Conflict/Synergy Among Different Uses on Land and at Sea and land-sea Interaction in Blue Growth

Tunisian scale

ENI CBCMED
Cooperating across borders in the Mediterranean

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Co-Evolve4BG

Analysis of Threats and Enabling Factors for Sustainable Tourism at Pilot Scale

Conflict/synergy and land sea interaction

Tunisian scale

INSTM

ANPE

Union for the Mediterranean
Union pour la Méditerranée
الاتحاد من أجل المتوسط

CPMR
CRPM

OVERVIEW

The present document was produced in the framework of **Co-Evolve4BG** project "*Co-evolution of coastal human activities & Med natural systems for sustainable tourism & Blue Growth in the Mediterranean*" in relation to Threats and Enabling Factors for maritime and coastal tourism development on a national scale" Co-funded by ENI CBC Med Program (Grant Agreement A_B.4.4_0075).

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REVIEW

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List of abbreviations

AFD	French Development Agency
ANPE	National Environmental Protection Agency
APAL	Coastal Protection and Planning Agency
AP	Action Plan
CC	Climate Change
CTN	Tunisian Navigation Company
DPH	Public Hydraulic Domain
DPM	Public Maritime Domain
EIA	Environmental Impact Assessment
GDF	General Direction of Forests
GDFA	General Direction of Fisheries and Aquaculture
ICZM	Integrated Coastal Zone Management
INS	National Institute of Statistics
INSTM	National Institute of Sea Sciences and Technologies
IWW	Industrial Wastewater
JICA	Japan International Cooperation Agency
KFW	Credit Institute for Reconstruction (Kreditanstalt für Wiederaufbau)
MIT	Tunisian Industry Ministry
MTD	Millions of Tunisian Dinar
MPD	Marine Public Domain
SD	Sustainable Development
SDG	Sustainable Development Goals
OMMP	Office of the Merchant Navy and Ports
ONAS	National Sanitation Office
NGO	Non-Governmental Organization
UNO	United Nations Organization

ONTT	Tunisian National Tourism Office
CSO	Civil Society Organizations
OTEDD	Tunisian Observatory for the Environment and Sustainable Development
MAP	Mediterranean Action Plan
MEA	Millennium Ecosystems Assessment
Co-Evolve4BG Project	Project of “Promoting the co-evolution of human activities and natural systems for the development of sustainable coastal and maritime tourism”.
MENA	Middle East and North Africa
METAP	Mediterranean Environment Technical Assistance Program
GDP	Gross Domestic Product
UNEP	United Nations Environment Program
SH	Stakeholders
TUNAC	Tunisian Accreditation Council
TWW	Treated Wastewater
CPP	Coastal Protection Program
PPP	Public Private Partnership
MSP	Maritime Spatial Planning
UE	European Union
UfM	Union for the Mediterranean
UC	European Commission
UICN	International Union for the Conservation of Nature
UTAP	Tunisian Union of Agriculture and Fisheries
RPA	Public Sanitation Network
SDAT	Tunisian Craft Development Company
SONEDE	National Water Exploitation and Distribution Company
STEG	Tunisian Electricity and Gas Company
STEP	Wastewater Treatment Plant
T&EF	Threats & Favorable Factors
WP3	Work Package Number 3

Abstract

The Mediterranean Sea is a biodiversity hotspot. Although it represents only 0.8% of the world's ocean surface, it is home to 7 – 8% of known marine species. It is subjected to strong pressures from human activity which is a source of various types of pollution; an estimated 80% of which comes from industrial emissions, municipal solid waste, and urban wastewater.

The preservation of the Mediterranean Sea is the subject of a growing regional concern and is a large part of the EU "Horizon 2020 program", which aims to reduce the various sources of anthropogenic pollution by 2020. Like the entire Mediterranean coastline, the Tunisian Mediterranean coast is not spared from the impacts of these sources of nuisance. Their extents and effects on the natural environment and the ecological state of the coasts and the sea depend directly on the interplay of conflicts and synergies between the various uses of the coastal zone and the sea. Finding the right equilibrium between these conflicts and synergies, and the resulting land-sea interactions, perfectly fulfils the principles of Blue Economy.

I. Introduction

The Tunisian coastline stretches over nearly 1300 km, including almost 600 km of sandy beaches. Generally, apart from a few very limited sites (30 to 40 km), this coastline is in a situation of regression, aggravated by exceptional and anthropoid phenomena. Indeed, the demographic and economic weight of the coastal regions has been increasingly clear since the beginning of the 20th century. Today, more than 70% of the socio-economic activities are concentrated on the coasts.

The French protectorate has centered economic activities, especially industrial and service activities, in the port cities and on the coastal fringe. Since then, the Tunisian economy has become extroverted. Following the independence of Tunisia, the new State has continued to develop the sectors of activities, relaying the economies of the former colonizing country, particularly through the development of tourism and industrial subcontracting.

In parallel with the evolution of the industrial sector, the coastal area has experienced a significant growth in its population, as well as impressive extensions, on occasion, of built-up areas and a concentration of infrastructures and services. After the many vicissitudes of the first half of the twentieth century, population growth, fueled by spectacular rural exodus, has become the rule in almost all coastal regions, especially since the 1970s. However, even areas long known for their migratory tradition, such as the Sahel, where the urban environment was centered on the city of Sousse until the advent of independence, are going to experience a reversal of this trend (INS, 1996).

More recently, seaside tourism has had remarkable effects in reinforcing the coastal-internal imbalance. Since the 1960s, mass seaside tourism has developed. Today, the Tunisian tourism sector offers a capacity of 237618 tourist beds, the majority of which are concentrated on the eastern coast. It is there that a series of sea-front hotels, aligned parallel to the shoreline, have been developed.

On the other hand, the coast is today the main tourist attraction with nearly 92% of tourist beds and industrial axis providing 85% of the manufacturing employment and harboring 94% of the establishments and sales. It is also the area with the highest standard of living and offers the most interesting conditions for innovation and dissemination of knowledge. Moreover, the concentration of economic activities and populations on the coast, which is a fragile area, is not without impact on the coastal environment. In this report, the aim is to study the conflicts/synergies between different uses of land and sea and the land-sea interactions with the perspective of developing a Blue Economy.

II. Coastal and Marine Domain: characteristics and impacts

The Tunisian coasts extend over a length of about 1300 km, showing characteristics that vary from one region to another. This results in a great variety of landscapes with topographical, geological, hydrological, climatic, and bio-ecological characteristics particular to one area or another (Figs. 1-3). This geomorphologic richness is marked by the presence of numerous coastal wetlands, numerous island areas, several beaches, and cliffs, making Tunisia one of the richest countries in terms of high-value coastal areas and seaside resorts.

In geomorphologic terms, the Tunisian coastline shows a clear opposition between the northern and eastern facades. The northern facade extends from the border with Algeria to the north-eastern tip of the Cap Bon peninsula. Its coast is framed by relatively large and rugged relief and the sea is often deep and rough. The course of this coast is often broken and rugged, thus individualizing a series of capes, some of which are particularly marked in morphology. The coast of the eastern facade, on the contrary, is framed by a weak topography and a gently sloping seabed. It is well sheltered from the winds, so that its waters are relatively calm. Its layout, even if it shows two large gulfs, the Gulf of Hammamet and the Gulf of Gabes as well as a certain number of capes and peninsulas. It remains clearly less cut out and less uneven than that of the northern facade. The morphology is overall well ventilated.

The low topography on the eastern side of the Tunisian coastline has also favored the extension of wetlands. The lagoons are thus more numerous than on the northern coast. They are found especially on the eastern coast of the Cap Bon peninsula, notably between Kelibia and Maamoura and towards the South of the country at Bhiret El Bibene. Sebkhas and Chotts are also very frequent and become very widespread. The coastal topography is weakest, such as in the Gulf of Hammamet, Mahdia, the Kerkennah islands, Djerba, in the different parts of the Gulf of Gabes and near the border with Libya. To the South of Chebba are added the maritime marshes favored by the importance of the tide which makes the originality of the Gulf of Gabes.

Figure 1. Geographic map of Tunisia

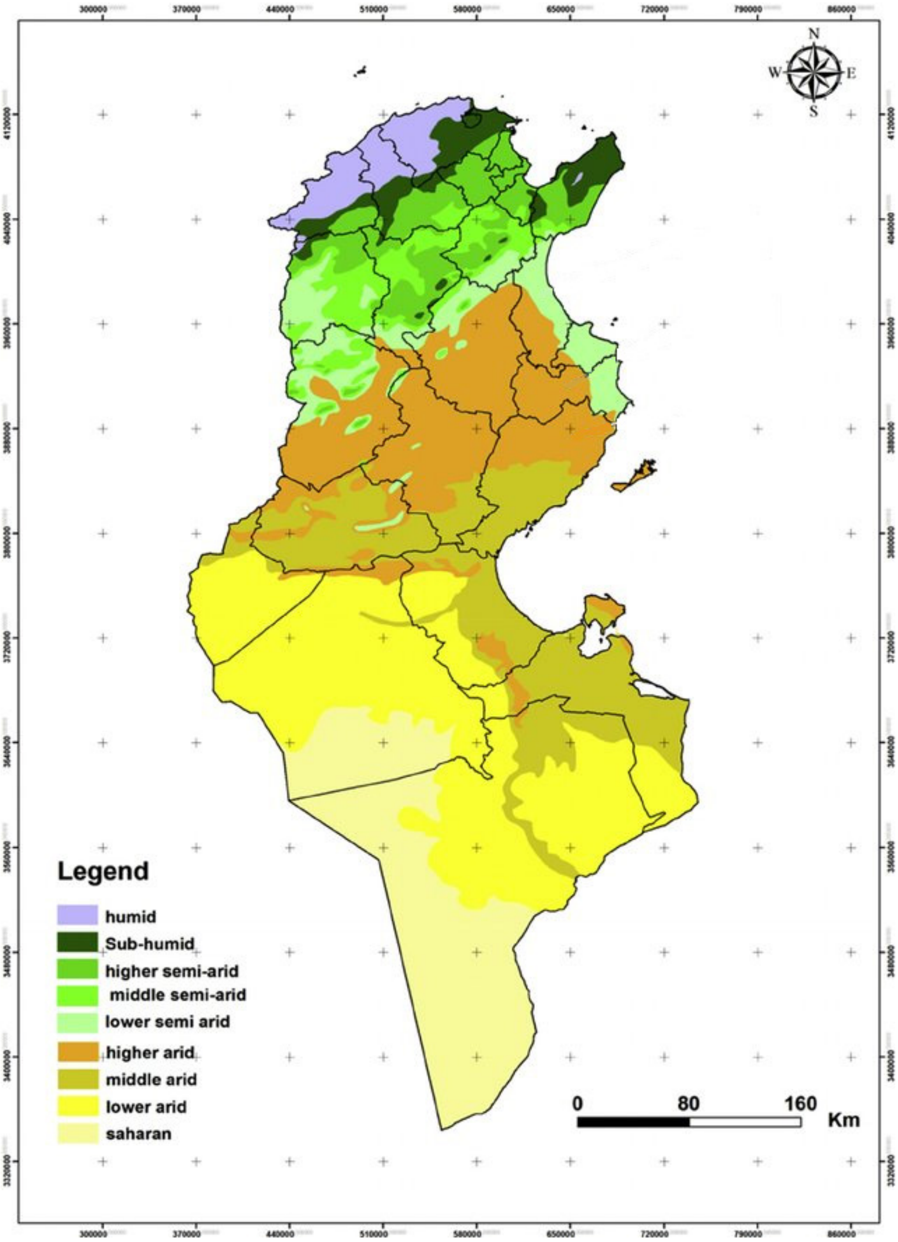


Figure 2. Bioclimatic map of Tunisia

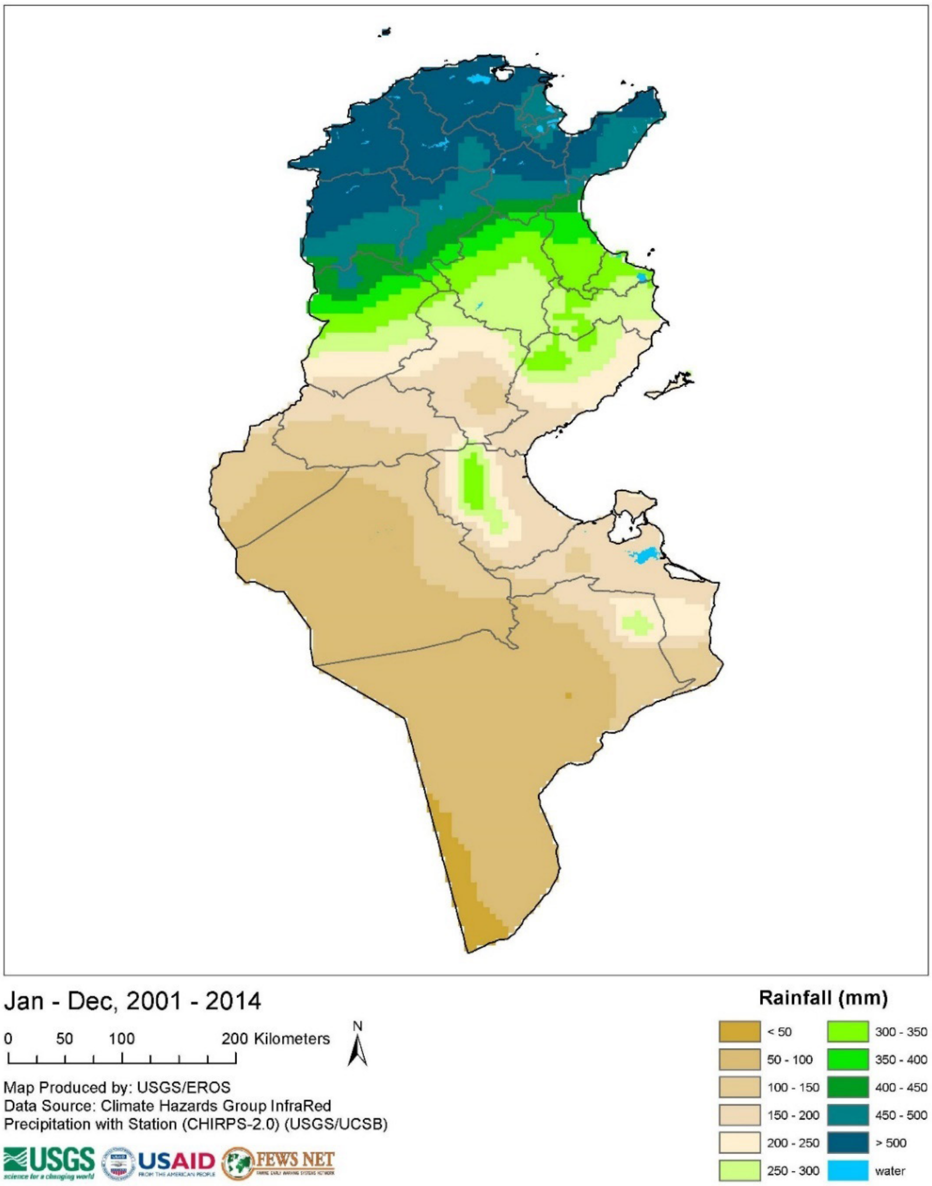


Figure 3. Rainfall map of Tunisia[1]

Tunisia's coastline is rich in a diverse mosaic of ecosystems and habitats. Whether on land or at sea, the Tunisian coastline is home to a very special biodiversity. Because seven major ecosystems representative of the Mediterranean can be found, either directly or nearby: coasts, islands, wetlands, mountains, steppes, desert, and oases.

1 USGS. Retrieved from https://earlywarning.usgs.gov/fews/product/287

III. Impacts of coastal use on the economic sectors

Among the impacts of coastal use on the economic sectors are those due to the effects of pollution and direct anthropogenic nuisances. The latter are the ones that weigh the most heavily on the functioning of ecosystems and habitats, their ecological states (*i.e.*, capacity to regenerate, resilience, capacity to dilute discharges and pollution from the continent) and their productivity (*i.e.*, capacity to generate natural resources). These impacts are also felt on natural wetlands (*e.g.*, lakes, lagoons, sebkhas, and wadi), habitats and ecosystems and on a multitude of economic sectors; particularly tourism (*e.g.*, degradation of habitats and the quality of bathing water, coastal erosion) and fishing (*e.g.*, degradation of ecosystems, drop in fish production).

Otherwise, with the effects of CC, beach erosion has been a problem since at least the beginning of the twentieth century. If today it has become better known and considered as a danger, it is mainly due to the multiplication of seafront developments that it threatens. Several permanent constructions, for example, especially those that appeared before the promulgation of the code of land use and urban planning, encroach on the public maritime domain, or occupy land with various natural risks (*i.e.*, flooding and erosion).

In addition to the development of mass seaside tourism, Tunisians who frequent the shores are more and more numerous and their seaside holidays are longer. To the forms of pressures due to the constructions of the seafronts are added those resulting from the behavior of summer visitors on the beach (*e.g.,* trampling and uprooting of the vegetation on the upper beach and dustbins), the impressive number of means of transport and equipment (*e.g.,* parasols, ice boxes, towels, and kitchen utensils).

III.1. Depletion of beach sediment budget

The depletion of beach sediment budget has been occurring in several ways. For instance, one way through which such beach impoverishment took place is associated to an increase in the number of physical obstacles in the natural longshore drift that has had the most direct effects.

Another long-standing practice that has only recently become prohibited is the removal of materials from beaches or the dunes that border them. For decades, however, it has contributed to the ruining of the foreshores of various coastal segments. Searching for sand at the seaside, especially for the needs of construction sites and sometimes even for large public works, was common practice in several coastal sectors, especially the oldest occupied ones, such as in the Bizerte region. The situation has changed, especially after the 1970s and the 1980s which saw an impressive acceleration in the development of the seaside due to the proliferation of tourist areas and the multiplication of second homes. The measures for the protection of beaches had not yet been really applied. In some areas, such as Djerba, the first-generation hotel units have been built, for the most part, from the sand of the beaches and their dunes.

Other obstacles are also likely to reduce the sediment supply to the shoreline. Because they maintain links and exchanges with a multitude of environments, beaches have seen their sediment budget affected even by developments located far from the sea. Reforestation and Water and Soil Conservation (WSC) works in the catchment area of the exoreic rivers have, despite their undeniable environmental values, disadvantaged various shores as the solid load of running water has been reduced. In some contexts, even limited quantities of sediment retained on slopes have had very significant effects on the shoreline. In Djerba, for example, the multiplication of plantations in the section of small hydrographic organisms installed on the slope break that dominates the Guellala-Fahmine agglomeration has had deplorable effects, particularly in marabout of Sidi Yati. Palm trees that were several meters from the shore, towards the end of the 1980s, have been caught up by the sea; some have disappeared, and others are regularly undermined by the waves.

It is also not uncommon to find that a whole part of the hydrographic network has been blurred and occupied by built-up areas or agricultural fields. Very expressive examples exist in the Skhira region and in the immediate hinterland of the tourist area, which is easily recognizable on various aerial photographs. In addition to the amputation of part of the sedimentary supply of the shoreline, this has increased the flooding risks. But it is above all the construction of dams on the Exoreic Rivers that exerts the most devastating impacts on sediment budgets of beaches. These structures have always trapped large volumes of sediment which generated each time difficulties, both upstream and downstream. The problem of siltation sometimes arose very quickly. The dams of Sidi Bou Baker, built in 1925 on Oued Meliane, are already totally silted up and have been abandoned for several years. Downstream, the shores have been deprived of some of the terrigenous materials that offered them vital sedimentary support. Thus, the silting of the Oued Chiba dam, on the eastern side of the Cap Bon peninsula, is estimated at 1093.7 m^3/year for a catchment area of only 64 km^2 (Abid, 1992). In the Gulf of Tunis alone, the hydraulic installations have led to an annual global sedimentary deficit for the shoreline of some 6.3 million tons.

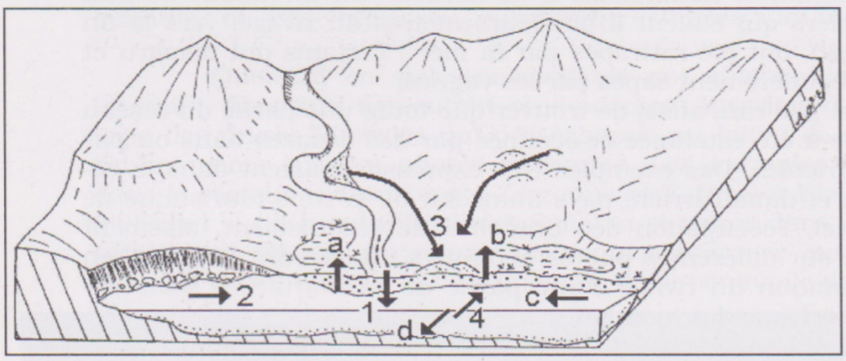


Fig. 32- Echanges sédimentaires entre une plage et les espaces qui l'encadrent.

-de 1 à 4- apport de sédiments à la plage ; 1-depuis le continent par un cours d'eau ; 2-depuis une côte à falaises, par la dérive littorale ; 3-depuis le continent, par le vent ; 4-depuis le large par les vagues et les courants marins.
-de a à d- départ de sédiments depuis la plage : a- vers une lagune littorale, par les vagues de tempêtes ; b-vers le continent, par le vent ; c-vers d'autres segments côtiers, par la dérive littorale ; d-vers le large par les courants marins.

Figure 4. Sedimentary exchanges between a beach and the surrounding areas (Oueslati, 2004)

From 1 to 4: sediment supply to the beach; 1-from the mainland by a stream; 2-from a cliff side by the littoral drift; 3-from the mainland by the wind; 4-from the open sea by waves and sea currents.

From a to d - departure of sediments from the beach: a-to a coastal lagoon by storm waves; b-towards the continent by the wind; c-towards other coastal segments by the littoral drift; d-out to sea, by sea currents.

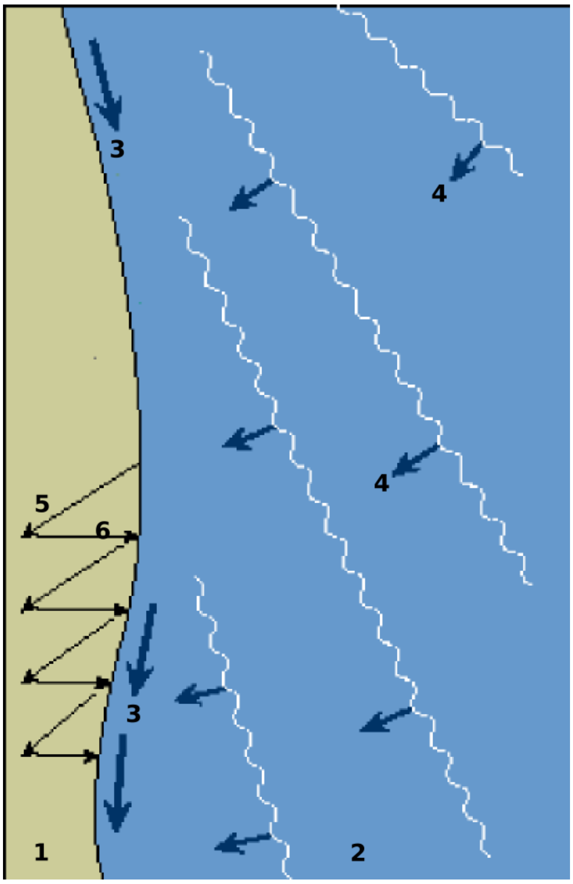


Figure 5. Long shore (Drift: 1=beach, 2=sea, 3=longshore current direction, 4=incoming waves, 5=swash, 6=backwash) (Johnson *et al.* 2017)

III.2. Sediment exchange disturbance between the different parts of the cross-sectional beach profile

The damage inflicted to beaches has very often come from the multiplication of built-up areas stuck to the shore. Building on the beach or even on its dune line amounts, in addition to fixing the coastline and thwarting sedimentary exchanges between the different parts of its transverse profile; exchanges which play a fundamental role in its balance. Nothing is significant other than the fact that almost all the sites having hosted major seafront developments have seen their beaches demarcated, sometimes to the point of disappearance.

Specialists in coastal geomorphology have repeatedly drawn attention to the fact that a beach is not limited to the only regular strip of sand on which bathers usually lie by the sea. It includes, in addition to this strip (called the lower beach), a part which is always covered by the marine waters (the fore beach) and another part called the upper beach. It can take the form of a bulge called a “border dune “ or “front-dune”, the construction of which often involves the simultaneous use of wind and waves.

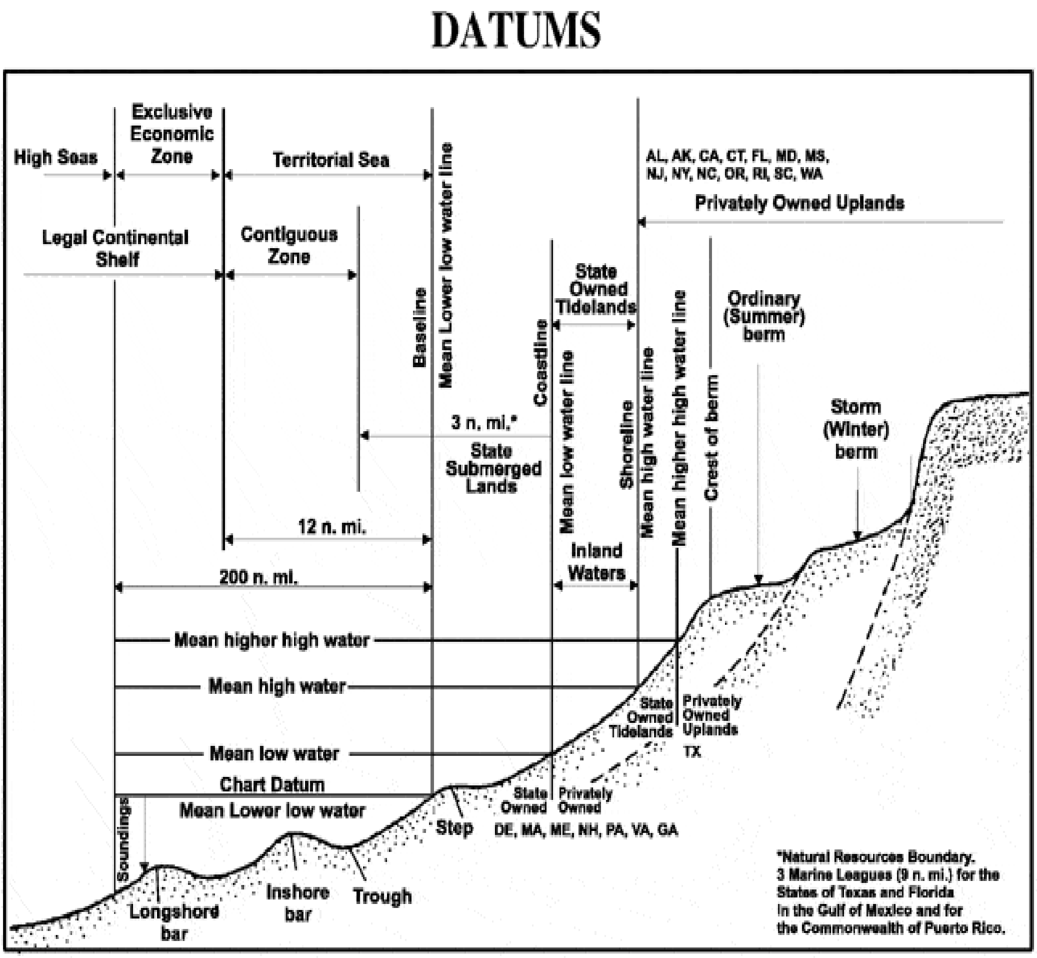


Figure 6. Principal tidal data related to a beach profile. The intersection of the tidal bangs with land determines the landward edge of a marine boundary

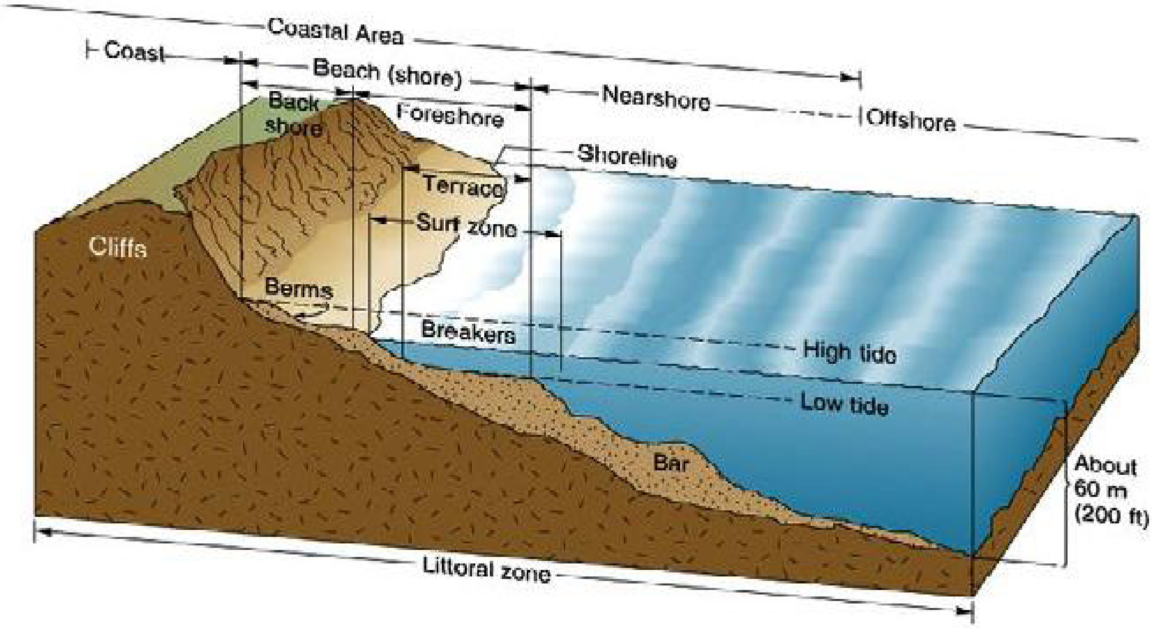


Figure 7. Diagram of zones of the shoreline (Johnson *et al.* 2017)

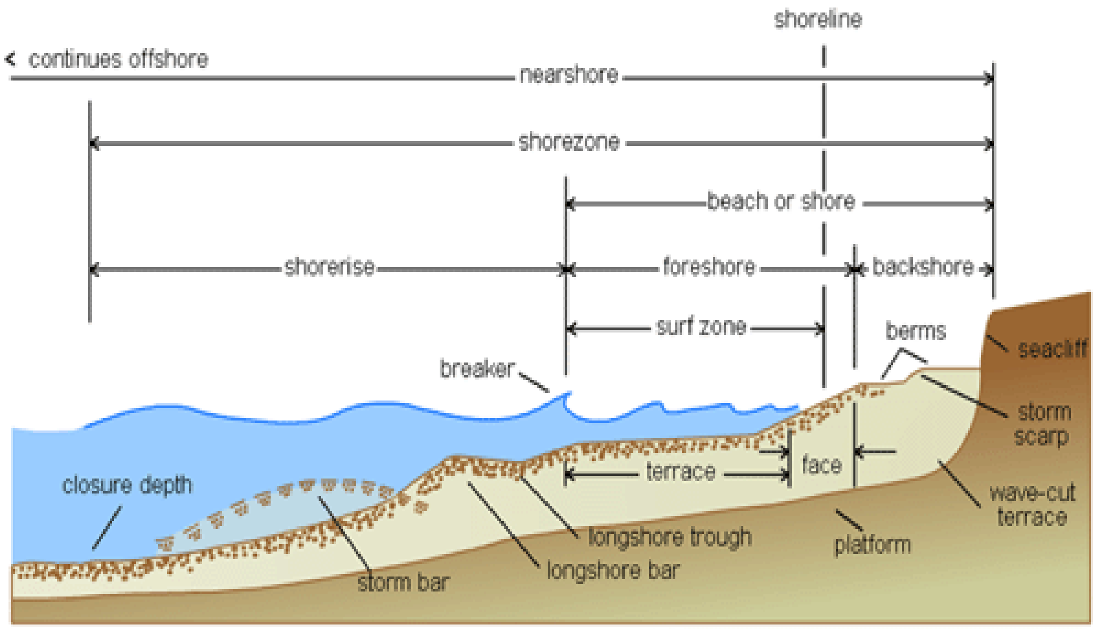


Figure 8. The different parts of a beach: most used terminology by geomorphologists in low-tide coastlines (Darsan *et al.* 2013)

III.3. Degradation of the quality of coastal waters

Shoreline degradation and the erosion of their beaches are also linked to pollution and various forms of mechanical destruction of marine flora and fauna. This is particularly the case of the Posidonia meadows which have been constantly retreating off different parts of the Tunisian coasts. However, when they are well developed and dense, they can, in addition to their biological properties, promote sedimentation and help limit the erosive action of marine waters. Indeed, by slowing down the progression of the waves they absorb their energy. Their disappearance leads to the opposite and favors a destabilization of the sediments on the seabed. This can in turn, compromise certain plant and animal species by reducing the clarity of the water. The reduction in the bioclastic fraction that results from all these changes has repercussions on the sediment budget of beaches.

III.4. Disruption of sediment transit along the shoreline

The main cause of such disruption is the obstacles put in place at sea. The Tunisian coastline now has many of them, of very varied nature and size. As the coastal drift current is very often monodirectional over large distances, these obstacles, even the smallest of them (*e.g.*, jetties, wharves and sewerage or rainwater drainage outlets) have sometimes had very apparent effects on sediment dynamics. However, it is the shore defense works (*e.g.*, groins and breakwaters) and above all the port facilities that have had the most serious consequences.

In fact, the issue has attracted attention quite early on, in Tunisia. Problems related to ports, for example, have started to be well known, especially in the literature on coastal geomorphology, since at least the beginning of the last quarter of the twentieth century. However, the number of port creations has only increased, sometimes in particularly sensitive sites which are very close to each other. There are already many types and vocations of ports: commercial ports, marinas, and fishing shelters. This evolution has certainly had beneficial effects in economic terms, but it has also generated various problems.

On the environmental level, which is most relevant to the current project, the most apparent consequences, or at least those on which the geomorphologic studies have focused the most, relate to the disruption of coastal sedimentary transit and changes in the position of the shoreline. The most recurrent pattern in the literature emphasizes the contrasting dynamics in the segments of shoreline bordering these developments. Depending on whether they are exposed to the current of the dominant littoral drift or are cut off from it, these segments experience progradation or erosion of their beaches.

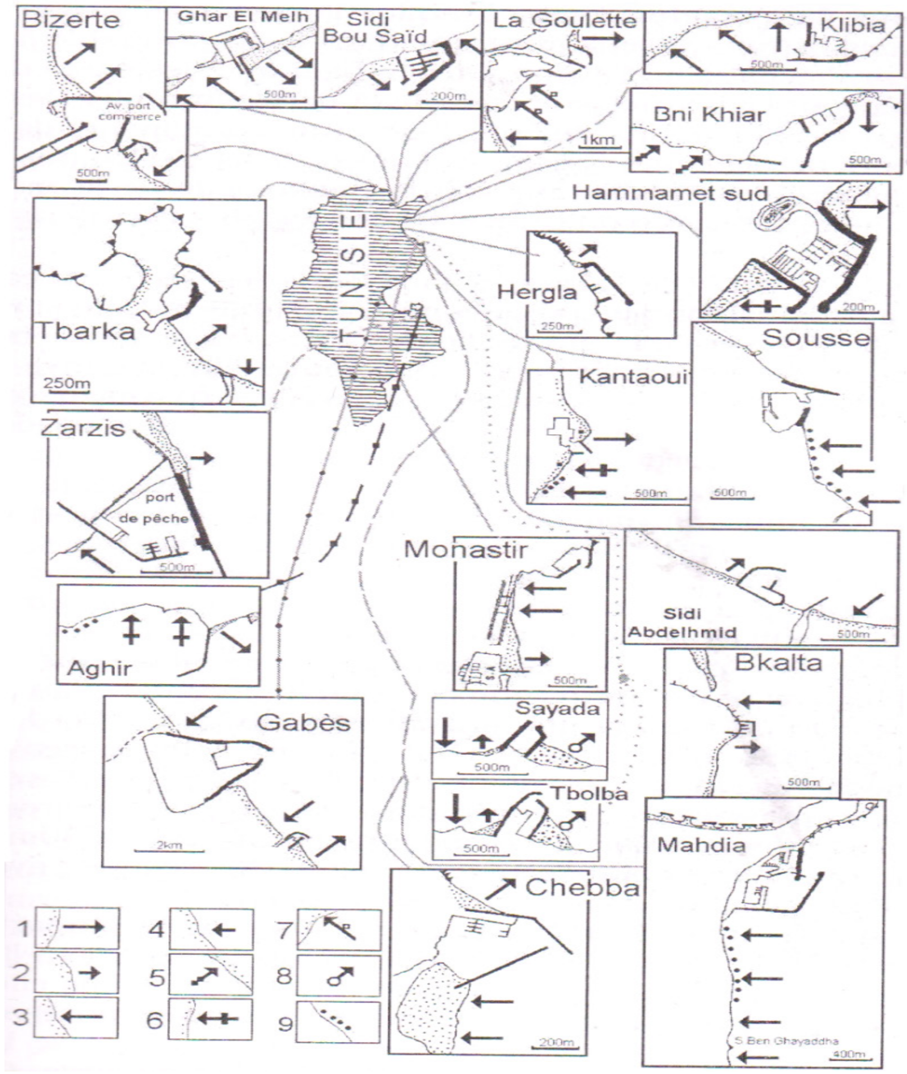


Figure 9. Sites through which we can better see the effects of port developments on the position of the shore (Oueslati, 2004)

IV. The impact of frequenting on coastal ecosystems

This section deals with the identification and description of the impacts derived from the use of a given site, in particular vulnerable sites and/or sites with landscape, natural (rich in biodiversity and natural resources) or cultural values. As well as the causes and consequences, both potential and proven, those manifest themselves in the natural environment and also on human populations whose health and safety may be affected.

In this way, the main impacts identified on site are related to the following phenomena:

- Coastal strip erosion.
- Coastal infrastructure.
- Anarchic urban sprawl and the destruction of habitats.
- Uncontrolled dumping of waste.
- The saturation of the facilities, caused by vehicles and users in some parts of the beach.

These phenomena have caused an impact on the forms and natural dynamics of coastal ecosystems. While the changes in the profile of the coastline seem to have a natural origin linked to marine dynamics, other findings can be attributed to anthropogenic reasons. Thus, in addition to tourism, both agriculture and fishing have contributed to its transformation, as have been reported in other sections of this report (Fig. 10).

IV.1. Induced beach erosion

Coastal erosion and retreat are most often linked to natural phenomena. However, in some coastal regions/areas, this erosion (*i.e.*, beaches oriented downwind of infrastructures like ports and dikes) leading to the retreat of the coastal strip is caused or accentuated by human action.

The morphology of the coastline is therefore very fragile and can often lead to major ecological changes in the back landscape and in the areas behind the coastline (*e.g.*, Lagoons, Sebkhas and Stretches of water and Wetlands). Particularly changes linked to the opening of the sea (maritimization or submersion and changes in the quality of the water in these areas), salinization of the soil and the coastal water tables, among others.

- The main actions linked to the erosion of beaches and more generally of coastal areas are:
- The presence of port infrastructures (sea dike).
- The presence of coastal developments (groins).
- The destruction of dune belts.
- The constructions on the coastal front.
- The massive circulation of vehicles and people on the beaches.
- Micro-erosion induced by bathers (in the case of resorts).

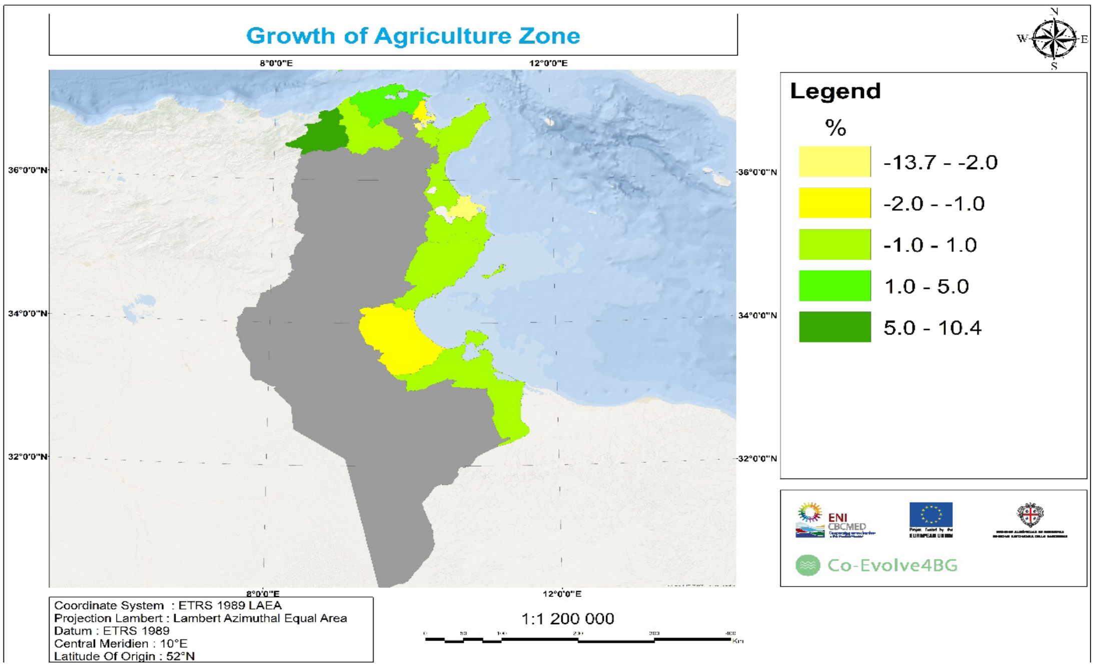


Figure 10. Growth of agriculture along the Tunisian coasts

Generally, the Tunisian coastal zones, in particular the beaches, also underwent the destruction of the dune belts, the main cause of which would be the destruction of land prior to urbanization, the installation of infrastructures or urban and leisure facilities. This destruction leads to the disappearance of native vegetation and habitats, as well as the sand storage function of the dunes and reduces protection against the effects of sea level rise or violent events such as storms. Under these conditions, and very often, beaches will be unable to recover their equilibrium profiles following marine erosion episodes, as they will lack sufficient sand to compensate for sediment losses. The anarchic mass constructions and urbanization of the coastal fringes, which often develop on the fringes of any thoughtful and programmed urban planning, very often give an anarchic appearance which considerably harms the landscape quality of the most coveted coastal areas.

In turn, the habitats and biocenoses close to coastal transit zones and lowlands will be affected by the various human aggressions and activities and will gradually disappear from the premises of the most important coastal traffic routes. Moreover, the mass traffic of vehicles and people on coastal areas with vegetation cover (*e.g.*, coastal wetlands) considerably increases fire risks.

Thus, parking vehicles on beaches and large seaside resorts is a serious problem. Indeed, a fairly large percentage of these spaces will be occupied by vehicles, causing traffic jams, hindering pedestrian traffic, blocking access of bathers and emergency vehicles to the sea and occupying a surface area that could be enjoyed by beach users. Waste is generated, the morphology of the beach is modified, soil is compressed due to the weight and maneuvers of vehicles and the visual impact on the landscape is quite heavy. It is a difficult problem as:

- The beach is the only space available for parking.
- In most cases, the public transport to the beaches is not organized.

Although to a lesser extent than vehicles, the movement of people is also responsible for the erosion of beaches, which morphology is also altered in certain regions of the country due to the involuntary extraction of sand that each user carries away. A study by Roig-Munar (2007) estimated the amount of sand that each user brings back from the beach at 33.64 grams. An amount that is only apparently infinitesimal since in one day on some very busy beaches (*i.e.,* Sidi El Mekki beaches); there is an average of 15,000 users (excluding peak days) with sand extraction of up to 504.6 kg/day. In the high season, multiplied by the number of days, the reached number and consequent sand extraction become significant.

IV.2. Beaches and marine water pollution

Numerous beaches of the Tunisian coastline are impacted by discharges of household waste, rubble, and construction debris particularly in the backshore, the dunes, and the back dunes. In addition, these sites are often the target of untreated wastewater discharges (failures of treatment plants and uncontrolled discharges of wastewater and black water). It should be noted that no official data on the type and degree of pollution of marine waters or beach sands are available. These aggressions are particularly observed in wetlands (*e.g.*, wadi, sebkhas, and lagoons). Therefore, no precise information can be provided in this respect. However, a certain level of contamination is likely, especially in sand, since, according to Oliveira and Mendes (1991; 1992)and Heaney *et al.*(2009; 2012), this is where pollution by bacteria and fecal pathogens is more concentrated than in seawater; the latter acting as a passive harbor of cumulative pollution.

IV.3. Destruction of natural ecosystems

The actions presented above, as well as the construction and the wild invasion of certain beaches and sectors of the Tunisian coastline, have led to the destruction, degradation and/or fragmentation of natural ecosystems. Thus, there are new types of hard constructions at the eastern end of the beach track, intended for a whole exploitation which is seaside tourism. Therefore, the morphology, the vegetation and the habitats of the dune barrier, the back fence and the beach have been severely and sometimes irreversibly disfigured. The destruction of the dune vegetation and the presence of exotic and nitrophyte species in the dune and back dune areas could be observed.

The Tunisian coastal ecosystem is currently experiencing a situation of extreme fragility, comprising only residual spaces. As part of the natural processes have ceased to function and their capacity for self-purification and natural recovery has been exceeded. Ecological vulnerability is very high and indigenous species are the ones particularly threatened.

IV.4. Landscape banalization

The attractiveness of the coastal fringe and its most coveted beaches is also spoiled by conditions linked to the loss of landscape quality. Concerning visual impacts, the presence of intrusive elements or elements that obstruct the visual fields should be noted. Moreover, the high urban human density, notably in some industrial sectors and ports, disrupts the sceneries of the coastal landscape. Today, the Tunisian coastline shelters, in several areas and regions, many elements breaking the scene particularly in both northern and eastern coasts.

IV.5. Artificialization of the barrier beach morphology

Today, the Mediterranean region is inscribed within a global context of climate change drivers, with Tunisia being one of its most impacted areas. One of the determining factors in the characterization of the various sub-drivers of such changes is marine dynamics. The latter is currently amplified by a phenomenon of coastal erosion generalized over the entire Tunisian coast. Thus, several sectors have been clearly identified, characterized by the predominance of erosive and sedimentary phenomena or by relative stability. In this respect, the APAL has carried out a general diagnosis of the entire Tunisian coast. It has identified regional and sectorial vulnerability to coastal erosion.

About the tourist use of beaches, in general, it can be argued that the pressure on the beach area manifests itself in situations of saturation and congestion caused by users, vehicles and recreational facilities. They also produce impacts on the morphology, dynamics, and functions of the ecosystems.

Respect of regulations concerning the DPM and the use of coastal space, including anarchic urban expansion and illegal construction, the treatment of solid and liquid waste and the conservation of protected areas have been blatantly ignored along the entire coastal fringe, especially during the last decade.

It can therefore be concluded that the Tunisian coastal fringe, particularly the beaches and the sectors most coveted by tourist and real estate projects, are currently an extremely vulnerable site. This is because of coastal instability, socio-economic tensions, and pressures, but also because of the contribution of anthropic impacts accumulated over the years and the pressure which is still exerted on this environment today. In the absence of vigorous regeneration measures and control of activities, there is a real risk of irreversible loss/degradation of this tourist resource with associated negative economic consequences. In view of global climate change, an integrated management of the coastal zone, within a framework of an ecosystem vision that considers the safety and health of users, is therefore necessary.

V. Identification of uses and impacts on the coastalarea

V.1. Impact on tourism

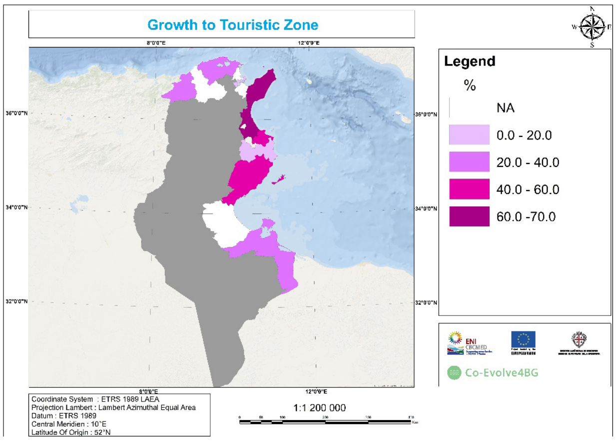
The different policies for the development of the tourism sector have had an impact on the evolution of the number of tourist beds. Developed especially after the 1970s, the tourism sector quickly became one of the pillars of the country's economy. Until 1965, the capacity of hotels was insignificant at 8,726 beds (SDAT, 1996). By 1995, it has already reached 142,500 beds. The number of visitors rose from 50,000 in 1962 to two million in 1985 and over 4 million in 1995. Thus, visitor units went, for the same dates, from 640,000 to 13.5 million and to 25 million (MEHAT, 1997). As of 2018, there were 237,618 beds and 8,299,000 non-resident tourists. To host the annual flux of tourist visitors, height marinas were built along the coasts of Tabarka, Bizerte, Sidi Bousaid, Yassmine-Hammamet, El Kantaoui, Cap-Monastir and Djerba. All these facilities will undoubtedly have an impact on the coastal environment.

According to the World Bank (2004), "tourist areas or resorts are not subject to any general regulations oriented towards the protection of the environment; criteria of density, height of buildings, size of hotel units, protection of developed or natural green spaces, *etc.*, remain at the discretion of developers. They, despite low acquisition cost land, maximize hopes of gains through high densities, far beyond the standards of the 1970s. The development model followed until now tends to be closer to the one that other Northern Mediterranean countries promoted in the 1950s (Costa Brava, Balearic Islands in Spain, and Languedoc coast in France) and which they have now abandoned.

Awareness of the poor risks-controlled development on the coast has led the Tunisian authorities to set up instruments for the provisional management of coastal areas, including:

- An inventory of coastal degradation, the development of protection, restoration, or rehabilitation actions (depending on the severity of the damage and the possibilities for intervention).
- Emergency operations (riprap) intended above all to protect adjoining structures (roads and residential areas).
- Drawing up a master plan for the development of sensitive coastal areas, intended to propose tolerable limits for development and occupation.
- The determination, in these plans, of priority sensitive areas which are the subject of management plans and the setting-up of protection perimeters, with reinforcement of land control on land under pressure.
- The design of plans for the beach's occupation in developed tourist areas as well as in areas of high weekend and summer use by residents.
- Pilot actions for the beaches regeneration and dunes that have been severely degraded.

Since the implementation of these programs, almost 80% of the coastline has been the subject of development documents considering the risks and fragilities of the environment. The conditions for intervention by the public authorities in the expropriation or purchase of land subject to strong urban pressure are determined for two thirds of the coastline. The inventories of the natural and cultural interests of coastal and lagoon areas are practically completed in the form of GIS or at least digital maps at appropriate scales.



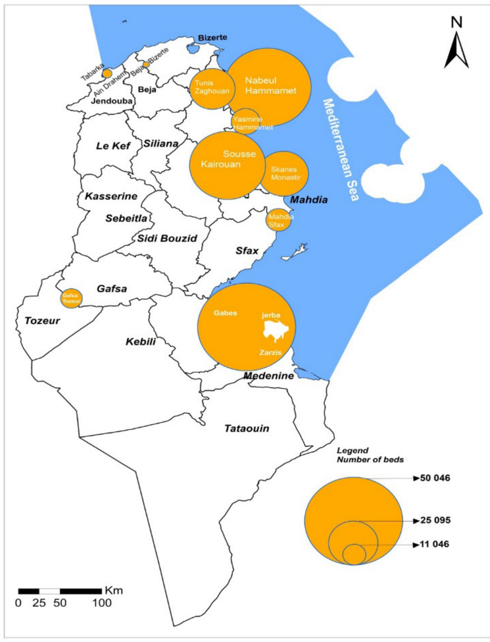


Figure 11. Growth of tourist areas established on the Tunisian coast

V.2. Industrial impacts on the coast and coastal zone

On the eve of independence, the working population in industry was estimated at 20,000 employees. Tunis had 12,000 to 13,000, or 2/3 of the national total. In the agro-food industry, for example, and apart from the crushing of olives in the Sahel and in Sfax and the fish canning industry (8 factories in Mahdia and 6 in Sousse), all the other enterprises are Tunisian. Concentration was also very strong for leather workers (7 tanneries in Tunis and 1 in Sfax) and the manufacturing of shoes (15 enterprises in Tunis and 2 in Sousse). In short, at that time, there was hardly any counterbalance in Tunis, since the mining conurbations in the West of the country, close to the Algerian borders, were confined to the extraction of phosphates or iron ore.

In parallel with the consolidation of the internal market and with a view to minimizing the danger resulting from an excessive concentration of the productive apparatus, especially in Tunis, in the 1960s, the State put in place a strategy aimed at promoting the industry. It is by the creation of development "poles" introducing a new spatial dimension and inscribing regional balance as an objective to be achieved. This involved essentially the creation of the National Cellulose Company in Kasserine (1960), the Tunisian Sugar Company in Kasserine (1961), the Phosphate Processing Company (NPK) in Sfax (1963), the Tunisian Refining Company in Bizerte (1964), the El Fouladh Company in Menzel Bourguiba (1964) and the Chemical Complex in Gabs (1952). The revisions of the industrial sector of Tunisia aimed at major economic shifts to achieve:

First, a driving force for economic development and this by:

- Increasing the share of industry in the GDP.
- Valorizing raw materials, if possible, on site, and transforming local products.
- Meeting the Tunisian market demand for manufactured products to decrease imports.
- Reducing unemployment by creating more jobs.

Secondly, a means of regionalization aimed at limiting the industrial concentration in Tunis, to reduce the macrocephaly of Tunis, by:

- Promoting two industrial "poles", one in the North in Bizerte-Menzel Bourguiba and the other in the South in Sfax.
- Diffusing the industry and development in the interior of the country through the creation of polarized industrial units, at Beja and Kasserine, for instance.
- Promoting the development of a new industrial center in Tunis, in order to reduce the macrocephaly within Tunis.
- Structuring of services through the creation of regional transport, trade, real estate, and other companies.

During the years 1963-1965, the country was covered by regional studies, with those of the Regional Development Units (URDs) constituting important and detailed monographs of the identifying, strengths, and weaknesses of each region (governorates) and sub-region (delegations) of the country. Moreover, the industrial fabric created during this period was not based on the development of inter-company subcontracting relations and the promotion of industrial integration. The industries of the 1960s therefore remained fragile and totally dependent on a very narrow domestic consumer market and an external market where competition was very fierce.

The liberal policy adopted by Tunisia since the 1970s has led to sustained industrial development with the creation of many small and medium-sized industries (SMIs) essentially in the coastal cities. They create a concentration of activities and aggravate the imbalance between the coast and the interior of the country and between the North and the South (Fig. 12).

From 1995 onwards, and in parallel with its policy of privatization and liberalization, the state aims to further develop the industrial fabric and to facilitate the integration of the

Tunisian economy into an international environment. Then, the State was led to sign a new cooperation agreement with the European Union providing for the establishment, in the long term, of a Free Trade Area (FTA). This trade association agreement (concluded on July 17th, 1995, and ratified in March 1998) is based on the principle of reciprocity and enshrines the free movement of goods in compliance with the provisions of the World Trade Organization (WTO). It excludes agricultural products and stipulates that "industrial products originating from both parties shall be reciprocally admitted for import free of customs duties and charges having equivalent effect and without quantitative restrictions or measures having equivalent effect.

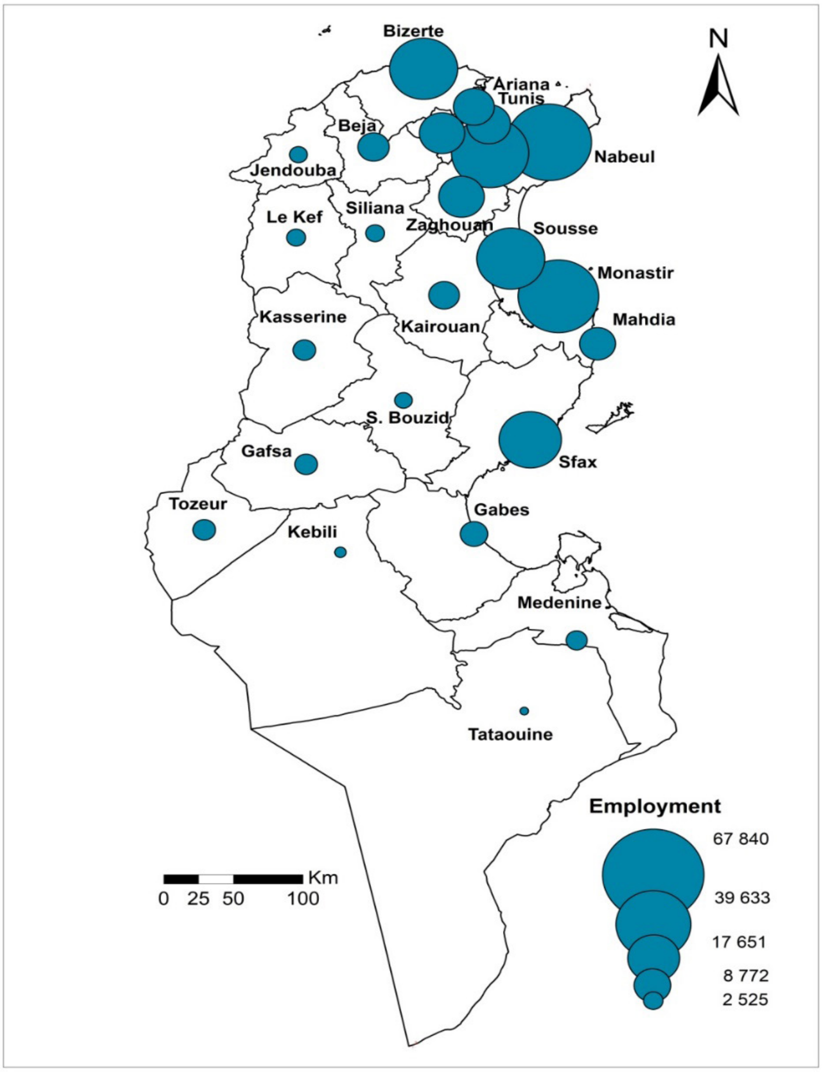


Figure 12. Geographical distribution of total industrial zone location and employment by governorate, 2010

Globalization requires an increasingly accentuated competition between Tunisian cities with the rest of the cities in the world, for the attraction of Foreign Direct Investments, raising and maintaining the competitiveness of Tunisian cities. They equipped some of them with logistics, platforms, and free zones; the Economic Activity Parks (EAPs).

In these EAPs, exclusive industrial plots are offered to companies that are totally export-oriented. The Bizerte (1993) and Zarzis (1994) EAPs offer industrial plots and premises, as well as various supplies to companies located in these parks, under special arrangements (tax, customs, and employment, among others). The companies operating the parks are mixed companies (public-private), with the following missions:

- The development of leased land.
- The promotion of the park.
- The assistance with the installation of companies those are located there, to become the sole point of contact, which gives a significant advantage.

The operating companies are also the park's trustees and are responsible for the maintenance and management of the common areas.

Companies operating and producing in the fields of technology and innovation can choose to set up in a techno park. Seven techno park projects have been planned for the 10th Plan (2001–2006). Only the El Ghazala techno park has been fully implemented. Two others, the one dedicated to the textile industry (Monastir-El Fejja) and the agro-food industry at Sidi Thabet, are placed under the supervision of the MITand are conceived as "competitiveness clusters" (techno park with large industrial areas managed by private companies). Companies operating and producing in the fields of technology and innovation can choose to set up in a techno park. The four most advanced techno park offer around 300 ha of industrial zones:

- Borj Cedria (88 ha): renewable energy, water, environment, and plant biology.
- Sidi Thabet (92 ha): biology and pharmaceutical industry.
- Sousse (60 ha): mechanics, electronics, information technology.
- Sfax (60 ha): information and communication technology (ICT) and multimedia.

Today, the only existing industrial space developed by a private developer and put up for sale is the district of Enfidha, located about thirty kilometers from the city of Sousse, which was developed by an Italian company, DIET and is currently being marketed. The objective was to create a district to European standard, close to the site selected for the deep-water port project and the new international airport in Enfidha. The company has already developed the first 50 ha of high-quality land.

Today, the industrial fabric of Tunisia counts 5,331 companies with a workforce of 10 or more, of which 2,350 are totally exporters (Table 1). Therefore, companies with a workforce of 10 or more employ 526,789 people.

Table 1. Industrial enterprises in Tunisia in 2020[2]

Sector	Totally exporters	Others	Total	%
Food industries	214	875	1,089	20.4
Building materials, Ceramics and glass industries	19	395	414	7.8
Mechanical and metallurgical industries	187	448	635	11.9
Mechanical, Electronic and household appliance industries	226	113	339	6.4
Chemical industries	139	423	562	10.5
Textile and clothing industries	1,311	286	1,597	30.0
WoodCorkand furniture industry	17	167	184	3.5
Leather and footwear industries	165	63	228	4.3
Various industries	72	211	283	5.3
Total	2,350	2,981	5,331	100

2 Tunisieindustrie. Retrieved from http://www.tunisieindustrie.nat.tn/fr/tissu.asp

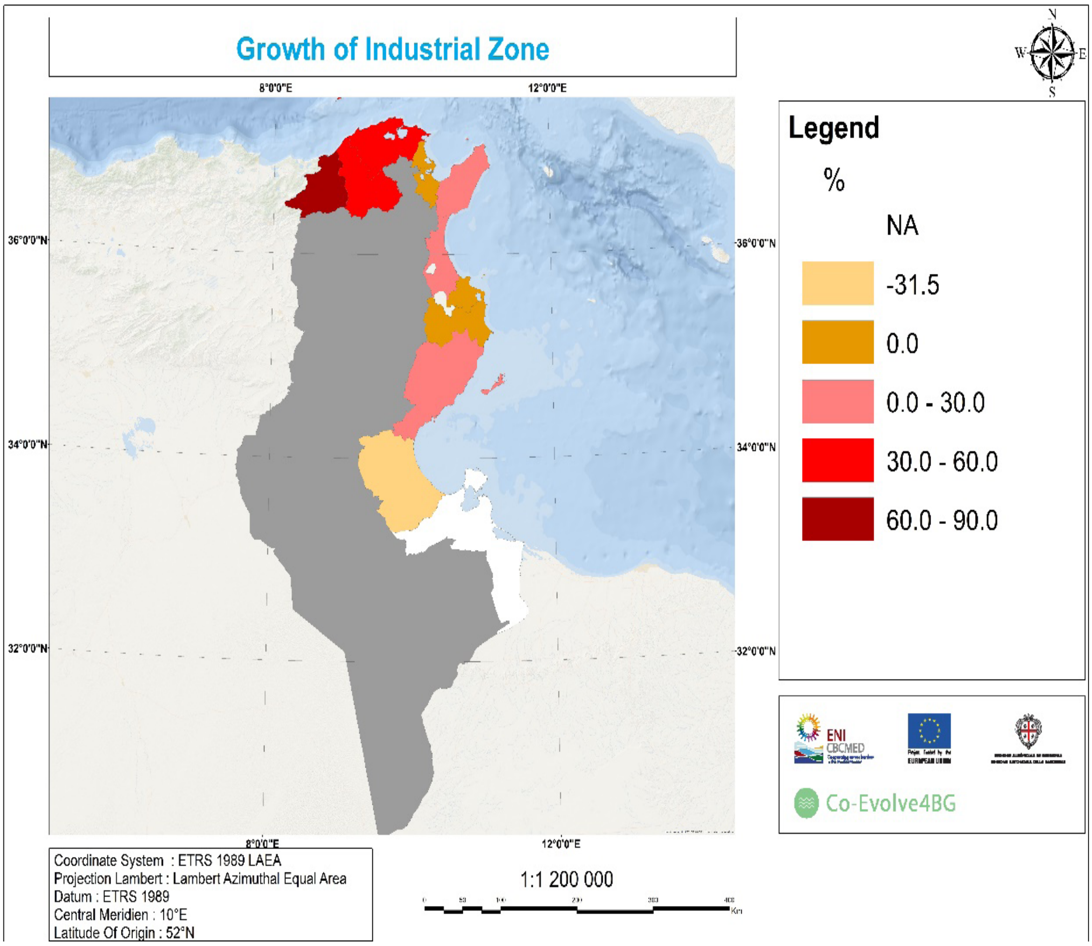


Figure 13. Growth of industrial zones along the Tunisian coasts

Despite the evolution of the industrial development policy in Tunisia, the industries in Tunisia remain a manifest and have an impact on the natural environment. According to the ANPE (2007), “industrial growth is proving incompatible with the requirements of sustainable development in its environmental component. Indeed, the latter has generally been little integrated into the approach of Tunisian industrialists”.

The ANPE (2007)considers that “the recommendations of these impact studies are sometimes not followed up and are not applied, due to a lack of sufficient means at the level of institutional control as well as a lack of human and financial resources at the level of the industries concerned. This is why, to date, the negative impacts of certain branches of industry remain and have sometimes worsened, due to a lack of timely action. Even if the Tunisian industrial fabric composed largely of subcontracting activities, is not very polluting. It does not prevent certain activities from having a negative impact on the environment”.

Until 2007, it is estimated that nearly 9,500 industrial companies were registered in Tunisia, including 5,468 with more than 10 jobs. The number of those considered to be polluting is not known precisely. Thus, in the documents of the Ministry in charge of the environment, it is estimated that 1,200 companies are polluting.

The ONAS for its part has sent a cadaster for Tunisian companies, but which covers various sectors such as industry, laundries, and service stations (petrol). Compared to this cadaster which includes 6,000 enterprises, 1,090 have been identified by the ONAS as polluting.

In collaboration with the ONAS services, ANPE (2007) attempted to characterize the degree of water pollution of these companies in greater detail. This is by setting 3 levels corresponding to the degree of pollution of their discharges and by identifying the number of companies in each of these levels, as follows:

- For discharges twice the standard, there are 230 companies.
- For discharges between 1.5 times and 2 times the standard, there are 200 companies.
- For discharges between 1 and 1.5 times the standard, there are 270 companies.

Thus, the ANPE (2007) estimates that, despite the approximation inherent in the method used, the number of highly polluting industrial companies can be estimated at around 400, of which between 200 and 250 are particularly polluting. Generally, these companies are responsible for several forms of air, water, or soil contamination. Some are responsible for the disturbance of the ecological system such as that of the littoral of Sfax and Gabes.

According to the European Commission (2013), the Gulf of Gabes is listed among the "pollution hot spots" of the Mediterranean, as it is one of the regions most impacted by polluting industries. Indeed, its industries are at the origin of a marked environmental degradation for man and ecosystems. Since the beginning of the 1970s, the phosphate transformation units of the Tunisian Chemical Group (GCT), installed in the industrial zone of Gabes, have been discharging into the sea every year about 5 million tons of polluting discharge: phosphogypsum. This material is a by-product of the production of phosphoric acid. The presence of phosphogypsum in the marine environment has strongly altered the ecosystems in the vicinity of the industrial zone. The effect on fishing production is obvious, even though the Gulf of Gabes has long been one of the main breeding grounds for several varieties of fish species and sea products (see below).

In addition to the impacts of phosphogypsum on the marine environment, the chemical industries of Gabes are responsible for atmospheric pollution, which has been controlled since the GCT began to make investments to reduce emissions. The atmospheric pollution directly impacts human health and the neighboring oasis agriculture, which has long been one of the most famous virtues of Gabes.

Other industries contribute to aggravating the situation. Among these are the fluorine chemical industries (ALKIMIA group, ICF), the ONAS wastewater treatment plant, the STEG power plant and the Gabes water desalination plant.

The water used in industrial processes is, in many cases, discharged into the natural environment, particularly into rivers that flow directly into the sea with a significant load of harmful agents.

The most common problems related to water discharges are those linked to the malfunctioning of treatment plants. Thus, when such treatment plants exist, they are designed to treat either a less polluting load or a lower flow rate. This is what leads to non-compliance of discharges with the standard NT106 002 (ANPE, 2007).

According to the ANPE (2007), the following examples are among the best known in Tunisia and are still awaiting a definitive solution:

- Tanneries discharging nearly 2,500 m3/day of water loaded with chromium, sulfide and solids suspended particulates.
- Liquid waste from the textile sector is estimated at about 250000 m3, of which 65% is discharged through the national network of ONAS and the rest into streams and rivers. These quantities are rejected by companies specialized in finishing. These liquid discharges represent a serious environmental problem given the dyes and suspended matter they contain.

VI. Maritime activities and impacts

The Tunisian coastline is indeed the site of a strong urban and industrial concentration. Almost all the Tunisian industry is located on the coastal fringe. Heavy industries as well as the most important power stations are, in their great majority, concentrated on the coast or on lakes in communication with the sea with direct contributions to pollution (Gabes, Menzel-Bourguiba, Bizerte, La Goulette-Rades and Sousse).

This state of localized artificialization of the shores, which does not respect the requirements of the environment, combined with exceptional meteorological phenomena, has caused significant coastal pollution, pronounced in certain localities.

VI.1. Fishing

The fishing sector occupies a primordial place in Tunisia at the socio-economic level. It is an activity largely anchored in the Tunisian culture and traditions and more particularly among the coastal populations.

Fishery products contribute to the protein diet of a large part of the population. On average, Tunisians consume 11 kg of seafood per year. Around 100,000 Tunisians live directly or indirectly from fishing and aquaculture activities. Fishing constitutes the main social and economic backbone of several localities and regions of the country.

Fishing is a very old activity on the Tunisian coast. Nowadays, it is practiced in accordance with article 4 of chapter two, reserved to the organization of the fishing effort, of the Decree of the Minister of Agriculture of September 28th, 1995, regulating the exercise of fishing, which subdivides the Tunisian maritime areas into three fishing zones delimited as follows:

- The northern zone, located between Kelibia and the Algerian border, is characterized by a relatively pristine, deep, and often turbulent sea and is recognized as being under-exploited.
- The eastern zone, located between Kelibia and the town of la Chebba, essentially the gulf of Hammamet, recognized as being moderately exploited.
- The Southern zone of La Chebba up to the Libyan border, marked by a very extensive continental shelf, a calm sea and an important tide, originally very rich in fish. This is the domain of the Gulf of Gabes, recognized as being largely over-exploited.

To balance an increasingly sustained fishing effort and growing pressure on fishery resources, the public authorities have been pursuing a policy of developing aquaculture in Tunisia for more than thirty years. Annual production in this domain has not ceased to evolve, it is currently close to 22,000 tons/year (GDFA, 2017), so a little less than 20% of national production.

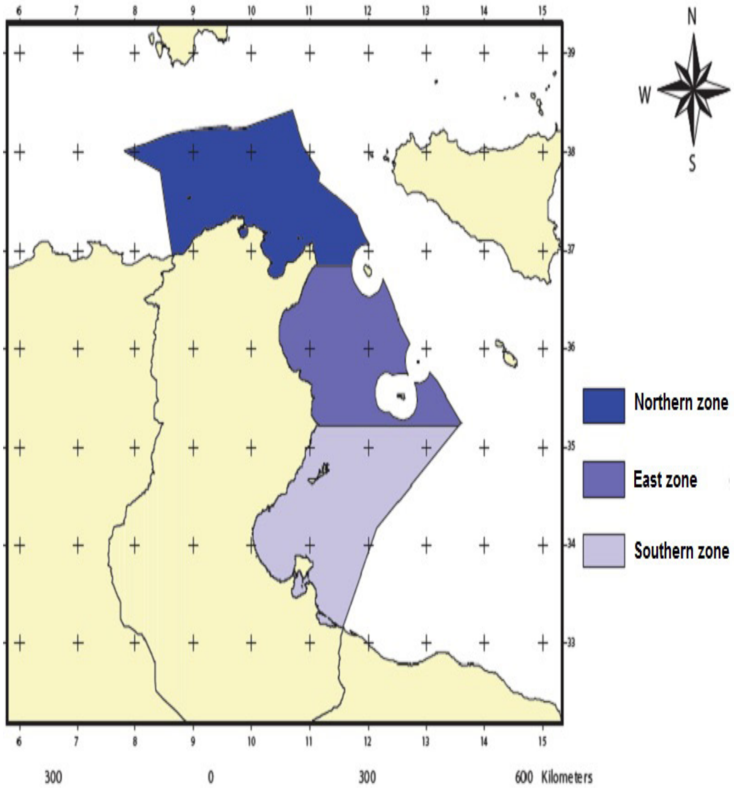


Figure 14. Geographical delimitation of fishing areas in Tunisian waters

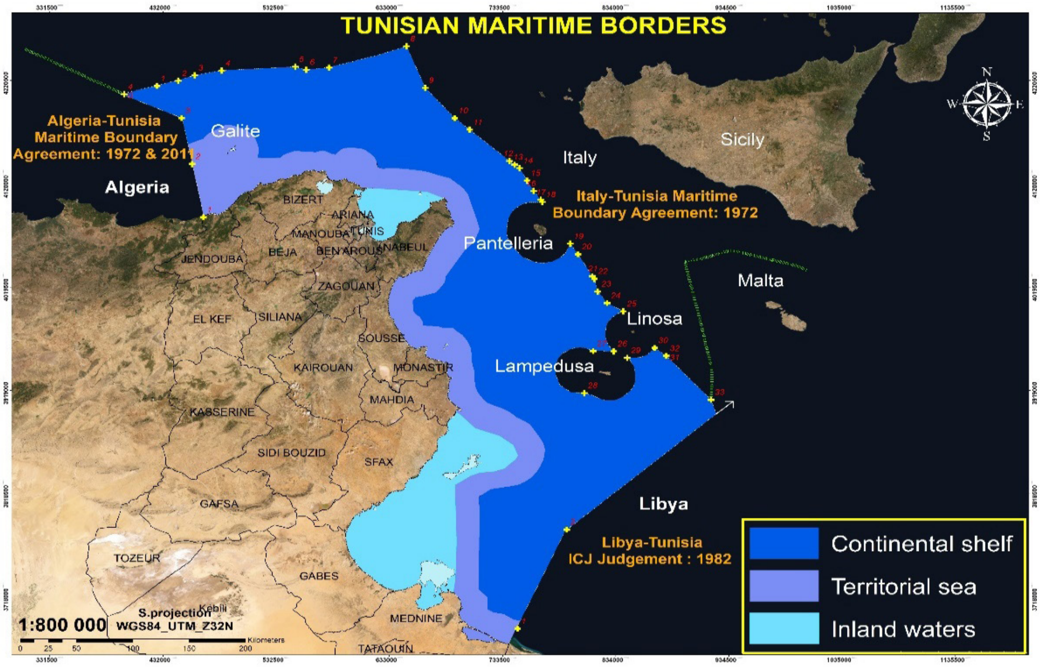


Figure 15. Map of regulatory Tunisian fishing areas

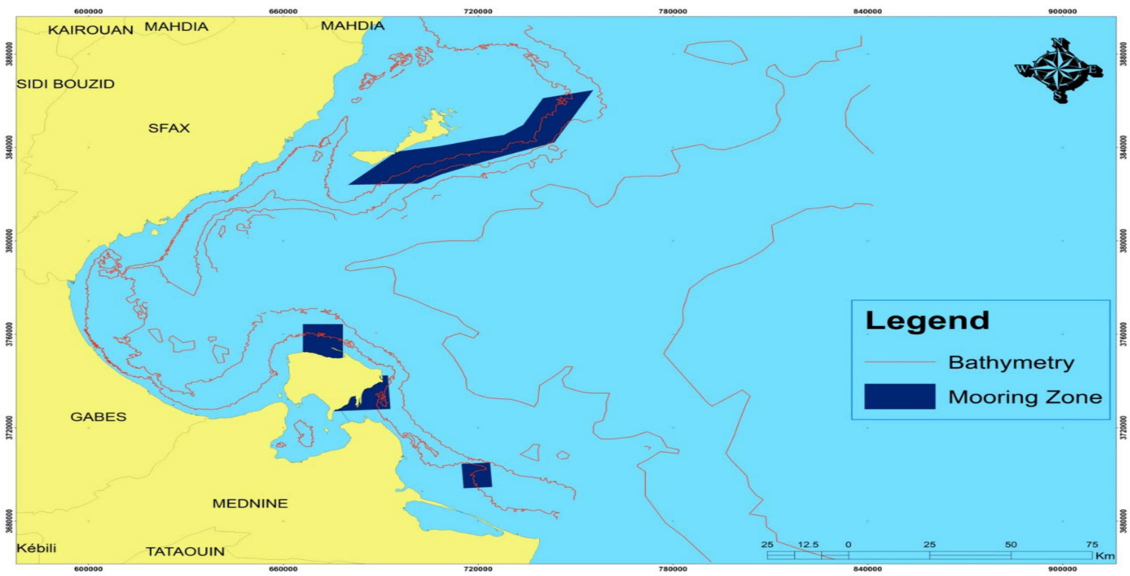


Figure 16. Map of mooring areas for trawlers operating in the Gulf of Gabes

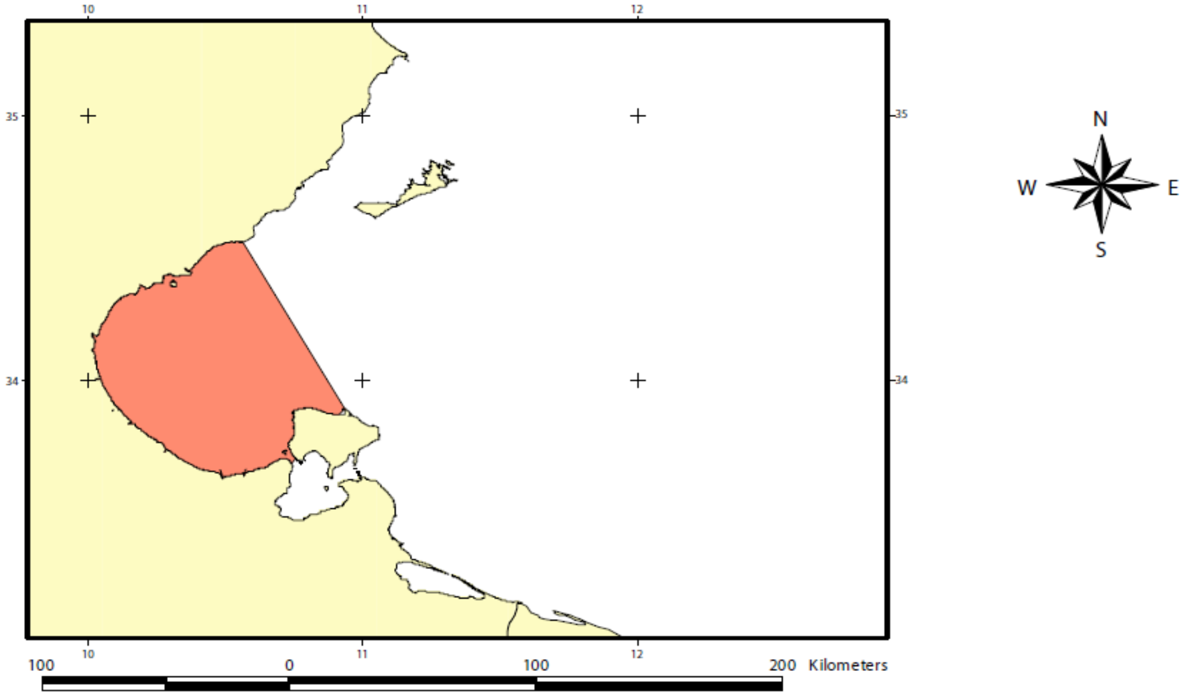


Figure 17. Map of the area with no access to navigation for trawlers

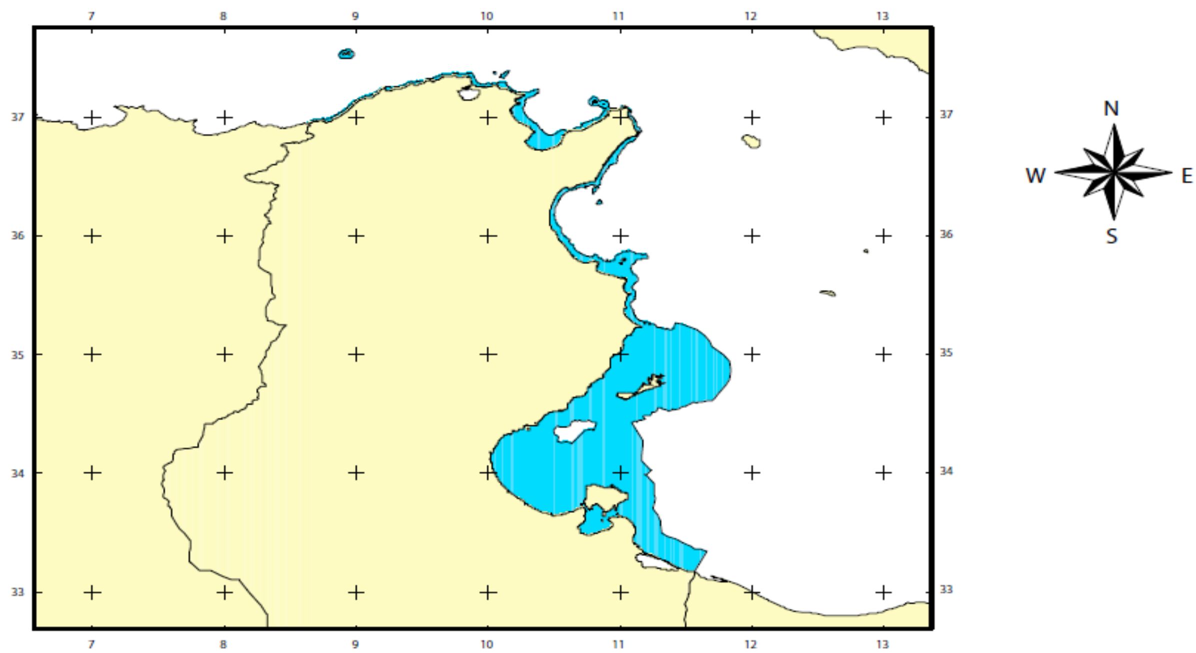


Figure 18. Map of prohibited access areas for light fishing (purse seiner using light and night fishing)

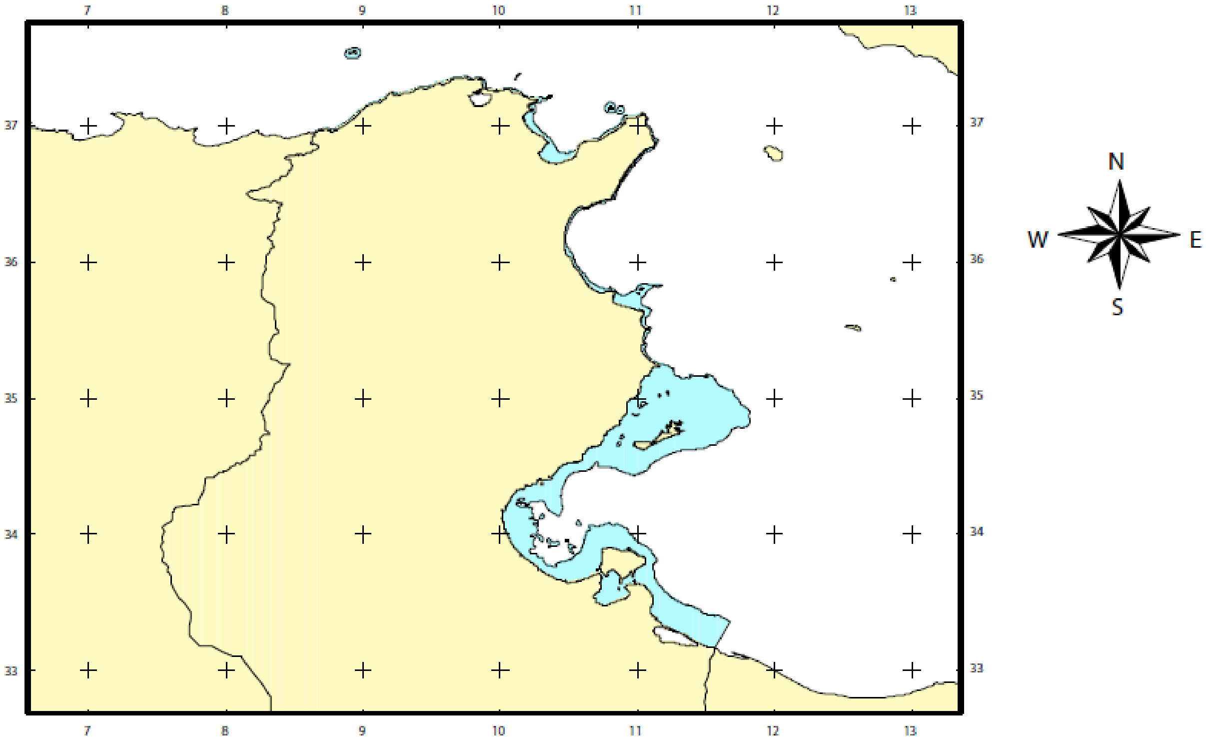


Figure 19. Map of prohibited access areas for purse seiner (without light and day fishing)

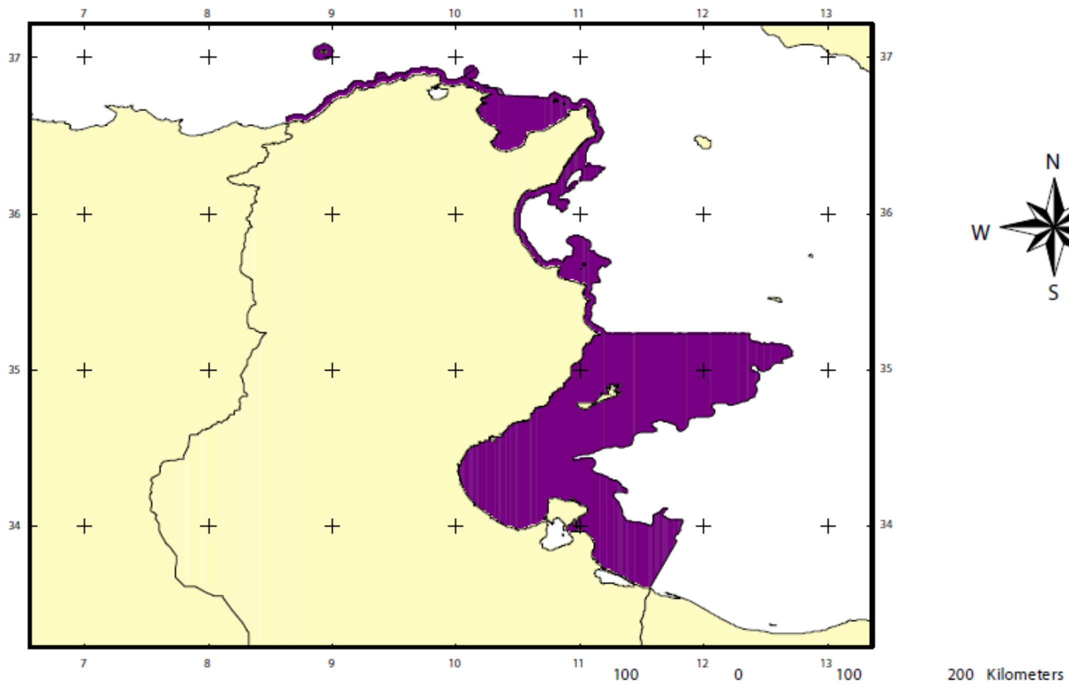


Figure 20. Map of no-access areas for trawling

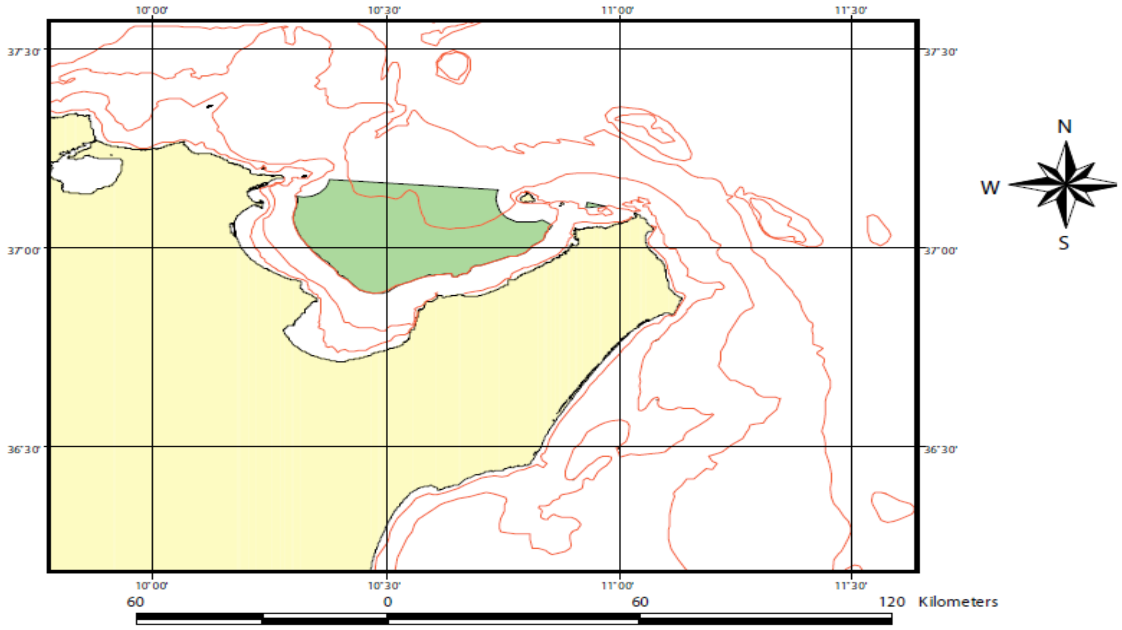


Figure 21. Map of the authorized trawling area in the Gulf of Tunis during the month of July of each year

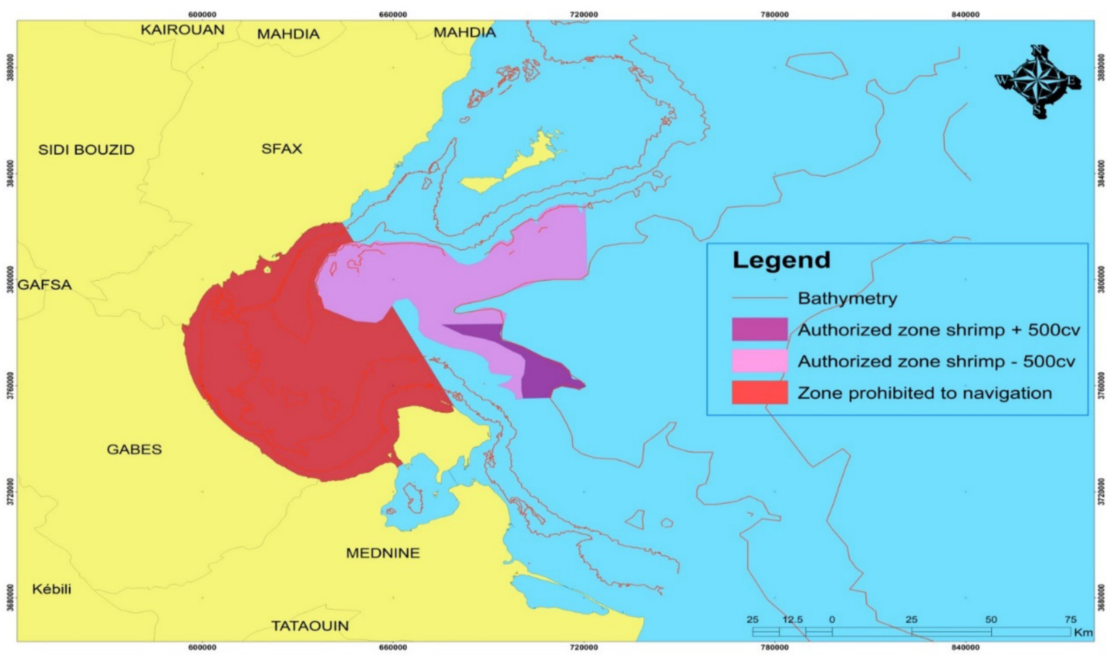


Figure 22. Map of authorized trawling areas in the Gulf of Gabes (during the shrimp fishing survey)

VI.2. Importance and diversity of the fishing sector

Fishing methods in Tunisia are multiple and diverse. They depend on the morphological characteristics of the seabed and the socio-cultural characteristics of the fishermen. There are essentially four main fishing modes:

- Coastal fishing, generally traditional.
- Fishing for blue fish, or small pelagic fish.
- Trawl fishing.
- Tuna fishing.

Coastal fishing: In Tunisia, coastal fishing is practiced on foot, by diving and/or on board non-industrial fishing units and at different depths. The inshore fishing fleet represents more than 92% of the active national fleet and the seafarers engaged in inshore fishing represent around 75% of the national fishing population. Inshore fishing landings represent 28% of the quantity and 43% of the value of fishery products. It is ranked first in terms of employment and value of production compared to other fishing methods and second only to small pelagic fishing in terms of quantities produced.

Figure 23. Motorized vessels for coastal fishing

Purse seiner fishing /Small pelagic fishing: Small pelagic fishing, also known as light fishing, is carried out, generally, at night in the three zones of the country using lamparos which concentrate the small pelagic species, generally with positive phototropism. The small pelagic fishing is also carried out at daytime without light, especially in the gulf of Gabes. Based on statistical data on fishing fleets published by the GDFA in 2017, the purse seiner fleet, which boat length is more than 15 m, represent 380 units including 94 units in the Northern zone, 194 units in the Eastern zone and 92 units in the southern zone. Tunisian purse seiner boats are, in 99% of the cases, built of wood (377 units). The fishermen working on board these boats in 2017 were around 5,651 people with an average of 12 people on board boats practicing day fishing and an average of 15 people for boats practicing night fishing. Landings of small pelagic fish in Tunisia increased from 20,000 tons in 1981 (36% of the total production) to 53,500 tons in 2006 (48% of the total production) and currently stands at 45,000 tons in 2018 (34% of the total production). For the period 2000–2018, 44% of small pelagic landings in Tunisia come from the Eastern zone, 30% from the Northern zone and 26% from the Southern zone.

Trawl fishing: Trawling is a relatively new activity in Tunisia compared to other fishing methods. The use of trawls began in the 1980s. Currently, trawl fishing is practiced in the three Tunisian regions, particularly in the southern region where the bottom is easily trawlable. The exaggerated and uncontrolled fishing effort of the benthic trawlers in the gulf of Gabes has led to the destruction of the seabed and the overexploitation of the majority of animal and plant biological resources. Despite the encouragement granted by the State for the orientation of the fishing effort towards the Northern region since the 2000s, the problem of overexploitation and degradation of the ecosystem of the gulf of Gabes persists. In 2009, biological rest was established for three months (July, August and September) of each year. The active trawler fleet is about 4% of the active national fleet. The population of fishermen practicing trawling corresponds to 12% of the national maritime population. Landings represent 24% of the quantity and 31% of the value of fishery products in Tunisia. Most Tunisian trawlers, *i.e.*, more than 60%, have Sfax as their home port.

Figure 24. Benthic trawl in exercise

Tuna fishing: Tuna fishing targets species of the tuna family, in particular Bluefin tuna. The active population involved in tuna fishing represents 1% of the national fishing population. The tuna fishing fleet represents less than 0.1% of the national fishing fleet. The landings of tuna fishing units represent 2% of the quantity and 4% of the value of Tunisian fishing products.

Fishing fleet: Regarding the fishing fleet, all modes combined, the GDFA estimated that in 2017 it has totaled 13,537 boats, divided into motorized coastal boats (BM), non-motorized coastal boats (BNM), trawlers, sardine boats and tuna boats. The fleet has been growing continuously since 2010 at an average rate of 3.2% per year; it is mainly the non-motorized boats on the coast that have seen the most significant increase, rising from 5,820 in 2010 to 6,508 in 2012. The fleet is particularly concentrated, with 60% of the fleet in the southern zone, in the gulf of Gabes. Along the Tunisian coast there are several fishing ports, dykes, and landing sites. These are fixed by law and are under the authority of the Agency of Ports and Fishing Facilities, APIP. There are 41 of them and they have an annual capacity of 150,000 tons. They are distributed as follows:

- 10 deep-sea ports for trawling, tuna, purse seiner and inshore fishing.
- 22 coastal ports, 4 of which are medium-sized and can accommodate small trawlers, sardine boats and coastal barges.
- 9 dykes or landing sites for inshore fishing.

Fishery production: The overall capacity of the fishing ports has not yet been reached. This has been determined based on the production objectives of 150,000 tons set for 2010, objectives that are currently not achieved.

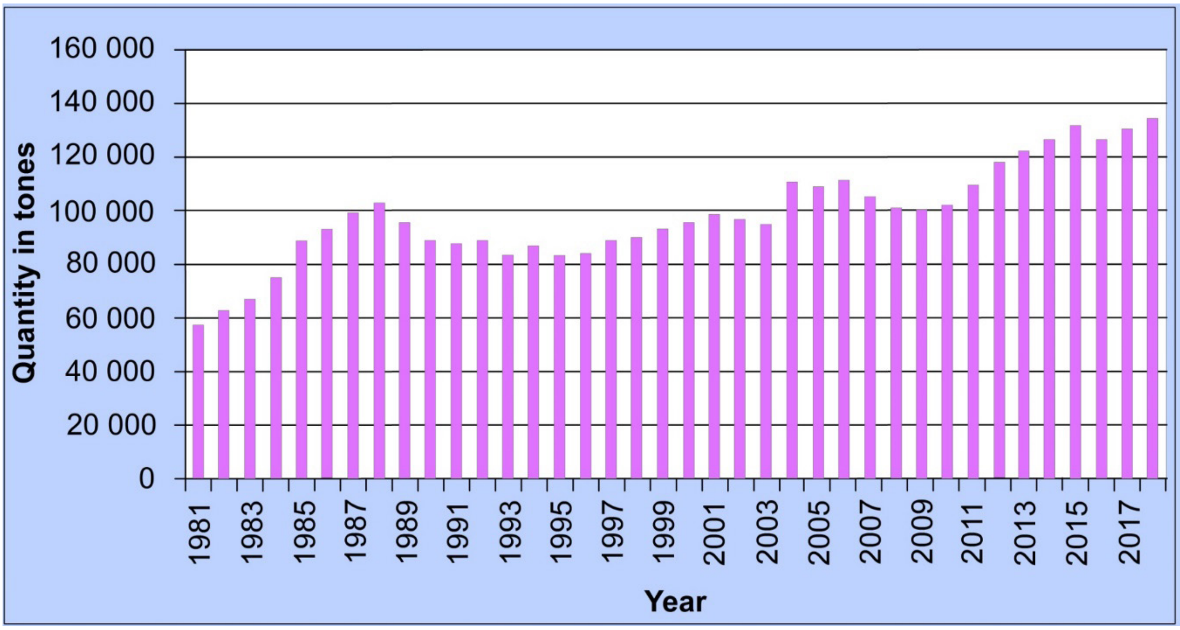


Figure 25. Evolution of total fisheries production, GDFA data, 2017

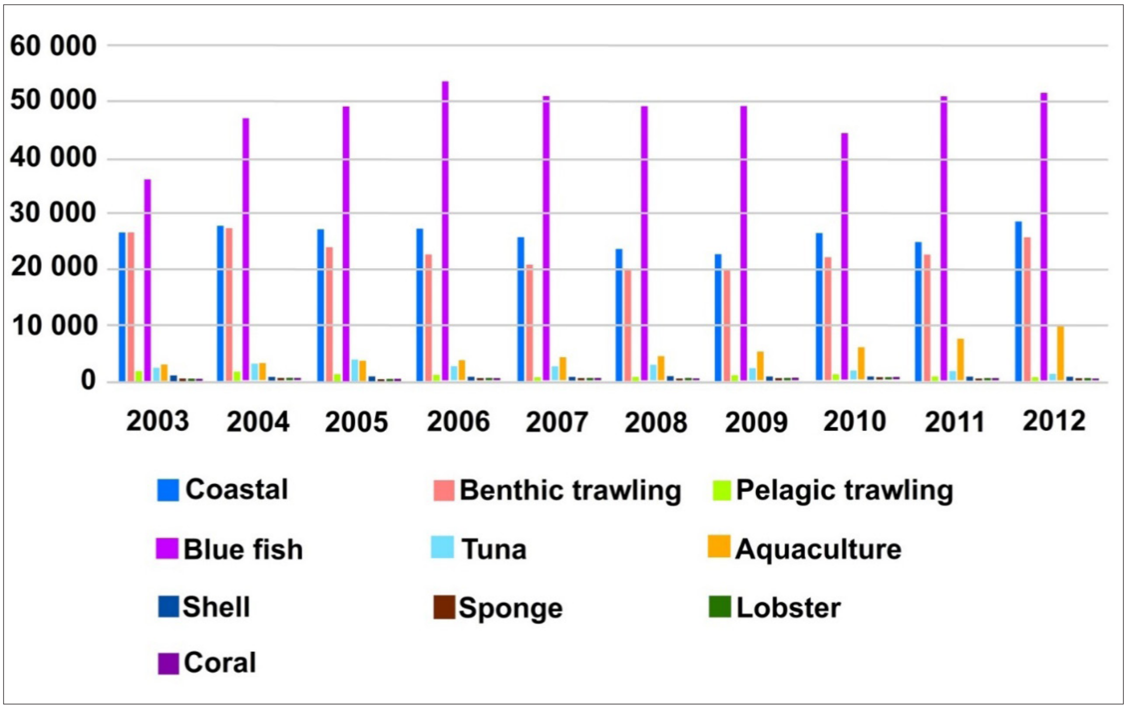


Figure 26. Evolution of production by type of fisheries, GDFA data, 2017

Following stagnation at 100,000 tons/year, the national fisheries production has seen in recent years, according to GDFA statistics, a significant increase reaching more than 130,000 tons in 2018.

- When the national production is broken down by type of fishing and according to GDFA statistics, the following characteristics and trends emerge:
- Coastal fishing, trawl fishing and purse seiner fishing are the three main types of fishing in Tunisia. In 2012, they alone accounted for almost 90% of the fishing effort in terms of quantity.
- Inshore fishing and benthic trawl fishing have been stagnating for more than ten years, each oscillating around 25,000 tons/year.
- On the contrary, purse seiner fishing, under the effort of a sustained political impetus over the last ten years, has seen significant growth, rising from 35,729 tons/year in 2003 to more than 45,000 tons/year in 2018.
- Also, and under the same political impulse, aquaculture is constantly growing in Tunisia, from an insignificant production during the 1990s, aquaculture is today close to 16% of the national production, it was estimated in 2018 at 22000 tons/year.
- Tuna fishing, on the contrary, is running out of steam and is practically decreasing from one year to the next, barely exceeding 1,300 tons/year in 2012.
- Coral, sponge, and lobster fisheries remain at low production levels, as available and accessible stocks limit this activity.

According to the PDGA's statistical yearbook, the turnover of this production reached 475 million TND in 2012. It is essentially divided into four major fishing groups: coastal fishing, trawl fishing, bluefish fishing and aquaculture representing 155 million TND, 122 million TND, 101 million TND and 73 million TND, respectively. The global evolution of this value since 2003 has shown significant growth essentially for two types of fishing, those with blue fish and aquaculture, which alone in 2012 will occupy about 37% of the total value against 21% in 2003.

On average, the highest price per ton of catch corresponds to the catches of specific fisheries. Indeed, and for the year 2012, it is 666,132 and 39,000 TND/ton respectively for coral fishing, sponge fishing and lobster fishing. For the other fishing categories, this price is 5.4 thousand TND/ton for coastal fishing and tuna fishing, 4.7 thousand TND/ton for trawl fishing, 2.9 thousand TND/ton for foot fishing and 1.9 thousand TND/ton for blue fish fishing.

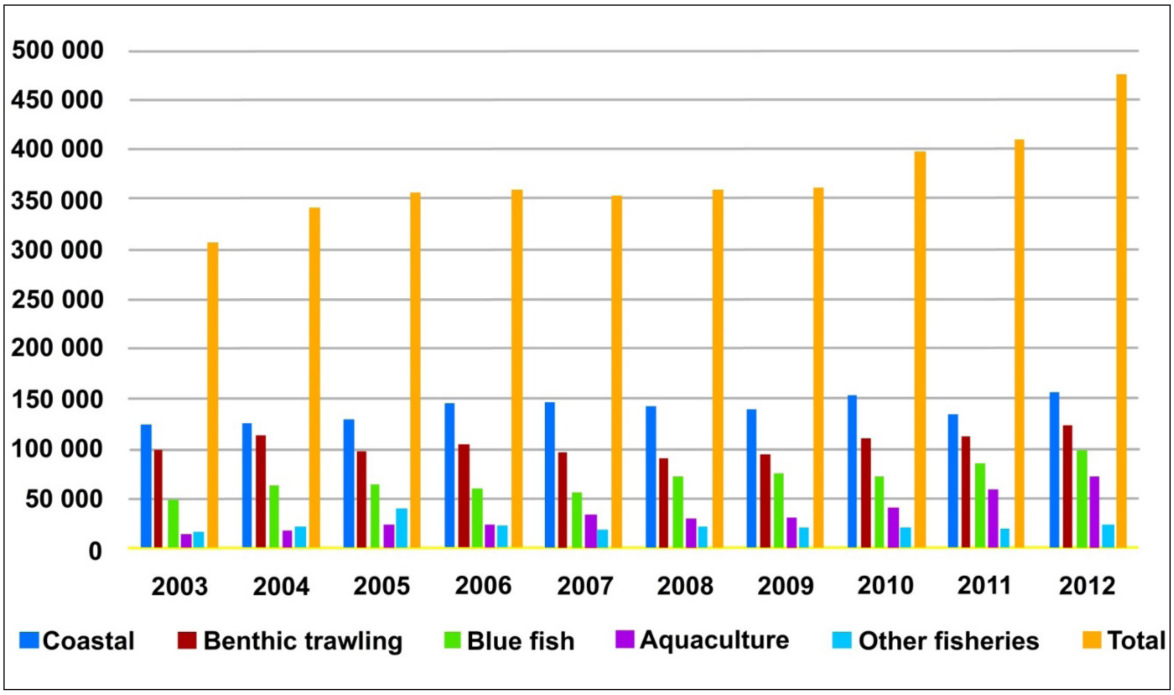


Figure 27. Evolution of the value by type of fishing

The trend between the years 2013 to 2020 is roughly similar (more or less) to that of the period 2010-2012 (between 400000 and 450000 or more for some years).

Exports of fishery products have evolved over the last decade with an increasing rate going from 15,000 tons in 2001 to 22,000 tons in 2010 and 25,000 tons in 2012. The average for exports during the last twelve years has evolved with an annual increase rate of 4.6%.

In terms of value, exports have also evolved in an increasing manner passing from 128 million TND in 2001 to 226 million TND in 2010 and 292 million TND in 2012. During this period, the annual growth rate was around 7.7%.

The groups of species most demanded by external markets are Mollusks, notably cephalopods, white fish, and crustaceans (products mainly fished in the gulf of Gabes). In terms of weight, mollusks come in first place with an average annual tonnage of 7,450 tons representing 39% of the total exported weight, followed by fish with 4,880 tons (25%) and crustaceans with 3,707 tons (19%). However, in terms of value, it is the fish production that is ahead of the other categories with an average annual value of 63 million TND representing 33% of the total value of exports, followed by crustaceans with 57 million TND (29%) and finally mollusks with 48 million TND (25%). According to data from the Central Bank of Tunisia (BCT), fishing activity thus represented 0.6% of the national GDP in 2010, or about 388 million TND.

VI.3. Aquaculture

Tunisia has long been a country of sailors and fishing, so that aquaculture remains a niche industry, accounting for 12% of the total fishery production value and generating 2,000 direct jobs. Tunisia's modern aquaculture industry began in the 1960s with a governmental establishment of shellfish farming. The first private hatchery of Sea Bass (*Dicentrarchuslabrax*) and Sea Bream (*Sparus aurata*) was established later in the 1980s. The fattening of Bluefin Tuna (*Thunnus thynnus*) was launched, and recent years have been marked by the expansion of floating and submersible cages for Sea Bass and Sea Bream. Tunisia's aquaculture production rose from a small 140000 tons in 1987 to 15,200,000 tons in 2016, valued at $75 million. The leading products in terms of quantity and value are sea bass and sea bream. While growth has been fast paced in recent years, Tunisia's Fisheries Association conducted a survey in 2016 which concluded that the aquaculture sector's potential future growth may be limited to 10% annually (Fig. 27).

At present, there are roughly 50 companies involved in aquaculture production:

- Shellfish farming: 12 private companies.
- Bluefin tuna fattening: 5 private companies.
- Other marine fish farming: 20 private companies.
- Inland fish farming: 15 private companies.

Most shellfish production is concentrated in northern Tunisia, particularly in the Bizerte governorate's lagoon, using both farm baskets and floating lines.

The primary marine aquaculture production area is in the Monastir governorate, along Tunisia's eastern shore. Marine aquaculture is practiced using modern and innovative techniques, whether in concrete facilities with a density of 60 kg/m^3 or in floating cages on the high seas. Fry is exclusively imported for sea bass and sea bream production while Bluefin tuna are imported for fattening.

Inland aquaculture is mostly practiced in the Beja governorate producing freshwater fish, including thinlip mullet (*Liza ramada*), common carp (*Cyprinus carpio*), zander (*Stizostedion lucioperca*) and flathead grey mullet (*Mugil cephalus*). Inland aquaculture consists of incorporating fry in dams, some of which are imported while others are bred locally.

The Tunisian aquaculture sector suffers ineffective disease control and poor feed quality as causes for below average performance within the aquaculture sector. The sector is not well organized in terms of value chain integration, relying exclusively on middlemen to get aquaculture products from the farm to the marketplace.

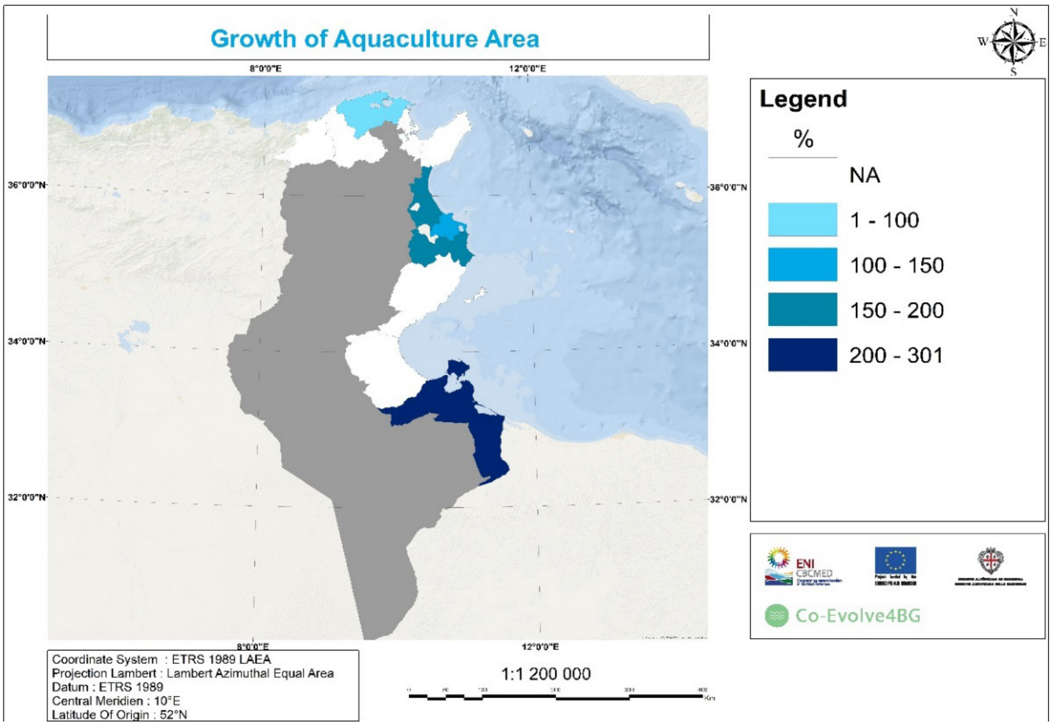


Figure 28. Growth in aquaculture areas in Tunisia

Figure 29. Tunisia Geographical Distribution of the Aquaculture Production Area (inland and offshore areas)

Table 2. List of the important aquaculture companies in Tunisia with geographic distribution coordinates

Name	X (DMS)	Y(DMS)	X(DD)	Y(DD)
SEPAT	33°29’25.55”N	11° 6’54.35”E	33.49043056	11.11509722
AQUAFISH	36° 3’56.00”N	10°32’38.06”E	36.06555556	10.54390556
RUSPINA	35°47’51.85”N	10°52’16.72”E	35.79773611	10.87131111
EMIR EL BAHR	35°15’51.37”N	1°10’14.37”E	35.26426944	11.17065833
AQUACULTURE TUNISIENNE	35°58’20.00”N	10°31’46.00”E	35.97222222	10.52944444
SUD AQUACULTURE TUNISIENNE	33°39’37.00”N	10°44’14.00”E	33.66027778	10.73722222
SCALA	35°44’35.89”N	10°49’35.56”E	35.74330278	10.82654444
TUNISIA TUNA	35°18’44.05”N	11° 8’42.96”E	35.31223611	11.14526667
SMT	35°24’45.51”N	11° 5’20.16”E	35.41264167	11.08893333
VMT	36° 0’21.63”N	10°34’5.99”E	36.00600833	10.56833056
TFT	36° 0’16.22”N	10°34’29.53”E	36.00450556	10.57486944
TUNIPECHE	33°42’0.00”N	10°46’0.00”E	33.70000000	10.76666667
BARRAGE LEBNA	36°45’31.78”N	10°54’12.50”E	36.75882778	10.90347222
BARRAGE LAKHMESS	35°59’49.31”N	9°28’41.75”E	35.99703056	9.47826389
MACHTA SALMA	37°15’40.12”N	9°59’41.92”E	37.26114444	9.99497778
TRITAR SLIM	37°15’39.16”N	9°59’58.98”E	37.26087778	9.99971667
M.A. TRAD	37°15’39.79”N	10° 0’11.24”E	37.26105278	10.00312222
ISPA	37°15’40.62”N	9°59’56.28”E	37.26128333	9.99896667
CULTIMER	37°13’52.00”N	9°51’20.00”E	37.23111111	9.85555556
FERME MARITIME DE BIZERTE	37° 9’19.00”N	9°53’53.00”E	37.15527778	9.89805556
SOCIETE TUNISIE LAGUNE	37°13’20.00”N	9°55’48.00”E	37.22222222	9.93000000
M.A. TRAD	37° 8’24.00”N	9°52’20.00”E	37.14000000	9.87222222

Consumption and trade: Per capita consumption of fishery products coming from both aquaculture and wild catch has slipped from 14 kg in 1988 to 12 kg in recent years. There is also a large disparity between coastal and interior regions, where per capita consumption is only 1.5 kg. According to a 2016-industrial survey, domestic demand for aquaculture products is likely to grow 10% annually and be driven largely by lower availability of wild catch fishery products. According to industry’s survey, Tunisia exported roughly 4,000 MT of aquaculture products in 2016 and was projected to export 8,000 MT in 2017. The most important export markets are Russia, France, Italy, Algeria, Libya, Canada, and the Gulf countries.

VI.4. Fishing tendency and impacts on the marine environment

VI.4.1. Evolution of Tunisian fisheries and stocks

As a result of the significant development of trawling, deep-sea fish stocks began to decline from the 1990s onwards, particularly in the North of the country. Tunisia then directed its fishing efforts in this area towards coastal resources (blue fish) by developing small boat fishing to the detriment of trawling.

At present, and despite this readjustment, Tunisian total stocks are tending to decline sharply. This is reflecting an excessive fishing effort, with little value and poor management and impacting biological resources without countering the deterioration in the income and standard of living of fishermen in the North. The latter, aware of the degradation of stocks, the existing tensions between fisheries (trawling and inshore fishing in particular) and very pessimistic about the future of their profession, have become really demanding. They have expected a lot from the implementation of concerted fisheries management plans between the different actors which take into account the evolution of stocks, their practices, as well as the needs of the profession.

VI.4.2. Impacts of fishing on biodiversity and fisheries resources

These impacts have generated several other eco-biological impacts at more local scales, including:

- Localized and intensified fishing efforts in several sites, such as the lagoons (Bizerte, Ghar El Melh, Lake of Tunis, Boughrara and El Bibene), the gulf of Gabes and the Kerkennah Islands.
- Negative interactions between gears and the environment.
- Signs of ecological malfunctioning.
- Among the most important impacts of the fisheries sector on the biodiversity and natural resources of the Tunisian marine ecosystem are the following:
- Overexploitation of resources.
- Destruction of coastal habitats.
- Trawling at shallow depths.

Illegal fishing practices (mesh size, area, season, prohibited gear and species) are one of the major factors in the degradation of the marine environment, particularly in regions such as the gulf of Gabes and the Kerkennah Islands. These practices, which are increasingly numerous along the Tunisian coasts, have led to the destruction of many ecosystems and the overexploitation of most fish stocks (with an increase in by-catches, capture of regulated species outside the authorized fishing seasons and targeting of certain size classes). This is partly linked to the failure of the current control, monitoring, and surveillance system for fishing activity at sea and on land.

Recreational fishing which affects marine biodiversity, fisheries and sustainability are still poorly studied in Tunisia. Today, only article 41 of the 1994 fisheries law refers to it to set the maximum number of long lines that can be used by recreational boaters. Insufficiently regulated, the evolution of recreational fishing techniques and methods has led to the emergence of certain illegal and prohibited practices (*e.g.,* new variants of underwater shotguns, use of jigging, synthetic (chemical) and electronic lures and bait). In addition, several professionals complain about the unfair competition from the pleasure boaters and the depletion of certain types of fish due to the exercise of the techniques.

One of the major factors hampering the fight against illegal fishing, habitat destruction and overexploitation of marine resources is the weak enforceability of existing legislation on fisheries management and control, and the protection of the marine environment, its biodiversity, and fisheries resources.

VI.4.3. Responses to the impacts of fishing and sustainable fisheries management initiatives

The latest study Strategic Study of Fisheries and Aquaculture concerning the elaboration of the national strategy for fishing and aquaculture in Tunisia (2016–2026), proposes an action plan for the period 2016-2026. There are several actions aimed at remedying/minimizing the alterations and impacts of fishing on the marine environment and those at the level of its "component 1" corresponding to "Fisheries Management". Among these actions, mention should be made of actions for:

- "Protection of habitats and aquatic ecosystems" (action 1).
- "Protection by artificial reefs of degraded areas and spawning grounds" (action 2).
- "Reinforcement of the networks of marine protected areas for the preservation of fishery resources" (action 3).
- "Control, monitoring and surveillance of fishing operations and landings" (action 4).
- "Improving the management of recreational fishing" (action 5).

VI.5. Shipping, cruising, and pleasure boating

Maritime transport constitutes one of the pillars of the trade promotion in Tunisia. Alone, it accounts for around 98% of the total trade. It is particularly characterized by the transport activities of passengers, cruise passengers and goods.

Tunisia today has eight commercial ports, Bizerte, Rades, La Goulette, Sousse, Skhira, Sfax, Gabes and Zarzis. In 2015, these ports ensured the transit of 28 million tons, as well as 729,000 passengers and 297,000 cars. Placed under the management of the OMMP (Office de la Marine Marchande et des Ports), these ports handle almost all of Tunisia's foreign trade. The port of Rades occupies an important place due to its specialization in the traffic of containers and rolling units, it ensures more than 20% of the global traffic. With its hundreds of thousands of passengers and cruise passengers, the port of La Goulette remains the first specialized port in Tunisia. In total, the maritime transport and port sector is operated by nearly 560 companies specialized in maritime and offering nearly 6,000 direct jobs. In addition, a deep-water port is currently being studied on the eastern coast in the Enfidha region.

VI.5.1. Distribution of maritime traffic according to ports

Tunisia has eight commercial ports along the entire Tunisian coastline, from the extreme north at Bizerte to the extreme south at Zarzis near the Libyan borders. They are represented and characterized as follows:

- The port of Bizerte - Menzel Bourguiba: dominated by oil traffic.
- The port of Rades: specialized mainly in container traffic, rolling units, hydrocarbon, and cereal imports.
- The port of La Goulette is dominated by passenger and cruise traffic.
- The port of Sousse handles the traffic of various goods.
- The port of Sfax: a multi-purpose port handling mainly containers as well as cereals and mining products.
- The port of Skhira: situated between Sfax and Gabes: an exclusively petrochemical port.
- The port of Gabes: an industrial port, dealing mainly with chemical products.
- The port of Zarzis: dealing mainly in oil products and bulk goods such as salt.

Tunisia's foreign trade through the eight commercial seaports amounts to around 29 million tons/year. They experienced a significant drop during the year of the revolution, from more than 30 million tons in 2010 to about 25 million tons in 2011. Since then, trade has gradually recovered, approaching the 2010 base year figures.

The traffic of goods regularly approaches 30 million tons, divided into 2/3 of import products and 1/3 of export products.

The CTN, a public company, is the main ship-owner of the country and provides regular lines linking the two shores of the Mediterranean Sea, particularly towards Marseilles and Genoa. Moreover, there are seven private companies in Tunisia which mainly ensure the transport of hydrocarbons and chemical products on international lines.

Figure 30. Main ports of Tunisia

Table 3. Main characteristics of commercial ports in Tunisia

Ports	Main Traffic	Number of Quays	Length of Quays (m)	Draught (m)
La Goulette	Passengers and cruise passengers	10	1,870	9
Rades	Containers and Semi-trailers Solid and liquid bulk	11	1,930	9.75
Bizerte-Menzel Bourguiba	Hydrocarbons, Cements and Steels	12	1,586	10.67
Sousse	General cargo	7	795	8.5
Sfax-Sidi Youssef	General cargo and Chemical fertilizers	15	2,550	10.5
La Skhira	Hydrocarbons and chemicals	3	450	15
Gabes	Chemicals and solid bulk	8	1,725	11.88
Zarzis	Hydrocarbons and Sea Salt	5	875	8

Figure 31. Commercial port (Containers and Rolling vehicles) of Rades

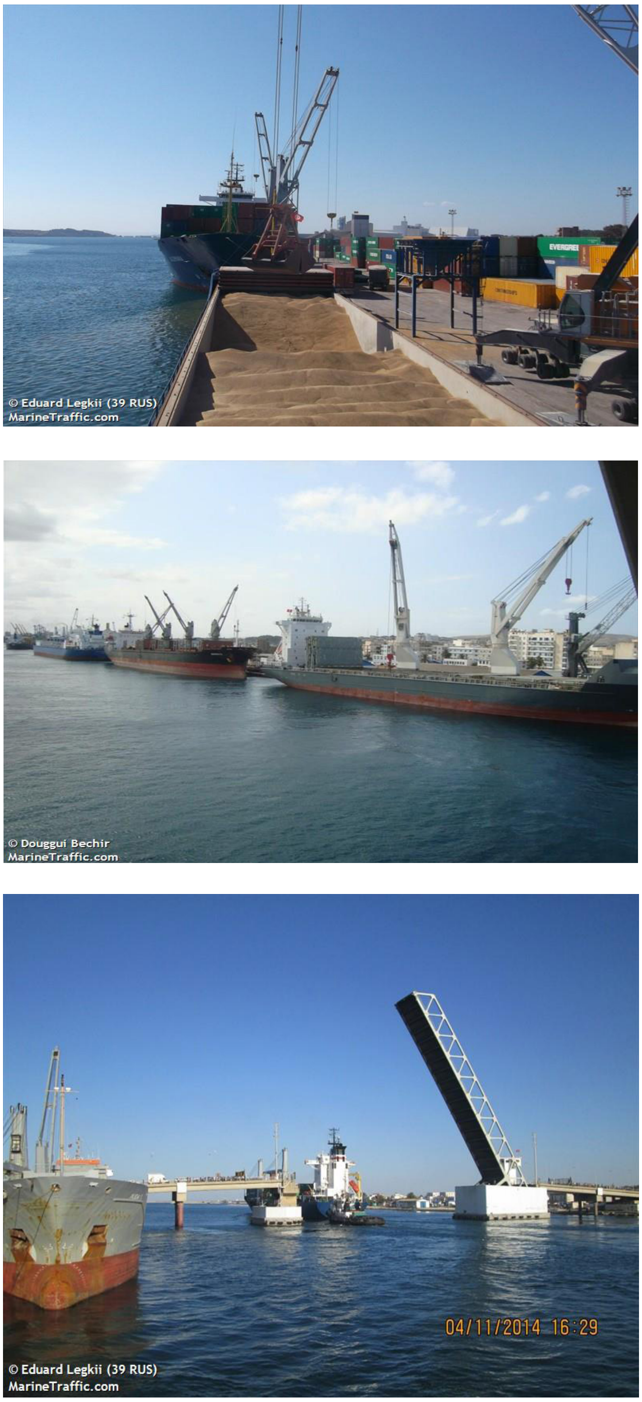


Figure 32. Maritime and naval activities of the Bizerte-Menzel Bourguiba port complex

VI.5.2. Economic weight per port

The commercial activity appears relatively more active and more sustained in four main ports of Tunisia, Rades, Skhira, Sfax and Gabes. They each monopolized in 2010 and successively in terms of tonnage exchanged, respectively 21%, 19%, 16% and 15% of the total tonnage.

Table 4. Maritime traffic by category of vessels at the level of commercial ports in Tunisia (*statistics for the first 9 months of the year 2019; t = tonnage, n=number)

Type of ship	Input			Output			Input + Output
	n.ships	Gross.t	t.march	n. ships	Gross.t	t.march	t.march total
Cruise ships	0	0	0	0	0	0	0
Car-ferries	420	15,402,295	120,658	421	15,433,942	214,975	335,633
General cargo	1,007	5,677,750	3,309,836	1,003	5,670,978	2,800,342	6,110,178
Roll-on-roll-off	735	16,334,097	1,333,040	734	16,334,996	886,647	2,219,687
Container ships	321	2,995,480	1,141,277	320	2,977,310	736,499	1,877,776
Dry bulk carriers	152	2,699,069	2,734,625	149	2,653,133	458,958	3,193,583
Liquid bulk carriers	210	3,140,166	1,748,715	177	1,844,406	948,855	2,697,570
Tankers	118	3,217,845	1,597,338	119	3,242,908	1,282,513	2,879,851
Gas carriers	130	915,177	501,173	131	922,395	42,564	543,737
Specialized ships	440	824,834	21,088	439	824,727	25,622	46,710
TOTAL	3,533	51,206,713	12,507,750	3,493	49,904,795	7,396,975	19,904,725

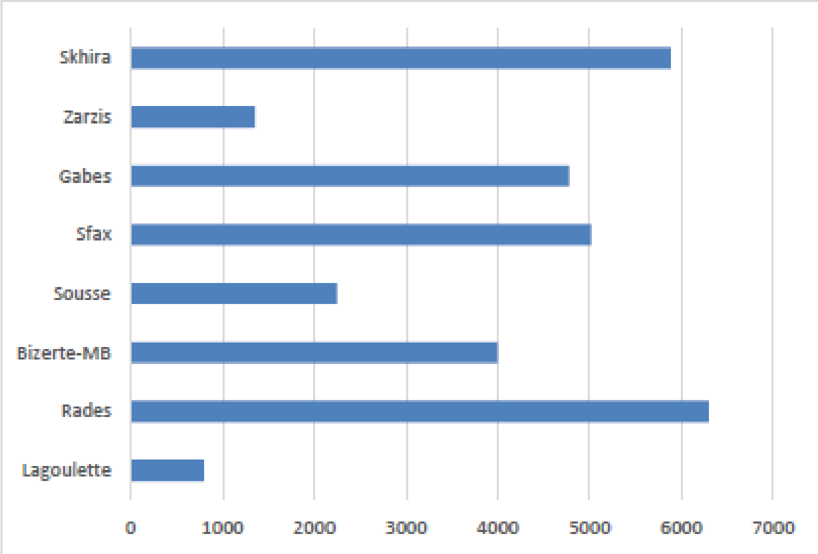


Figure 33. Tonnage by port in 2010 (in thousands of tons)

Five groups of essential products are exchanged at Tunisian ports. These are, and in decreasing order:

- Hydrocarbons: regularly approach 10 million tons, thus often representing more than a third of the trade.
- General goods (general cargo): around 7 million tons.
- Bulk solids: around 6 million tons.
- Cereals: which stagnate at a little over 3 million tons.
- Bulk liquids: represented essentially by the products of the chemical industries of phosphate transformation which have seen serious disturbances following the revolution.

VI.5.3. Recreational maritime traffic: marinas

From Tabarka and Bizerte, on the northern coast, to the gulf of Gabes in the south, via the Cap Bon peninsula and the entire east coast, yachtsmen can access around thirty ports and anchorages. A total of eight marinas border the Tunisian coast:

- Tabarka Marina.
- Bizerte Marina.
- Gammarth Marina (Carthage).
- Sidi Bou Said Marina.
- El Kantaoui Marina (Sousse).
- Yasmine Hammamet Marina.
- Monastir Marina; and
- Houmet-Essouk Marina (Djerba).

These eight marinas have a total capacity of almost 3,266 moorings (bollards): the leasing indicates the ownership of the mooring, as opposed to the rental, which should not be confused with the actual occupation; one can rent a mooring and not occupy it.

In addition to these dedicated harbors, there are a dozen fishing harbors, accessible to yachtsmen and which accommodate small boats moored at their quays such as zodiacs, speedboats and sailing boats.

Table 5. Ring capacities of marinas in Tunisia

Marina	Rings (bollard)
Tabarka Marina	140
Bizerte Marina	800
Gammarth Marina	466
Sidi Bou Said Marina	400
Yasmine Hammamet Marina	720
El Kantaoui Marina	340
Monastir Marina	300
Houmet-Essouk Marina (Djerba)	100
Total	3,266

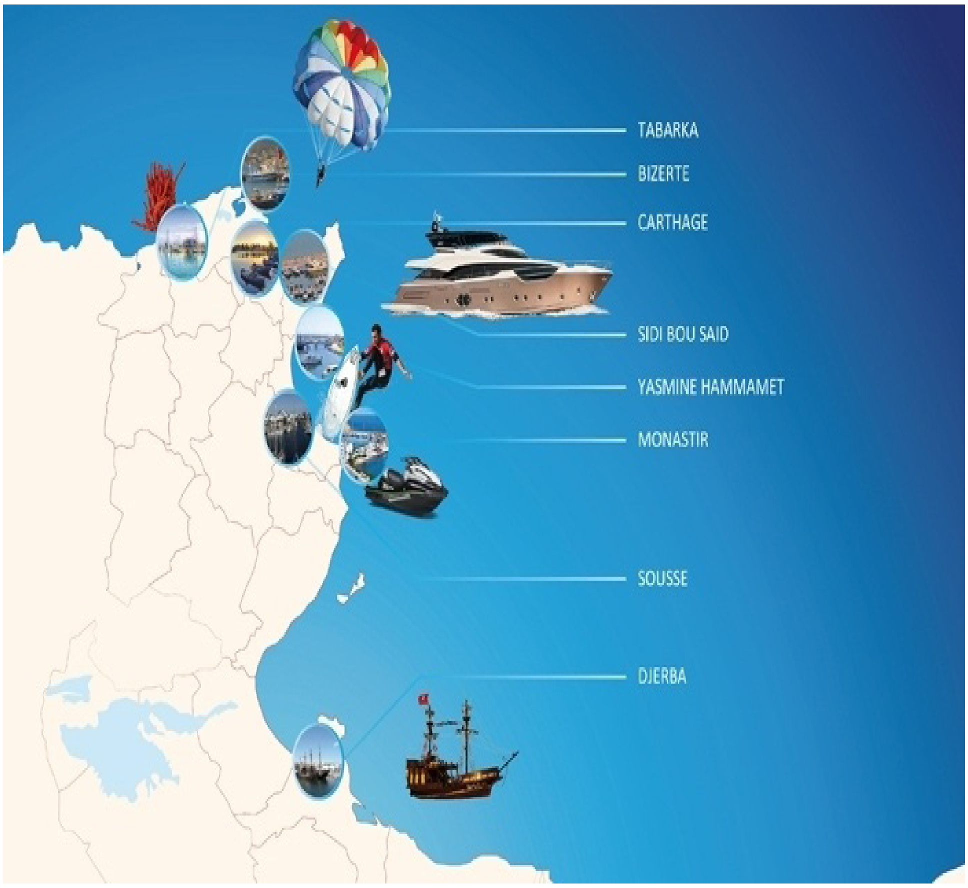


Figure 34. Distribution of Marinas and recreational ports in Tunisia

The environmental and ecological impacts of maritime activities such as fishing, maritime transport or recreational tourism are not directly felt in the area: they can be described as “long and silent impacts”.

VII. Impacts of power, sanitation, and desalination stations

VII.1. Impacts of power stations

VII.1.1.Impacts generated by coastal power stations

Among the different main impacts generated by the operation of these rather heavy, but totally strategic installations for the development of the country and especially at the level of the coastal cities with industrial and tourist vocations, are:

- The operation of the various installations (e.g., turbines, transformers, pumps, suction basins, desalination basins, pipes, drainage channels, discharge pipes and cooling installations) of the power plants on the environment and human health.
- Noise and vibration emissions.
- The discharge of cooling water.
- Water discharge.
- The collection and suction circuit of water from the power plants.
- Atmospheric emissions.
- Solid discharges.

VII.1.2. Impacts generated by power plant installations

These are the direct impacts in direct relation to the types of installations and technical processes of the power plants (gas circuit power plant, or gas oil circuit power plant). These impacts represent as many threats and risks to the environment as well as to human health, in areas adjacent to coastal and marine environments. Otherwise, these installations generate several by-products which also represent the same risk, such as chemicals (which are carried along with the washing water and neutralization pits), oils (engine lubrication oils such as oil for pumps and turbines and oils for electric transformers and drainers). It should be noted that transformer oils contain quite dangerous products and constitute a danger to public health.

These various effluents in aqueous solutions discharged into the receiving marine environment and in view of the current situation of lack of performance of the ONAS's STEPs, comply little, or not at all, with the national discharge standards in force. The impacts of these poorly treated, if not untreated at all, discharges constitute a source of second- or even first-degree contamination of the natural environment.

Water discharges: Different types of water discharges are foreseen for the different types of power plants in Tunisia (combined cycle power plants, gas-fuel power plants, fuel oil power plants), such as:

- Discharge of boiler water and ancillary installations.
- Sanitary and Rainwater discharges.
- Discharge of sea water.
- Desalination discharge: condensate and brine discharged by seawater desalination plants for cooling needs (raw water) of the power plants.

Solid waste: These include the discharges of dredging products (*e.g.*, dredging of seawater suction basins, decantation/neutralization basins and cooling basins), the discharges of wastewater channels (often loaded with oily and chemical products), domestic discharges and industrial discharges (*i.e.*, discharge channel from the Sousse power plant via the Hamdoun Oued). Among these solid discharges are also those from combustion (solid deposits from the combustion of fuel oil and coal coke). The liquefied gas stations are not concerned by this type of discharge. Finally, residues from dredging operations of onshore and submarine infrastructures also cause several types of solid discharges (suction basins, settling/neutralization basins + sludge and solid deposits from dredging of cooling water and wastewater discharge channels). They are sometimes quite significant and whose discharges are often at the detriment of the marine environment surrounding the power plants.

Noise emissions: These emissions include the effects, noises and acoustic pressures emitted by the turbogenerators and their auxiliaries (*e.g.*, pumps, turbines, transformers and boilers). Many of these emissions affect both the terrestrial environment and the marine environment, with acoustic noises propagating through marine waters (*e.g.*, noise from the suction of seawater, noise from water and solid discharges into the marine environment).

Vibration emissions: Several types of vibrations are generated by the operation of power plants, notably bearing vibrations and shaft vibrations which are of particular concern in the turbo-generator group at the power plants and rotating machine shafts (*e.g.*, turbogenerators, turbines, compressors and generating sets).

Atmospheric emissions: These atmospheric emissions have a direct impact both on the quality of the air and on the quality of water, especially sea water (air/water exchange). The operation of power plants causes significant atmospheric emissions. Among the main polluting gases emitted by the latter figure are Sulphur Oxides (SOx), Nitrogen Oxides (NOx) and dust; these are the combustion residues of the foodstuffs used for the operation of power plants (coal coke, fuel oil and gas). The continuous emission of these gases directly affects both human and animal health and the environment with all its biotic components.

Impairment of the quality or pollution of surface water or groundwater: These water alterations are mainly due to the infiltration of the products of industrial discharges from the stations into groundwater (*e.g.*, oily and chemical discharges, pumping and discharge water, domestic wastewater from the stations), which is very likely to contaminate surface water, groundwater and the modification of the quality of these waters. Surface discharges also affect fresh water adjacent to the stations (*e.g.*, wadi, sabkhas and lagoons). These discharges will be drained at sea. Cooling water from pumps and turbines (overheated water) is discharged directly into the sea. This warm water affects biodiversity, the fauna and flora habitats adjacent to the marine influence zone of the stations.

Impacts due to dredging operations in the seawater suction basin: This water sucked in from the adjacent sea is used to cool the electricity production facilities at the power stations (*e.g.*, turbines, pumps, boilers, and transformers). The impacts of dredging these basins consist of the solid waste discharge from the bottom of the basin (*e.g.*, sediment, algae and confined organic matter). This waste is likely to contaminate soil resources (bad smell and blackish color) and may harm the neighboring tourist activity.

Impacts on the quality and use of soils and the coastal zone: The quality and location of the land and coastal area adjacent to the plants are largely affected by the operation of the plants. Thus, the land around the power stations loses its agricultural, real estate (especially tourist) and commercial or even industrial value (in relation to the security risks carried by the operation of the power stations such as risks of explosion, risks of gas leaks, risks of fire and major risks in the event of natural disasters that include floods and earthquakes).

VII.1.3. Economic impacts

Coastal power plants cause various socio-economic, environmental, and human health impacts. One of the greatest advantages of building these plants is their proximity to the sea; sea water being a vital source for the power plant, particularly for cooling equipment. From a socio-economic point of view and several direct impacts can affect neighboring local communities due to the location of coastal power plants.

Impact on farmers: The agricultural landscape in the surroundings of the power stations is mainly marked by the practice of coastal agricultural crops (*e.g.*, market gardening, arboriculture, and extensive grazing). Otherwise, the coastal plains sheltering these power stations present highly urbanized areas (*i.e.*, Rades power station and Sousse). The exploitation of these installations on the groundwater leads to the deterioration of the piezometric quality of the water table used by the farmers via recourse to surface wells.

Impacts on the tourism sector: Many power stations (*i.e.*, Sousse and Rades power stations) built near tourist areas (Sousse-Monastir zone for the first and Carthage-Gammarth zone for the second) may directly or indirectly impact the latter. Indeed, these tourist zones can suffer from local warming of bathing waters, or even the deterioration of the quality of these waters (favoring the appearance of extreme phenomena such as colored waters, phytoplankton blooms, or jellyfish blooms). Otherwise, the thermal dispersion of the water remains rather random, due to winds and currents. Sometimes this dispersion can be totally stopped during periods of calm waters and stagnation of the latter (especially during the hot seasons corresponding to the peak of tourist activity and bathing). Moreover, the wastewater coming from the industrial zones (generally not far from the power stations) juxtaposing the power stations, or from natural tributaries (often in the vicinity of the power stations;*i.e.* Oued

Hamdoun next to the power station of Sousse, Oued Meliane next to the power station of Rades) is already hotter than that of the power station. It further accentuates the influence of these industrial water discharges on the neighboring tourist zones. The construction of offshore outfalls for a more efficient dispersion of these waters is rather expensive. Numerous stations are waiting for the installation of these dispersion channels for a better compatibility with the environment, in particular the neighboring marine and coastal environment.

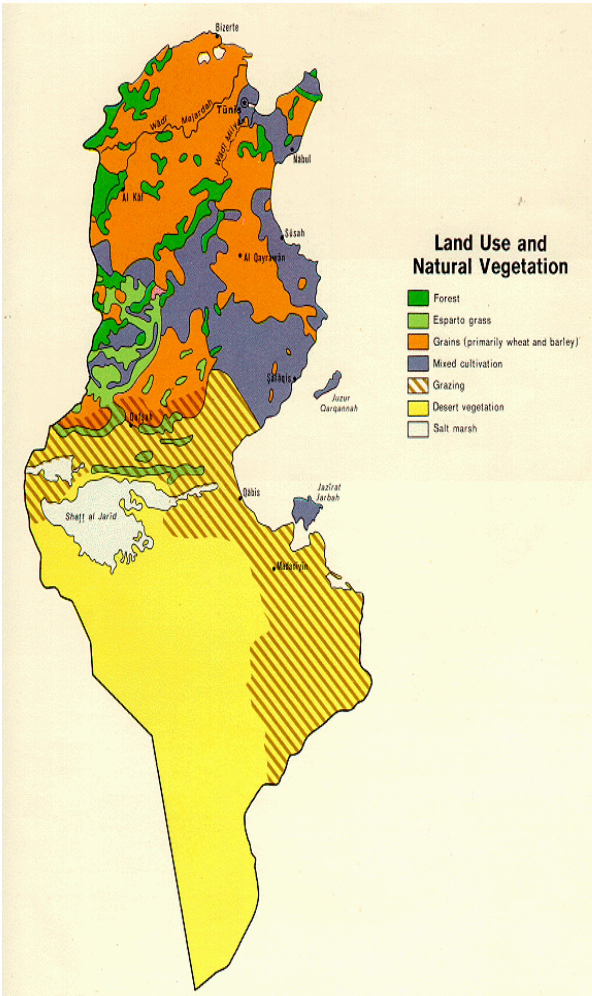


Figure 35. Map of land use in Tunisia[3]

Impact on the surrounding population: These are populations in urban areas juxtaposing power stations (*i.e.*, the Rades power station) and small farming and fishing communities (*i.e.*, the Sousse power stations). Communities in industrial zones (Rades) are also affected by these impacts. These impacts affect the activity of these communities, particularly those of local fishermen and the local tourist sector, but above all their health. It should be noted that very often Tunisian power plants see the birth of a whole

3 Berkeley.Retrieved from https://www.lib.berkeley.edu/EART/tour/thematic.html

social and economic dynamic. The latter is often at the expense of the installations annexed to the plants (*i.e.*, local fishermen settling and carrying out their fishing activities around the suction port of the Sousse power plant; thus, the latter use this suction port illegally). Such practices nevertheless remain tolerable despite the risk they present for safety, security, and human health.

VII.1.4. Environmental impacts

Erosion impacts: As an example, for the Sousse power plant, at the mouth of the suction channel leading the water towards the power plant, two groins have been erected to slow down the waves by forming an obstacle in front of the coastal transit. The attenuation of this transit has created significant areas of erosion downstream of the power plant. Similar facts characterize other coastal sites of electricity production. This erosion is even more amplified with the influence of sea level rise, the amplification of extreme coastal and marine phenomena, urban sprawl, the concreting of the neighboring coastline, the creation of ports and marinas and the destruction of local marine habitats.

Impact on the landscape: Power plants are rather cumbersome installations, with a multitude of facilities that extend over ten or even a hundred hectares. Thus, their existence is most often detrimental to the urban (tourist) and natural coastal landscape.

Figure 36. Rades power station

Figure 37. Sousse thermal power plant

VII.2. Sanitation stations

Today, the wastewater connection rate (collected domestic and industrial effluents) is 90% in Tunisia. However, the performance of the treatment plants (STEPs) on the coast needs to be improved. Indeed, these coastal STEPs are the oldest, also the most saturated and those requiring the most investment. The control of industrial pollution also remains a crucial issue: many industries discharge their effluents into the collectors of domestic networks without appropriate pre-treatment. These inadequacies lead to a lack of conformity of the discharges from certain stations. It should be noted that a major program to rehabilitate and improve the performance of the national sanitation network (2018-2028) is currently being implemented. Of course, this program aims at improving the capacities and performances mainly of the network of coastal STEPs, whose discharges flow into the marine environment. Among other targets, the program aims to ensure:

- The adequacy of the quality of discharges required for the transaction to the standard in force and the draft standard.
- The adequacy of these standards to the characteristics of the transaction's STEPs and those of the receiving environments of Treated Wastewater (TWW).
- The effectiveness of the control of Industrial Wastewater (IWW).
- The discharge of solid waste generated by STEPs.

VII.2.1. Receiving environments of treatment plants and quality of treated effluent

The receiving environments (marine environment, lagoons, sabkhas and wadi) of the TWW of the STEPs are classified according to Tunisian legislation, into environments forming part of the DPM and environments forming part of the Public Hydraulic Domain DPH. From an environmental point of view, the description of the receiving environments of STEPs in Tunisia has highlighted the existence of several types of environments according to their characteristics:

- Less sensitive environments whose characteristics enable them to assimilate TWW from STEP without significant impacts on the quality of the environment.
- For the WWTPs of the transaction, the sensitive receiving environments whose environment has been subject to several natural or anthropogenic (industrial activities) stresses are as follows:
    - The receiving environment of the STEPs in Southern Tunisia (*i.e.*, Djerba Aghir STEP).
    - The receiving marine environment in the south is relatively closed in certain localities (Djerba Aghir, Kerkennah, *etc.*..) and the polluting discharges discharged there are only very weakly assimilated and/or diluted. This marine environment of the southern coasts is often affected by a series of phenomena resulting from a combination of natural and anthropic factors (highly polluting industrial activities in the gulf of Gabes). It is characterized by high nitrogen and phosphorus contents involving significant eutrophication phenomena. It is also characterized by:
- A receiving marine environment characterized by a shallow depth (i.e., Kerkennah)
- A dynamic of surface currents, whose circulation often has a low amplitude, which limits the dispersion of pollutants discharged into the TMEs and often causes them to return to the coast.
- At the level of certain localities of the gulf of Gabes (Sfax South and Gabes) the marine environment is degraded by the pollutants which are discharged there, mainly coming from the industrial activities of these regions (WWTP of Sfax South and Gabes). These pollutants mainly come from the phosphate transformation industries installed on both coasts since the 1970s.
- However, in comparison with the industrial discharges directly discharged into the sea (the phosphate industries), the discharges from WWTPs in these regions represent a minority source of pollution of the Gabes and Sfax Southern coasts (<10%).

In addition, the purification stations in the North of Tunisia (*i.e.*, Choutrana, Tunis North and Korba) have less significant impacts on the marine environment than those in the

Sahel and the Southern Region. In fact, the marine environment in these regions is more dynamic with a fairly large current and movement of water masses, allowing an acceptable hydrological diffusion, which limits the direct impact of wastewater discharges on the marine environment. However, this does not exclude major structural defects: treatment capacities of STEPs that are largely undersized in relation to the wastewater produced. Treatment that does not go beyond secondary or primary treatment and often wastewater exceeding the capacity of these STEPs is discharged raw into the receiving environment, particularly during the summer season, peak flows of domestic and industrial wastewater to the STEPs. Finally, the receiving environments forming part of the public hydraulic DPH domain are located within the concession perimeter of the South lot:

- The receiving environments of the stations of the South Lot are characterized by an arid to semi-arid climate and the existence of bodies of water that are dry outside flood periods. These characteristics reflect a water deficit balance involving significant evaporation of spilled TMEs with partial infiltration into groundwater tables when pedological and geological conditions permit (permeable soils).
- Significant stagnation of TMEs (damage to the quality of the receiving environment) and their arrival at sea, particularly outside periods of high floods, which favors the dilution of large volumes of rainwater.

Control of industrial wastewater discharges: The quality control of industrial wastewater is necessary in order not to alter the functioning of the treatment process and not to degrade the quality of liquid effluents and sewage sludge. Indeed, for many physical and chemical parameters, the quality of treated wastewater depends mainly on the quality of the raw effluents discharged into the networks upstream of the treatment plants. Thus, the management of industrial wastewater still suffers from many inadequacies and weaknesses, the most important of which are the following:

- Pre-treatment at the source before discharge to the public grid is generally not effective if not already in place for many industrial units. Indeed, industrialists do not have the technical and operational capacities to operate these facilities properly, so that most pre-treatment facilities are not functioning properly or are out of order.
- Due to the ineffectiveness of control and sanctions (especially in the country's current economic climate), industrialists do not have sufficient incentives to minimize pollutant discharges and to finance and implement appropriate measures. At present, ONAS does not have sufficient staff and equipment to ensure quality control of industrial discharges to the public sewerage network. Within this framework, a reinforcement of the material means is planned with the help of a program financed by the AFD: French Development Agency (DepolMed Program: Depollution of the Mediterranean).

Current performance of wastewater treatment plants: According to ONAS services, currently and based on the results of treated wastewater analyses in most Tunisian STEPs, most pollutants do not exceed the thresholds of the current standard NT 106.02.

However, an insufficiency of the organic matter treatment in the effluents revealed among others for the concentrations of COD, BOD5 and NK. For the other pollutants, the concentrations observed are not very high, except for the Sfax South STEP. Nonetheless, ONAS does not measure the concentrations of all the pollutants listed in standard NT 106.02.

Disposal of by-products from STEPs: Currently, the disposal of sewage sludge and other solid by-products such as screenings is not structured. The quantities of sludge produced are stored at the STEPs sites, often on the ground, without special measures to prevent contamination of soil and personnel. The screenings are dried in the open air and then disposed of in a landfill. Runoff water and soil leaching, particularly during the rainy season and major floods, can carry this sludge and especially the contaminants it contains to the DPH (wadis, lagoons, lakes, Sabkhas) or the DPM (sea) in the immediate vicinity of the sludge storage sites.

The STEPs' Sludge Management Master Plan foresees in the short term the temporary storage of sludge in sheds (storage not exceeding 4 years) with a concrete platform and a leachate drainage system. This 4-year period should be used by ONAS to choose an elimination/recovery method (*i.e.*, by agricultural spreading or by co-incineration) and to implement a permanent solution.

VII.2.2. Characterization/evaluation of the receiving environments parameters

<u>Classification of receiving environments</u>: ONAS's STEPs discharge their treated effluents either into the public hydraulic domain (lakes and rivers) or into the public maritime domain (sea). The status of TWW intended for reuse in agriculture is not well specified and the receiving environment of these waters must be that of the DPM or the DPH, depending on where the STEP is supposed to discharge its TWW. In Tunisia, the DPM is composed of the natural maritime public domain that encompasses the shoreline, the lagoons in natural communication with the sea (including the gulfs), the terrestrial waters including the Exclusive Fishing Zone (EPZ), the Exclusive Economic Zone (EEZ) and the artificial maritime public domain (*e.g.,* roadsteads, ports, and artificial islands). The natural maritime public domain includes:

- The sea shore made up of the coastline alternately covered and uncovered by the highest and lowest waters of the sea, by the land formed by the lays and relays and by the sand dunes located in the immediate vicinity of these lands which is subject to the provisions of the forestry code.
- Lakes, ponds and Sabkhas in natural and surface communication with the sea.
- The soil and subsoil of inland maritime waters and the territorial sea, as defined and organized by the texts that provide for them.
- The soil and subsoil of the continental shelf for the purpose of exploring and exploiting their natural resources.
- The Exclusive Fishing Zone (EPZ).
- The Exclusive Economic Zone (EEZ).

The artificial maritime public domain includes roadsteads, ports, and artificial islands. In its first article, the Water Code of the Tunisian Republic defines the public hydraulic domain in the following terms:

- Watercourses of all kinds and the land included in their freeboards.
- Reservoirs established on watercourses.
- Sources of all kinds.
- Underground water tables of all kinds.
- Lakes and Sabkhas.
- Aqueducts, wells and public drinking troughs as well as their dependencies.
- The navigation, irrigation or sanitation canals executed by the State or on its behalf for public utility purposes as well as the land that is included in their freeboards and their dependencies.

Characterization /Evaluation of receiving environments: The characterization of the receiving environments of STEPs is based on the following parameters:

- The renewal rate of the medium: this parameter can be evaluated by the closure/ opening of the medium. Thus, the lagoons are shallow bodies of water, isolated from the sea by a loose cord of sand or pebbles and their communication with the sea is made through more or less numerous openings. They lead to a low renewal of the waters of the high seas with a greater natural capacity for self-purification. Indeed, the ecological functioning of lagoons is a source of ecosystem services that harbors biodiversity reserves, nursery areas for fish, migratory refuges for poultry fauna, rainwater purification filters, fishing, and aquaculture production areas. In return, this interface role subjects these environments to strong anthropic pressures. Thus, the increase in discharges at the level of the catchment basins leads to a deterioration in the quality of their water with increasing eutrophication of these environments.
- The initial state of pollution of the receiving environment: it is assessed based on recent characterization studies and the inventory of pollutants from other sources of discharge.
- Discharge rate from STEPs: the potential quantities of pollutants to be discharged into the receiving environment are assessed.
- The level of protection: this is an indicator of sensitivity to be considered when characterizing the receiving environment. The Ramsar zones and IBAs (Important Bird Areas) will be considered. Ramsar is a convention whose mission is the conservation and wise use of wetlands through local, regional, national actions and international cooperation, as a contribution to achieving sustainable development worldwide.
- The presence of fishing, aquaculture, and bathing activities: these uses practiced in coastal areas make the receiving environments highly sensitive to pollution, particularly bacteriological pollution, and pollution by heavy metals.

It is important to point out that this study is based on the analysis of available data and measurements. The latter are not available for all STEP receiving environments. In fact, most of the data collected are measured or evaluated within the framework of an Environmental Impact Assessment (EIA) or within the framework of research projects. These studies are available in the case of receiving environments that are highly sensitive to anthropic pollution (case of the gulf of Gabes or Raoued beach). No specific studies have been carried out on the receiving environments forming part of the DPH.

Description of the receiving environments of the STEPs: The table below summarizes the different STEPs within the concession perimeter, describes the nature of the receiving environment and proposes a classification based on Tunisian regulations in DPM and DPH.

Table 6. Classification of receiving environments in ONAS coastal STEPs

STEP NAME	Rejection on the receiving ecosystem	Nominal Hydraulic Capacity (M³/Day)	Nominal Biological Capacity (KG DBO5/Day)	Domain Classification
Northern Tunisia STEP				
Choutrana 2	Drainage canal of « El Khalij » and submarine emissary under construction	40000	20000	Maritime
Southern Tunisia STEP				
El Hamma	Sabkha of Fejij	4060	2030	Hydraulic
Gabes	At sea without an emissary	17260	9050	Maritime
Mareth/Zarrat	3.5 Km in wadi, discharge without drainage	2860	633	Hydraulic
Metouia/ Ouethref	4 Km in Oued Melah, discharge without drainage	2700	1735	Hydraulic
Ajim	AT Sea, future drainage	1950	900	Maritime
Djerba Aghir	At sea without drainage	15730	3325	Maritime
Medenine	OuedGueblaoui	8870	3500	Hydraulic
Zarzis town	At sea without drainage	1335	600	Maritime
El Hancha	Sabkha of El Jem	700	300	Hydraulic
Jebeniana	At sea without drainage	1312	709	Maritime
Kerkennah	At sea without drainage	2700	950	Maritime
Sfax North	At sea without drainage	17900	8800	Maritime
Sfax South	At sea without drainage	49500	21600	Maritime
Ben Guerden	Sabkha	7500	540 (4)	Hydraulic

VII.2.3. Standards governing industrial wastewater

The management of industrial wastewater is carried out through the industrial discharge services at the level of the regional directorates and at the level of the treatment directorate for Greater Tunis. These services ensure that industrial wastewater complies with the regulations in force and with the NT106-002 standard.

NT106-002 Standard defines the limit values not to be exceeded for discharges into public sewers. For certain parameters, the Standard indicates an upper tolerance limit that could be applied instead of the limit value and this after advice from the Ministry of Equipment. The controlled concentrations on the raw effluent must comply with the limit values indicated in the Table of the Standard.

The new Standard defines the limit values not to be exceeded for industrial discharges according to the type of industry considered. It differentiates between 14 different types of industries:

- Fruit and vegetable industry.
- Milk and its derivatives.
- Meat industry and slaughterhouses.
- Oil and fat industry.
- Fish and seafood industry.
- Beverage industry.
- Mechanical and metalworking industries.
- Electrical, electronic, and household appliance industries.
- Cell and battery industry.
- Chemical and pharmaceutical industries.
- Textile and clothing industries.
- Leather and shoe industries.
- Pulp, paper and paperboard industries.
- Building materials, ceramics, and glass industries.

In addition, the list of parameters to be checked also depends on the type of industry being checked. For industries not covered by the sectors of activity listed in Annex 2 of the draft Standard, and for all treatment plants whose raw water consists of a mixture of effluents from several activities, the effluent concentrations must comply with the values specified in Annex 1 for discharges into the Public Sanitation Network (RPA).

Article 4 of the new Standard stipulates that industrial installations in the sectors mentioned must carry out periodic analyses of the parameters indicated in the Standard according to the sector to which they belong. Furthermore, contrary to the current

Standard, Article 8 of the new Standard sets the frequency of analyses for the control of effluents discharged into the receiving environment (DPH and DPM). These controls must be carried out by the operators of industrial installations who must record the results of all the analyses carried out in a register which they make available to expert controllers, sworn and authorized agents under the authority of the Ministry of the environment and the Ministry of public health.

Article 9 of the draft Standard stipulates that the agreement for the connection of an industry to a collective urban or industrial station is only issued when the collective sanitation infrastructure allows the treatment of the industrial effluent in accordance with the legislation and regulations in force.

Technical tools for IWW management: The management system of the IWW to control pollution from industrial sources is mainly based on:

- The census of polluting industrial activities in the catchment areas of STEPs by means of the Cadaster of Industrial Discharges in Tunisia (CADRIN) which should be continuously updated. The CADRIN is a qualitative and quantitative data bank concerning the discharges of the industrial units taken in charge by the ONAS. It was created in 1996, was upgraded in 2000, and then a WEB version with access via the ONAS intranet in 2010. The data entered by the "Industrial Discharge Service" at the level of the regional directorates is designed to contribute to the monitoring and control of industrial pollution.
- The monitoring of wastewater of industrial origin and of pre-treatment plants belonging to industrial companies by means of periodic analyses.
- The monitoring of infringements in terms of pollutant discharges exceeding the thresholds recommended in NT 106.20 Standard.
- The monitoring of work on the construction of pre-treatment units.
- Assistance and supervision of industrial companies wishing to improve the operation of their pre-treatment facilities.

In addition, a KFW funded industrial zone remediation program (KFW, 2013) includes the following works in the Northern Region:

- Soliman: extension of the existing domestic wastewater treatment plant (phase 1 of the program).
- Bizerte: connection of the Menzel Jmil, El Azib and Technopark industrial areas.
- Menzel Abdurrahman: on the Bizerte wastewater treatment plant (phase 1 of the program).
- Grombalia: construction of a new wastewater treatment plant for industrial wastewater of Grombalia and possibly Bouargoub (phase 2 of the program).
- Bouargoub: extension of the existing wastewater treatment plant (phase 3 of the program).

- Utique: construction of a new wastewater treatment plant for industrial wastewater (phase 3 of the program).
- Medjez-el Bab: connection of the industrial zone to the wastewater treatment plant of Medjez-El Bab (phase 3 of the program).

For the Southern region, only Sfax is concerned by this industrial zone sanitation program which foresees the construction, in phase 2, of a wastewater treatment plant dedicated to industrial wastewater for the industrial zones of Madagascar and the new fishing port. The technical feasibility studies for these plants have been completed. It is worth noting the completion of the priority accompanying measures at institutional, legal, and organizational levels for a better management of industrial wastewater treatment provided for in the first and second tranches of the program approved by KFW and adopted as preconditions. This is part of the Program contributing to the Depollution of the Mediterranean (DEPOLMED) financed by AFD and aims at strengthening ONAS's logistical and human resources, particularly at the level of the Metrology Department within ONAS (2019). However, ONAS does not have a program to inspect the pre-treatment facilities of the 4000 units connected to the public sanitation network and the resources that need to be made available do not seem to be sufficient to carry out these inspections.

- DEPOLMED Project: This project consists in supporting ONAS in the implementation of the first part of an ambitious investment program in the field of coastal zone sanitation. It provides for:
- The rehabilitation and extension of the 4 coastal wastewater treatment plants of South Meliane, North Sousse, Jedaida and Kelibia, and about 540 km of networks, 53 pumping stations and 29,000 connection boxes.
- Strengthening ONAS's capacities in key areas of its mission: management of investment projects, operation and maintenance of infrastructures combined with self-monitoring of wastewater treatment plant discharges, control of industrial sanitation, communication, and public consultation.
- Impacts:
- Water pollution of the coastal marine environment (Bizerte Lagoon, Ghar El Melh Lagoon, gulf of Tunis, gulf of Hammamet, Bay of Monastir and gulf of Gabes): improved or additional installed treatment capacity of more than 115,000 m^3/day of domestic effluents.
- Negative socio-economic impacts on coastal populations and communities carrying out activities sensitive to marine pollution (fishing and tourism).
- Connection of 60,000 new people and improved service and individual well-being for nearly 1.2 million people already connected.
- Reduction of greenhouse gas emissions: overall carbon balance of 73,000 teq CO_2 per year.

- Effect of adaptation to climate change in a national context of water stress: by increasing the water resources that can be mobilized by treated wastewater used for groundwater recharge and irrigation.

Current situation of the IWW management: The STEPs that are part of the concession perimeter and receive IWWs are represented in the table below:

It should be noted that the share of purification products called "industrial" for a STEP according to the annual reports of the ONAS, does not necessarily indicate a contribution of highly polluted industrial discharges. In fact, it simply refers to everything that is not domestic (*e.g.*, traders, schools, hotels, hospitals, and crafts). Especially in the case of tourist areas, the high rate of industrial wastewater corresponds essentially to commercial activities which do not necessarily cause deterioration in the quality of the sludge.

Table 7. Characteristics of industrial discharges for coastal STEPs (Data collected during visits to STEPs mentioned below)

Steps	ReceivingIWW	Type of industries	Percentage of effluent
Choutrana	Yes	2%	
El HAMMA	Yes	Thermal station of Hammamet	2%
Gabes	Yes	Vegetable oil waste	5%
Mareth	No		
Metouia	Yes	Slaughterhouses	5%
Ajim	No	-	-
Aghir	No	-	-
Medenine	No	-	-
Zarzis town	No	-	-
El Hancha	Yes	Carton and cheese factories, Auto wash	7%
Jebeniana	Yes	Poultry slaughterhouses, milk factory, vegetable oil waste, textile, Auto wash	6%
Kerkennah	No	-	-
Sfax Nord	No	Oil waste and poultry slaughterhouse	1%
Sfax South	Yes	Several types: vegetable oil waste, Agrifood, textile, fisheries	25%
Ben Guerden	Yes	-	2%

In table 7, the percentages indicated represent the share of IWW from all types of industries, mainly agrifood industries, which emit significant organic loads. This data is collected during visits to STEPs.

In general, STEPs receive between 1% and 25% of industrial discharges in their raw effluents. The STEP receiving the most industrial discharges is the STEP of Sfax South which industrial discharges represent about 25% of the raw wastewater. The industries identified for this STEP are mainly the fishing industry, the food industry, textiles, and the discharges of vegetable oils.

To evaluate the current situation of the management of industrial discharges in the ONAS network, the results of analyses of the TWWs of the STEPs (results carried out over the years 2016, 2015, 2014) were studied. Thus, it was noticed that, for example for the TWW of Sfax, the exceedances of the thresholds indicated by the NT106.02 Standard are frequent during the last three years of 2014, 2015 and 2016. It should be noted that, despite these exceedances, the STEP has continued to supply TWW for irrigation since 1989. Indeed, the study of Belaid (2010) on the evaluation of this irrigation impact on soils and plants in the perimeter of El Hajeb, reusing the TWW of the STEP of Sfax since 1989 has shown that the irrigation by TWW has affected the irrigated soils in the same way for salinity, but differently for heavy metals. However, this work concluded that the accumulations of metallic elements in olive leaves are statistically insignificant.

Moreover, the observation of the ONAS analyses results has shown that the analyses are not carried out on all the parameters indicated by the Standard in force. The parameters that are not measured or that are rarely measured are: detergents, hydrocarbons, oils, fats, Cadmium, Cobalt, Copper, Lead, Nickel, Zinc, Total Chromium, Chromium IV, Fluorides, Phenolic compounds, Chlorinated solvents, Boron, Tin, Molybdenum, Active Bromine, Barium, Silver, Arsenic, Beryllium, Antimony, Selenium, Titanium, and pesticides. They make it impossible to identify high levels of chemical/ organic pollutants of industrial origin.

According to the ONAS, apart from the Sfax South STEP and in general for the parameters measured regularly, the values recorded are in their majority lower than the limit values of NT 106.02 Standard, probably indicating compliant discharges upstream of the WWTPs.

VII.2.4. Actual situation on the STEPs

It is worth mentioning that STEPs are subject to the NT 106.02 Standard for treated discharges, which sets threshold values for different chemical and biological parameters depending on the classification of the receiving environment as DPM or DPH. These limits are not subject to modification by EIAs.

It should be noted that the most important STEPs in terms of their nominal loads are the Choutrana and South Sfax STEPs. Indeed, their nominal flows are 40,000m^3/d and 49,500 m^3/d, respectively.

The Choutrana STEP rejects, according to the analyses of the last three years of the parameters measured by the ONAS, TWW conforming to NT 106.02, except for chlorides, Platinum, Fecal coliforms, and Fecal streptococci. Considering the new Standard, TWW of Choutrana complies with all the threshold values of the new Standard except for fecal coliforms and fecal streptococci.

For chlorides, their concentration slightly exceeds the threshold value of the new Standard for DPM releases. The STEP of Sfax South provides a poor quality of TMEs with an excess for Chlorides, COD, BOD5, MES, NtK, PT, Sulphates, Al + Fe, Cyanides, Lead, Mercury, Fecal coliforms, Fecal Streptococci and Salmonella according to the Standard in force and an excess of Threshold values for COD, BOD5, TSS, NtK, PT, Cyanides, AL + Fe, Lead, Zinc, Hexavalent Chromium, Fecal Coliforms, Fecal Streptococci, Salmonella when based on the new Standard. Some of these pollutants originate from the domestic urban waters, but the highest concentrations are due to industrial discharges that do not comply with the current standard for discharges in RPA. Given that more than 20% of the gross discharges treated at the plant level are of industrial origin, it would be essential to strengthen controls on the pre-treatment facilities of industrial units and the quality of their discharges.

Pollutants that exceed the thresholds of the NT 106.02 Standard and the new Standard for most STEPs are COD, BOD5, NT and PT indicating insufficient treatment of organic matter in effluents. It is expected that after rehabilitation work and improvement of the treatment process at the STEPs, discharges should meet the threshold values indicated for these parameters in the new Standard, which is less restrictive for the concentration of NtK and PT compared to the current standard.

For the other pollutants, the concentrations are not very high (except for the Sfax South STEP) and a more reinforced control upstream of the STEPs will make it possible to make the industrialists responsible and to reduce these concentrations below the current Standard.

However, ONAS does not measure the concentrations of all the pollutants listed in the Standard in force, which does not allow a more precise vision of the quality of the TMEs of the STEPs.

Analysis of the tables of levels and frequencies of excess of the new Standard shows that the parameters with the most significant excess are those relating to organic load (COD, BOD5, TSS, NT and PT). This is due to the failure of urban waters treatment, a problem that will be addressed after rehabilitation and upgrading of the processes of the STEPs concerned. The STEPs with significant excess levels and frequencies are mainly those of Sfax South, Gabes, El Hamma and Metouia/Ouethref.

Table 8. Current situation of the STEPs targeted by the ONAS analyses over the period from 2014 to 2016

STEP	Year of entry into service	Rated hydraulic capacity m³/d	Nominal biological capacity kg BOD5/d	Submission to Reject Limits	Date of obtaining the operating permit / issuing authority	Validity permit / expiry date	Discharge limits of the operating permit	Parameters exceeding release limits in the 3 years (2014, 2015 and 2016) under the old standard	Parameters exceeding the discharge limits within 3 years (2014,2015 and 2016) according to the new standard
Choutrana 2	2007	40,000	20	Yes	Not specified	No expiration date	NT 106.02	Chlorides, Platinum, Fecal coliforms, and streptococci	Chlorides, Coliforms, feces, Streptococci
El Hamma	2004	4,060	2,030					Chlorides, DCO, DBO5, MES, NtK, PT, Sulphates, Cyanides, Mercury, Fecal coliforms, streptococci, feces	Chlorides, DCO, BOD5, MES, NtK, PT, Sulphates, Cyanides, Mercury, Fecal coliforms, streptococci, feces
Gabes	1995	22,100	9,050					DCO, DBO5, MES, NtK, PT, Sulphates, Cyanides, Mercury, Fecal coliforms, Fecal streptococci, Nematode eggs	DCO, DBO5, MES, NtK, PT, Sulphates, Cyanides, Mercury, Fecal coliforms, Fecal streptococci, Nematode eggs
Mareth/Zarrat	2007	2,860	633					Chlorides, DCO, DBO5, MES, NtK, Nitrites, PT, Sulphates, Cyanides, Mercury, Fecal coliforms, Fecal streptococci	DBO5, MES, NtK, Nitrites, PT, Sulfates, Cyanides, Cadmium, Lead, Mercury, Fecal coliforms, Fecal streptococci, nematode eggs

Metouia/ Ouethref	2007	2,700	1,375					chlorides, DCO, DBO5, MES, NtK, PT, Sulfates, Cyanides, Cadmium, Lead, Mercury, Fecal Coliforms, Fecal Streptococci, Nematode eggs	Chlorides, DCO, DBO5, MES, NtK, PT, Sulfates, Cadmium, Plumb, Mercury, Fecal coliforms, Fecal streptococci, Nematode eggs
Ajim	2016	1,950	900					NIL	NIL
Djerba Aghir	2001	15,730	3,325					DCO, PT, Sulphates, Cyanides, Mercury, Fecal coliforms, Fecal streptococci	Mercury, Fecal coliforms, Fecal streptococci
Medenine	2000	8,870	3,500					Chlorides, DBO5, MES, NtK, Nitrites, PT, Sulphates, Cyanides, Mercury, Fecal coliforms, Fecal streptococci	Chlorides, MES, NtK, Nitrites, PT, Sulphates, Mercury, Fecal coliforms, Fecal streptococci
Zarzis town 1992	1992	1,335	600					DCO, DBO5, MES, NtK, PT, Sulphates, Cyanides, Mercury, Fecal coliforms, Fecal streptococci, Salmonella	DBO5, MES, NtK, Sulphates, Mercury, Fecal coliforms, Salmonella
El Hancha	2005	700	315					Chlorides, NtK, Nitrites, PT, Cyanides, Mercury, Fecal coliforms, Fecal streptococci	NtK, Nitrites, PT, Sulphates, Lead, Mercury, Fecal coliforms, Fecal streptococci
Jebeniana	2007	1,312	709					NtK, PT, Cyanides, Mercury, Fecal coliforms, Fecal streptococci,	DBO5, NtK, Pt, Cyanides, Mercury, Fecal coliforms, Fecal streptococci.

Kerkennah	2007	2,700	950					DCO, DBO5, MES, NtK, PT, Cyanides, Mercury, Fecal coliforms, Fecal streptococci, Salmonella	NtK, PT, Cyanides, Mercury, Fecal coliforms, Fecal streptococci, Salmonella
Sfax North	2004	17,900	8,800					MES, NtK, PT, Cyanides, Mercury, Fecal coliforms, Fecal streptococci, Salmonella	MES, NtK, PT, Sulphates, Cyanides, Mercury, Fecal coliforms, Fecal streptococci, Salmonella
Sfax South	2006	49,500	21,600					DCO, DBO5, MES, NtK, PT, Sulphates, Al + Fe, Cyanides, Lead, Mercury, Fecal coliforms, Fecal streptococci, Salmonella	DCO, DBO5, MES, NtK, PT, Cyanides, AL + Fe, Plumb, Zinc, Hexavalent chromium, Mercury, Fecal coliforms, Fecal streptococci, Salmonella
BenGuerden	2019	5,200	2,700					NIL	NIL

VII.3. Desalination stations

VII.3.1. Project for the improvement of the quality of water distributed in the South of Tunisia

For about ten years, the Tunisian State has been carrying out a project to improve water quality in southern Tunisia. In this context, a station with the objective of “improving the quality of water distributed in Southern Tunisia” was launched by SONEDE. The aim of the project is to reach a salinity rate inferior or equal to 1.5 g/liter against more than 2 g/liter in all regions and localities where the population is higher than 4,000 inhabitants. Indeed, Tunisia, faced with a decrease in its water resources due to drought and climate change, has opted like many other countries in the MENA region for seawater desalination.

The SONEDE project will be implemented in two phases:

- The first phase, which includes the construction of 10 small water desalination plants has already been carried out with a budget of 40 million dinars and the plants have been put into service. It included stations in the governorates of Medenine, Guebelli, Tozeur and Tataouine where an improvement of water has been noted.
- The second phase of this project was launched in 2017 and will be carried out over a period of 3 to 4 years (Financing of the project by the KFW). It involves the installation of 6 water desalination plants in southern Tunisia (Sidi Bouzid, Gafsa, Tozeur, Guebelli and Medenine) with a cumulative production capacity of 31,000 m^3/day. These desalination plants will be installed in Gafsa - Legsar - Mdhilla - Guetar - Ayeycha (9000 m^3/d), Metlaoui - Moulares - Redayef (6000 m^3/d), Meknassi - Mzouna - Bouzayen (3000m^3/d), Dgueche (2,000 m^3/d), Bechli - Beni Mohamed - Janaaoura - Blidette - Jersine - Nouel (2000 m^3/d) and Ben Guerdene (9000 m^3/d).

VII.3.2. Water Resources Strengthening Project (2017-2019)

This project consists of:

- The construction of seawater desalination plants with a cumulative capacity of 70,000 m3/d.
- The completion of 34 boreholes.
- The supply and lying of pipes.

The beneficiaries of this project are spread over the whole Tunisian territory. Its cost will be covered by public funding (State Budget).

VII.3.3. Sea water desalination

It is planned to build three sea water desalination plants: the first one in Djerba, the second one in Zarrat (governorate of Gabes) and the third one in Sfax.

Djerba desalination plant: The Djerba (governorate of Medenine) crap water desalination plant is the first of its kind in Tunisia. The plant officially started operating in May 2018. With an initial treatment capacity of 50,000 m^3 of seawater/day, this capacity will be expandable up to 100,000 m^3 of seawater/day. The Djerba desalination plant has been designed and implemented to cover the island's water needs, reduce the water deficit in southern Tunisia and improve water quality in the governorate of Medenine.

This project consists of the construction of a desalination plant with a capacity of 50,000 m^3/d extendable to 75,000 m^3/d, the construction of tanks, pumping station and supply and installation of 25 km.

The Project is funded by the KFW and the AFD.

Zarrat desalination plant (Gabes): The construction of a seawater desalination station in Zarrat (Gabes) started at the end of 2018. The station's commissioning is scheduled for the beginning of 2021. During the signing ceremony of an implementation agreement On May 21st, 2021, the overall cost of the project was estimated at 231.6 million TND (€96.5 million) covered by a financing loan agreement (€82 million). It was signed in 2016 between Tunisia (participation of the Tunisian State at €14.5 million) and the KFW (German Development Bank). This project executed by SONEDE will cover the drinking water needs for 1.145 million inhabitants of the governorates of Gabes, Medenine and Tataouine, by 2035. It will also make it possible to face the water shortage through the desalination of seawater and to mitigate the overexploitation of groundwater. The project will establish a desalination station, with a capacity of 50,000 m^3/day (which capacity could be increased to 100,000 m^3/day by 2027), three water storage tanks with a total capacity of 15,000 m^3, desalinated water pumping station and 60 km of water pipes to serve the governorates of Gabes, Medenine and Tataouine. The cost of projects to be carried out in cooperation with SONEDE in the field of drinking water amounts to € 1billion. The ultimate objective is to face the water shortage in southern Tunisia. Indeed, Tunisia would be at the top of the list of countries affected by the water shortage since it only has about 450 m^3/day/inhabitant, while 1,000 m^3/day/inhabitant is considered a situation of shortage.

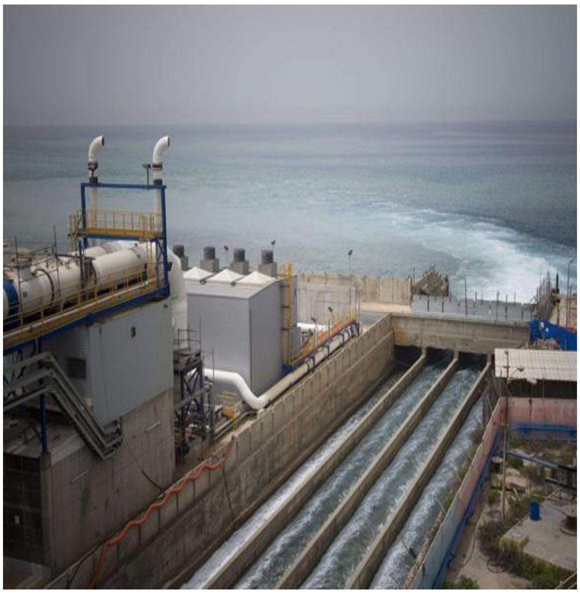


Figure 38. Pipes discharging brine (water saturated in salt) into the sea

Figure 39. Example type of projected infrastructure of a desalination plant

Sfax desalination plant project: This project aims to strengthen the resources and the security of the long-term drinking water supply in the Greater Sfax region and to improve the quality of the water supplied. The project will build a desalination plant with a capacity of 100,000 m^3/day, with a capacity of up to 200,000 m^3/day and is financed by JICA.

The Sfax seawater desalination project is taking shape. Work on this project was initially scheduled to start in March 2020 (the start has been delayed to 2021, given the current context of the global Covid-19 pandemic). The project is implemented by SONEDE. It will allow the construction of a desalination station in Gargour, located 20 km from Sfax. The facility will have a capacity of 100,000 m^3/day. The water treated in the plant will be stored in a tank. The project also includes the construction of a pumping station and the laying of pipes for the delivery of drinking water to Sfax. SONEDE intends to double the installation capacity (200,000 m^3/day) in the future. The first phase of the project will require a total investment of 956 million Tunisian dinars (€306.7 million). The Tunisian state is funding the project with a loan of €256.5 million from the Japan International Cooperation Agency (JICA). According to JICA, the desalination project will improve the quantity and quality of drinking water supply in the Sfax region, thereby “contributing to the improvement of living conditions and to economic and social growth” in the region. Currently, the drinking water supply for the populations is very limited in Sfax.

VIII. Assessing the costs of damage

It is difficult to assess the implications of ecosystem changes induced by human activities on the coast and to manage them efficiently, considering the interactive effects of the different human pressures on the coasts (Fig. 40). Indeed, many of these effects take time to appear because they most often occur at a distance from the modification sites on the one hand, and because the greater costs and benefits of these modifications benefit the various actors on the other.

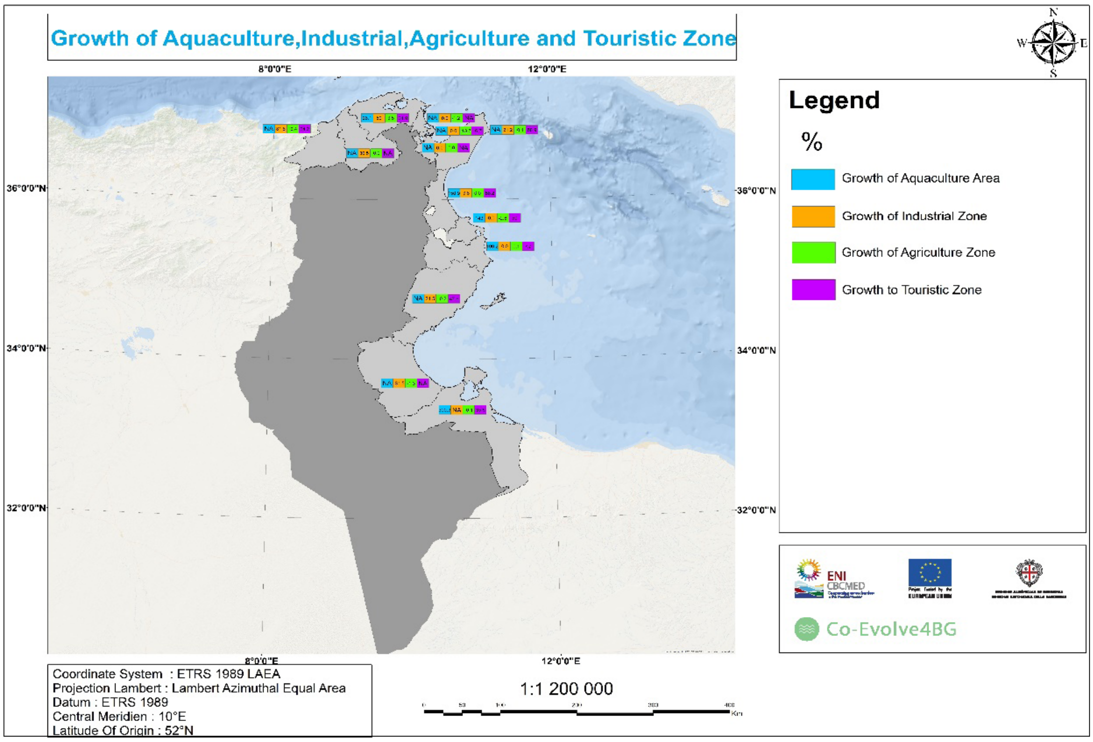


Figure 40. Growth of aquaculture, industry, agriculture, and tourism on Tunisagriculture

There is a substantial inertia (delay in a system's response to a disturbance) in ecological systems. This often results in a long lag period between the modification applied to an underlying force and the full manifestation of the consequences of that modification. For example, the accumulation of phosphorus in large quantities in many agricultural soils threatens rivers, lakes, and oceans in coastal areas, with increased eutrophication. However, years or decades may pass before the full impact of phosphorus is visibly manifested through erosion and other processes. Similarly, global temperatures will take centuries to reach equilibrium because of changes in atmospheric greenhouse gas concentrations and it will take even longer for biological systems to respond to climate change.

In addition, some impacts of ecosystem changes may not occur far from the locations of human activities where the change occurred. For example, changes in the upper reaches of rivers affect water flow and quality in downstream regions. Similarly, the destruction of an important fish feeding area in a coastal wetland can lead to a decrease in fish caught at distance from the original feeding ground. Inertia in ecological systems, the temporal and spatial shifts in the manifestation of the costs and benefits of ecosystem change, often result in situations where people who suffer (downstream landowners) from the damage caused by the change are not the same people who receive the benefits. These temporal and spatial characteristics make it extremely difficult to fully assess the costs and benefits of ecosystem change or to attribute these costs and benefits to the various stakeholders involved. Moreover, the institutional arrangements for ecosystem management currently in place are poorly designed to meet these challenges.

It has been scientifically established, albeit incompletely, that change in ecosystems increase the probability of the appearance of non-linear changes, including accelerated, abrupt, and potentially irreversible changes, with significant consequences for human well-being.

Ecosystem changes generally occur gradually. However, some are non-linear in nature. As soon as a threshold is crossed, the system is transformed to take on a totally different state. And these non-linear changes are sometimes abrupt; they can also be of great magnitude, difficult, costly, or impossible to reverse. The ability to predict the occurrence of non-linear ecosystem changes is improving, but for most ecosystems these potential non-linear changes, although science can point to increased risks of change, it cannot predict the thresholds beyond which change will occur. Examples of large-scale non-linear changes include disease outbreaks, sudden deterioration of water quality, and the appearance of "dead zones" in coastal waters, the collapse of fisheries and disruptions to regional climate. Some historical large-scale non-linear changes are:

- The collapse of the Atlantic cod stocks off the coast of the island of Newfoundland in 1992, associated with eutrophication and hypoxia. Once the nutrient loading threshold is reached, changes in freshwater and coastal ecosystems can occur abruptly and extensively. They cause harmful algal blooms (including blooms of toxic species) and sometimes lead to the formation of oxygen deficit zones that destroy virtually all animal life and the collapse of fishing. The collapse of the Atlantic cod stocks forced the closure of the fishery after hundreds of years of exploitation. Better still, depleted stocks could take years to recover or not recover at all, even if the fishery was significantly reduced or stopped altogether.
- The 1997-1998 El Niño events that led to the meringue of diseases: excessive flooding caused cholera epidemics in Djibouti, Somalia, Kenya, Tanzania, and Mozambique. Warming of the great lakes in Africa because of climate change may create favorable conditions for increasing the risk of cholera transmission in surrounding countries. This illustrates the emergence of diseases. If on average each person infected with a disease transmits it to at least one other person, then an epidemic occurs, whereas if the infection is transmitted on average to less than one person, the epidemic stops.

- The introduction of the zebra mussel into aquatic systems in the United States, for example, has resulted in the expulsion of the local clam from Lake St. Clair and annual costs of $100 million to the energy industry and other users. This event represents the introduction of allochthonous species and the loss of autochthonous species.
- Regional climate change: Deforestation generally leads to reduced rainfall. Since the existence of the forest is fundamentally dependent on rainfall, the relationship between forest loss and reduced rainfall can be a positive reaction which, under certain conditions, can lead to a non-linear change in forest cover.

The prevalence of poisoning due to the consumption of marine organisms and the emergence of new pathogens as well as seafood poisonings are increasing and some of these poisonings, such as “ciguatera”, affect human health. Episodes of dangerous algal blooms (including toxic algae) in coastal waters are increasing in frequency and intensity, affecting other marine resources such as fish and shellfish, as well as human health. During a particularly severe outbreak in Italy in 1989, the harmful algal blooms cost the coastal aquaculture industry $10 million and the Italian tourist industry $11.4-15 million.

Additionally, the frequency and impact of floods have significantly been increasing over the past 50 years, partly due to changes in ecosystems. For instance, there has been an increase of the exposure of coastal populations to tropical storms due to the destruction of mangrove forests and the increase in downstream flooding because of changes in land use in the upper reaches of the Yangtze River. Annual economic losses due to extreme events have increased tenfold since the 1950s, reaching about $70 billion in 2003, with 84% of insured losses due to natural disasters (floods, fires, storms, drought, and earthquakes).

In other places, the change in land use may result in higher nutrient loading (if the land is converted to high intensity agriculture), increased greenhouse gas emissions (if the forest is cut down) and higher numbers of invasive species (due to disturbed habitat), spilling over aquatic habitats. These changes include:

- Habitat conversion, through conversion to agriculture: Under the MEA scenarios, an additional 10-20% of pasture and forest land is projected to be converted between 2000 and 2050 (mainly to agriculture). The projected land conversion is concentrated in low-income countries and drylands. Forest cover is projected to continue to increase in industrialized countries.
- Overexploitation of natural resources, particularly in fisheries: In some marine systems the biomass of fish targeted by fisheries (including both target and by-catch species) has decreased by 90-99% since pre-industrial fishing levels. Fish are increasingly being caught from lower trophic levels of low value as populations of higher trophic level species are depleted. These pressures continue to increase in all MEA scenarios (Millennium Ecosystem Assessment, 2001).

- Invasive alien species: The spread of invasive alien species and disease-carrying organisms continues to increase due to both deliberate movement and accidental introductions related to increasing trade and travel, with significant damaging consequences for local species and many ecosystem services.
- Pollution, especially nutrient input: Humans have already doubled the flow of reactive nitrogen across the continents. Some projections suggest that this could increase by about two-thirds by 2050. Three of the four MEA scenarios predict that the global nitrogen flux to coastal ecosystems will increase by another 10-20% by 2030 (medium certainty), with almost all this increase occurring in developing countries. Excess nitrogen contributes to the eutrophication of freshwater and coastal marine ecosystems and to the acidification of freshwater and terrestrial ecosystems (with implications for biodiversity). To a certain degree, nitrogen also plays a role in the creation of ground-level ozone (leading to a loss of agricultural and forest productivity), the destruction of ozone in the stratosphere (leading to a loss of the ozone layer and an increase in UV-B radiation at the earth's surface causing an increased incidence of skin cancer) and global warming. Resulting health effects include the consequences of ozone pollution on asthma and lung function, increased allergies, and asthma due to high pollen production, the risk of Blue Child Syndrome, an increased risk of cancer and other chronic diseases from nitrate in drinking water, and an increased risk of a variety of lung and heart diseases due to the production of fine particles in the atmosphere.
- Anthropogenic climate change: Recently observed changes in climate, warmer regional temperatures, have already had significant impacts on biodiversity and ecosystems. They included changes in species distribution, population size, breeding season or migratory events and an increase in the frequency of pests and disease outbreaks. Many coral reefs have experienced episodes of bleaching, often partially reversible, when local sea surface temperatures have risen by 0.5 to 6 degrees Celsius monthly, above the average of the warmest months.

By the end of the century, climate change and its impacts could be the most important direct underlying force responsible for biodiversity loss and changes in ecosystem services. Scenarios developed by the Intergovernmental Panel on Climate Change (IPCC) predict a further increase in global average surface temperatures of 1.4 to 5.8 °C Celsius by 2100, an increase in the incidence of floods and droughts and an additional 8 to 88 cm sea level rise. Damage to biodiversity will increase on a global scale with increasing rates of climate change and an increasing absolute volume of change. Conversely, some ecosystem services in some regions may experience an initial enhancement due to projected changes in climate (such as increases in temperature and precipitation) and thus these regions may experience net benefits at low levels of climate change. However, as climate change becomes more severe, the negative ecosystem impacts offset the benefits in most parts of the world. The balance of scientific evidence suggests that there will be a significant net detrimental impact on ecosystem services if global average surface temperatures increase by more than 2 Celsius above the pre-industrial period level, or at rates above 0.2 degrees Celsius per decade (medium certainty)

Based on the IPCC, this would require limiting greenhouse gas concentrations to less than 550 parts per million carbon dioxides (medium certainty).

Under all four MEA scenarios, projected changes in underlying forces will result in significant growth in the consumption of ecosystem services, continued loss of biodiversity and further degradation of some ecosystem services.

- Over the next 50 years, food crops are projected to increase by 70-85% under MEA scenarios and water demand by 30-85%. Water withdrawals in developing countries are projected to be more severe under these scenarios, although they are projected to decline in industrialized countries (medium certainty).
- Food security will not be achieved under the MEA scenarios by 2050 and child malnutrition will not be eradicated (it is projected to increase in some regions) despite increased food supply and more diversified diets (medium certainty).
- Deterioration in the services provided by freshwater resources (such as aquatic habitat, fish production, water supply for households, industry, and agriculture) is projected in the scenarios, particularly in those that are reactive to environmental problems (medium certainty).
- Habitat loss and other ecosystem changes are projected to lead to a decline in local diversity of native species under all four scenarios by 2050 (high certainty). Overall, the number of plant species at the equilibrium level is projected to decline by 10-15% due to habitat loss alone over the period 1970-2050 under the MEA scenarios (low certainty). Other factors such as over-exploitation, introduction and expansion of invasive species and climate change will further increase the rate of extinction.

IX. Land Use Interaction and Coastal Tourism Impact

The impacts of tourism on the environment are both positive and negative. The positive impacts of tourism lie in the protection of natural sites through their enhancement and their opening to visitors. However, the negative impacts of tourism lie mainly in the pressure exerted on space and natural resources such as soil, water, and energy.

Up to now, the development models are thought to have tended to concentrate tourist infrastructures and superstructures in areas outside the cities. Apart from the fact that these developmental models isolate tourists and place them in relatively isolated spaces, the tourist areas concentrate the negative impacts of tourism in space and fortunately they are mostly equipped with the basic infrastructure necessary for the management of such impacts. However, the development of tourism has been accompanied by the development of urban areas around tourist centers. The outstanding examples are the areas of Hammamet North and Hammam Sousse. The management of the impacts of this urbanization is not considered in the development of basic infrastructures in tourist areas. This implies negative environmental impacts that exceed the carrying capacity of the developed infrastructures, generating environmental pressures in the tourist areas. The impacts of tourism on the environment are both positive and negative.

More specifically, tourism and related urbanization are putting negative pressures on the coast, water, and energy. These pressures mainly take the form of coastal erosion and pollution of bathing water due to the discharge of treated wastewater and waste. The development of the tourist activity, as has been shown previously, has mainly taken place on the coast, with 95% of the hotel capacity being located on the coast and 92% of the overnight stays taking place in these areas.

Figure 41. Coastal degradation in a tourist area in Djerba

Studies show, for example in the Tabarka region, where exploitation began in 1992, hotels have been built in dune and pre-dune areas, contrary to regulations; thus, giving free rein to the sea's advance. In Djerba, Sousse and Hammamet, a constant retreat of the dune zones and beaches was regularly observed, especially downstream from the ports. Retreats of 25 to 35 meters of beach have been observed in Sousse since the end of the 80s following the creation of the marina. In Djerba, hoteliers regularly try to mitigate the phenomenon of erosion by artificial silting and even by rockfill. Every year, artificial recharging is necessary.

The evolution of water consumption per tourist per night is quite significant in the tourist sector compared to that of households. This consumption has increased since 1999 to reach peaks of 700 liters and more per day and per tourist per night, as opposed to an average of less than 90 liters per inhabitant on a national scale. To compensate for this excessive consumption, the tourist sector often resorts to the reuse of treated wastewater in the irrigation of golf courses and green areas. Some hotel chains also proceed to the desalination of sea water and brackish water by the method of reverse osmosis.

Energy consumption per overnight stay has been rising for at least the last 20 years, from 15 kwh/night in 1997 to around 18 kwh in 2010, the reference year. In 2011, despite a significant decrease in tourist activity, energy consumption exploded. The energy transition does not yet seem to be one of the priorities of Tunisian hoteliers.

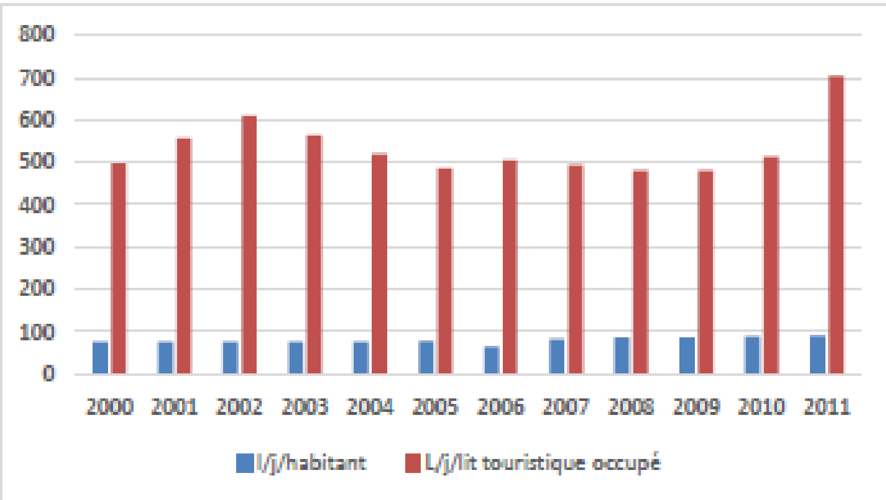


Figure 42. Specific consumption of drinking water per occupied bed in the tourism sector.

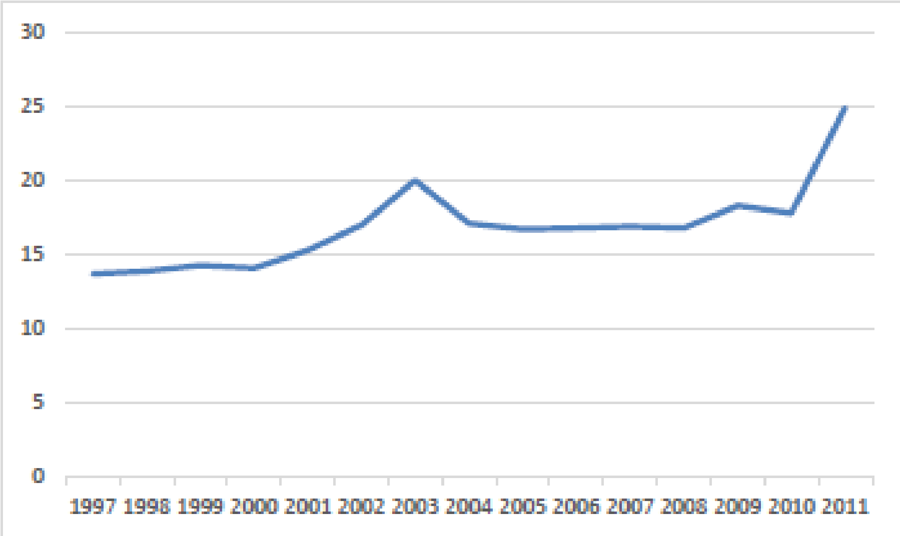


Figure 43. Electricity consumption per overnight stay in the tourism sector

Losses of the tourist activity caused by beach erosion in the region of Sousse and Monastir: METAP's 2005 study on the costs of environmental degradation in Tunisia's coastal areas revealed that these costs are particularly reflected in losses in human health as well as in direct benefits and returns on natural resources. In relation to natural resources, three areas have been identified as priorities: tourism, fisheries, and agriculture. The pilot zone on which the study was carried out particularly covers the governorates of Sousse and Monastir extending from Enfidha to Bekalta over a linear area of about 140 km. It is a shallow zone with a predominance of sandy beaches. In the pilot zone, the most important direct economic losses in relation to the degradation of the environment at the level of tourist activity are those caused by the erosion of the beaches and the consequent loss of income. Approximately 5 kilometers or 250 ha of beaches suffer from severe erosion in the area. The loss of beaches for hotels results in loss of clients, lower prices, or major investments in beach restoration. This erosion is usually caused by constructions in the sea that change the current regime or the destruction of sand dunes by constructions too close to the shore. Interviews conducted in May 2005 as part of the study showed that hotels with serious erosion problems have seen their occupancy rates decrease. Of course, there may have been other factors that influenced this decrease, but the interviews suggested that these direct losses in clientele could be evaluated at more than 800,000 DT/year for a single hotel. With 5 to 10 main hotels suffering at that time from severe erosion in the study area, the author of the study suggests that the total losses could have reached 4-8 million TND/year. As for the direct income from the developed beaches, this is of the order of 160,000 TND/ha/year, assuming an approximate income of 2.6 TND/day per visit and 100 days×600 visitors/ha of beach. The current loss of beach due to erosion is about 3-4ha, which would correspond to a loss of 468,000 to 624,000 TND/year. Other causes of the loss of beaches are urbanization and the development of the port which led to the disappearance of about 21 ha of beaches during the last 10 years. The high maximum value of the losses is obtained by assuming that all the lost beaches are suitable for controlled developed activities with rental of umbrellas, *etc.*.. The minimum value is obtained by assuming that only half of the beaches are suitable for these developed activities. This conversion of land use would thus correspond to an average loss of 1.6 million TND /year. The total loss in the study area, caused by the erosion of beaches, at the level of the tourist sector, would thus vary between 6 and 10 million TND/year, at 2005 prices.

For an alternative tourism, in Tunisia: Alternative Tourism is the generic name given to the different alternatives of mass tourism which is mainly at the heart of Tunisian tourism. According to certain specialists, Tunisia is more a hotel destination than a touristic destination. Independently of the definitions, it should be remembered that the "so-called alternative tourism puts at the center of the journey the encounter, exchange and the discovery of other cultures. It favors the involvement of the local population in the different phases of the tourist project and a more equitable distribution of the resources. These are the reflections of the supporters of "alternative tourism" who consider that classic, mass tourism in Tunisia has for too long been focused on short-term profitability at the detriment of the development of the regions and their populations. The impact on the natural environment would obviously not have contributed to the development of the local populations, whose traditional practices and cultures are ignored or in most cases threatened. The idea in the future is to promote tourism "whose impact on the natural and cultural environment would not be harmful". And it is in this way that specialized tourist agencies and accommodation were born in Tunisia in recent years. Alternative tourism in Tunisia is only in its infancy and will certainly not replace mass beach tourism; yet it represents a complementary alternative. It remains to be seen whether it is not too late, at least in certain regions, to mend the situation. The spectrum of alternative tourism includes sustainable, rural, solidarity and responsible tourism.

X. Land -Sea interaction for sustainable Blue Economy

The blue economy is an economic model inspired by natural ecosystems and advocating the principles of Sustainable Development by valorizing what is available locally and transposing the prowess of nature to an industrial scale. This concept is based, among other things, on the principles of the circular economy where each waste becomes a source of energy for another activity.

The blue economy is part of the natural resources sustainability system and job creation. The term refers to the "blue planet", integrating the air, the sky and all the elements of the "green" economy.

The blue economy wishes to go beyond the green economy and the circular economy, by seeking to "imitate nature". This is by seeking to superimpose itself on the natural evolution of nature (of the shoreline, the littoral and the coastal zone) and not to defy this evolution at the risk of harming the coastal and marine environment, without leading to economic, social and environmental benefits that are sustainable in time and space.

- To this end, developing a sustainable blue economy automatically means working for a better implementation and strengthening of the Integrated Coastal Zone Management (ICZM) of the Tunisian coastline. Therefore, ICZM and Maritime Spatial Planning (MSP) are, if implemented, practical tools and solutions. They guarantee the sustainability of coastal natural resources and the sustainable management of the marine environment, by local authorities (*i.e.*, governorates, delegations, and municipalities) and NGOs/SCs in the ICZM process. Thus, among the recommendations made during the numerous analyses and evaluations of the ICZM process in Tunisia, and those for a better implementation and strengthening of the ICZM concept on the Tunisian coastline, the following are particularly mentioned:
- The empowerment and participation of local NGOs in ICZM approaches and in the implementation of programs and action plans should be a key objective and an instrument for improving the performance of sustainable coastal zone management and for the adoption of ICZM principles.
- Good sustainable management and governance of environmental issues in the coastal zones can be achieved through a better public-private partnership. They included recognition of the local civil society role. For example, the quality of governance and the functioning of the partnership management mechanism have a direct influence on the sustainable management of the sites concerned. Thus, measures in favor of the assumption of responsibilities by civil society should include awareness-raising, environmental education, monitoring, control, participation in decision-making and public information.

Due to the low representation or even absence of citizens' organizations and other non-governmental stakeholders with little and/or no involvement in ICZM processes, to varying degrees, the ICZM strategies, action plans and programs have not been allowed for discussions on key issues related to the ICZM process in Tunisia.

XI. Conclusions

In Tunisia, the seaside tourist offers, which started with a few punctual hotel units parallel to the shoreline, has gone through several concepts of tourist development to meet the demand of tour operators who are their intermediaries with the European clientele. The Tunisian State, a primordial planning actor in developing these concepts, has not ceased, since the 1980s, to disengage itself to encourage tourist promoters to take over the tourist development. The new disengagement of the State is compensated by the strong entry of private investors to develop the new types of integrated resorts being grafted onto the old classic zones and town centers. This policy has led to the realization of urban operations increasingly dominated by the mass hotel industry and by the real estate offer to meet the lucrative stakes of their private promoters. To this end, the example of the Yassmine-Hammamet resort shows us that if the State allows itself to be guided only by private developers, it risks achieving results that diverge totally from the main stakes. Tourist areas and resorts designed for development have a negative impact on the coastal environment. The construction of marinas and hotel units to the detriment of the coastal dunes is responsible for beach erosion.

In addition, there are several threats and impacts linked to the exploitation of the marine environment and its natural resources (fishing and aquaculture, shipping and maritime traffic, industrial and urban wastewater emissions, desalination, exploitation of the coastal zone, offshore oil, and gas exploitation). These impacts are more amplified by the effect of climate change and Sea Level Rise (SLR), particularly regarding coastal erosion, submersion of the coastal zone, Stalinization of coastal aquifers and the increased risk of flooding of coastal areas. In this respect, let us not forget the elaboration in 2017 of a “Climate Risk Assessment” study and the elaboration of an emergency response plan in the coastal fringe of Ghar El Melh, Kalaat El Landalouss and Djerba (APAL, UNDP in the framework of the project “Coastal Resilience to Climate Change Risks”). The results of this study may be useful for the current project, particularly for the Djerba area, a site targeted by the Co-Evolve project.

Regarding the impacts caused by the different uses on the coastal zone and its natural ecosystems, it appears that the Tunisian coastlines is today characterized by a general aspect of degradation and pollution, a symptom of the current anthropic pressures which are rapidly increasing. They have undergone considerable spatial changes and mutations, with the expansion of land devoted to agriculture and conservation. Traditional agricultural uses have proved to be more respectful of the natural environment, while other more aggressive uses associated with construction are beginning to radically alter the morphology and dynamics of the coastal areas.

However, it should be based in mind that the coastline is subject to very aggressive marine erosion phenomena which threaten to destroy the already very fragile coastal zone. The consequences of which may lead to a definitive ‘maritimization’ of the coastal wetlands.

By way of final reflections, it should be noted that there is a generalized trends about the current environmental situation of the coastal zone in Tunisia. This concern is due to the increasing threats to the coastal space which is subjected to pressures in both the very short term, as is reflected by the increasing coastal erosion, or in the medium and long terms, as reflected by the rise in sea level due to climate change. Thus, very rapid hydro-geomorphologic changes are observed, which change the configuration of this coastal space from year to year. Natural processes are occurring at a faster pace; faster than the pace at which administrations implement their management.

The lack of a clear response and thoughtful decisions do not sometimes meet social expectations, which leads to social frustration. The implementation of actions offering short-term benefits does not guarantee environmental sustainability, let alone economic and social sustainability. The coastal fringe, particularly its most vulnerable areas (as identified by APAL (2019)studies and diagnostics) must be compelled for rapid actions to respond to the radical changes in its landscape. Due to rising anthropic activities that put an even more increasing pressure on it, changes in the coastal fringe will be occurring faster and the interests at stake in this space will be greater.

XII. References

Abid A., 1992. Improving access to scientific literature in developing countries: a Unescoprogramme review. IFLA journal, 18: 315-324.

National Agency for Environmental Protection, ANPE, 2007.

APAL, 2019. Le littoral de la Tunisie : Chiffres-clés. Agence De Protection et d'Aménagement du Littoral (APAL).Projet « AddressingClimate change vulnerabilties and risks in vulnerablecoastal areas of Tunisia » APAL-PNUD-FEM. Réédition Décembre, 74.

Belaid N., 2010. Evaluation des impacts de l'irrigation par les eaux usées traitées sur les plantes et les sols du périmètre irrigué d'El Hajeb-Sfax: salinisation, accumulation et phytoabsorption des éléments métalliques (Doctoral dissertation, Limoges).

Darsan J., Ramnath S., Alexis C., 2013. Status of Beaches and Bays in Trinidad (2004-2008). Oceanography& Coastal Processes. Institute of Marine Affairs, Technical Report, page 8.

GDFA, 2017. Indicateurs de pêche et d'aquaculture en Tunisie. Par Romdhane N. 2017. Présentation publique, GDFA, MARHP, Tunis-Tunisie-2017.

Heaney C.D., Sams E, Wing S, Marshall S, Brenner K, Dufour A.P., Wade T.J., 2009. Contact with beach sand among beachgoers and risk of illness. American Journal of Epidemiology, 170:164-72.

Heaney C.D., et al. 2012. Fecal Indicators in Sand, Sand Contact, and Risk of Enteric Illness Among Beachgoers. Epidemiology, 23: 95-106.

INS, 1996. Institut National de Statistiques, Indicateurs démographiques et économiques de la Tunisie

Johnson C., Matthew D., Affolter Inkenbrandt, P., Mosher C., 2017. An Introduction to Geology; Salt Lake Community College, Free Textbook for College-Level Introductory Geology Courses, 2017 [https://opengeology.org/textbook/]

MEHAT, 1997. Schéma Directeur d'aménagement du territoire national, Tunis, 1997 : 274.

Miossec J.M., 1996. Le tourisme en Tunisie, un pays en développement dans l'espace touristique, Thèse de Doctorat soutenue à l'université de Tours, Janvier 1996 : 1333.

MIT, 2011. Tourisme : la révolution durable ; Belin ; Paris ; 332 .

Roig-Munar F.X., 2007. Microerosion induced by beach users. The case of Menorca (Balearic Islands). Geographic Investigations, 43: 161-167

Oliveira J.S., Mendes B.S., 1991. Pollution of beaches and coastal areas: preventive measures and quality standards. Meeting on Management of Municipalities and Water Management.] Cascais, Portuguese Association of Water Resources (APRH)/ Municipality Service of Water and Sanitation (SMAS).

Oliveira J.S., Mendes B.S., 1992. Qualidade da Agua do Litoral Portugues. [Water quality in Portugal.] 1° Congresso da Agua, Vol. 2. Lisbon, Portuguese Association of Water Resources (APRH), 155-179.

ONAS, 2019. Etude environnementale complémentaire (rapport définitif) : Conception, Redaction, et passation des contrats de PPP dans le secteur du l'assainissement en Tunisie. Arab Financing Facility for Infrastructure (AFFI). ARTELIA – BIRD & BIRD – DAKHLAOUI AVOCATS, 241.

Oueslati A., Slim H., Trousset P., Paskoff R., Bonifay M., Lenne J., 2004. Le littoral de la Tunisie. Étude géoarchéologique et historique (Vol. 1, No. 1). Persée-Portail des revues scientifiques en SHS.

Tourisme, 2018. Chiffres du tourisme 2018 : décryptage et contradictions. Article online : Réalités.com, le 7 février 2019 : [https://www.veilleinfotourisme.fr/international/pays-de-n-a-z/tunisie/tunisie-chiffres-du-tourisme-2018-decryptage-et-contradictions]

Tunisian Craft Development Company SDAT, 1996.

World Bank, 2004. Tunisie : Analyse de la performance environnementale », rapport final, 119 p.

XIII. Electronicreferences

https://www.afrik21.africa/tunisie-la-construction-de-lusine-de-dessalement-de-sfax commence-en-mars-2020/

https://lapresse.tn/2786/la-station-de-dessalement-de-leau-a-djerba-vise-un-prix-mondial/

https://africanmanager.com/Gabès-une-nouvelle-station-de-dessalement-des-eaux-de-mer-a-zarat/

https://www.espacemanager.com/la-station-de-dessalement-deau-de-mer-zarat-mise-en-service-en-2021.html

https://africanmanager.com/Gabès-demarrage-avant-fin-2018-des-travaux-de-construction-de-la-station-de-dessalement-de-leau-de-mer-de-zarat/

http://www.sonede.com.tn/index.php?id=56

http://www.transport.tn/fr/maritime/presentation?page=1

https://www.discovertunisia.com/tunisie-activites/plaisance

https://www.leaders.com.tn/article/25320-les-marinas-en-tunisie-huit-ports-et-3-226-anneaux

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