# Pollution and Other Anthropogenic Pressures Affecting Ecosystems

## 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

# Pollution & other anthropogenic pressures affecting ecosystems

## Tunisian scale

INSTM

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# 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


## Contributors

**Noureddine ZAABOUB**, PhD

National Institute of Marine Sciences and Technologies, Tunisia

**Mouna MRAD**, PhD

Water Technology and Research Center, Tunisia

## Reviewers

**Wafa FEKI SAHNOUN**, PhD

National Institute of Marine Sciences and Technologies, Tunisia

**Leila BASTI**, PhD

Tokyo University of Marine Science and Technology, Japan

**Olfa SEBEI**, Technical staff

National Environment Protection Agency, Tunisia

## Supervisor

**Béchir BEJAOUI**, PhD

National Institute of Marine Sciences and Technologies, Tunisia

# LAYOUT

**Khouloud ATHIMEN**, Engineer, Technical Coordinator

National Institute of Marine Sciences and Technologies, Tunisia

**Houaida BOUALI**, Engineer

National Institute of Marine Sciences and Technologies, Tunisia

**Mohamed Ali BRIKI**, Engineer

Coastal Protection and Planning Agency, Tunisia

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# Abstract

The debate on the definition and classification of ecosystem services is important. These different approaches have their own strengths and weaknesses. At the beginning of the establishment of this approach without the different types of ecosystems, criticism has focused on the double counting of benefits from services. The most recent approaches avoid the risk of double counting by distinguishing between intermediate and final services. However, integrating the two visions, environmental and economic, into a single approach can make the difference in business management and policy making. Marine and coastal ecosystems produce a variety of provisioning, support, regulating and cultural services.

The integration of the ecosystem services dimension in the tourism sector is illustrated by the exploration of environmental resources in the field of tourism and the adoption of management plans in this context. In Tunisian scale, as other Mediterranean country, there are direct impacts from Beach Maritime tourism. Concerning pollution effects, water pollution (sea, lakes, rivers, and sources) in most cases is related to discharges of untreated wastewater due to the absence or malfunctioning of installations of water treatment. The solid waste is another source of threat that affect marine environment. The natural and agricultural areas have been reduced by an important growth of tourism construction of housing. In the natural environment, fauna and flora are widely affected by tourism activity, degradation of landscapes as well as sites and monuments of historical importance, the installation of modern equipment and infrastructures associated with tourism. In the same context, there is a reduction of arable land and jobs causing the decline of agriculture in coastal area.

Tunisia is involved in the principles of integrated monitoring, which covers for the first time, biodiversity, non-native species, marine pollution and waste, coastline, and hydrography in an integrated manner. It aims to facilitate understanding the interactions between tourism and threats on costal environments.

# I. Classification of ecosystem services

Ecosystem services are tools designed to add value to different socio-economic sectors and to have helpful economic impacts. This process needs a better understanding of the links between biodiversity, ecosystem functions, ecosystem services, their benefits and associated social and economic values as part of human well-being. This approach is well detailed by Millennium Ecosystem Assessment (MEA, 2005) and the Economics of Ecosystem sand Biodiversity initiative (TEEB, 2010). This approach consists in describing the different relationships between the ecosystem and the socio-economic environment (Fig. 1).

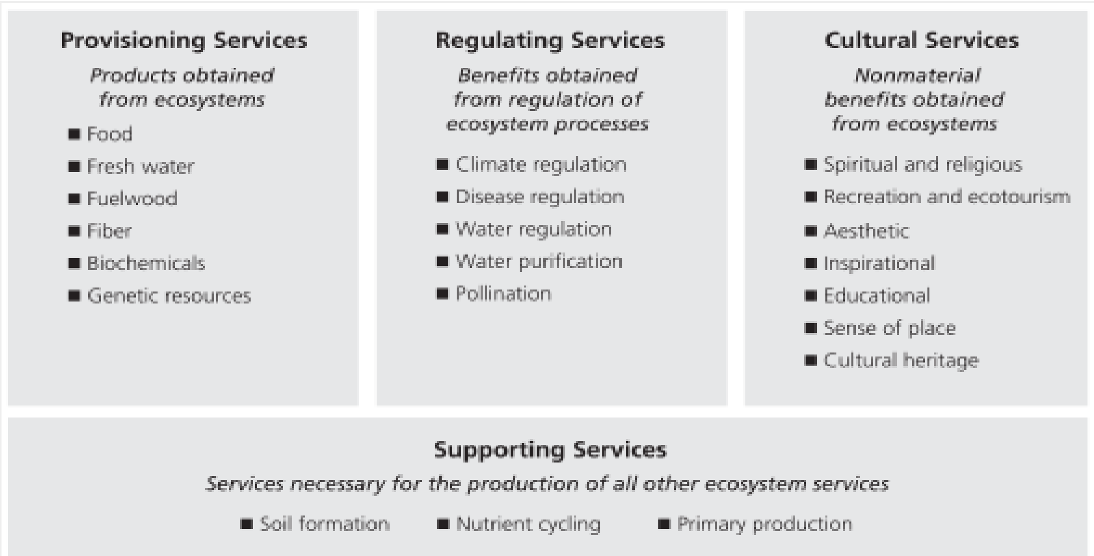



**Figure 1.** Millennium Ecosystem Assessment categories of ecosystem services

More comprehensive and adopted approach and classification of ecosystem services was detailed by European countries as an International Classification of Ecosystem Services - CICES (Haines-Young and Potschin, 2018). In this classification a fourth horizontal classification is the "supporting" section, which comprises structures, processes, and functions. In this conceptual framework (cascade model), unlike the previous conceptualizations of ESS, the final services are separated by the benefits and by the associated values (Fig. 2).

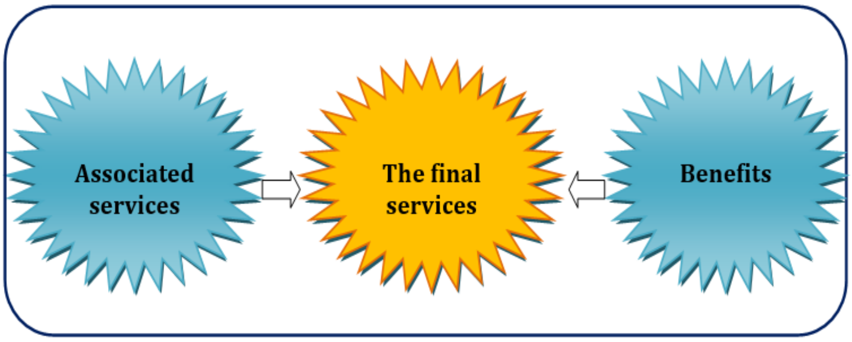



**Figure 2.** Web of environmental ecosystem services categories

Recent CICES update by Haines-Young and Potschin (2018), distinction between ecosystem services and their associated benefits, was one of the key tasks identified by the user community that was tackled in the revision of CICES (Table 1).

**Table 1.** International Classification of Ecosystem Services – CICES (Haines-Young and Potschin, 2018)

| Section | Division | Group |
|---|---|---|
| **Provisioning** | Nutrition | Biomass |
| | | Water |
| | Materials | Biomass, Fibre |
| | | Water |
| | Energy | Biomass-based energy sources |
| | | Mechanical energy |
| **Regulation & Maintenance** | Mediation of waste, toxics and other nuisances | Mediation by biota |
| | | Mediation by ecosystems |
| | Mediation of flows | Mass flows |
| | | Liquid flows |
| | | Gaseous / air flows |
| | Maintenance of physical, chemical, biological conditions | Lifecycle maintenance, habitat and gene pool protection |
| | | Pest and disease control |
| | | Soil formation and composition |
| | | Water conditions |
| | | Atmospheric composition and climate regulation |
| **Cultural** | Physical and intellectual interactions with ecosystems and land-/seascapes [environmental settings] | Physical and experiential interactions |
| | | Intellectual and representational interactions |
| | Spiritual, symbolic and other interactions with ecosystems and land-/seascapes [environmental settings] | Spiritual and/or emblematic |
| | | Other cultural outputs |

In costal North African coastal zones, ecosystem services become more promoted as way to prove the important place of ecosystem and overemphasize benefits resulting from natural resources (Costanza et al. 1997). Ecosystem services can provide a decision-making tool for local and national authorities throughout relevant set of potential benefit that can promote different sectors in the region mainly tourism. The classification of ecosystem services that distinguishes provisioning (*e.g.*, food, water, and fuel), regulating (*e.g.*, water and air regulation), cultural (*e.g.*, recreation and spiritual values) and supporting services (*e.g.*, nutrient cycling and photosynthesis) gives more and more indicators that can be used according to Feld et al. (2009) at local to regional scale. On the other hand, ecosystem services are wieldy associated to relative indicators. The abiotic indicators, such as area Measurement and fragmentation, are applicable at regional landscape and broader scales. In this approach there is a strong linkage between indicator types (abiotic vs. biotic) and spatial scales (local vs. regional and larger scales). The application of indicators is conditioned by representativeness and the presence of data and protocols to sample or otherwise obtain this database. This issue may be different from one country to another. The supply of ecosystem services was discussed and applied, considering the most important three Tunisian coastal cities concerning provisioning services (García-Nieto et al. 2018). Ecosystem services supply evaluates spatial and temporal patterns. According to García-Nieto et al. (2018), the ES supply trends for Tunis, Nabeul and Sfax changed from 1990 to 2006, with an increase in the supply of provisioning (fodder, energy biomass, wild food, biochemical and medical services). In general, the North-African peri-urban area showed stronger increases of ecosystem services supply capacities. In other cases, the supply of regulating ecosystem services in Tunisia was more important than provisioning, cultural ecosystem services increased around Nabeul and Tunis.

General trend using Land cover data and an expert-based method shows that overall urban area increased at the expenses of decreasing agricultural land, the Ecosystem service provided by the Mediterranean peri-urban areas was reduced (Fig. 3). Therefore, ESS assessment methods based on land cover data, such as the “matrix approach”, are poorly applicable to marine case studies. They underline the importance of defining simple methods for marine ESS assessment and of identifying the related monitoring priorities, which from the results of this analysis appear to be the collection of habitat distribution data. Among the most important indicators in this approach seems to be related to the spatial distribution of SPAs (Service Provision Areas), implying that the mapping of marine and coastal habitats should be considered as a key monitoring priority. The SAC (Service Connection Area) can be mapped in a rough and general way by estimating a range of ecologically significant influence of the focal habitat in relation to several ecosystem services. The SBA (Service Benefit Area) can be mapped in a simple way and can be supported using data available in the Mediterranean region, reflecting the anthropogenic effect and its relationship with the marine environment.

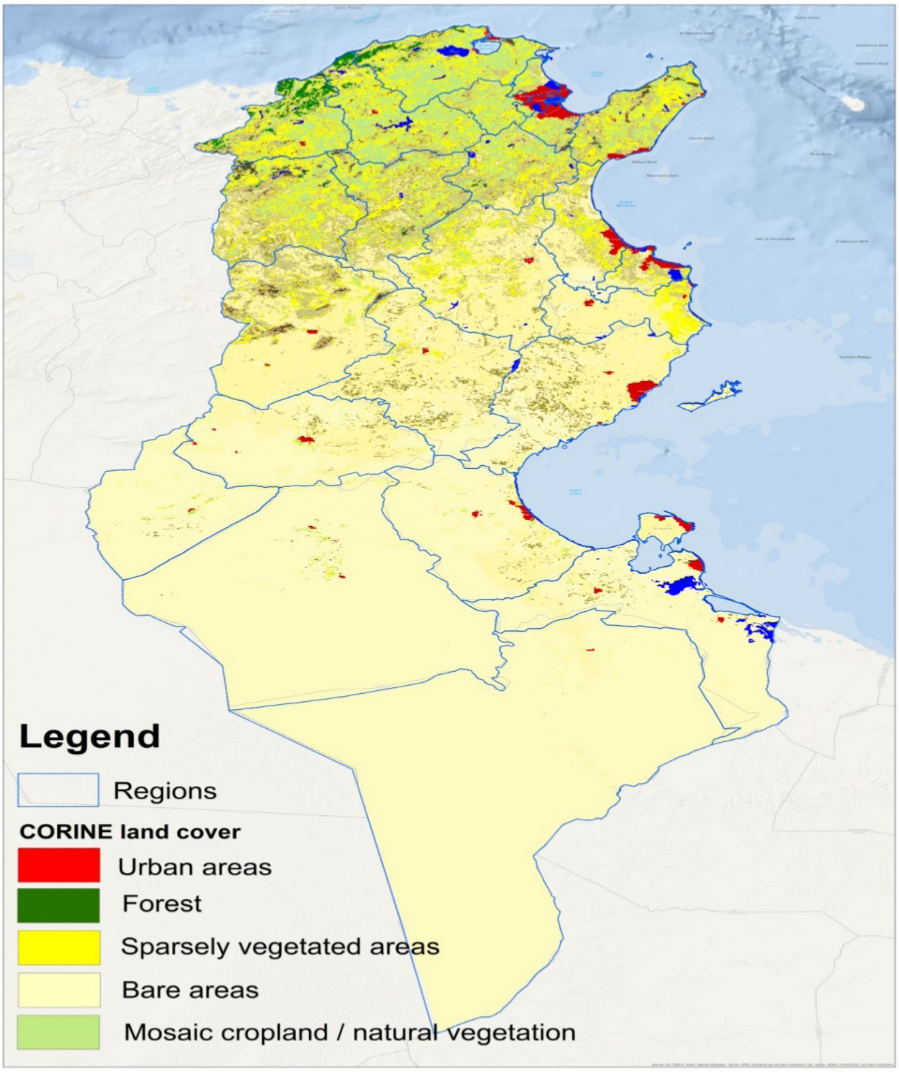



**Figure 3.** CORINE land cover map for Tunisia (Ben Hassine et al. 2014)

# II. Coastal ecosystems and associated services

In ecosystems (E) the biotic and abiotic components interact, the result is the production of ecological functions. Ecological outcomes may benefit people directly or indirectly through interim processes (IP) and collectively these outcomes are called ES.

This ESs provides benefits (B) associated with ESs as associated services. These are benefits can be evaluated in different ways according to studied process. For example, in relation to life nutritional value and other economic and non-economic aspects measures of human well-being.

The ecosystem (E) is home to ecological functions that generate ecological outcomes in space s1. Through interim processes (IP) taking place in locations s2, s3, …, sN–1, generated ES provide benefits (B), either throughout the process, interim benefits (IB), or at the end of the process chain (Drakou et al. 2017).

As well, the value added or lost indicated by +/- in the figure along each step of the process, including those associated with positive and negative externalities and contributes to the net benefit (NB) felt at each spatial scale. These benefits can be produced at the ecosystem level, through the IPs and/or down the process chain. Benefits that occur across IPs are called Intermediate Net Benefits.

Figure 4 define the operational space(s) for each component in this framework defined as the spatial territory, with limited location and defined extent where each framework component spatially occurs. When services and benefits occur in the same area, mapping the human benefits that flow from an ecosystem is straightforward (*e.g.,* when one looks at a salt marsh and derives aesthetic benefit). In most cases though, interim steps occur between the ecological outcome and the final NB.

An ecological outcome may generate different types of benefits to humans through varying IPs (*e.g.,* fish harvest could generate benefits to the fisher, processor and to the final consumer). In Figure 4, arrows identify the different steps that occur within this process and show generically the different interim “goods or services” (ES) and the associated net benefits (IB) that could be generated (Drakou et al. 2017).

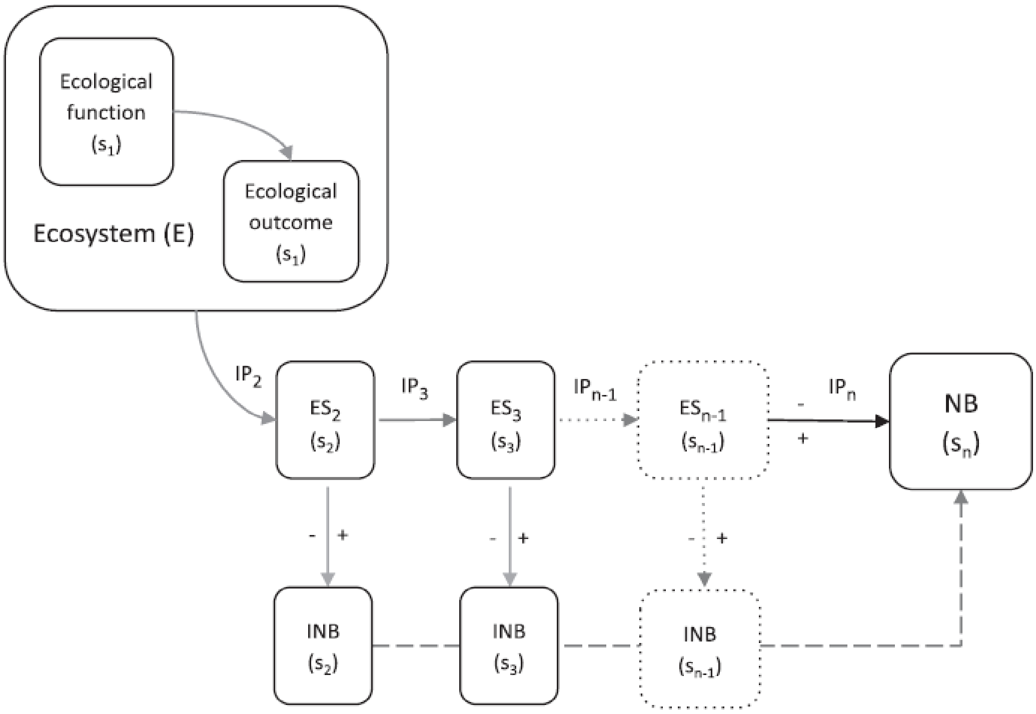



**Figure 4.** The proposed extra-local ES provision framework (Drakou et al. 2017)

The integration of ESS dimension in the tourism sector is illustrated through the exploration of environmental resources around the world for tourism and adoption of management plans for this aim. A clear and studied interaction can promote demands of sustainable tourism development and to safeguard those key strengths of the tourism product which, first, the environmental, urban, and cultural. This relation has been manifested through the following important points with descriptive list of the ESS supplied by coastal environment is given here:

- Cultural diversity: The diversity of ecosystems is one factor influencing the diversity of cultures.
- Spiritual and religious values: Many religions attach spiritual and religious values to ecosystems or their components.
- Knowledge systems (traditional and formal): Ecosystems influence the types of knowledge systems developed by different culture.
- Educational values: Ecosystems and their components and processes provide the basis for both formal and informal education in many societies.
- Inspiration: Ecosystems provide a rich source of inspiration for art, folklore, national symbols, architecture, and advertising.

- Climate value: Ecosystems provide a rich source of climate services explored for coastal tourism sunbathing, pleasure boating, snorkelling, reef walking and scuba diving.
- Natural areas: This aims at ecotourism, which may be defined as service in relation to natural areas that preserves the original environment by ensuring the well-being of the local population and the relationships of ecosystem components.

## III. Scaling of ecosystem services to the Mediterranean scale

The classification of ecosystem services including provisioning (*e.g.*, food, water, and fuel), regulating (*e.g.*, water and air regulation), cultural (*e.g.*, recreation and spiritual values) and supporting (*e.g.*, nutrient cycling and photosynthesis) services increasingly provides indicators. They can be used according to Feld et al. (2009) at the local to regional scale in the Mediterranean.

To understand how environmental management affects ecosystem services, it can state that complexity is due to the consideration of different types of "scales": spatial scales, temporal scales, and scales of biological and human organization. Biodiversity, conservation and management will only be effective if it understood how problems and solutions depend on these scales. At one scale this may be climate change, while at others it is habitat loss and fragmentation or disturbance that needs to be addressed (Henle et al. 2010, 2014).

The natural environment is diverse in space and time and these variations are very significant and affecting diversity of living species. It is essential that these variations take place at a wide range of spatial scales: climates vary on different dimension scales.

# IV. Direct impacts from beach maritime tourism

One of the important impacts is pollution effects: Air pollution due mainly to automobile traffic, to the production and use of energy. The Water pollution (sea, lakes, rivers, and sources) in most cases related discharges of untreated wastewater due to the absence or malfunctioning of installations of water treatment. The solid waste is another source of threat with discharge from recreational boats and motor boating (oil spill). There is another solid waste origin, pollution of sites by garbage dumps (picnics, *etc.*) and the absence of inadequacy of a system for the disposal of waste (mainly in the form of household waste). In touristic complexes, noise pollution is mainly due to traffic, cars, or the use of recreational vehicles (snowmobiles, motorcycles, motorboats, and touring planes), but also to the crowd of tourists or to the animation which accompanies it (advertising podiums, beach party and contests).

Reduction of natural and agricultural areas during last decades is an important growth of tourism leading to the construction of housing, tourist facilities and infrastructures. They are based on zones that were previously free spaces, on previously natural or agricultural areas. Some natural ecosystems (beaches and forests) are often made inaccessible to the public. Destruction of flora and fauna: the various types of pollution listed above as well as the reduction of natural and agricultural areas are responsible for the disappearance of part of the flora and fauna. The excessive use of natural areas also leads to the disappearance of some flora and fauna (*e.g.,* abusive harvesting, negligence, and unconsciousness sometimes at the origin forest fires).

Degradation of landscapes as well as sites and monuments historical data with the implementation of modern equipment and infrastructure in this tourist zone often leads to environment degradation. These new settlements are not always in harmony with the traditional buildings. The tourist development is often anarchic and dispersed, affecting the historical and natural aspect of the landscape.

Competitive effects with development of tourism lead to the occupation of space and drain a whole part of the local jobs to its benefit. There are inevitably effects of competition and this is most often to the detriment of traditional activities (reduction of arable land and jobs causing the decline of agriculture for example).

# V. Ecosystem threats and impacts from tourism

## V.1. Introduction

Since Tunisia does not have a national monitoring program related to the state of the marine and coastal environment, implication of Tunisia in United Nations Environment Programme Mediterranean Action Plan. Tunisia has several monitoring programs led by different institutions, National Environmental Protection Agency (ANPE) monitors effects of environment accidents on marine coasts, Department of Environmental Health and Environmental Protection (DHMPE) monitors bathing waters and INSTM has several research programs for coastal environment. According to Abdouli (2017), since the adoption of Decision IG.22/7 on Integrated Monitoring and Assessment Programme (IMAP) in 2016, contracting parties continue until these days to update their national monitoring programmes to incorporate the new elements of IMAP. The EU-funded EcAp MED II project supports eight eligible countries in the preparation of their national IMAPs. PAP/RAC oversees assisting these 8 countries to prepare these documents for the coastal zone and river network indicators. IMAP provides the basis for the contracting parties to define and implement their national integrated monitoring programmes and to work together within the framework of the Barcelona Convention UNEP/MAP to produce and update a common indicator based on regional assessments of the state of the Mediterranean Sea and coasts. A peculiarity of IMAP (compared to other regional monitoring and assessment programmes/WRCs) is the inclusion of an ecological objective focusing on the terrestrial part of the coastal zone. This reflects the fact that the Barcelona Convention includes coastal zones in area interest, in line with the ICZM Protocol.

National IMAP for Tunisia is based on the implementation of the three common indicators hydrographic (OE7) and coastal (OE8) data for monitoring the status of the marine and coastal environment. This is included in an approach based on the identification and assessment of the risk and degree of threat to ecosystems with a view to alerting and decision support.

In the framework of The Programme for the Assessment and Control of Marine Pollution in the Mediterranean (MedPol), APAL and UNEP concluded a Memorandum of Understanding for the period 2018-2019. It is launch of an Integrated Monitoring and Assessment Program for the Mediterranean Sea and Coasts and Related Assessment Criteria (IMAP) in Tunisia. This monitoring program would be dedicated to three ecological objectives: OE5 (eutrophication), OE9 (Pollution) and OE10 (Marine and coastal Litter). IMAP introduces the principles of integrated monitoring, which covers for the first time, biodiversity, non-native species, marine pollution and waste, coastline, and hydrography in an integrated manner. It aims to facilitate the implementation of Article 12 of the Barcelona Convention and other monitoring programs, under different protocols. To promote this action, it can present an inventory of observatories, monitoring and surveillance systems in Tunisia:

- Coastal Observatory-APAL.
- OTEDD, ANPE.
- Sea Observatory and its Monitoring Networks, INSTM.
- INM.
- CHOMN.
- CNCT.
- Greater Tunis Urban Observatory.
- Real Estate and Land Observatory.
- Cadastre of Industrialists, ONAS.
- Water Quality Monitoring Network, COPEAU (ANPE), ONAS, DHMPE and INSTM.
- National Agricultural Observatory (ONAGRI).
- Ministry of Tourism and Handicrafts (Statistics); and
- National Institute of Statistics.

Coastal anthropogenic activities in Tunisia are respectively affected by urban, industrial, and touristic activity in most cases the three types of activity are interrelated. Threats from tourism can be evaluated directly from Maritime coastal tourism typologies and related costal activates.

In the CO-EVOLVE4BG project typologies of coastal tourism were identified, they are:

- Beach/Maritime tourism.
- Urban/Cultural tourism.
- Cruising.
- Recreational boating (Yachting/Marinas).
- Nature/Ecotourism; and
- Medical/Tourism.

Based on the list of impacts presented above, a review of the main impacts from each coastal tourism typology was performed, whose achievements are illustrated in the next paragraphs.

### V.1.1. Direct impacts from Beach/Maritime tourism

Beach tourism brings apparent economic benefits to the local communities, but environmental costs are associated with them. Such costs can be substantial and unsustainable in the long term, especially for small island resorts.

***Ecosystem fragmentation and degradation:*** Coastal environmental areas continue to be deeply explored because of the prevalent belief of the nature being inexhaustible and renewable. This has led to an indiscriminate and unplanned growth of tourism infrastructure in many agricultural coastal areas and forest coastal areas. However, the negative impacts of tourism lie mainly in the pressure exerted on space and natural resources such as soil, water, and energy. The development models devised so far have tended to concentrate tourism infrastructure and superstructure in areas outside the cities (agriculture and forest). Such development isolates tourists and places in relatively appropriate touristic places. These tourist areas concentrate the negative impacts of tourism spatially and are fortunately most of the cases equipped with the basic infrastructure necessary for the environmental preservation and management. However, the development of tourism has been accompanied by the development of urban areas around tourist centres or touristic cities. As examples are the areas of Tabarka touristic zone built on forest area, touristic managements are installed in dune area and meadows unlike the regulation, with minimal exchange between dune and water level. In the northeast of Tunisia Hammamet Nord and in the centre east Hammam Sousse touristic zone are built in agricultural area in Zarziss touristic zone is built in natural Saharan natural environment. In this zone, a regular disappearance of dune and costal sandy beaches was observed mainly after ports infrastructures (Houimli, 2008). Setbacks of 25 to 35 meters in sandy beaches were observed at Sousse since 1980 following the creation of the marina. In Djerba, hoteliers regularly seek to mitigate the phenomenon of erosion by artificial silting up and even through riprap. Every year, artificial recharging is necessary. The management of the impacts of this urbanization is not considered in the development of basic infrastructure in tourist areas. This implies negative environmental impacts that exceed the carrying capacity of the developed infrastructures, generating environmental pressures in the tourist areas.

***Wildlife disturbance and exploitation:*** Then the negative effects in environmental degradation started emerging. Specialists' tours such as photographic safaris and wildlife watching can affect animals through noise, visual and scent disturbances and by affecting predation and breeding behaviour. Similarly, wildflower tours can affect plant biodiversity if participants collect plants or fruit, introduce weeds or pathogens, or start fires. In some destinations, tourism can produce a local economic boom. It led to uncontrolled high impact private development and resource consumption, waste generation beyond the capacity of local waste treatment disposal systems, if any, land clearance and harvesting with major impacts on biodiversity. In addition, infrastructure built for tourism may be used for illegal collection of endangered plant and animal species. Small-scale operations may eventually

***Solid Waste:*** Solid waste pollution might compromise tourist flow to marine areas and threaten new private sector investment in hotel developments, *etc.* in these areas. The municipality and tourism industry often bear the cost of clean up to ensure locations remain attractive for tourists. Marine litter (also called marine debris) is waste created by humans that has been discharged into coastal or marine environments, resulting from activities on land or at sea. Most of the marine litter consists of plastics. 8 million tourists visit Tunisia yearly, of which 95% visit coastal resorts (Adair and Abdallah, 2015). Over one year, tourists increase waste generation across Tunisia by 6%, costing an additional budget to manage. However, given the seasonal nature of tourism and lack of waste treatment facilities in highly urbanized zone including Sousse, Mahdia and Nabeul, the impact of tourist waste generation is likely much higher in these locations.

### V.1.2. Direct impacts from Urban/Cultural tourism

Recent decades Tunisia promotes cultural and urban tourism, through the participation of all interested parties in the field of protection, enhancement, and preservation of cultural and environmental heritage. Several programs were applied to upgrade the environment in areas that attract visitors. This is especially on tours and in old cities, mountain villages, oases, and urban parks through the creation of a fund for the protection of tourist areas financed by tourism professionals.

***Solid waste:*** Cultural and urban tourism is mostly related to old cities in Tunis, Sousse, Monastir, Mahdia, Djerba and others. Solid waste management responsibilities between different stakeholders must be clarified. Many stakeholders are involved in solid waste management, but the responsibility of each one should be well defined. National responsibility is related to:

- Ministry of Equipment and Environment.
- Interior Ministry.
- National Waste Management Agency (ANGed).
- Environmental Protection Agency (ANPE).
- Ministry of Finance.
- Ministry of Health.
- Ministry of Industry.
- Ministry of Commerce.
- Minister of Agriculture.

For local level the communes ensure waste collection, with the collaboration of regional councils/rural councils and Maintenance and Zone Management Group Industrial (GMG). However, the mismanagement of waste is considered the main factor contributing touristic old cities pollution. Many other factors should also be taken into consideration, such as street litter, manufacturing sites, plastic processing, and transport. Accumulation of solid waste in streets during the day increase pollution and widely affects tourism quality. In Touristic urban zones, the most striking solid waste pollution is organic pollutant (60%) and plastic pollutant (10%) from total solid waste (Chaabane et al. 2018).

***Air pollution:*** Reading the ANPE data, until 2016, most Tunisian data related to air pollution (fine particles) exceeds the OMS recommendation but is located below the Tunisian limit value (http://www.anpe.nat.tn/Fr/air_11_167).

The average value of data collected is higher than the OMS recommendation and below the Tunisian limit threshold. In Gabès, the air pollution recorded the largest number of measurements exceeding the Tunisian standard (ANPE, 2016). In Tunisia, according to official data 2015 (ANPE, 2016), the number of cars and mainly touristic bus running on diesel is higher than those running on Gasoline, which represents a significant part of the emission of fine particles. In this figure there are the most visited cultural touristic cites, centre of Tunisia (Bab Saadoun) and Sousse cities. The main overruns recorded are concentrated in Gabès and Sfax and affected by air pollution by the Tunisian chemical group of Sfax (Fig. 5). These tow industrial zones are considered as most dust dispersive zone to nearby touristic and natural protected area such as Djerba Island and Kerkennah Island. After the centre of Tunis, Sousse has the lowest air pollution days in the assessed period (2004 and 2016). According to continuous interest to air pollution, more restrictive effect low on air pollution standards began to be applied since January 2021.

***Light Pollution:*** Over last decades there has been an exponential increase in the use of artificial light to illuminate the night. This trend continues to this day. On land, streetlights, lighting in office buildings and homes, floodlit sports facilities, industrial complexes, *etc.*, are the sources which inadvertently introduce light into nature. In coastal areas, where many cities are located, long stretches of the shoreline are strongly illuminated. Indeed, light pollution of shallow seas has become a global phenomenon. Light in urban skylines can present irregular silhouettes that can be more important in touristic coastal zone where night activity is present for most hours of the night such in Tunis, Hammamet, Sousse and Djerba. It is important to note that there is no Tunisian study on effects of light pollution on marine and coastal wildlife, disturbances of aquatic fauna and biological activities.

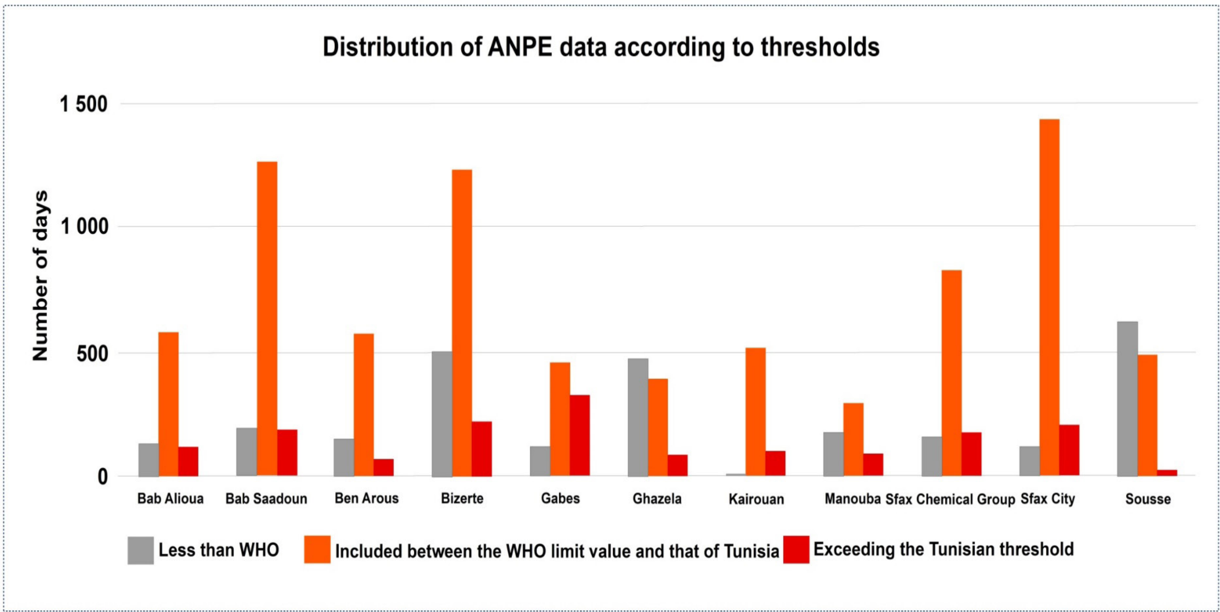



**Figure 5.** Recent data of atmospheric fine particles 10µg (PM10) in different Tunisian city (Lac, 2019)

### V.1.3. Direct impacts from Cruising

Recent years there is an increase in cruise ship waste management, likely due to the growth of tourism market, with an annual increase of 7.4% in the number of passengers between 1990 and 2018 (Lourenço Sanches et al. 2020). However, this growth may aggravate environmental, social, and economic impacts, making it essential to promote research and studies in the area (Lourenço Sanches et al. 2020). The cruise industry is the fastest growing until 2010 in Tunisia tourism industry. After 2010 there was a decrease, this growth as shown in Table 2. It is important to inform that in southern Mediterranean Sea that the ports of La Goulette (Tunisia) and Alexandria (Egypt) are the only ones with infrastructures comparable to the ports on the northern shores of the Mediterranean. The cruise traffic evolution is quite different when comparing the variation of traffic last decade. The cruise passenger movements that were recorded in 2017 per country and the respective variations observed when comparing these data with those of previous years. Tunisia (602.4%), Malta (14.0%) and Spain (6.4%), are the countries that registered the most significant growth of annual passenger movements in 2017 comparing to the previous year.

**Table 2.** Cruise Passenger Movements per Med Cruise Country

| Country | 2017 | % Share in 2017 | 2016 | Variation 2017/2016 | 2013 | Variation 2017/2013 |
|---|---|---|---|---|---|---|
| Italy | 9.535.688 | 36,80% | 10.381.551 | -8,15% | 10.494.569 | -9,14% |
| Spain | 7.074.594 | 27,30% | 6.651.111 | 6,37% | 5.994.886 | 18,01% |
| France | 2.498.725 | 9,64% | 2.564.945 | -2,58% | 2.241.596 | 11,47% |
| Greece | 2.068.308 | 7,98% | 2.300.473 | -10,09% | 2.489.184 | -16,91% |
| Portugal | 1.227.277 | 4,74% | 1.190.404 | 3,10% | 1.147.730 | 6,93% |
| Croatia | 1.159.203 | 4,47% | 1.269.993 | -8,72% | 1.397.778 | -17,07% |
| Malta | 778.596 | 3,00% | 682.970 | 14,00% | 477.759 | 62,97% |
| Montenegro | 541.017 | 2,09% | 536.644 | 0,81% | 317.746 | 70,27% |
| Gibraltar | 404.995 | 1,56% | 404.005 | 0,25% | 278.139 | 45,61% |
| Turkey | 201.714 | 0,78% | 500.330 | -59,68% | 1.530.888 | -86,82% |
| Monaco | 168.017 | 0,65% | 185.392 | -9,37% | 249.806 | -32,74% |
| Cyprus | 123.397 | 0,48% | 141.358 | -12,71% | 271.673 | -54,58% |
| Slovenia | 72.175 | 0,28% | 78.923 | -8,55% | 65.434 | 10,30% |
| Israel | 26.757 | 0,10% | 27.632 | -3,17% | 88.364 | -69,72% |
| Morocco | 23.550 | 0,09% | 97.311 | -75,80% | 0 | n.d. |
| Tunisia | 5.317 | 0,02% | 757 | 602,38% | 511.065 | -98,96% |
| Bulgaria | 2.716 | 0,01% | 6.942 | -60,88% | 8.670 | -68,67% |
| Romania | 1.891 | 0,01% | 6.912 | -72,64% | 54.614 | -96,54% |
| Ukraine | 1.636 | 0,01% | 1.242 | 31,72% | 91.949 | -98,22% |

***Solid Waste:*** Solid wastes are supposed to be treated, separated, and sterilized before been incinerated or grind and rejected as organic waste. Most pollutant factor is the releasing of oil waste in marine environment. It is difficult to determine cruise vessels solid waste tossed overboard. For solid waste volume puts pressure on the environment, especially in terms of waste disposal at ports. All cruise ships should strictly follow a waste reduction program and that ports should provide adequate waste management facilities, including segregation and recycling, to optimize local facilities whenever possible. It is nearly impossible to monitor the vessels and (as with recreational vessels) it is difficult to distinguish shipboard waste from land generated waste once onshore. Evidence of illegal dumping of solid waste must therefore come from passengers on board or other vessels. Some cruise vessels have addressed the waste issue using on-board waste incinerators. However, solid waste is often dumped in landfill sites at tourist destinations, thereby contributing to pollution and habitat loss in highly sensitive environments.

***Water pollution:*** In average cruise with 3000 passengers, ships are needlessly dumping vast amounts of raw sewage and other harmful wastes, plastic and organic into some of the most pristine parts of marine area every day. Each day a cruise ship generates as much as:

- 113 $m^3$ of sewage also called "black water;"
- 965 $m^3$ of dirty water from shower, sinks, laundries, and dishwashers, also called "gray water," which can contain raw sewage and toxic chemicals, dry cleaning

and industrial cleaning products. This waste not only carries bacteria which are harmful to human and ecosystems, but it also sickens and kills marine life including fish and corals.

***Air Pollution:*** The cruise industry has the potential to affect air quality through engine emissions. Most marine fuels are residual fuels with higher concentrations of contaminants such as sulphur. Recent studies have suggested that ocean-going vessels have the potential to affect air quality in coastal regions, port areas and heavily travelled trade routes where annual sulphur emissions from ships equal or exceed land-based emissions. In Tunisian coastal zone NOx and SOx gases, emitted in large quantities into the air and carried by wind towards the urban area and the sea, mainly from industrial zone installed not a long way from touristic area. Considering Bizerte as potential touristic zone, it receives for air pollution by the emission of 9 tons/day of dust, containing ferrous oxide and carbon monoxide (Derouiche, 1997).

***Oil Effluent:*** Around 26 $m^3$ of oily bilge water are rejected in marine environment per day from cruise ship of 3000 of packagers. Cruise ships also produce toxic chemicals and hazardous waste from dry-cleaning procedures, used batteries and paint waste from brush cleaning. Waste oil is produced from normal leakage from the main engines and generators, the cleaning of fuel filters, losses during maintenance and leaks from hydraulic systems. Fuel oil spillages are a particular problem as heavy fuel oil is more toxic than crude oil. It is also important to consider the unreported incidents that have an impact on the environment. In Tunisia most affected zones by oils effluents are ports of Skhira, Menzel Bourguiba and Zarziss (REMPEC, 2003). Zarziss is a touristic zone and this pollution effects (Tank washings 9,600 $m^3$/year) can affect coastal area. For the other ports, the effect can be lower but for Menzel Bourguiba the port is near a wet land area that is considered as touristic destination (dirty ballast 71.905 $m^3$/year). The same case for Skhira (Oily Wastes: Average annual volume of dirty ballast 449.680 $m^3$/year) oil effluent pollution that can affect Djerba island.

Alien Species: The introduction of non-native species through discharge of ballast water is another potential environmental impact of the cruise industry. In the US, the Council on Environmental Quality found that over 130 non-native species have been introduced to the Great Lakes since 1800, with almost a third thought to have been carried by ships. Introduced species cause problems because they can disrupt the food web of the ecosystem and clog the intake pipes of power plants and water treatment facilities.

***Ecosystem fragmentation and degradation:*** Dredging channels for the larger vessels causes increased turbidity that is damaging to both corals and sea grass beds. In the same way, high numbers of snorkelers on a cruise trip can damage marine habitats and disturb wildlife. To date little research has been undertaken to investigate the potential impacts of vessel movements through the generation of waves and propeller-induced turbidity and ships' wash on marine habitats, although this matter has recently received increasing attention. Ships generate waves which get bigger and more energetic the faster the ship goes relative to its length.

### V.1.4. Direct impacts from Recreational boating

In Mediterranean Sea recreational boats activity have an impact on environment, most of recreational are motor powered that can affect the marine ecosystem. Results show that marine flora, which constitute an ecologically and most affected habitat in coastal environment, are suffering from damage caused by anchors effect. Anchoring was the largest threat on the marine environment in southern Mediterranean Sea particularly in Tunisia. The activities conducted by boaters such as sunbathing, swimming, snorkelling and scuba diving had an important environmental impact. On the other hand, in front of hotels where beach water skiing activity, the discharge of bilge waters and driving on a parachute behind the boat in touristic areas are carried out along all summer days. These activities are causing noise stress, release of fuel and noxious odours. Overall, this indicates that a primary element for coastal management in busy boating areas must be the anchoring of recreational boats and the specific impacts associated with motor of beach touristic water games activity.

### V.1.5. Direct impacts from Nature/Eco-tourism

In Tunisia natural resources have long been key tourist attraction and their value environmental tourism. Natural resources are considered as important tools for the development of "nature-based" and "ecotourism" products. The negative impacts of ecotourism in coastal areas affect wildlife disturbance, uncontrolled natural resources exploitation and unsustainable fauna and flora use. The social parameter introduce in generally Tunisian countries local community will affect social and cultural values (UNESCO, 2005). This encourages unsustainable exploitation of community resources that are based on small projects, the increasing number of visitors can change the use of resources in the fishing sector (*e.g.,* the involvement of local communities can help to minimize negative impacts). Other impacts can be cited such as accidental or unintentional change in biodiversity or disruption of the food chain.

### V.1.6. Direct impacts from medical and wellness /Tourism

Health and wellness tourism in Morocco, Tunisia, Lebanon, and Egypt have a great interest considering medical and wellness tourism. Health tourism involves thermal and marine water therapy activities for a wide range of health and wellbeing purposes such as healthcare and health assessment. In touristic zone a medical centre interest to tourism health activity surgery, operation, plastic surgeries cure, healing, rehabilitation, and convalescence, adding other activities at the visited destination. Tunisia is already well established in this sector aiming for strong growth, compared to Lebanon and Egypt. In Tunisia, according to Ministry of Agriculture and Water Resources, the General Direction of Water Resources report (DGRE, 2005), about 1,143 million $m^3$ are exploited from geothermal resources. 76% of which is used for agricultural purposes, 19% for water drinking and 5% for industry and tourism (Ben Mohamed, 2010). According to this author, the expansion of use for tourism should be well studied because of the particularity of most thermal sites cultural, natural, and other considerations.

## V.2. Effects of tourism on ecosystem

### V.2.1. Noise pollution

Habituation and touristic entertainment projects are most the increasing number of sound sources in modern life. These effects make harmful noise more insidious: noisy neighbours, streets, cars, horns, trains, planes, fireworks, parties of all kinds. The risk factors of noise are, in addition to the sound intensity, the duration of exposure, but especially the frequency of the sound (high-pitched sounds being more dangerous). At the physiological level, this leads to the degradation of part of the hair cells of the inner ear as we have said fragile, few and not renewed, which can lead to an irremediable loss of hearing. Young people are the most exposed to intense noise (shopping centres, smart phones, beach party, discotheques, *etc.*) in addition to surrounding noise and are physiologically the most fragile. Studies carried out on student audiograms show that approximately 10% of young people aged 17 or 18 suffer from an average hearing loss of between 15 and 40 d centred on 4000 Hz. Psychological effects also, linked to noise pollution, are increasingly cited including nervous breakdown.

The World Health Organization (OMS) recommends an ambient noise level of less than 35 decibels (dB) for a proper night's rest. The threshold of acoustic danger is set at 90 dB. Above 105 dB, irreparable hearing loss occurs. The threshold for acoustic pain is set at 120 dB. Above this level, the noise becomes intolerable, causing extreme pain and hearing loss. It should be noted that labour legislation has laid the foundations for an international agreement on the sound power level not to be exceeded: 85 dB. In addition, the law provides for limiting the output power of personal music players to 100 dB and the level in discotheques to 105 dB. The protection measures are simple and indispensable, simple, and essential; they can be summarized as follows:

- Limit the intensity of music players and plan rest periods.
- Get out of the disco or party halls for a few moments to rest your ears.
- Require noise limitation in common areas such as discos and party rooms at 100 db.
- Apply the law on the use of exhaust pipes and horns.
- Require good insulation of housing.
- Impose the wearing of a helmet in a noisy workplace.

Finally, hearing is a wonderful sense that allows us to appreciate beautiful music, to position ourselves in our environment, as well as to alert us to dangers! Modernism is unfortunately accompanied by a multitude of sources of sound aggression quantitative which can cause serious alterations in our hearing and even in our health (without forgetting qualitative aggressions, insults, profanity, and others…).

In touristic area discos, festivals and nightclubs needs stricter sound limits to be respected by a limit of 105 decibels. Welcoming the public, they will also have to install certain devices to prevent risks related to noise levels. Find out the places, and the penalties provided for.

### V.2.2. Air pollution

In Tunisia, air quality monitoring has been assessed from 20 years ago. With the help of some thirty sensors spread across the country, the Tunisian National Environment Protection Agency (ANPE) collects information on the main pollutants: fine particles, ozone, sulphur, carbon dioxide and nitrogen dioxide, to limit their emissions (Tables 3,4, Fig. 6).

**Table 3.** Atmospheric Pollutant, Suspended particles, Nitrogen Dioxide, Sulphur dioxide and Ozone (2004-2016) (Lac, 2019)

| Pollutant (µg/m3) | Different Standard | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Tunisian Standard | Tunisian Standard NT106.04 | | | | | | OMS recommended values | | |
| | Optimal Threshold | | | Threshold limit | | | Optimal threshold | | |
| Suspended particles (Exceeding 1x/year) | 24H | | annual | 24H | | annual | 24H | annual | |
| | 120 | | 40-60 | 260 | | 80 | 50 | 20 | |
| Nitrogen Dioxide (Exceeding 1x/month) | 1H | 24H | annual | 1H | 24H | annual | 1H | 24H | annual |
| | 400 | 400 | 150 | 660 | 660 | 200 | 200 | 200 | 40 |
| Sulphur dioxide (Exceeding 1x/year) | 24H | | annual | 3H | 24H | annual | 10mn | 24H | annual |
| | 125 | | 50 | 1,300 | 365 | 80 | 500 | 20 | 50 |
| Ozone (Exceeding 2x/month) | 1H | | | 1H | | | 1H, information threshold | 1H, alert threshold | 8H |
| | 150-200 | | | 235 | | | 160 | 240 | 100 |

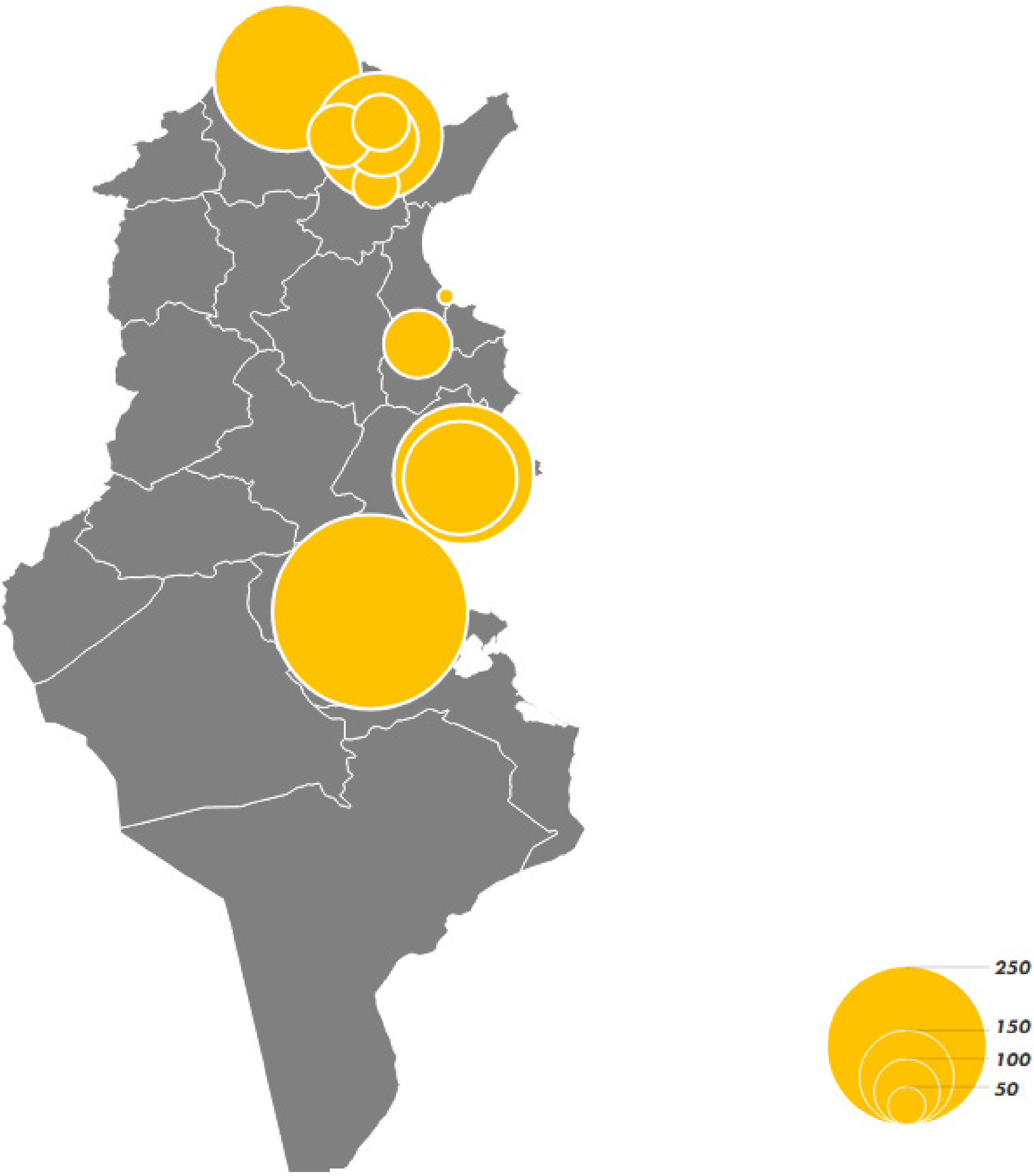



**Figure 6.** Atmospheric fine particles overshoot (1x/year) PM10, 10µg (Lac, 2019)

Between 2004 and 2016, the ANPE recorded for each sensor at least dozens of overruns of the Tunisian standard relating to fine particles. Reading the ANPE data, until 2016, most Tunisian data relating to fine particles exceeds the OMS recommendation but is located below the Tunisian limit value.

In Tunisia, air quality monitoring has been assessed from 20 years ago. With the help of some thirty sensors spread across the country, the ANPE collects information on the main pollutants: fine particles, ozone, sulphur, carbon dioxide and nitrogen dioxide, to limit their emissions.

**Table 4.** Average distribution of NOx, SOx, and particulate matter (2008)

| Sector | NOx | SOx | PM2.5 | PMcoarse |
|---|---|---|---|---|
| Agriculture | 3.89 | 0.02 | 2.36 | 1.45 |
| Industry | 7.44 | 58.24 | 6.66 | 4.08 |
| Transport | 32.31 | 4.88 | 0.64 | 0.39 |
| Utilities | 25.65 | 46.58 | 0.20 | 0.12 |
| Rest of Emissions | 6.19 | 11.50 | 14.50 | 8.88 |
| **Total** | **75.48** | **121.21** | **24.35** | **14.92** |

EDGAR database for NOx, SOx and particulate matter
Distribution of PM10 based on ENPI country report Tunisia: PM2.5: 62%; PMco: 38%. Data are for the year 2008

## V.3. Water pollution

In southern Mediterranean Sea, Tunisia relatively well endowed in the field of water management, Tunisia has well-developed water national programs (by SONEDE) and supply networks. Nearly all its urban population and 90% of its rural population have access to drinking water, while 85% of Tunisian urban dwellers also have access to improved sanitation facilities. The total urban population of about 7 million inhabitants; with connected to the ONAS network about 6.3 million inhabitants or 90.3% of the population total. It should be remembered that ONAS is not intended to take charge of non-urban populations. However, the country has only a limited number of underwater outfalls, which compromises the proper disposal of effluents.

The discharge of untreated sewage and pollution from agriculture threats Tunisia's marine and coastal ecosystems. While reducing nutrient discharges into the Gulf of Tunis is a national priority, the government has established a national plan for improved wastewater management in collaboration with the ONAS. The improvement of wastewater disposal in Tunisia will make a significant contribution to international efforts to fight pollution in the Mediterranean. It will also benefit the Tunisian population, who will benefit in concrete terms from a healthier environment with better waste management on the Tunisian territory.

The sanitation in Tunisia has been under increasing pressure in recent years. Delayed investments and tariff increases have prevented ONAS from improving its services as required and meeting the growing demand especially in coastal cities. The additional funding approved today will contribute to the construction of essential infrastructure, institutional capacity building, improved water quality and environmental monitoring systems and to the design of future projects in support of the national wastewater improvement program. In Tunisia, 80% of the wastewater collected by ONAS is of urban origin and 80% is domestic (Fig. 7). Industrial and tourist waters are poorly represented with important charge of water.

The number of water treatment stations (Fig. 7) has increased from 5 in 1975 to 109 stations in 2010 including those in rural areas (ONAS, 2010). These stations are spread over almost the entire territory, mainly in the following areas urban areas and near the coast. From 2010 to 2018, the water treatment stations in Tunisia increases to 122 with an annual total volume treated in 2018 around 275 million of $m^3$ (Table 5). In this increase is accompanied with an over saturation of sewage treatment plant. In 2018, table below shows these statistics (ONAS, 2018).

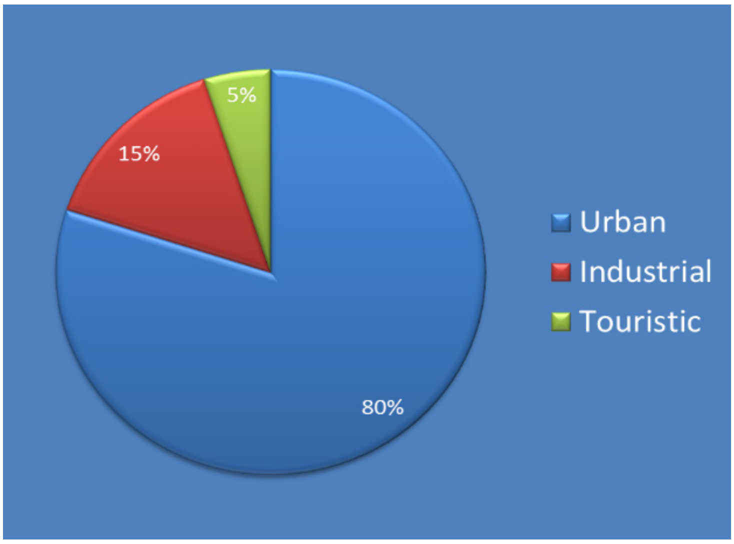



**Figure 7.** Origin of wastewater collected in Tunisian wastewater plan

**Table 5.** Wastewater flow and particulate matter quantification in coastal rejects

| STEP 2018 | Flow of treated wastewater m³/ year | Data refer to average (Annual) | | |
|---|---|---|---|---|
| | | DBO5 ($mgO_2/l$) | DCO ($mgO_2/l$) | MES (mg/l) |
| Tunis | 38,375,912 | 32 | 100 | 45 |
| Ariana | 49,749,976 | 29 | 100 | 32 |
| Manouba | 3,601,630 | 18 | 61 | 19 |
| Ben Arous | 20,692,558 | 37 | 104 | 27 |
| Grand Tunis | 112,420,076 | 31 | 99 | 35 |
| Nabeul | 27,556,991 | 27 | 100 | 27 |
| Zaghouan | 1,442,254 | 41 | 103 | 42 |
| Beja | 4,041,421 | 44 | 177 | 87 |
| Siliana | 1,283,753 | 34 | 114 | 48 |
| Bizerte | 11,233,498 | 38 | 123 | 41 |
| Jendouba | 4,536,873 | 44 | 133 | 70 |
| Nord | 52,212,930 | 34 | 118 | 43 |
| Sousse | 29,862,336 | 42 | 176 | 36 |
| Monastir | 16,374,303 | 70 | 223 | 96 |
| Mahdia | 6,452,679 | 71 | 213 | 132 |
| Centre | 66,262,275 | 55 | 189 | 68 |
| Sfax | 18,138,056 | 98 | 299 | 123 |
| Medenine | 6,704,296 | 34 | 120 | 49 |
| Gabès | 8,684,771 | 75 | 167 | 95 |
| Sud | 43,533,763 | 76 | 217 | 93 |
| **Balance sheet 2018** | **274,429,044** | **45** | **144** | **54** |

## V.4. Eutrophication

The Tunisian coastline is about 1200 km long and occupies roughly 2.5% of the total coastline of the Mediterranean including the shores of coastal lagoons. Because of the development of its industrial, touristic, and agricultural activities, Tunisian marine resources began to get contaminated. Consequently, there has been a growing interest in eutrophication as one of the most pertinent disturbance processes on aquatic ecosystems. In fact, the water quality of coastline in many areas of Tunisia has deteriorated due to massive discharge of nitrogen and phosphorous from domestic, touristic, and industrial wastewater as well as agriculture drainage. The impact of eutrophication could appear on variable aspects of the ecosystem.

In Tunisia, eutrophication has been accompanied by epidemic Harmful Algal Blooms (HABs), which cause serious ecological problems in the aquatic ecosystem. HABs negatively affect the aquatic animals in localized areas as well as in the whole ecosystem by activities such as clogging of fish and shellfish poisoning by toxin secretion and causing localized anoxia.

The effect of eutrophication is not restricted only to the biological and ecological characteristics of the aquatic habitat, but many extend to cause severe social-economic losses. In fact, HABs have direct impacts on human health and negative influences on human wellbeing, mainly through their consequences to coastal ecosystem services (fisheries, tourism, and recreation). In humans, toxicity is caused by the ingestion of contaminated seafood products (fish or shellfish), skin contact with toxin-contaminated water, or the inhalation of aerosolized toxins or noxious compounds.

With regards to the impact of HABs on the aquaculture activities on Tunisia much work has been done. Nevertheless, until date, no data describe the effect of HABs on human wellbeing. In this mini review an attempt has been made to summarise the most vulnerable Tunisian areas to eutrophication as well to HABs. The classification of sites depends on the HABs risk on aquaculture activities then to human food.

The Gulf of Gabès, on the southern coasts of Tunisia represents half of coasts and provides more than 60% of the country's fishing reserve and activity, which increase the economy income. In this area, the nature of the coastal environment is highly complex due to the interaction of various factors such as anthropogenic and touristic inputs caused by urbanization, industry, marine traffic, over-fishing, and related agricultural activities. HABs are frequently observed in Tunisian National Monitoring Stations Network of Phytoplankton in Gabès Gulf, and they are responsible for closing shellfish harvest stations for long periods. Shellfish are the object of a very important national exploitation. Many blooms of the toxic dinoflagellate *Alexandrium minutum* have been recorded since 1990 in the Gulf of Gabès. Since 1995, multidisciplinary monitoring programs did closely survey this harvest. Nine potentially harmful dinoflagellates species are recorded in the Gulf of Gabès: *Alexandrium minutum*, *Amphidinium carterea*, *Coolia monotis*, *Karenia selliformis*, *Karlodinium venificum, Ostreopsis* cf. ovata, *Prorocentrum concavum, Prorocentrum lima* and *Prorocentrum rathymum*. *A. minutum* indicated the highest values of relative abundance to identified potentially harmful dinoflagellates in different stations with a maximum density of $21.33 \times 10^4$ cells $L^{-1}$.

In 2005, *A. minutum* bloomed at Jaboussa (5.95 × $10^3$ cells $L^{-1}$) and Skhira (5.93 ×$10^3$ cells $L^{-1}$). In spring (April, May) 2006, *A. minutum* growth gradually extended along the coast of the Gulf with a peak recorded at Ras Younga (8.98 × $10^3$ cells $L^{-1}$) and substantial densities were also found in spring at El Hicha (1.09 × $10^3$ cells $L^{-1}$) and in the Boughrara Lagoon (1.03 × $10^3$ cells $L^{-1}$) with, however, the most important total phytoplankton abundance (3.77 × $10^6$ cells $L^{-1}$) to be recorded.

Bizerte Lagoon is one of the most important aquaculture areas in Tunisia, recognized for its shellfish-producing activities (mussels, clams, and oysters). Over the last 10 year the lagoon's annual production has not exceeded 200 tons per year. Aquaculture in the lagoon has suffered from severe seasonal losses of bivalves, one of the incriminating factors being HABs reaching for some species 488 × $10^3$ cells $L^{-1}$. Analysis carried over a 5-year period (from 2007 to 2011) showed the presence of three potentially toxic dinoflagellate genera: *Alexandrium* spp., (488 × $10^3$ cells $L^{-1}$), *Prorocentrum* spp. (5 × $10^3$ cells $L^{-1}$), *Dinophysis* spp. (210 × $10^3$cells $L^{-1}$) and one diatom genus: *Pseudo-nitzschia* spp. (21,700× $10^3$cells $L^{-1}$).

The Gulf of Tunis, located in north-eastern Tunisia, is one of the most important gulfs for fisheries and the most urbanized and industrialized area in the country. In this area, harmful microalgae assemblages were dominated by three toxic epiphytic dinoflagellates: *Ostreopsis sp*., *Prorocentrum lima* and *Coolia monotis* (Hachani *et al.*, 2018). These toxic microalgae were observed, both on macrophytes (1.03 × $10^5$ cells $g^{-1}$ FW; 13 × $10^3$ cells $g^{-1}$ FW and 865 cells $g^{-1}$ FW, respectively) and in the water column (23.5 × $10^3$ cells $L^{-1}$; 3.72 × $10^3$ cells $L^{-1}$; 1.04 × 10 $^3$cells $L^{-1}$, respectively). The proliferation of most harmful species is widespread in summer when water temperature is warm and especially in bay zones. The Gulf of Tunis is a reservoir of potentially toxic species that could pose a real threat, both to ecosystems and to public health.

Ghar El Melh Lagoon (GML) is a Ramsar site on the north-eastern coast of Tunisia. It has mostly become eutrophic due to the combined effects of agricultural drainage from the Utica floodplain, raw sewage discharge from the town of Ghar El Melh and due to local summer tourism. Because of eutrophication, GML has a remarkable abundance of phytoplankton, especially on *Ruppia* leaves, including harmful species. Phytoplankton was mainly dominated by dinoflagellates (*Prorocentrum lima* 6.$10^5$ cells $g^{-1}$ FW, *Dinophysis* spp. 2× $10^5$ cells $g^{-1}$ FW) and diatoms (*Thalassionema* 1.92 × 105 cells g–1 FW) with sequences of harmful species proliferation attaining more than 70 % of total phytoplankton, all bioindicators of water deterioration. The number of toxic dinoflagellates was high in summer and autumn and the presence of many harmful species such as *Prorocentrum* spp. and *Dinophysis* spp., was recorded.

All toxic microalgae observed in different Tunisian area described below are well known for their ability to secrete biotoxins. Five human syndromes are presently recognized as to be caused by these biotoxins: Amnesic Shellfish Poison (ASP), Ciguatera Fish Poisoning (CFP), Diarrhetic Shellfish Poisoning (DSP), Neurotoxic Shellfish Poisoning (NSP) and Paralytic Shellfish Poisoning (PSP).

## V.5. Solid Waste production

A large amount of solid waste is generated in coastal areas. Tourism has an important direct effect in total amount of this assessment especially during the summer, mainly in most big tourism cities like Sousse, Hammamet, which makes its management more complicated. Municipalities lack the organizational and financial means to ensure sustainable solid waste management (SWM) in touristic areas and need an intervention from all actors to Make pressure and implement sustainable solutions. In Tunisia the hierarchical institutional framework is organized as follows in Figure 8, where a clear role for ministry of tourism should be attributed to be involved in solid waste management activity.

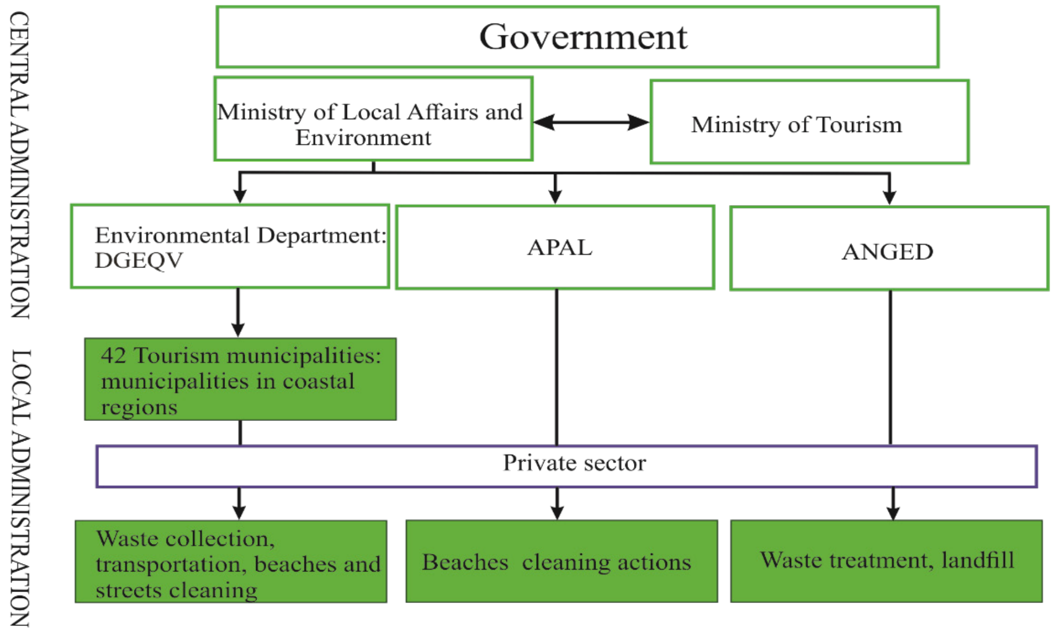



**Figure 8.** Institutional framework of SWM in tourism in Tunisia (Chaabane et al. 2019)

Solid waste management SWM is an environmental aspect of tourism process as cleanliness of these destinations is an essential requirement. In Tunisia for instance, tourism saw a 17.4% increase in arrivals in 2019 compared to the same period in 2018, that generate more waste. Through exhaustive coverage and the recycling of packaging, the appearance of tourism destinations, roads and beaches will be significantly improved. Collected items for recycling shows that the quantities collected have decreased considerably since 2009, reaching only 5400 tons in 2017 and 3400 tons in 2018. The performance of current SWM shows that it has failed to ensure the cleanliness of tourism destinations is sustainable. Tunisia generates 2.8 million tons of Municipal Solid Waste (MSW), between 20% - 30% of which are recyclable materials (Table 6). The current system for packaging in Tunisia (ECO-Lef) only receives 3400 tons in 2018 compared to 15,800 tons in 2010 and the total recycling rate in the country does not exceed 5%, which makes the waste management system inefficient and unsustainable. In Tunisia, solid waste assessment in some touristic areas Gammarth and Hammamet reveals this distribution (Fig. 9).

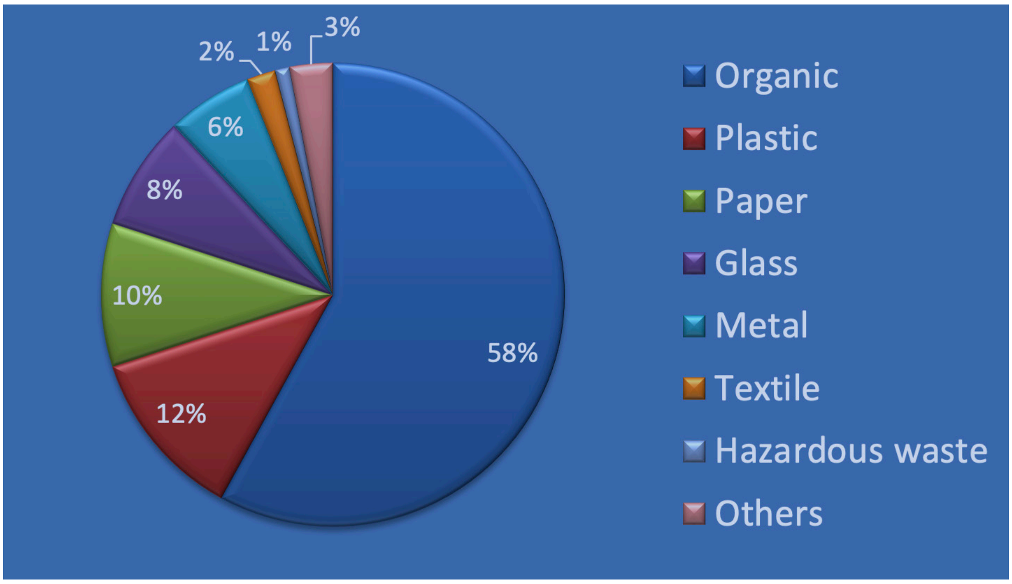



**Figure 9.** Characteristics of the solid waste generated by hotels in Gammarth and Hammamet in Tunisia, 2018 (Chaabane et al. 2019)

With extended producer responsibility (EPR), the individual responsibility can be transformed into collective responsibility and a concrete EPR organization (System Operator/Producer Responsibility Organisation) should be established. Those producers and importers responsible for the financing and organization of the EPR system must therefore organize or assume system responsibility through a predetermined form of organization. This institution is then referred to a system operator. The producers of products subject to EPR should be clearly defined. According to OECD, the "producer" is defined as the entity with the greatest control over the selection of materials and the design of the product. This could be the brand owner/importer or the filler of the packaging rather than the firm that produces the container.

**Table 6.** Principal types of Solid Waste (SW) generated from different hotels departments (Chaabane et al. 2019)

| Department/zone of the hotel | Types of waste | Guest (Other type of residences) | Hotel |
|---|---|---|---|
| Beach | Paper, plastic, carton | 100% | 0% |
| Wellness area | Wipes, diaper, waste resulting from personal hygiene (bathroom kit, soap remainders) | 100% | 0% |
| Outdoor area (park, pool, garden, golf course) | Garden waste, paper, plastic | 10% | 90% |
| Kitchen | Food preparation waste, carton packing, metal packing, paper, textile | 0% | 100% |
| Local restaurant and bar | Meal remains (bio-waste), glass, plastic, and metal packaging | 95% | 5% |
| Laundry service | Tablecloths, towels, clothes, rags | 0% | 100% |
| Furniture and stock | Plastics, paper, cardboard | 0% | 100% |
| Maintenance service | Paint remains, cans, light bulbs, paper, plastic | 0% | 100% |
| Offices and administrative activities | Cardboard packaging, plastic bottles, glass, paper, ink cartridges, batteries | 0% | 100% |
| Conference rooms | Paper, plastic, meal remains, glass | 90% | 10% |
| Lifts and stairs | Paper, plastic | 100% | 0% |
| Rooms | Metal, plastic, and glass packaging (mini bar), paper and newspapers, plastic cups, layer, wipes, personal hygiene waste (toilet bag, soap remainders), courtesy waste (slippers, shower cap, disposable products), batteries, medical waste | 100% | 0% |

Tourist zones generate different types of solid waste with an important part that can be sources of marine pollution depending on:

- Hotels waste management.
- Sites of waste reject.
- Associated touristic activity on beaches and nearby cities.

This approach is related to the number of hotels and the number of tourists and visitors. The presented methodology refers to the waste generated by tourists at the hotel was calculated based on the amounts of SW generated by tourists (Qwt). The following formula was used to estimate and compare the waste generated in Tunisia (tons/months) for the recent years 2010, 2012, 2015 and 2016 (Fig. 10).

$$Qwt = Nt \times Itwg \times Ds/1000 \text{ (t/year)}$$

Where:

Qwt = amount of waste generated by tourists

Itwg=tourist waste generation rate (kg/capita/day): in this example Ilwg=1 kg/guest/day.

The variables of Ds, Nn, Na and Nt were collected based on the statistics of the Ministry of Tourism:

Ds = Nn/Na

Nn = number of overnight stays

Na = number of arrivals (in calculated month)

Nt = number of tourists (in calculated month)

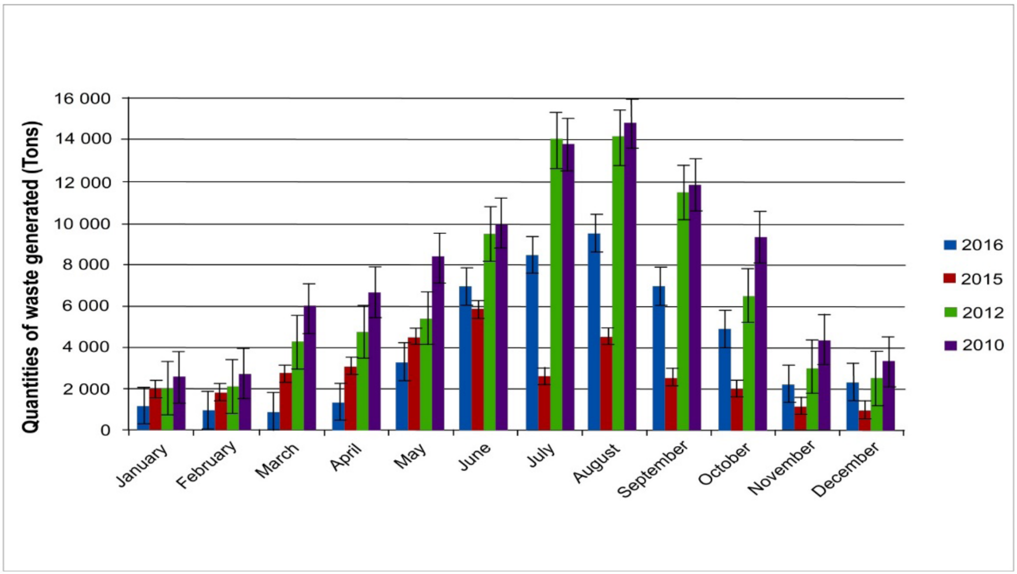



**Figure 10.** SW generation from accommodation establishments between 2010 and 2016 in Tunisia (Ton/Month) (Chaabane et al. 2018)

Figure 11 shows a progressive increase in generated waste close to marine environment hotels during the summer period, with a peak during July and August. The quantity decreased during the years 2015 and 2016. Figure 12 shows the increase in the quantities of SW generated in hotels in Hammamet during the summer period in 2017. This period begins with a first increase in May and peaks during June, July, and August (between 2,500 tons and 3,000 tons).

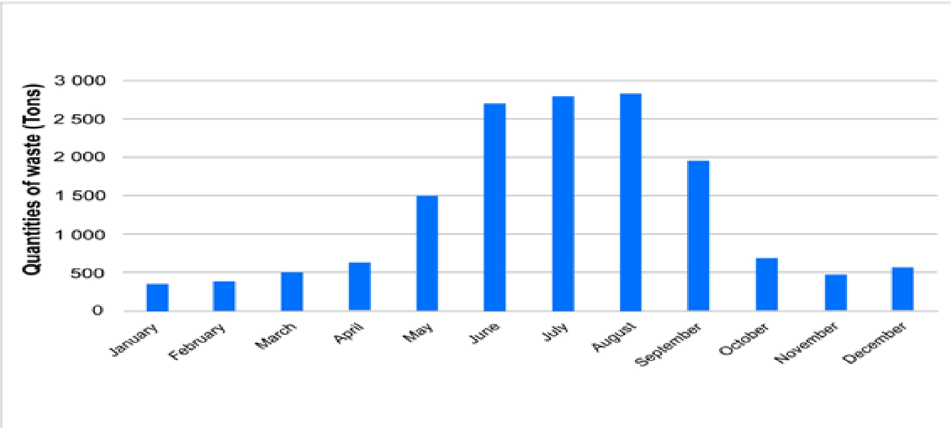



**Figure 11.** Evolution of SW attributable to tourism (tons/month) in Hammamet (2017) (Chaabane et al. 2018)

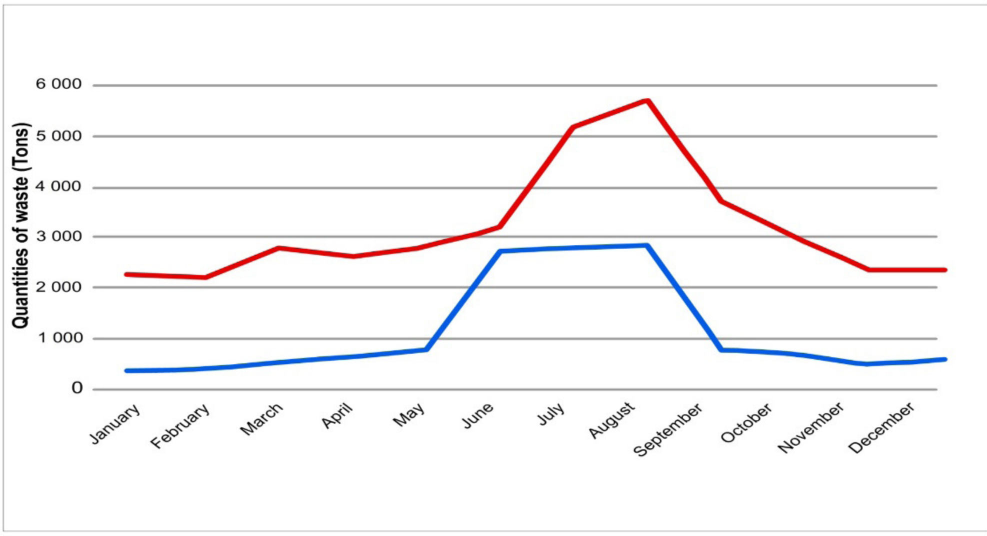



**Figure 12.** Comparison of SW generated in Hammamet by tourism (Blue) and households (Red) in 2017 (Chaabane et al. 2018)

## V.6. Marine litter

Around 80% of the litter that accumulates on shorelines, the sea surface and the sea floor is made up of one or a combination of different plastic polymers (Fig. 13) (Galgani et al. 2015, UNEP and GRID-Arendal, 2016). The cigarette butts, bags, remains of fishing gear and beverage containers are the most common litter assessed on coastal zone. Coastal tourism has been recognized as a main source of marine litter, mainly by direct discharge. It is very difficult to quantify the input from this sector. Proxy indicators, such as earnings related to the sector in particular regions or number of tourist arrivals, can be used as a means of assessing its significance (UNEP, 2015).

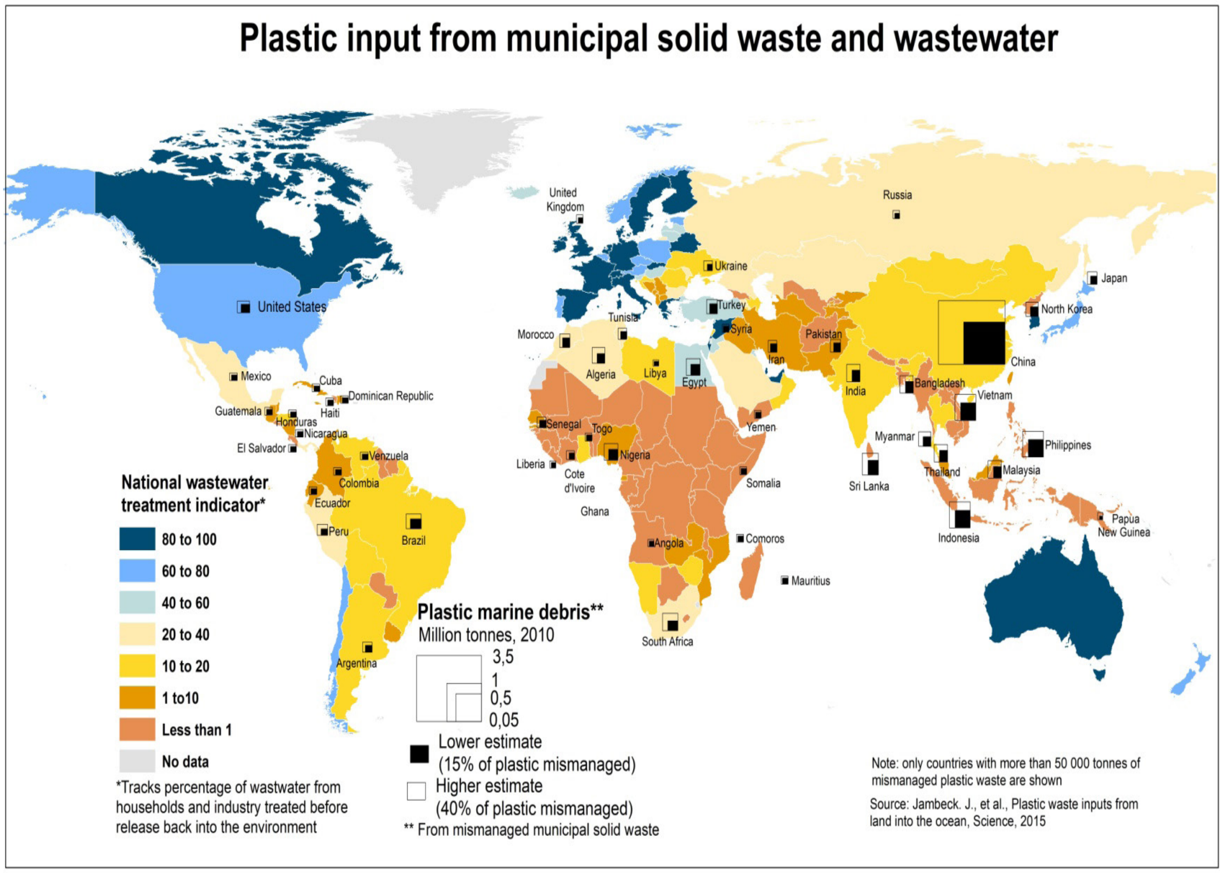


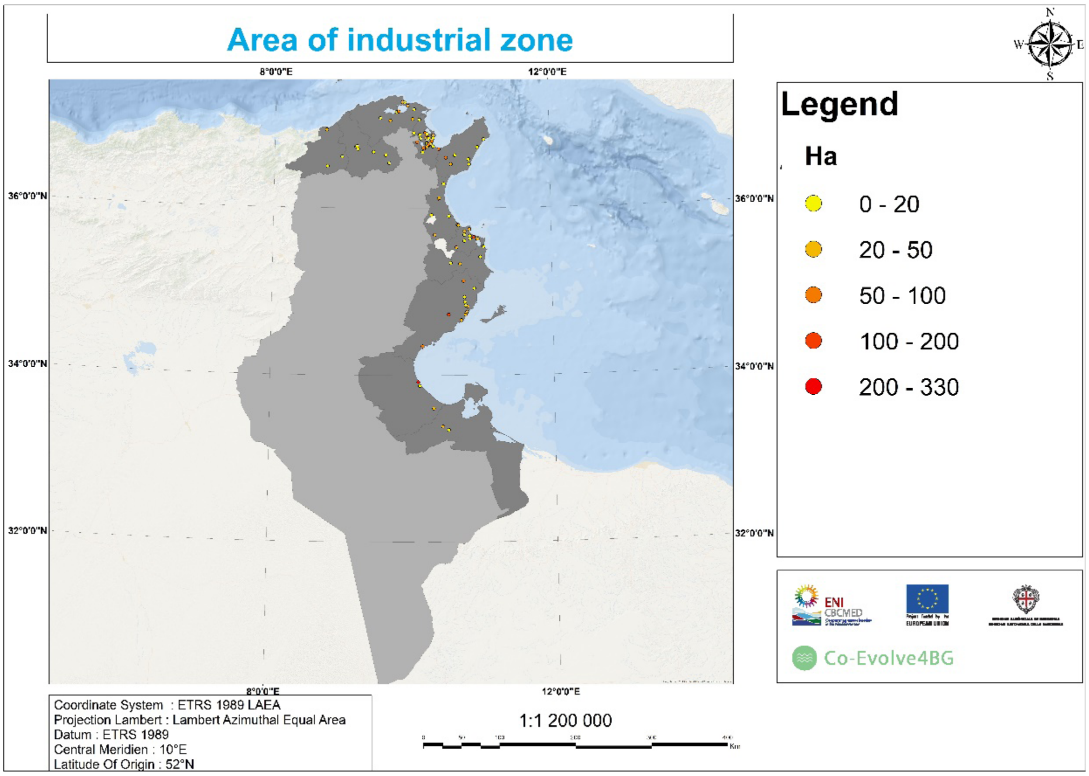

**Figure 13.** Plastic waste in puts from continent in marine environment in 2015

River discharges depends on the intensity and type of industry, the socio-economic activities, population density in the catchment area basin and the influence of tourism activity involving related activities. The implementation of environmental land protection and waste treatment measures may help to reduce the leakage of debris. The reparation and extent of impervious surfaces (built-up areas) in watersheds has been used as a proxy for the input of marine litter (plastic debris) through watercourses, as it is directly related to both urbanization diversity and runoff volume (Lebreton et al. 2012).

Tunisia touristic activity represents a source of environmental pressure on natural resources and coastal areas (water and waste pollution). More than 8 million tourists visited Tunisia in 2018 and tourism accounts for 8% of Gross Domestic Product (GDP). However, tourism in Tunisia has undergone major changes in recent years. In Tunisia, SWM is mainly the responsibility of municipalities. In Tunisia, there are 44 tourism municipalities shared on 18 governorates, as proposed by Ministry of Environment, and supported by APAL. Furthermore, the solid waste generated from hotels is mostly mixed (Chaabane et al. 2019). According to these authors, 83% of hotels in touristic region collect mixed waste, which is then sent to landfills. In this case, in term of solid waste quantity, tourist generates the double of the MSW amount produced by a local resident that gave rise to around 35 million tons of MSW per year (Chaher et al. 2020).

## V.7. Ecosystem degradation and fragmentation

In Tunisia, infrastructure is one of the most parts of the territory that can offer a satisfactory attractiveness; development projects affect urban areas unevenly. Under these conditions, rebalancing is impossible. The trend towards the concentration of economic, political-administrative, and cultural powers in the large coastal cities is confirmed. There is an important link between tourism and industrial units but not every time a direct one. There is other economic aspect for their instauration. But in some agro alimentary and chemical industry tourism is the first direct local market. In the same context and as shown in Figure 14 the oil platform is installed in front or nearby an important member of touristic zone such as Djerba, Hammamet, Sousse… Their effect on environment should be speared to other activity to distinguish the source of threats.



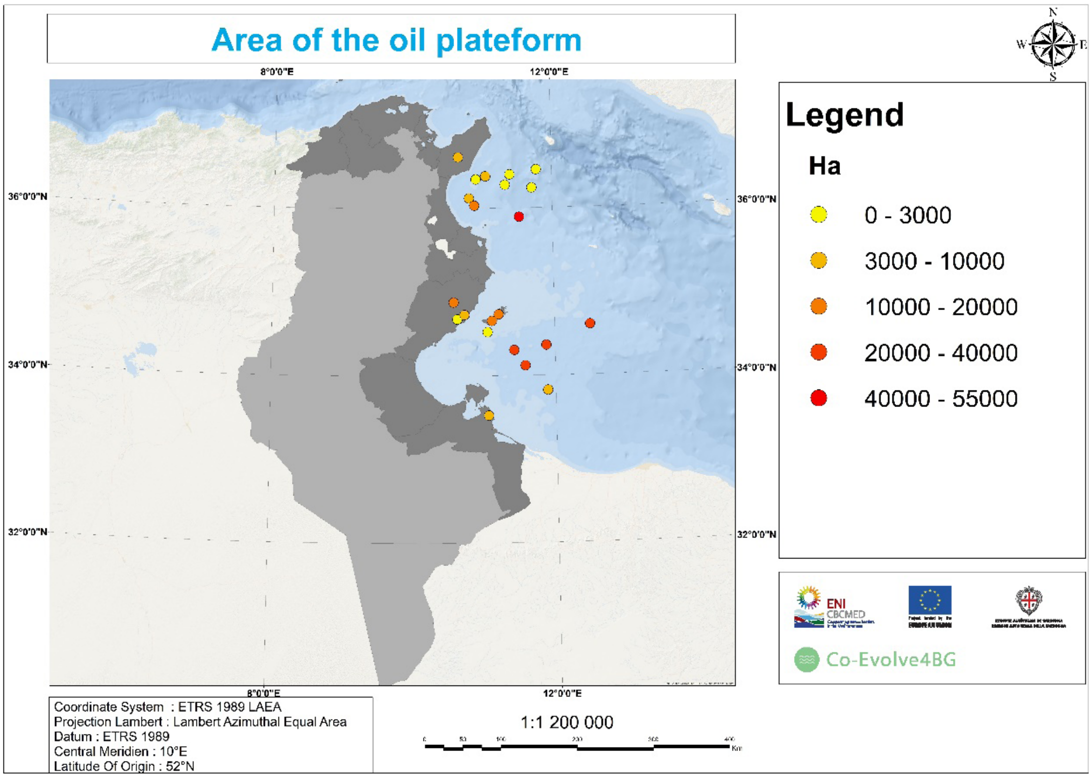




**Figure 14.** Industrial area zones and oil platforms along the Tunisian coasts

The urbanization and construction of tourist buildings along beaches, as well as the exploration of water resources affect the sedimentary process and contribute to beach erosion.

The National Program of Action for the Implementation of the National Strategy of The Tunisian Ministry of Agriculture, Forestry and the Fight against Desertification has identified on the Tunisian territory units of analysis of this processes that correspond to socio-agro-ecological zones (ZSAE). This action intends to preserve environment from coastal urbanization activity involving touristic areas (Figs. 15, 16).

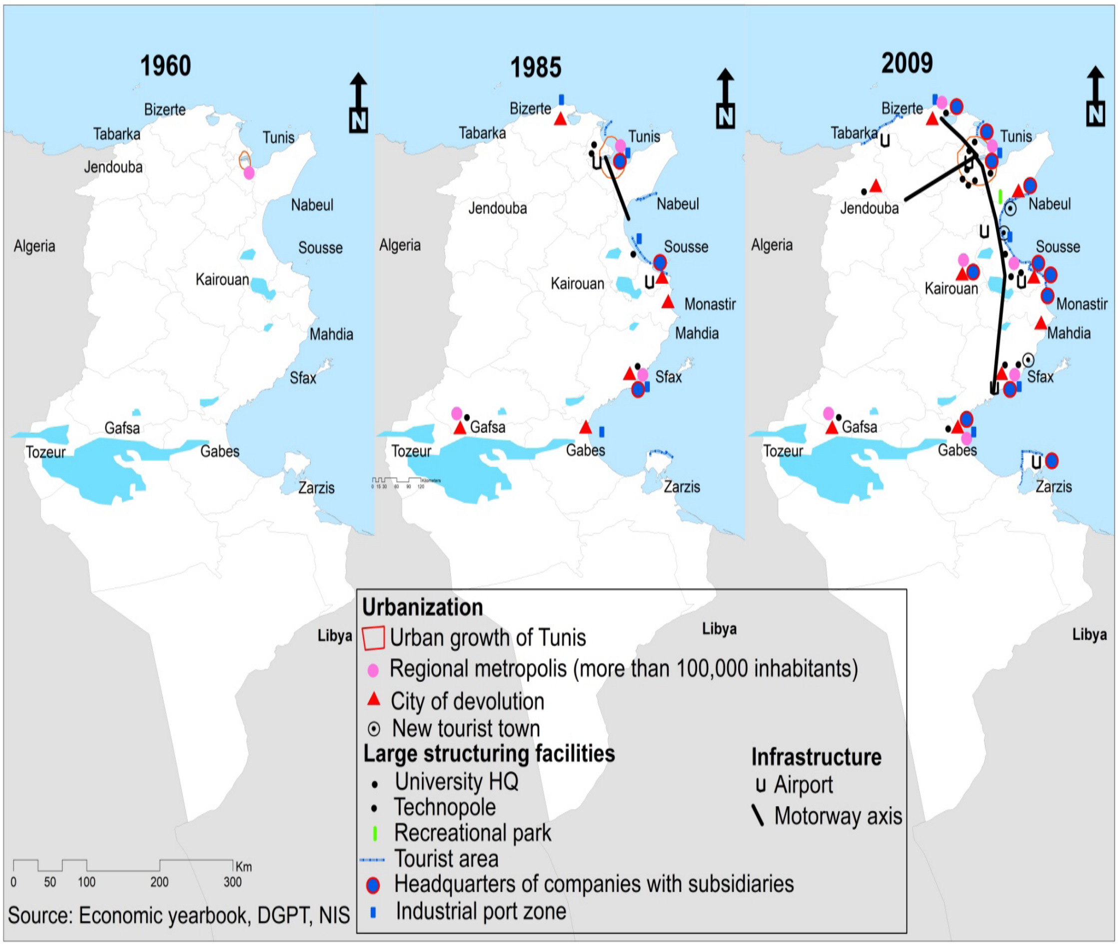



**Figure 15.** Coastal area degradation and fragmentation between 1960 and 2009

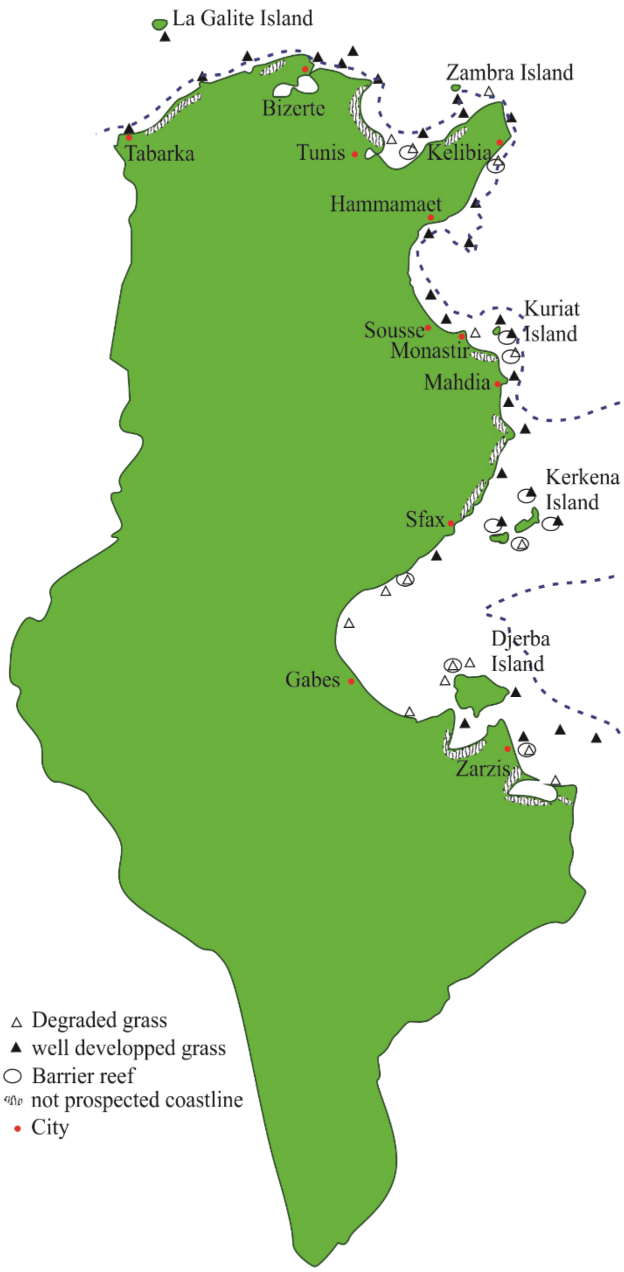



**Figure 16.** Marine area degradation in nearshore Tunisian coastline

## V.8. Wildlife disturbance and exploitation

Concerning wildlife, the 2008 update of the diversity study biological inventory in Tunisia has reconsidered the inventory methodology based on the analysis of the biocenotics, especially for invertebrates, practiced in the 1998 study.

In Tunisia, there is an institutional environmental control of wildlife disturbance and exploitation Environment named the forest code 2017. The forest regime is the set of rules special provisions applying to forests, rangelands, forest lands, national parks and reserves natural, wild fauna and flora. This is to ensure protection, conservation, rational exploitation and to guarantee users the legal exercise of their rights. It is important to note that forestry land is understood to mean any land, which for ecological and economic reasons finds its best use in the establishment of a forest.

Threats to Wildlife are calcified as follows:

- Forest clearing.
- Reduction in the diversity of natural landscapes because of the practice of a habitat-destroying agriculture.
- Overgrazing.
- Chemical pollution of watercourses.
- Destruction of natural biotopes by urban development and expansion cities.
- Ponds and water points are drying out faster and faster because of the climate warming and on-going desertification.

Threats Affecting Wetland Biological Diversity: Threat factors to coastal wetland biodiversity: (Table 7)

- Pollution (organic and industrial) leading to eutrophication.
- Unsustainable exploitation.
- Disruption of ecosystem functioning.
- Wild frequentation and clan destination.
- Lack of appropriate management.
- Multiplicity of institutional bodies with lake of coordination in actions related to environmental lows, quality of environment and tourism.
- Pressure from urban and industrial pollution.
- The pressure of fishing activities on foot, especially in tidal areas, case of the vast Kneiss wetland Kerkennah.

Threats to the marine environment: The threat factors affecting the marine flora are essentially:

- Pollution.
- Modification of sedimentary inputs generally resulting from coastal facilities
- The phenomenon of anchoring by ships.
- The introduction of invasive alien species.
- The modes of operation, in particular trawling.

On the other hand, the Tunisian coastline suffers from marine erosion. Indeed, the accelerated rise in sea level due to climate change, coupled with the occupation of coastal land of the public maritime domain, has contributed to the amplification of marine erosion in several coastal regions in Tunisia (Fig. 17).

**Table 7.** Biodiversity in Tunisian marine coast

| Component of the marine biodiversity | Number of species | |
|---|---|---|
| | 1998 study | 2008 study |
| Macroflora | 414 | 414 |
| Microflora | 200 | - |
| Invertebrates | 1,233 | 2,060 |
| Fauna Ichthyic | 232 | 232 |
| Aquatic Avifauna | - | 105 |
| Aquatic mammals | - | 10 |


**Figure 17.** Vulnerability of the Tunisian coast to accelerated rise in sea level (in blue)

## V.9. Light pollution

The presence of anthropogenic artificial lights in the night environment with too much light pollution has consequences: it washes out starlight in the night sky, interferes with astronomical research, disrupts ecosystems, and has adverse health effects and wastes energy.

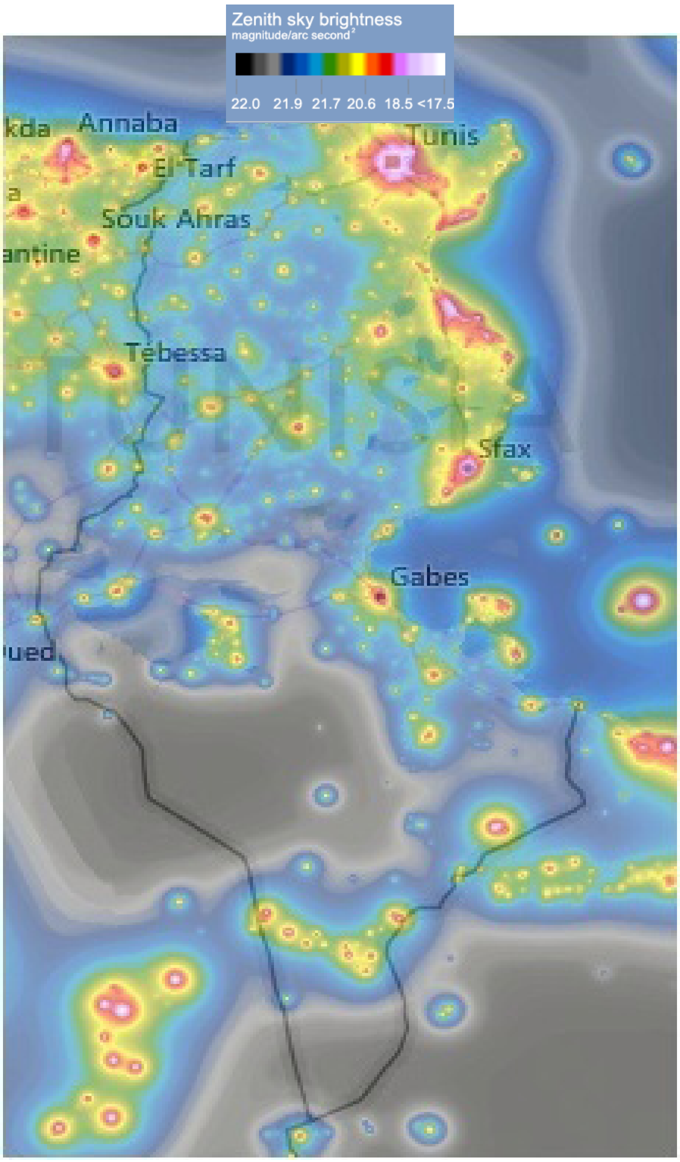



**Figure 18.** Light pollution map Tunisia

The main problem in touristic zone is the presence of light in most of costal area along beaches coastline that is not recommended for biota in marine area mainly sea turtles and marine Mammals (Fig. 18). According to FFWCC/USFWS, 2016 it is important to include for new construction and remodelling of existing structures when such remodelling includes alteration of exterior lighting or replacement of any glass or glazing. The provision of the ordinance applies to all developments water ward of the Coastal Construction Control Line (CCCL), or if the development creates any artificial light that will be visible from the beach.

The recommendation of new construction near beaches or remodelling any existing structures when such installations include alteration of exterior lighting or replacement of any glass or glazing are subject to new lighting standards, including:

- The use of Certified Wildlife Lighting fixtures and bulbs.
- Provide low-mounted fixtures whenever possible; and
- Use of film glass with an inside-to-outside light transmittance value of 45% or less.

## V.10. Invasive species

Alien species are considered as important process generated by anthropogenic activities such as pollution, overfishing, intensification of maritime traffic, aquaculture, and global warming (Bax et al. 2003; Galil, 2009, 2011). According to Zenetos the The number of Alien species in the Mediterranean Sea has increased with one new record every nine days as an average rate. Marine biological invasions are considered a major threat to the biodiversity of the Mediterranean Sea, affecting habitats and ecosystem function. Invasive species can have several origins among these factors the impact of tourism activity such as cruising and recreational boating.

Until March 2015, a total of 136 alien species have been reported in Tunisian waters among which are 34 crustaceans, 31 molluscs, 26 fishes, 18 annelids and 27 species from other taxa (Figs. 19, 20). From these species, 62 % are established, 30 % are Casual, 4% are Questionable and 4% are Cryptogenic. Most of these species (61.76%) are of Indo-Pacific or Indian Ocean origin (Ounifi-Ben Amor et al. 2015).

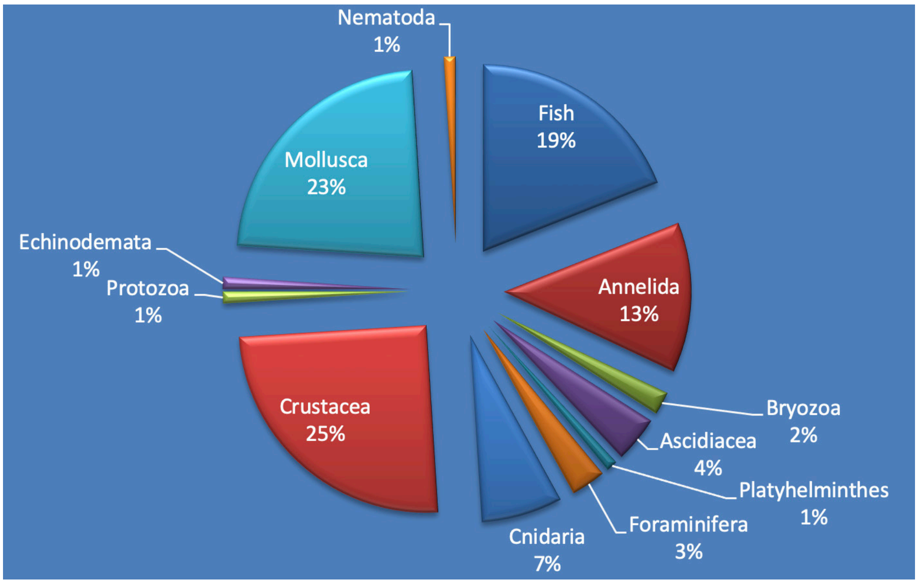



**Figure 19.** Percentage of alien marine fauna in Tunisian waters per taxonomic group

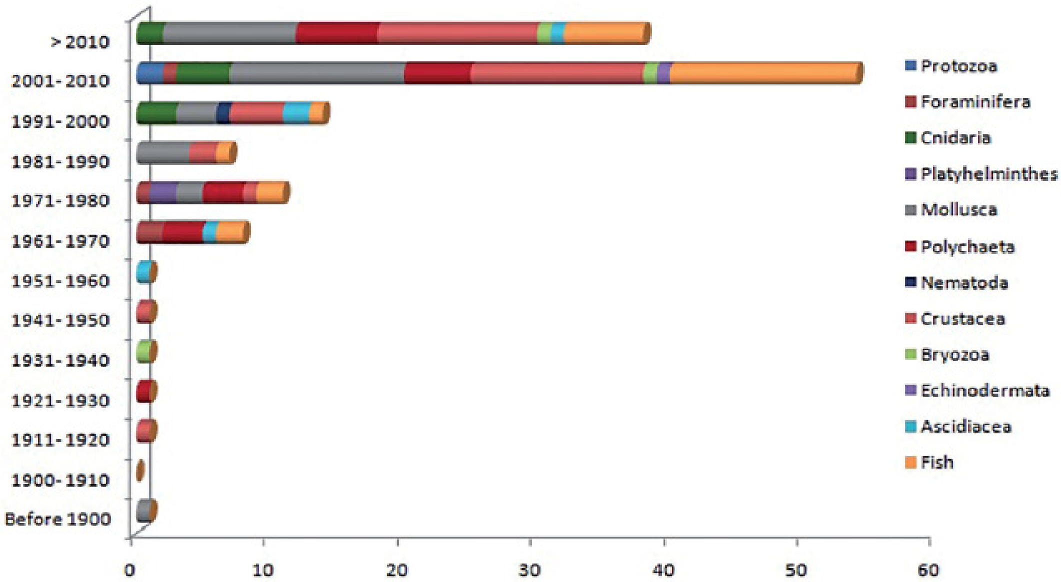



**Figure 20.** Number of new introductions per decade/per area of alien fauna in Tunisian waters according to the division of the Mediterranean by the MSFD, based on the reported year of first sighting

On the other hand, the list of alien marine macrophytes introduced into Tunisia was update in light of available data and new observations (Fig. 21). Until 2014, a total of 27 alien marine macrophytes are assessed in Tunisian costal area (Sghaier et al. 2015). Fourteen alien marine macrophytes are established, whereas seven cryptogenic and two casual species require further investigation. Eleven species are considered as invasive or potentially invasive in the Mediterranean Sea: *Acrothamnion preissii*, *Asparagopsis armata*, *A. taxiformis* (Indo-Pacific lineage), *Hypnea cornuta*, *Lophocladia lallemandii*, *Womersleyella setacea*, *Caulerpa chemnitzia*, *C. cylindracea*, *C. taxifolia*, *Codium fragile* subsp. *fragile* and *Halophila stipulacea.*

Table 8 shows that most macrophytes alien invasive species are present in most industrialized zone and touristic area in Tunisian coast (Sghaier et al. 2015). Marine fauna alien Invasive species in Tunisia are in most cases related to harbour activity maritime transport, cruising, and recreational boating Yachting/Marinas (Ounifi-Ben Amor et al. 2015).

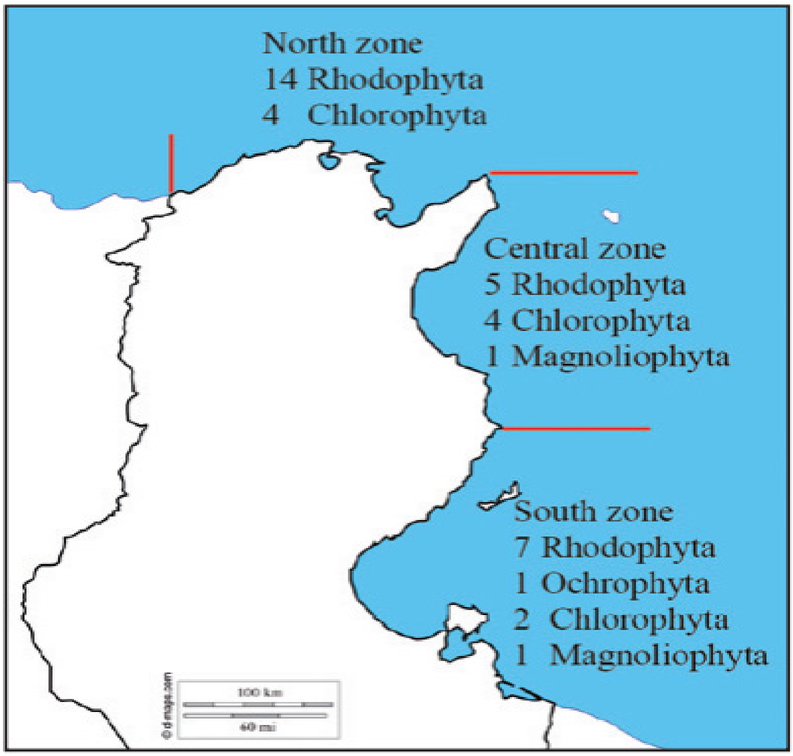



**Figure 21.** Number of alien marine macrophytes (established, casuals, cryptogenic) recorded in Tunisia until 2014 (Sghaier et al. 2015)

**Table 8.** Marine alien Invasive fauna and macrophytes species defined in Tunisia. Species recorded up March 2015 with the First sighting in Tunisian waters (WMED or CMED)

| Species | Origin | 1st Tunisian sightings/1st WMED sighting |
|---|---|---|
| Marine fauna alien Invasive species in Tunisia (Ounifi-Ben Amor *et al.* 2015) | | |
| **Bivalvia** | | |
| *Fulvia fragilis* | Indian Ocean | 2001 Ben Souissi *et al.* 2003 |
| *Pinctada imbricata radiata* | Indo-Pacific/ Red Sea | 2008 Diawara *et al.* 2008 |
| *Ruditapes philippinarum* | Temperate North Pacific | 1996 Ben Souissi *et al.* 2005a |
| **Gastropoda** | | |
| *Bursatella leachii* | Circumtropical | 2001 Ben Souissi *et al.* 2003 |
| *Cerithium scabridum* | Indian Ocean/Red Sea | 2009-2010 Antit *et al.* 2011 |
| Animalia: Polychaeta | | |
| *Ficopomatus enigmaticus* | Subtropical | 1944 Heldt, 1953 |
| *Hydroïdes dianthus* | Northwest Atlantic | 1965 Vuillemin, 1965 |
| *Hydroides dirampha* | Circumtropical | 1978 Zibrowius, 1978 |
| *Hydroïdes elegans* | Circumtropical | 1965 Vuillemin, 1965 |
| **Decapoda** | | |
| *Libinia dubia* | West Atlantic | |
| *Percnon gibbesi* | West Atlantic | 2004 MedMPA, 2004 |
| *Portunus (Portunus) segnis* | Indian | |
| *Metapenaeus monoceros* | Indo West Pacific | |
| *Trachysalambria curvirostris* | Red Sea | |
| **Animalia: Bryozoa** | | |
| *Amathia verticilla* | Atlantic | |
| Marine alien invasive macrophytes in Tunisia (Sghaier *et al.* 2015) | | |

| | | |
|---|---|---|
| **Rhodophyta** | | |
| *Acrothamnion preissii (Sonder)* | Indian - Pacific | Bizerte, Cap Zebib, Raf-Raf |
| *Asparagopsis armata Harvey* | Indian - Pacific | Cap Serrat, Hammamet |
| *Asparagopsis taxiformis (Delile)* | Indian - Pacific | North coast, Mahdia |
| *Hypnea cornuta (Kützing)* | Red Sea - Pacific | Djerba |
| *Lophocladia lallemandii (Montagne)* | Red Sea- Indian-Pacific | Gabès |
| *Womersleyella setacea (Hollenberg)* | Pantropical | Cap Bon |
| **Chlorophyta** | | |
| *Caulerpa chemnitzia (Esper)* | | Cani Island, Bizerte Harbour, Sousse |
| *Caulerpa cylindracea Sonder* | Indian - Pacific | North coast, Mellita |
| *Caulerpa taxifolia (Vahl)* | Pacific | Sidi Daoud |
| *Codium fragile subsp. Fragile (Suringar) Hariot* | Pacific | Bizerte, Chott-Mariem |
| **Magnoliophyta** | | |
| *Halophila stipulacea (Forsskål) Ascherson* * | Red Sea - Indian | Sfax |

# VI. Threat caused by coastal and maritime tourism

Threat indicators caused by coastal and maritime tourism are a part of the European Indicator System looks for sustainable management of destinations by providing tourism stakeholders with an easy and useful toolkit (ETIS, 2013). Indicators are used from most interested by services including stakeholders to measure and monitor their sustainability management processes, in this case those related to ecosystem services.

European Tourism Indicator System Detailed Indicator Reference Sheets for Sustainable Destinations. Monitoring network shows that treated and non-treated water rejects is the main source of threats in coastal area with high flow of non-treated water in summer, due to the overflow of water rejects in marine in nearby marine area of touristic zone. Table 9 shows that Tunisia harbour needs more control to water ballast control by The International Convention for the Control and Management of Ships' Ballast Water and Sediments which was adopted in December 2007. It was adopted by consensus in London on Friday, February 13, 2004. The Convention will enter into force 12 months after its entry into force, ratification by 30 States, representing 35% of the gross tonnage of the world merchant fleet. In As of January 2010, 21 countries had ratified the Convention (Argentina, Australia, Barbados, Brazil, Egypt, Finland, Kenya, Kiribati, Maldives, Marshall Islands, Netherlands, Nigeria, Norway, Republic of Korea, Republic of Moldova, Republic of Korea, Republic of Korea, Saint Kitts and Nevis, Spain, Sweden, Syrian Arab Republic, and Tuvalu).

**Table 9.** Threat indicators caused by coastal and maritime tourism

| TEIS/ Environmental Impact | CO-EVOLVE threat Indicator | CO-EVOLVE4BG threat Indicator |
|---|---|---|
| Water Management | | Water pollution: treated, partially treated and non-treated water rejects |
| Reducing Transport Impact | | Ballast water reject control |
| Climate Change | | |
| Solid Waste Management | Unitary waste production compared to overnight stays | SW generated by tourists (Qwt) |
| Energy Use | | |
| Landscape and Biodiversity Protection | Natural land cover surface over artificial land cover surface | Natural land cover surface over artificial land cover surface |
| Light and Noise Management | Artificial sky brightness N. people exposed to road noise over 55 dB | Artificial sky brightness N |
| Bathing Water Quality | Bathing water quality | |

# VII. Pressures to coastal ecosystems

The major threats to the coastal landscapes of Tunisia are common along the Mediterranean coastal zone. They are related to uncontrolled development, urbanization, increasing national and international tourism, land-based pollution, unplanned or over-exploitation of natural resources, in particular freshwater. These findings are assessed using the Landscape Character Assessment (LCA) as a tool for landscape. Pressure related to limitation with loss or change of wetland habitat that affect hydrology and sedimentology, as well as contamination and pollution. In this case pressures lead to changes in environmental state, such as eutrophic state, hypoxia, erosion, and that threats the sustainability of the of ecosystem. There are also changes in the state of the ecology, such as loss of plants and sea grasses.

- Changes in the structure and function of the wetland ecosystems affect ecosystem services that are often underestimated.
- The loss of ecosystem services affects human welfare as well as the regulation of climate change by coastal wetlands.

Indirect pressures, such as sea level rise (Newton et al. 2020), further aggravate these cumulative impacts and multi-stressors.

In Mediterranean Sea, multiple pressure sources continue to be a significant presence in our seas and their combined effect is of growing concern: Maritime activities with continual increase cause a significant damage to sea floor habitats. Fishing pressure is reducing but recent years there is clear overfishing practice affecting ecosystem equilibrium. Pollution by nutrient enrichment and contaminants remains an environmental challenge mainly with more and more non-treated water rejects. Non-indigenous species are spreading, and their impacts are not fully assessed. Marine litter presents a principal pressure that is wieldy affected by population increase in coastal area.

## VII.1. Human activities along the Mediterranean coastline

Mediterranean coastlines differentiate a principal activity that are Classified according to their pressure impact in most previous assessment with CO-EVOLVE approach. The Deep and Comprehensive Free Trade Areas (DCFTA) with Tunisia have assessed environmental approach related to human activity. The Yale University Environmental Performance Index (EPI) ranks Tunisia as no. 99 out of 132 assessed countries – among 'Weak performers in maritime sustainability (Emerson et al. 2012). In Tunisia the priority of human activity is:

***Water resources***: Water overexploited mainly from catchment area that affect hydrodynamics, nutrient supply, and sediment composition environment. In the offshore zone, the absence of continental inflow, especially through the construction of dams, causes a decrease in the accumulation of sandy deposits before the littoral drift carries, a short-term depletion of sand settles in these areas. As less sand accumulates on the shoreline, the beach sediment budget will consequently influence the rate of accumulation of drill dunes, which is expected to decrease over time (Vogiatzakis and Cassar, 2007). Other alterations related to water resources that can cause major changes in the coastal landscape, such as the construction of saltworks and the excavation of water channels that cross the land to transport waste or water to the sea. In the 'Ecosystem Vitality' index, however, the scores are lower. The main contributors to the overall low score in ecosystem vitality are water resources (Table 10) (DCFTA, 2013).

**Table 10.** Policy recommendations for water scarcity and water quality

| Policy measures | Potential to address within DCFTA | Potential to address outside DCFTA |
|---|---|---|
| Law enforcement for industry compliance to standards. | | ✓ |
| Improved water treatment and recycling. | | ✓ |
| Development of less water resources consuming strategies in agriculture. | | ✓ |
| Promote sustainable water resources management in the tourism sector. | | ✓ |

***Agriculture activity:*** Agriculture is a predominant sector, although the tourism sector has developed enormously in recent decades (see below) along the promontory coastline. Much of the coastal zone is either agricultural (where the terrain permits) or natural/semi-natural, mainly where the topography is rugged. However, some of the higher terrain is, in places, terraced. The coastline includes different aspects of land use depending on the degree of urbanization, in the presence of several biotopes typical of coastal areas. In Tunisia, agricultural intensification can also lead to freshwater pollution due to excessive use of water for irrigation. This might affect water availability and scarcity; water pollution may be impacted by over fertilizing which could pollute underground water. In coastal agricultural areas, over-exploitation of water can lead to the intrusion of salt water into freshwater bodies, often resulting in irreversible degradation of the quality of the water, which becomes brackish or saline. Measures necessary to ensure the rational use of water should be taken. Losses through evaporation and runoff should be minimized. Water quality in freshwater aquifers should also be routinely supervised.

***Industry:*** An apparent pressure on the coastal areas of the promontory is development, which is manifesting itself in private residential and large leisure and relaxation complexes. This type of industry is well established in different areas of Tunisia. Indeed, as an example, the development of high-density tourism such as dense interior development near the demarcation line occurs in various localities along the north, central and southern coast of Tunisia. In Yasmine Hammamet, for example, an entire "city" has been erected along the waterfront. The centre of Sousse city has been able to associate to tourism industry various industry textile products. As well as the city of Monastir, the tourism is very affected by the industrial discharges of Hamdoun stream.

The south of Tunisia, from the Sfax city to Gabès the chemical industry mostly affects coastal area in the region.

***Fishery and aquaculture:*** The fishing and aquaculture sector plays an important role in both the socio-economic and food sectors. Fishery production, which has been growing steadily to reach 102 t in 1988, declined during the 1990s, then recovered slowly to reach a production of 130 t in 2014. Consumption per capita and per year has followed the same trend (after 13.5 kg in 1988 it dropped to 8.5 in 1990 and then rose in recent years to 11.5 kg) and this with a very unbalanced regional distribution since consumption in the inland regions does not exceed 1.5 kg per capita per year. Fishing contributes almost 8% of the agricultural products and 13 percent of the value of its exports. Aquaculture in Tunisia evolves with an annual growth rate of 20 % until 2014 where it has been stable due to the increase in exchange rates (euro/dinars). The current production is about 11.700 t (2014) which represents almost 10% of the total Tunisian fisheries production. The value of exports from the aquaculture sector is about 20 million Tunisian dinars (TND) in 2014 (equivalent to almost USD 11 million). The aquaculture sector currently provides more than 1.744 direct and permanent jobs.

***Maritime transport:*** There is 97% of traded goods pass through the seas, *i.e.*, 10.25 billion tons in 2014, transiting through the ports before being routed to the hinterland. This is the least polluting mode of transportation (3 times less than road and 15 times less than rail) and the most economical. The yachting offer in the Mediterranean: more than 1,532 marinas, 46,000 km of coastline and 400,000 moorings with a fleet of 2 million boats including 422,000 are over 6 meters long. In fact, 80% of the nautical activity in the Mediterranean is shared between France, Italy, the United States and Spain. While the share of Tunisia and Morocco does not exceed 2%. Tunisia currently has 08 marinas in operation with a Mooring capacity of 3,200 mooring rings with an occupancy rate of 80%. Fishing in Tunisia has a social and economic dimension: 8% of the value of the Tunisian fishing industry of agricultural production and 17% of the value of agri-food exports:

*41 ports. *11,500 fishing boats.

*52,000 direct jobs *Average production per year of 102,000T.

## VII.2. Threats indicators to and from tourism

The Threats indicators to and from tourism are summarized in Table 11:

**Table 11.** Proposed environmental indicators

| TEIS/ Environmental Impact | POPULATED CO-EVOLVE threat Indicator | CO-EVOLVE4BG threat Indicator |
|---|---|---|
| Reducing Transport Impact | | |
| Climate Change | | |
| Solid Waste Management | Unitary waste production compared to overnight stays | SW generated by tourists (Qwt) |
| Sewage Treatment | | Sewage Treatment |
| Water Management | | Water pollution |
| Energy Use | | |
| Landscape and Biodiversity Protection | Natural land cover surface over artificial land cover surface | |
| Light and Noise Management | Artificial sky brightness<br>N. people exposed to road. noise over 55 dB | |
| Bathing Water Quality | Bathing water quality | |

# VIII. Conclusions

This bibliographical feedback highlights the main characteristics of the Tunisian coastline related to tourism, as one of the most frequent anthropogenic activities in coastal environment. In the Tunisian context, the main threats affecting the stability of coastal areas in relation to ecosystem services and tourism were identified.

Ecosystem services are needing an imported interest to distinction between them and their associated benefits as key tasks identified by the user community in Mediterranean Sea.

Exploration of environmental resources around the world for tourism is the main subject of ecosystem services and their benefits in coastal environment. In Tunisian scale, a direct impact was described from beach maritime tourism such as cultural diversity. The ecosystems provide a rich source of inspiration for art, folklore, national symbols, architecture, and advertising. The natural areas may be defined as service in relation the original environment by ensuring the well-being of the local population and the relationships of ecosystem components. Considering the important climate value in tourism, ecosystems provide a rich source of climate services explored for coastal tourism sunbathing, pleasure boating, snorkelling, reef walking and scuba diving.

Ecosystem threats and impacts from tourism typologies of coastal tourism were identified as beach/maritime tourism, urban/cultural tourism, cruising, recreational boating (Yachting/Marinas), nature/ecotourism and medical/tourism. The review of the main impacts from each coastal tourism typology was performed, whose achievements are illustrated in environmental direct impact. Impacts mainly affect water quality, solid waste management, eutrophication, noise, light and Threats Affecting Wetland Biological Diversity.

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## PARTNERS

## ASSOCIATES PARTNERS

Bs partage 95 05 05 15
Design and Editing