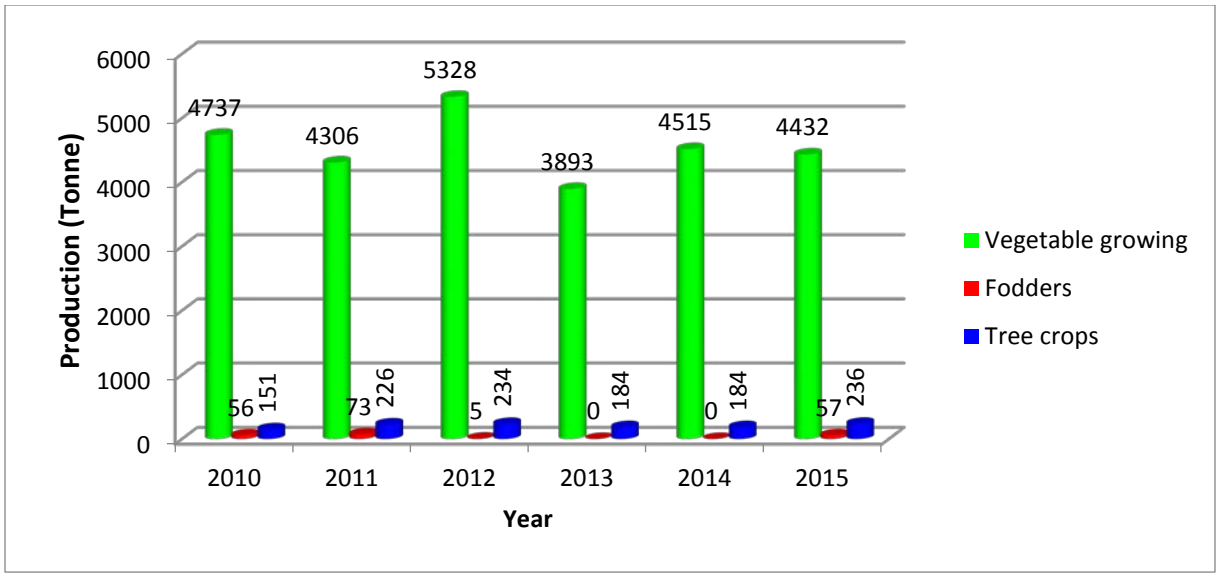


Figure 76 Evolution of vegetable production in the municipality of Monastir

4.4.4. Irrigation and Water Use Efficiency

The number of irrigated perimeters increased from 15 to 45 between 2010 and 2015 (**see Figures 77, 78, and 79**). Irrigated perimeters are unevenly distributed between the public and private sectors: in 2015, only 1 of 45 irrigated perimeters was public, and all the other (44) were private areas. The area of the public irrigated perimeters increased between 2010 (90 ha) and 2015 (124 ha). The cultivated areas represent 2/3 of the irrigable land. In the private sector, the use of irrigated areas has stopped since 2013. As in the case of the public sector, this is due to the scarcity of water resources, the very high cost and quality of groundwater resources.

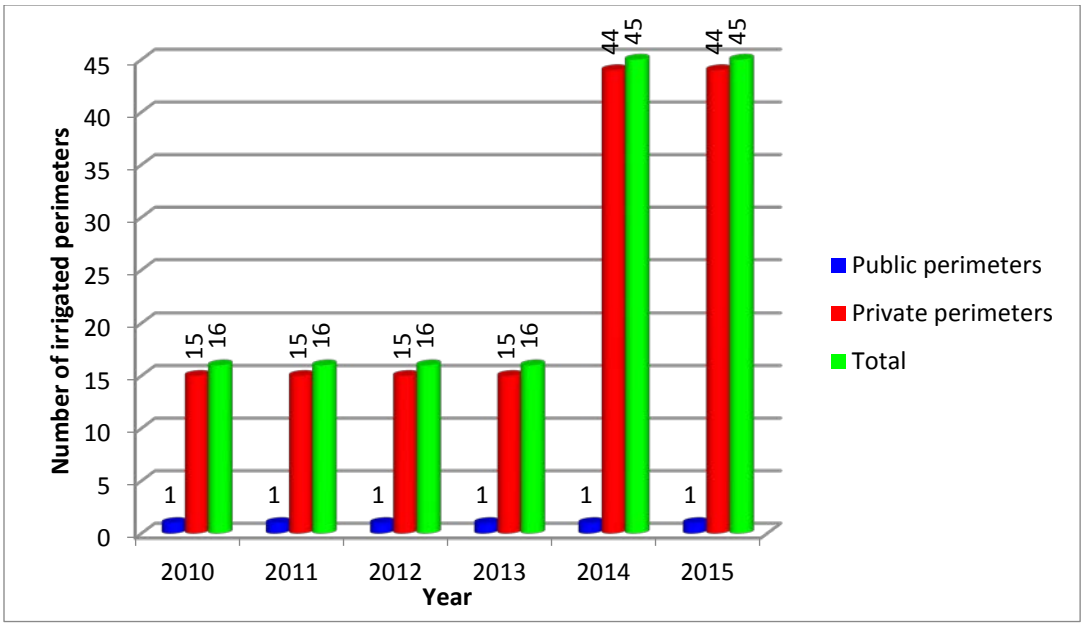


Figure 77 Evolution of the number of irrigated perimeters in the municipality of Monastir

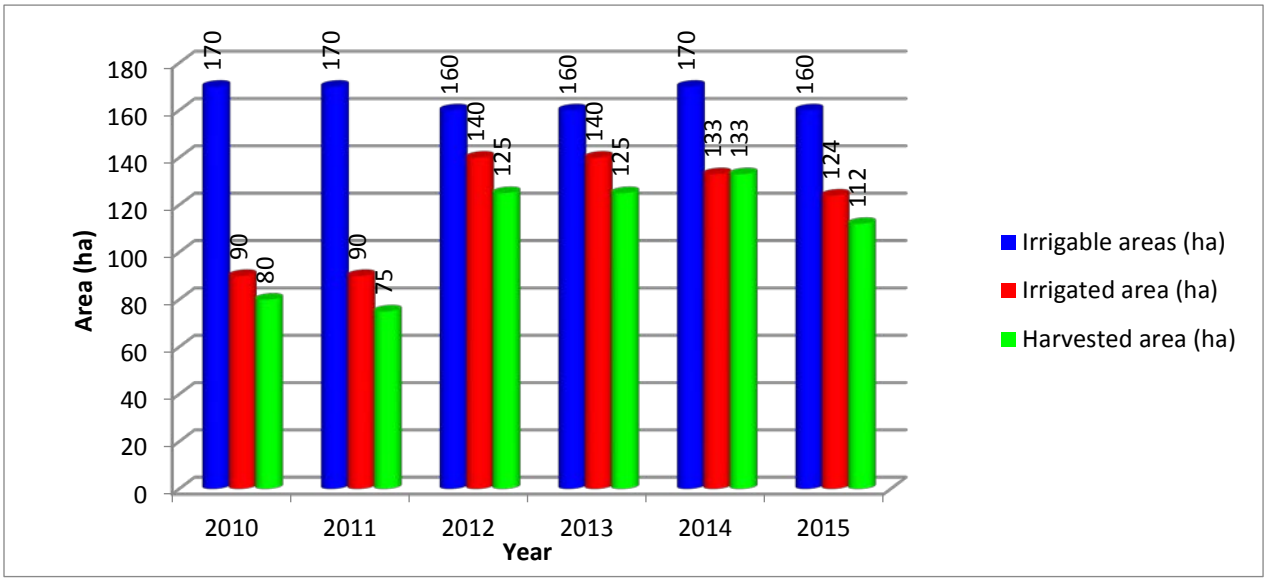


Figure 78 Evolution of public irrigated perimeters in the municipality of Monastir

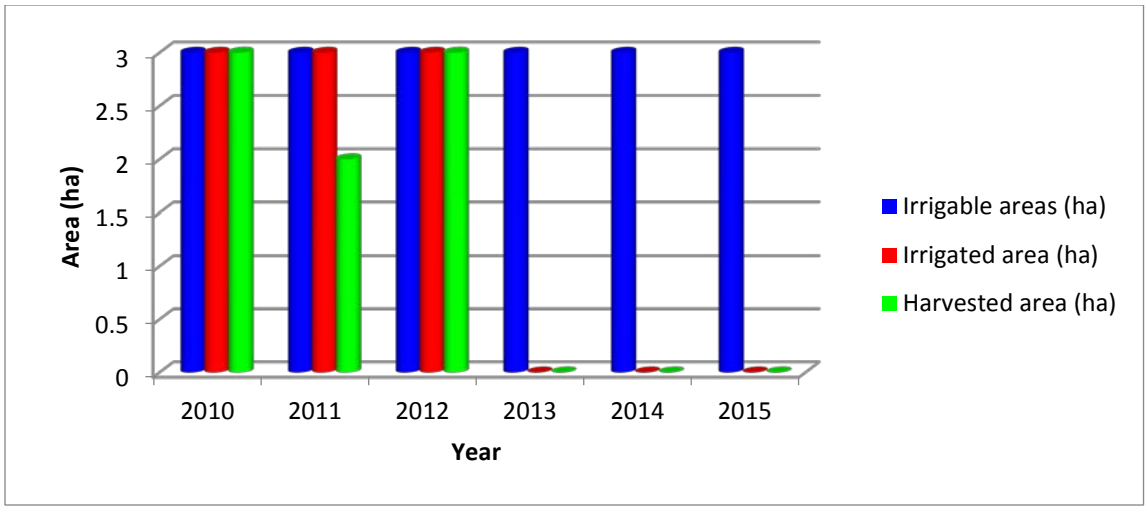


Figure 79 Evolution of private irrigated perimeters in the municipality of Monastir

5. ANALYSIS AND DISCUSSION

Despite severe limitations of data both at national and local levels that were available for this report, and the limited timeframe for this study, some observations can be made that will be helpful in determining practical opportunities for synergies between different sectors and interest groups to improve human well-being while not jeopardizing sustainable development.

First, potential opportunities for the NEXUS approach need to take the context of Tunesia into account. The Tunisian territory is unequally populated with 13 coastal governorates containing 65.3% of the total population with a high population density. This therefore puts more pressure on natural resources in these areas. With limited water resources of no more than 4,860 Mm^3/ year, of which 1,550 Mm^3/year are renewable, Tunesia's agriculture still uses the largest share of water resources in comparison to other sectors. The quantity and quality of water resources are degrading especially in coastal areas in southern Tunisia, with the increased presence of seawater intrusion and the overexploitation of groundwater which continues to increase from one year to the next.

Most of these challenges therefore directly impact the water situation. The Tunesian water supply is well below the poverty line and water scarcity threshold of 430m3 /year and there seems to be a geographical disparity in water availability (both quantity and quality). Coastal regions with high populations have low water supply ratios, while low-population regions get more than 70% of the water resources mobilized. This is further exasperated with strong governance centralization which shows its limits. Despite democratic transition, lack of government stability has prevented the development of a strategic vision of water policies, while strong social pressures have led to crisis rather than preventive management of the sector. However, forecasts have shown that by 2030 the balance between resource supply and demand in the different sectors will show a slight surplus, provided that efforts are continued to use brackish water desalination, recycle treated water, and to implement the water-saving policy in the agricultural sector.

The challenges facing Tunesia's water sector trickle down to the local level. In the Monastir governorate, poor water quality and low levels of groundwater resources is evident. The municipality of Monastir has two saline water tables that occupy the lowest reserves in the governorate. This situation is further aggravated in summer when the population in Monastir is multiplied by 3 or 4 times due to domestic tourism. Finding ways to solve the issue, the drinking water administration and the sanitation administration have increased water and sanitation tariffs several times after the Arab spring. However, no solid solutions and/or strategies are set in place to help solve the issue.

In agriculture, water and land use are occupied mainly by the urban area, and Sebkha course. Agricultural land accounts for only a small proportion of 15 to 20% due to the quality of soil. Water used for agriculture is usually taken from the Nebhana dam, which has dried out in 2016. This therefore leaves a total of 2.5 Mm3 of treated waste water to be used for commercial irrigation on golf courses (tourist area), municipal green areas, hotel gardens and irrigated perimeters. 8 sewage treatment plants provide 6Mm3 of the treated water and currently one waste water functional station, which drives liquid waste being discharged into the sea remain stagnant in an ejection zone which directly emphasizes the urgent necessity of upgrading the waste water treatment plant.

Possible interventions are suggested to help over-come these problems, which include a future strategy for water resources that integrates water security as a limiting factor in socio-economic development and the importance of groundwater as a strategic resource. Other suggested interventions include; upgrading the wastewater treatment plant and creating a groundwater monitoring system. The current situation post-revolutionary reconstruction however, offers a unique opportunity to reflect on the water governance framework and the role that private sector participation (PSP) can play as well in the development of the water sector. Due to the recasting of the legislative framework and the ongoing reflections on the country's new economic development models, an updated strategy on the water sector is needed therefore needed before the relevant choices are made.

6. CONCLUSION, RECOMMENDATIONS AND PROPOSED INTERVENTIONS

6.1. Recommendations and Conclusion

The water sector in Tunesia is facing urgent challenges, the most serious concerns being: severe shortages in the available water resources, ground water over-exploitation, and poor institutional management.

Accordingly, stakeholders recommended that the national water strategy be updated to include; the mobilization of non-conventional resources such as the desalination of seawater and the increased use of treated wastewater. It is also recommended to develop a new governance scheme for water operators which can help assist in decreasing financial burdens on the water sector. It was clear that investing in more complex studies are needed to help improve the advancement technology usage. Major water shortage challenges can be faced if a network for transferring water from northern Tunisia to southern Tunisia is upgraded.

Therefore, the proposed interventions as an outcome of this study, are mainly related to solving these issues and help enhance the situation in the case study area. Water and soil conservation techniques under a NEXUS approach can represent a pioneered solution for water problems in Monastir.

6.2. Proposed Interventions

6.2.1. Recovery of treated wastewater and improvement of the recharge of the Monastir groundwater table

The Frina station is the only STEP in the Monastir region and receives a significant amount of wastewater per day (13.21 Mm3 / year). It is based on secondary treatment of treated wastewater. These waters cannot be used in the irrigation of irrigated perimeters.

The proposed idea is either to use a tertiary treatment chain of treated wastewater instead of the secondary treatment currently used, or to realize a new treatment station for treated wastewater with tertiary treatment. In this case, good quality water will be provided, and instead of throwing it into the sea, it will be used in the irrigation of irrigated perimeters (El Omrane and SidiNassar), and in the irrigation of olive fields In the Monastir region. The advantages that can be gathered are:

- Wastewater valorisation

Improving the recharge of the Monastir groundwater, thus increasing water reserves, and reducing the salinity of groundwater, which, is currently between 3 g/l and 7 g / l,

- Protection of the sea and the coastal zone from pollution by poorly treated wastewater.

The improvement of vegetable production, mainly vegetables, which have been regressing in recent years, and olives. The production of olives, based on rainwater, is usually done once every two years or even once every three years. On the other hand, examples in other regions, such as Sidi Bouzid, Sfax, Kairouan, etc., have shown that irrigated olive trees can be harvested each year.

This project requires training cycles, for the various phases of tertiary treatment of wastewater, for the managers and staff of the National Office of Sanitation (ONAS). Theproject can therefore be led by National Office of Sanitation (ONAS) and the Municipality of Monastir, with assistance of CRDA.

6.2.2. Implementation of a pilot project for soilless cultures and a training center

The project aims to promote landless agriculture Hydroponic in Monastir, through the implementation of a pilot project, for the production of Green Fodders. This project will serve as a training center that targets farmers in Monastir to show them the whole process, feasibility and gain of this project that will be easier to produce on their farms. Landless crops often use little water and space and can also help develop urban gardening activities and encourage lifelong learning in adults.ToT sessions will be needed during the implementation of this project; the trained staff will lead the training for local farmers permanently after the implementation of the project

This project can be managed and implemented by URAP (Regional Union for Agriculture and Fisheries) and the " Children Voice " association. CRDA assistance is required.

6.2.3. Implementation of a Groundwater Monitoring Network

According to data provided by the CRDA of Monastir, the Monastir groundwater is not monitored (no monitoring piezometers). The idea is to install piezometers equipped with a multi-parameter probe for the monitoring of surface groundwater (water table fluctuation) and water quality (salinity and chemical elements). We propose piezometer by 5 km2.This project requires training for CRDA technicians to use specific software for the acquisition and processing of data supplied by piezometers.

This project can be managed and implemented by CRDA and Regional Union of Agriculture and Fisheries (URAP).

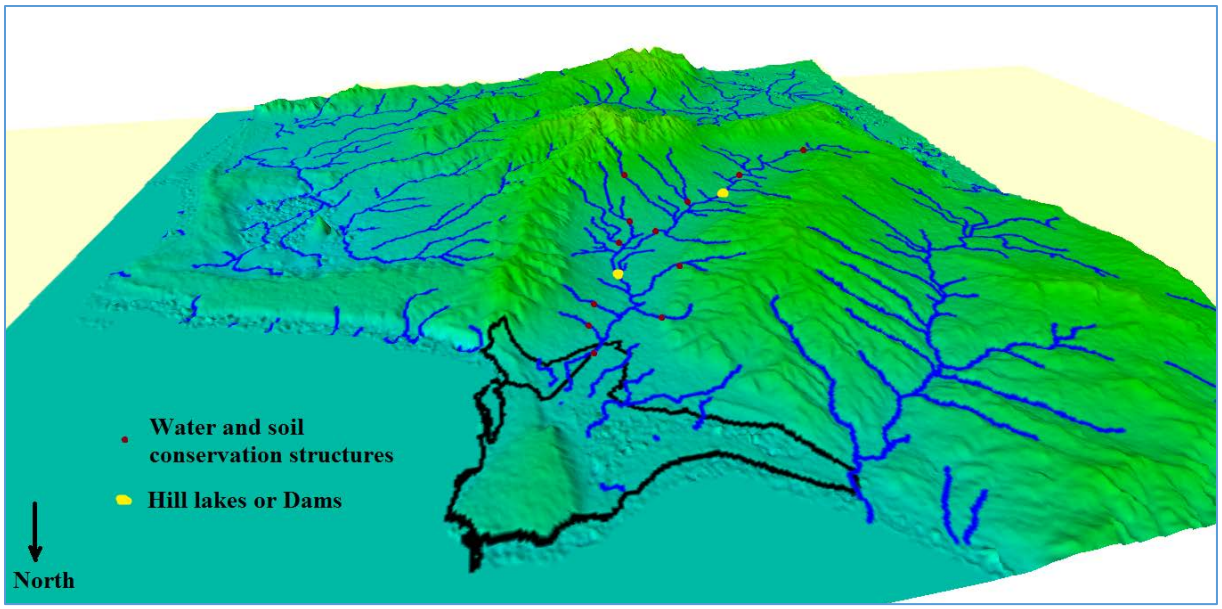
6.2.4. Water and soil conservation and protection of the Monastir city against flooding

The city of Monastir is characterized by average annual rainfall between 300 and 400 mm / year. However these rains can be in the form of very torrential downpours with significant rainfall amounts and in a very short period of time. This typically results in significant water erosion of the watersheds and strong transport from upstream to downstream and catastrophic flooding downstream and in the city of Monastir.

The idea of this project is to propose anti-erosive structures on the wadis located upstream of the watersheds, even outside the city of Monastir (which represents the outlet of these basins (in the regions of Bembla, Jammel and Zéramdine)). Thus we propose:

- Water and soil conservation structures, with gabions, concrete, dry stones ... ..), in the wadis bed, to fight against water erosion.
- The realization of the hill lakes

Indeed, Oued El Melah, which drains these regions, and originates from the hills of Zéramdine-BeniHassen, joins the Oued Khniss in the municipality of Monastir. This project can be managed and implemented by CRDA and DGF.



Map showing the proposed hill lakes or dams and the structures of water and soil conservation.

6.2.5. Greenhouse rain water Catchment system with water solar pumping Technics

The project aims to improve crop production, mainly vegetables. The catchment system, rainwater, with solar water pumping will replace the traditional greenhouse irrigation system and collect the necessary water on its roof. This technique reduces the consumption of water and electricity. This project is part of the national agricultural strategy. The government provides 50% of the project cost. URAP and CRDA, together with MINARET, can provide 25% and the farmer provides 25%. An actual capacity building program already exists for this project by CRDA and APIA. However, exposure and dissemination will be needed for replication.

The project can be managed by Municipality, URAP and assisted by CRDA and APIA

6.2.6. Rainwater harvesting tanks for use in municipal gardens and farmers

The proposed zone of project is near the sea port of Monastir. This location is known by the presence of wadis that drain rain water to the sea. This rainwater can be used by farmers during periods of high flooding, if large reservoirs are used to retain large quantities of rain. Waters must be treated before they are used in the irrigation of vegetables, since they are obtained by urban runoff (polluted by the infrastructure).

The cost of installing a rainwater collection system varies naturally depending on the amount of water we want to recover (the size of the tank varies its price), but also the use of the water A system designed to be connected to the home network is more complex and more costly than a system for irrigation or watering gardens.This project can be implemented and managed by the municipality.

6.2.7. Thermal solar systems for Greenhouses heating and agriculture

This project will upgrade the production and the profitability of greenhouses agriculture. Farmers will benefit from solar heating system to enhance their production during the cold season. The solar system will replace other energy resources and help to improve production and earnings. The project can be led by URAP, Municipality with assistance of CRDA. Awareness campaigns are needed for engaging local farmers.

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