Coastal Ecosystem Protection

Tunisian scale

ENI CBCMED
Cooperating across borders in the Mediterranean

Project funded by the EUROPEAN UNION

REGIONE AUTÒNOMA DE SARDIGNA
REGIONE AUTONOMA DELLA SARDEGNA

Co-Evolve4BG

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

Coastal Ecosystems protection

Tunisian scale

INSTM

ANPE

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

CPMR
CRPM

OVERVIEW

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

This document constitutes the **Deliverable 3.1.4.11** (Coastal Ecosystems protection – Tunisian scale) of the **Activity 3.1.4**(Threats and Enabling Factors at Nationalscale: Overview) under the **Output 3.1** (Integrated analysis of Threats and Enabling Factors for sustainable tourism at MED scale) of the project.

REVIEW

Contributors

Othman JARBOUI, PhD
National Institute of Marine Sciences and Technologies, Tunisia
Hechmi MISSAOUI, PhD
National Institute of Marine Sciences and Technologies, Tunisia
Hanem DJABOU, Engineer
National Institute of Marine Sciences and Technologies, Tunisia

Reviewers

Hafedh ABDELMALEK, PhD
University of Bizerte, Faculty of Sciences, Tunisia
Leila Basti, PhD
Tokyo University of Marine Science and Technology, Japan

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

Index

Index iv
List of figures v
Abstract vii
I. Introduction 1
II. Strategies and measures facing threats to ecosystems 3
II.1. Introduction and scope 3
II.2. The main initiatives and policy guidelines at the Tunisian level 3
II.2.1. Institutional framework 3
II.2.2. Regulatory framework 7
II.3. Tunisia facing Climate Change 7
II.4. The Concept of Integrated Coastal Management Zones (ICMZ) 9
II.5. Tunisian policy for monitoring and control of the climate change and coastal zone 10
II.6. Relationships and gaps between policy measures and linkages to coastal tourism 11
II.7. Implementation of policy measures 12
III. Cumulative Impacts: Ecosystem Protection and Tourism Sustainability 14
III.1. Introduction and scope 14
III.2. The main human activities causing pressures on ecosystems 14
III.3. Impact of the accumulation of these pressures 16
III.4. Tools for cumulative impact assessment in marine spatial planning 17
III.5. Ecosystem protection as a factor in sustainable tourism 18
IV. Analysis of trade-offs in ecosystem protection, aquaculture, fishing, and tourism sustainability 20
IV.1. Introduction and scope 20
IV.2. Agency for the protection and the management of the coastline (APAL) ..22
IV.3. Fishing in Tunisia and interaction with marine ecosystem 22
IV.4. Aquaculture and regulatory measures taken in Tunisia 24
IV.5. Sustainable tourism 25
V. Establishment of guidelines to involve tourists in citizen sciences activities ...28
V.1. Introduction and scope 28
V.2. History and definition of citizen science 28
V.3. Concept of citizen science 29
V.4. Interest of citizen science 30
V.5. Citizen Science and the Tunisian Context 31
V.6. Citizen science projects for monitoring the quality of coastal ecosystems 32
V.7. In Tunisia 32
V.8. Projects in other Mediterranean regions 35
V.9. How to Involve Tourists in Monitoring Ecosystem Quality? 36
VI. Conclusions 37
VII. References 38

List of figures

Figure 1. Human pressures on the sea (WWF, 2015) 15

Figure 2. Cumulative pressures on the marine ecosystem (UNEP, 2015) 16

Figure 3. Maritime Public Domain 21

Figure 4. Concept of citizen science 30

Figure 5. National Stranding Network of marine turtles and cetaceans in Tunisian coasts 35

Abstract

This report aims to identify the different threats to the morphological stability of the Tunisian coastal ecosystems. It is developed through the review of existing data at national and regional scale. The document is structured as follows. Section 1 provides an overview of the present and the future possible trends of Climate, Sea Temperature and Sea Level at Tunisian level in the light of Climate Change. Section 2 highlights the morphological characteristics of Tunisian coastal ecosystems. Section 3 focuses on reporting the trend of evolution of Tunisian costal ecosystem considering the foreseen relative Sea Level Rise scenarios and the present erosion trend.

I. Introduction

Developing tourism sustainably and protecting coastal ecosystems at the same time is a challenge to be taken up by any government, civil society, and competent authorities. In Tunisia, the tourism sector plays an important role in the country's economy and ensures a considerable inflow of currency. In addition, it contributes to the development of other economic sectors such as transport, communications, crafts, commerce, and construction. As a result, it participates in the development of certain regions, particularly coastal ones. Tunisia is home to many diverse coastal ecosystems, from the north to the south of the country. These ecosystems are often under pressure and become increasingly threatened and it is time to act to protect and conserve them. It is therefore essential to reconcile coastal ecosystems with their users for their protection but also to ensure the sustainable development of certain vital sectors for the country, particularly tourism.

To do this, this deliverable must, first, provide an analysis of the existing strategies and measures applied across Tunisia to face the threats fronting coastal ecosystems. It will identify both the pressures and the key tools to estimate the cumulative impacts of threats on ecosystems and to support decision making. Then it will tackle tradeoffs in ecosystem protection and tourism sustainability. Later, it will give guidelines for involving tourists in citizen science activities.

For this, 5 complementary activities were identified and carried out, namely:

- **Activity 1:** Analysis of existing strategies and measurements/actions facing relevant threats to ecosystems: For this component, the main political initiatives, and directives at the Tunisian level as well as the relationship and the gaps between the political measures and the links with coastal tourism. In a second step, the implementation of these policy measures was examined.
- **Activities 2 and 3:** Analysis of pressures and tools to estimate their cumulative impacts and support decision-making / Analysis of trade-offs in ecosystem protection and tourism sustainability: Regarding these two activities, the main human activities causing pressures on coastal ecosystems are identified and analyzed. In addition, the impact of the build-up of these pressures is studied. Next, the main cumulative impact assessment tools in marine spatial planning are identified. Finally, the protection of coastal ecosystems could be a factor for sustainable development for tourism in Tunisia is presented.
- **Activity 4:** Analysis of trade-offs in ecosystem protection, aquaculture, fishing, and tourism sustainability: For this activity, the conflicts of interest between the various stakeholders and users of coastal ecosystems are identified. Particular attention will be given to fishing and aquaculture activities and their interaction with the sustainability of tourism in Tunisia.

- **Activity 5:** Establish guidelines to involve tourists in citizen science activities: During this last activity, citizen science is defined, their main projects for monitoring the quality of coastal ecosystems are identified and to the involvement of tourists in monitoring the quality of ecosystems is evaluated.

Finally, it is important to point out that the information collected and analyzed comes essentially from scientific studies carried out on the various subjects treated. The reports and documents from organizations and institutions of interest were also taken into consideration. Finally, some information and data have been collected from recognized websites.

II. Strategies and measures facing threats to ecosystems

II.1. Introduction and scope

Located in Northeast Africa, Tunisia occupies a strategic geopolitical position at the crossroads between the Middle East, Europe, and Africa. The country covers an area of about 162000 km². The Tunisian coastal line which extends over 2.29 km (APAL and UNDP, 2012) represents about 5% of the entire Mediterranean coastline. The landscape is quite varied, ranging from mountainous formations in the north and west of the country, to steppes in the center, wide plains in the northeast and desert in the South of the country. Tunisia's climate is Mediterranean and is characterized, overall, by great variability and semi-aridity. At the marine level, the country is home to many varied and rich ecosystems. These vary from one region to another. In the north, particularly rocky bottoms were finding with abundant coral reefs. In the Eastern region, specific ecosystems of rocky bottoms alternate with those of sandy and sandy-muddy bottoms. In the south, the Gulf of Gabès is formed by a vast continental shelf.

To preserve this wealth and these rather varied ecosystems, Tunisia has made a significant effort, through its competent authorities and its supervisory ministries. This effort has been particularly expressed through the establishment of a comprehensive legislative and regulatory framework. In addition, its policy of monitoring and control of the climate and the coastal zone, to achieve sustainable tourism, has made significant progress in recent years.

Thus, in what follows, the main measures and policy guidelines undertaken by Tunisia to address the various threats to ecosystems are outlined. In addition, the relationship between these measures and the links with coastal tourism are emphasized. Finally, the levels of implementation of these measures are analyzed.

II.2. The main initiatives and policy guidelines at the Tunisian level

II.2.1. Institutional framework

Currently in Tunisia, a multitude of institutions and organizations intervene in the coastal ecosystems either through a transversal and integrated planning and management of the space or through a sectoral exploitation strongly influencing the use of space and its natural resources. Three main Ministries are particularly concerned by the coastline and coastal ecosystems, namely the Ministry of the Environment and Sustainable Development, the Ministry of Equipment, Housing and Spatial Planning and the Ministry of Agriculture, Hydraulic Resources and Fisheries.

Ministry of Environment and Sustainable Development:

Its missions are:

- Protecting the environment.
- Safeguarding nature.
- Promoting the quality of life.
- Establishing the foundations of sustainable development in the general and sectoral policies of the State.
- Improving the living environment.
- Implementing the rules of good ecological governance in all sectors of activity and combating pollution.

The Ministry has two technical departments: The General Directorate for the Environment and Quality of Life and the General Directorate for Sustainable Development. With respect to the coastal areas, the agencies, and organizations through which the Ministry works to formulate and implement the country's environmental policy are as follows:

- **National Agency for Coastal Management (APAL):** This is a non-administrative public institution created by law n° 72-95 of July 24, 1995. It is called upon to implement the state policy in the field of protection and development of the Tunisian coastline, to protect the public maritime domain against encroachments and illegal occupations, and to give its approval to any development and equipment project on the coast before its execution and within the framework of consultation with stakeholders.
- **National Agency for Environment Protection (ANPE**): It is a public establishment of industrial and commercial nature, created under the law n° 88-91 of August 2, 1988. Its supervision as well as its initial mission was substantially revised by the law 92-115 of November 30, 1992, and, because of the creation of a Ministry in charge of the environment and sustainable development. It is also responsible, for participating in the elaboration of the government's general policy in terms of pollution control and environmental protection, and its implementation through specific and sectoral actions as well as global actions within the framework of the national development plan. In addition, the ANPE should propose to the competent authorities any measure of a general or specific nature designed to ensure the implementation of the government's policy on pollution control and environmental protection. Measures to ensure the preservation of the environment and strengthening of the mechanisms leading to it. In general, to propose measures to prevent risks and natural or industrial disasters. ANPE Ensure polluting discharges control and monitor, as well as treatment plants of those discharges. It collaborates with other stakeholders on research concerning Environment Protection and supervises also national monitoring networks on Air, Water, and polluted sites quality (RNSQA, COPEAU and SITPOL). Finally, it is also responsible for combating all sources of pollution and nuisance and all forms of environmental degradation.

- **Tunisian Observatory of Environment and Sustainable Development (OTEDD):** It is under the supervisionof ANPE.Its main mission is to assist decision-making by assessing the state of the environment and sustainable development indicators in Tunisia. The OTEDD is in charge, among other things, of collecting data and information from the various ministries, producing statistics and indicators on the environment, developing, and implementing of information systems relating to the environment and sustainable development.
- **National Waste Management Agency (ANGED):** Created with the aim of contributing to the improvement of the citizen's living environment through the protection of the environment and the safeguarding of its resources by controlling and managing waste. It encourages waste recycling, waste energy recovery and waste material valuation.
- **National Sanitation Office (ONAS**): Its mission is to ensure the management of the sanitation sector and the protection of the environment against sources of water pollution. It oversees the construction and operation of the sanitation network. It ensures operation, maintenance, renewal of all facilities dealing with sanitation services in cities. It is also in charge of elaborating and realizing integrated projects dealing with wastewater treatment and rainwater disposal.

Ministry of Equipment, Housing and Spatial Planning

This Ministry intervenes in various fields including that of land use planning and maritime infrastructure directly related to the management of coastal areas. For this purpose, it has two General Directorates:

- The General Directorate of Land Use Planning. This department is also in charge, of carrying out studies and research to understand the natural and economic specificities of the different regions of the country as well as the elaboration and implementation of orientations in favor of a rational management of the territory and a sustainable development.
- General Directorate of Air and Maritime Services. It oversees:
- The realization of seaports, the new commercial, fishing, and yachting harbors.
- The monitoring of the operations of the delimitation and revision of the delimitation of the maritime public domain as well as its protection.
- The management of the maritime public domain and the protection of the coastline against marine erosion.

Ministry of Agriculture, Hydraulic Resources and Fishing

This Tunisian Ministry oversees formulating and implementing the country's agricultural, water resources and fisheries policies, as well as creating a favorable climate for the development of these sectors. It includes:

- The Bureau of Planning and Hydraulic Balances (BPEH): The BPEH is responsible for determining conventional and non-conventional water resources, setting the water needs of the various socio-economic sectors and proposing plans and programs for the allocation of water resources to the various users, considering supply and demand.
- General Directorate of Water Resources (DGRE): This General Directorate oversees setting up and managing networks for measuring and observing the country's water resources, assessing and establishing general water resource balances, developing the basis for water resource mobilization plans and their exploitation. The DGRE includes a Directorate of Groundwater in charge of programming and monitoring the exploitation of groundwater, including the coastal aquifers.
- National Company for the Exploitation and Distribution of Water (SONEDE): It is a non-administrative public law company mainly in charge of the production and supply of drinking water throughout Tunisia. It is also responsible for all water collection, transport, treatment, and distribution facilities.
- General Directorate of Forestry (DGF): The General Directorate of Forestry is the focal point for Tunisia for the RAMSAR Convention and oversees the management of wetlands and national parks in Tunisia.
- General Directorate for Fisheries and Aquaculture (DGPAq): It has many tasks; it is responsible for collecting and processing statistical data on production and fishing efforts. The DGPAq also issues fishing authorizations, controls, and monitors the fishing activity of all units, draws up and establishes fisheries development plans and ensures the application of the fishing regulations in force. In addition, the DGPAq draws up strategies and plans for the development of fisheries and aquaculture and specific programs aimed at the protection of fishery resources and to ensure their sustainable management.
- Regional Agricultural Development Commissions (CRDA): CRDAs are public administrative institutions with legal responsibility and financial autonomy present at the level of the 24 governorates including the coastal governorates. They are responsible for the implementation of national agricultural policy, water resources and fisheries at the local level.
- Agricultural Development Groups (GDAs): GDAs are non-profit associations grouping users of water and natural resources with the aim of ensuring the protection and development of these natural resources.

Other Sectorial Ministries

The other sectorial ministries involved in coastal ecosystems management are the Ministry of Tourism and the Ministry of Industry. In addition to public bodies, several other actors are involved in the coastal zone, including the private sector, academic and research institutions, and civil society.

II.2.2. Regulatory framework

Tunisia has an important regulatory and legislative arsenal that governs the management of coastal ecosystems and covers the various aspects of environmental protection, including those related to the phenomenon of climate change. However, the regulatory framework has some gaps that require its updating and the strengthening of tools for the implementation of regulations. In addition, it is worth highlighting an important advance in the field of the environment with the declaration of the right of Tunisian citizens to a healthy and balanced environment and participation in climate security. In fact, in Article 45 of the new Tunisian Constitution adopted on January 26, 2014, which states that "The State guarantees the right to a healthy and balanced environment and participation in climate security. The State must provide the necessary means to eliminate environmental pollution". In addition, the main regulatory texts relating to the environment in general and the management of coastal ecosystems are the following:

- Decree No. 85-56 of January 2, 1985: relating to the regulation of discharges into the receiving environment.
- Law No. 88-91 of August 2, 1988, amended by Law No. 92-115 of November 30, 1992, and Law No. 2001-14 of January 30, 2001: on the creation of the National Environmental Protection Agency.
- Law No. 94-122 of November 28, 1994, amended by Law No. 2003-78 of December 29, 2003: on the code of land use and urban planning.
- Law No. 95-73 of July 24, 1995: relating to the maritime public domain (DPM).
- Law n° 95-72 of July 24, 1995: relating to the creation of an agency for the protection and development of the coast (APAL).
- Law No. 96-29 of April 3, 1996: on the national emergency response plan to combat marine pollution incidents.
- Decree n° 2005-1991 published on July 11, 2005: relating to the environmental impact study fixing the categories subject to the impact study and the specifications.
- Law No. 2009-49 of July 20, 2009: on marine and coastal protected areas.
- The Water Code: relating to the use of water in the public domain.

II.3. Tunisia facing Climate Change

Nowadays, it cannot talk about the protection of marine ecosystems without talking about climate change. In Tunisia, sea level rise is beginning to be clearly visible on the coasts. Some archaeological remains show an elevation ranging from 20 to 40 cm since historical times. Similarly, records of tide gauges indicate a rise in sea level at some sites affecting the shoreline and the morphology of the coast. The study of the vulnerability Tunisian coastline map to climate change mentioned that most of this sea

level rise was recorded between 1992 and 2002 linking this increase to a change in kinetic energy on the Mediterranean scale. This sea level rise would have more accentuated repercussions once coupled with the effects of climate variability. For example, storms will cause changes in the coastline that may further aggravate erosion in addition to sand displacement. A first sea level rise assessment for Tunisia was carried out in 2008 as part of the study of the environmental and socio-economic vulnerability of the Tunisian coastline to accelerated sea level rise due to climate change. The scenario that was retained among three scenarios advanced in the study is that of a sea level rise of 55 cm by 2100 for a global warming of 0.25 °C per decade. In addition, the study of the vulnerability map of the Tunisian coastline in 2012 has estimated at about 3000 ha the Tunisian urban coasts threatened by submersion caused by a sea level rise. A large part of these coasts hosts large residential urban residential agglomerations threatening many inhabitants. Coastal infrastructures are also threatened by an Accelerated Sea Level Rise (ASLR). Sandy beaches are among the most sensitive to a rise in sea level.

A total of 1% of the Tunisian coastline is protected by structures, including embankments with rock-fill protection embankments (55%), isolated breakwaters at sea (25%) and groins to protect against marine erosion in ports. The protective structures of Tunisia's 41 ports and fishing shelters would be particularly vulnerable to an ASLR, which would generate additional management and maintenance costs. The study on the costs of environmental degradation in Tunisia carried out by the World Bank in 2004 estimates the annual costs of an ASLR at about 0.13% of the annual GDP. This cost would amount to 0.63% of GDP if direct economic losses were considered.

Thus, regarding climate change, Tunisia was among the first in the region to have affirmed its willingness to contribute actively to international efforts to combat climate change. To this end, Tunisia ratified the United Nations Framework Convention on Climate Change (UNFCCC) in 1993 and the Kyoto Protocol in 2002. Since then, many actions have been undertaken by the Tunisian authorities, with the support of international cooperation (*e.g.,* UNDP, WB), to give climate change an important place in the country's development policy. Initially, these actions focused mainly on capacity building for public and, to a lesser extent, private actors, given the novelty of this issue in the country and in the world in general.

In addition, the fishing sector would be among the sectors most affected by the phenomenon of climate change, the traditional inshore fishery (which is carried out at a depth of 1 to 50 m). The fishing activities carried out in this coastal range will be affected in the first place by the increase in average water temperatures that would induce changes in the type of coastal species and an intensification of marine invasion by non-endemic species. Lagoon fishing will also be affected by the increase in temperature and sea level rise.

It is important to note that the tourism sector is among the strategic development sectors that will also be affected by this phenomenon. The tourism infrastructure is at risk of being damaged and will then need to be raised or reinforced. A downgrading of

some hotels may be conducted, leading to the loss of jobs. Climate change would also have negative impacts on the industrial sector, particularly the fish products industry and the phosphate industry located in the coastal areas of the south of the country.

Finally, Tunisia has done a lot of work in safeguarding the national heritage, both land and sea. For example, the RAMSAR convention entered into force in Tunisia in March 1981; currently 42 sites, more than ten of which are considered marine areas, are included in the list of wetlands of international importance (RAMSAR site) with a total area of approximately 845 hectares.

II.4. The Concept of Integrated Coastal Management Zones (ICMZ)

Integrated Coastal Zone Management is a tool for the governance of the coastal area that ensures the participation of a wide range of partners. While taking into consideration the interactions between the natural resources of the maritime and coastal areas, the socio-economic constraints, and the possible conflicts of interest of the different sectors concerned. Moreover, this management must reconcile economic development, social balance and environmental protection which represent the three pillars of sustainable development of a territory. This approach, responding to the specificities of coastal areas, guarantees their sustainable development. The ICZM Protocol adopted within the framework of the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean (7th Protocol of the Barcelona Convention) was signed on the Conference of Plenipotentiaries on the ICZM Protocol held in Madrid on 20 and 21 of January 2008 by the contracting countries including Tunisia and entered into force on 24 March 2011. This Protocol is the first supra-state legal instrument aimed at encouraging Mediterranean countries to move towards an integrated approach to coastal management to better manage their coastal zones and to face current and new coastal environmental challenges.

An action plan for the implementation of this ICMZ Protocol between 2012 and 2019 was also adopted in February 2012 detailing the tasks and actions needed to support countries in the implementation of this protocol. It is through capacity building of the parties concerned and by establishing synergies with the conventions and agreements previously established to promote this protocol (PAP and PFN, 2011).

Although, Tunisia signed the Protocol on Integrated Coastal Zone Management in 2008, the ratification of this protocol has not yet taken place. This law project was expected to be presented to the national assembly for a vote in 2011 but the revolution and the succession of governments have since created other “priorities” which have hindered the ratification of the ICZM Protocol.

APAL has been designated as the national focal point for the Protocol and is responsible for ensuring its implementation.

II.5. Tunisian policy for monitoring and control of the climate change and coastal zone

Weather forecasting in Tunisia is provided by the National Institute of Meteorology (INM). The institute has an observation network that covers the entire Tunisian territory in almost all climatic, seismological and pollution factors. The operation of the forecast is ensured by the INM in a continuous manner, 24 hours a day and 7 days a week. The forecasts are provided in the form of bulletins, guidelines or files and they are communicated via different communication media to different users. These forecasts are established for a period ranging from a few hours to seven days, distinguishing, however, between very short and short-term forecasts, valid for the next 24 and 48 hours, and medium-term forecasts valid for the next 3 to 6 days. Climatology concerns the study of climate and its action on human health and various socio-economic sectors. For this purpose, INM has climatological observations dating back to the beginning of the 20th century. These data are collected and then validated. They are then processed and stored. Thus, data dating back to 1950 are put on magnetic media. They are organized in a climatological database, managed by an information system that includes software and analysis tools. These provisions facilitate the use of climatological data by users inside and outside the INM. Similarly, the use of the database allows for the various user requests for information to be responded to in an optimal timeframe. In recent years, the INM has also invested in the dynamic modelling of climate change and the downscaling of global models.

In general, the specific role of the INM as well as its data in the monitoring of coastal ecosystems in Tunisia is crucial. Indeed, the availability of data on the temperature (in air and on the sea surface), on the winds and their directions, on the rains, their intensity, and frequencies, on the sea salinity allows scientists to predict possible evolutions and changes in the climate at the level of marine ecosystems. Data analysis also makes it possible to understand and predict certain phenomena such as the invasion of species, the proliferation of planktonic blooms, the scarcity or disappearance of certain marine species, *etc.*

On the other hand, APAL has set up a dynamic information tool, the Information and Decision Support System (SIAD), with the aim of facilitating decision-making in monitoring and protection of the Tunisian coastline. The SIAD facilitates the measurement, storage, collection, management, processing, analysis, and interpretation of meteorological, oceanographic, and physio-chemical data. Indeed, the data are measured and transmitted to the APAL Coastal Observatory in real time thanks to a device composed of three fixed buoys, four mobile buoys and four tide gauges equipped with sensors and located at sea. The APAL Coastal Observatory is the unit in charge of setting the remote acquisition parameters and maintaining the measuring instruments. The observatory is also responsible for the data generation and validation process from the raw data. The Observatory also produces the metadata sheets corresponding to each series of measurements. The data is stored in a Database Management System (DBMS) installed on the Observatory server. The Observatory is also responsible for the

supply and exploitation of the geo-catalogue which is a search tool for the data available on a server dedicated to the storage of the data that will later be disseminated (APAL, 2014).

II.6. Relationships and gaps between policy measures and linkages to coastal tourism

It is crucial to identify specific, measurable, and achievable objectives, based on existing policies, as well as indicators to monitor progress towards achieving the objectives. Sustainable tourism plans that promote green tourism (tourism activity operating in an environmentally friendly manner) are likely to lead to an increase in tourism activities in protected areas. In this sense, it is particularly important to coordinate tourism and public use policies in natural sites for the objectives of conservation and the restoration of coastal ecosystems.

Conflicts between coastal protection instruments and the sustainable tourism plan:

Coastal areas are an important tourist attraction for a sustainable tourism and Tunisia's strategy for 2030 to strengthen tourism, to promote the rehabilitation of developed coastal areas, contributing to the intensification of tourism in key areas, thus increasing pressure on environmental and natural resources. Furthermore, the Coastal Protection aims to regulate and restrict development in the area to conserve and protect the natural capital and prevent any fragmentation of the coastal zone from the interior.

Conflicts between protected area instruments and the sustainable tourism plan:

Sustainable tourism plans encourage green tourism, sub-segments of particular interest such as bird watching, cetacean watching and actions such as the promotion of products based on natural heritage that can intensify tourism activities in Marine Protected Areas. In this sense, it is necessary to reconcile tourist uses with the respective existing regulations concerning the most sensitive and fragile elements of the territory (Protected Natural Areas). Such as the need for permits and authorizations to carry out any tourist activity in the network, and therefore to regulate the activities and practices of green tourism in national parks that are sources of conflict.

In addition, the various sectorial actions and strategies need to be made consistent to establish complimentarily between them. Hence the need to put in place a National Climate Change Strategy (NCCS) aimed at a sustainable and coherent integration of mitigation and adaptation components in the country's development policy.

Although the institutional framework is well developed, climate change issues are mainly under the responsibility of the Ministry of Environment and Sustainable Development. This Ministry is, in fact, involved in international negotiations and leads several national initiatives and projects to promote the integration of climate change mitigation and adaptation actions in sectorial policies and in the planning and management of natural resources. The INM is involved in the provision of climate data and the realization of downscaling models for the assessment of climate scenarios at

the national level. Currently, the INM is finalizing the downscaling modelling work of climate projections for Tunisia. The National Committee for Climate Change was established in 1996 within the framework of a UNDP regional capacity development program. It was an informal entity responsible for coordinating work related to climate change mitigation and participation in international negotiations. It was to support the work of the National Commission for Sustainable Development (CNDD).

Moreover, the integration of climate change into sectorial development policies remains limited. There is no national cross-sectorial structure dedicated to the formulation of national policies on climate change mitigation and adaptation and to the harmonization of efforts made at the level of the different sectors. As a result, there is a significant need for networking and strengthening coordination between the different sectorial actors to consolidate their respective actions in climate change mitigation and adaptation. Also, there is a need for capacity building of these institutions to increase awareness of the challenges imposed by climate change and to promote the systematic integration of climate considerations into sectorial policies, including in the coastal zone.

II.7. Implementation of policy measures

The political measures undertaken by the Tunisian State to face the threats to the Tunisian marine ecosystems are essentially translated into actions and decision making. The latter are, in most cases, coordinated and executed by the services of the competent authorities, via the organizations and institutions concerned.

For the climate change field, for example, many actions have been undertaken by the Tunisian authorities, with the support of international cooperation (*e.g.,* GIZ, UNDP and WB), to give threats to ecosystems an important place in the country's development policy. The actions have focused, initially, on capacity building of public sector and to lesser extent private actors, given the novelty of this theme in the country and in the world in general. In addition, Tunisia provided, in May 2010, a list of nationally appropriate mitigation actions (verbal note sent by the Embassy of the Republic of Tunisia in Berlin to the Secretariat of the United Nations Convention on Climate Change). This note was followed in October 2010 by a document identifying the main areas of intervention (transport, industrial construction, waste and miscellaneous) and presenting in much greater detail the Tunisian plan to be followed and the waste treatment plan.

In addition, Tunisia has become aware and has developed tools to promote the implementation of integrated coastal zone management (ICZM), both institutionally and legally, and in terms of knowledge development in relation to the challenges encountered. However, limitations are nowadays hindering an effective application of this integrated management in the field. A fundamental reason for the limitation in the application of the ICZM approach is the fact that ICZM plans, although prepared according to a participatory approach, do not have the force of an obligation to be applied by other sectors.

The other aspect on which efforts should be doubled concerns the awareness of the sectorial actors and the large population on the major challenges and risks incurred by the coast in case of a continue development with the same trend in the future. Also, the popularization and sharing of good practices in terms of actions for adapting the coast to climate change is essential for rapid progress towards integrated and sustainable coastal zone management.

III. Cumulative Impacts: Ecosystem Protection and Tourism Sustainability

III.1. Introduction and scope

According to UNEP (2007), population growth and densification of the coastal population added to overconsumption patterns increase the demand for ecosystem services and energy, which affects biodiversity. They affect every component of biodiversity: genetic variability, species variability, ecosystem variability and the links between each of these components. Today, there is no marine region unaffected by humans; moreover, 41% of the oceans are strongly affected by multiple causes (Halpern *et al.* 2008). In addition to what could be described as traditional sources, climate change issues are also being grafted onto these sources. In addition, different forms of pollution (chemical, thermal, sewage and hazardous waste) are caused by the intensification of maritime traffic, coastal dredging, agriculture, forestry, oil, and mining extraction. Biodiversity is also threatened by invasive species. The main unintentionally inoculated sources are ballast water that is transported across the seas in ships' tanks and is recharged without following costly and all-too-frequently avoided discharge procedures. However, the primary cause of the spread of invasive species is related to aquaculture (Cury and Morand, 2004).

In what follows, the main human pressures on coastal ecosystems will be first identified and their possible cumulative impacts as well as the tools to estimate them will be analyzed. Secondly, the different trade-offs in the protection of coastal ecosystems and the links with the sustainability of the tourism sector in Tunisia will be detailed.

III.2. The main human activities causing pressures on ecosystems

Fig. 1 (WWF-France, 2015) summarizes well the human pressures on the marine ecosystem in the Mediterranean and Tunisia, in particular: tourism, coastal development, maritime transport, land-based sources of pollution, professional and recreational fishing, aquaculture, underwater mining, oil and gas industries and offshore wind energy. As a result, ecosystems and certain categories of marine species are particularly vulnerable to threats posed by human activity. Species remaining on the surface (including the larvae of many commercial fish) are vulnerable to oil and other floating pollutants and increased ultraviolet radiation. Species requiring more than one habitat for development are threatened even if only one of these habitats is disturbed.

There is a synergy between all these pressures, which can lead to certain phenomena becoming more pronounced. For example, overfishing associated with the fact that there are no unexploited areas left cause fish populations to collapse even faster. The loss of essential habitats, such as spawning areas or nurseries, also prevents some species from completing their life cycle (Cury and Morand, 2004). Contrary to popular

belief, marine species are no less vulnerable to disturbance and overexploitation than terrestrial species: the drastic decrease in marine and ocean dwellers is less visible and perceptible, but real and worrying.

Furthermore, it is important to note that the most well-known effect of climate change is that of sea level rise, which causes flooding and the destruction of habitats. It causes important ecological damage, such as mangroves, coral reefs, and deltas, rich in biodiversity, not to mention its effects on human populations in flooded areas. In addition, there is an issue related to water acidification. The CO_2 dissolved in the ocean forms carbonic acid, which acidifies the seawater whose pH has been constant for 300 million years. Acidification will cause problems for calcified plant organisms and marine invertebrates: some will no longer be able to build their skeletons and others, such as squid, may have difficulty transporting oxygen in their bloodstream, which has become more acidic. It is estimated that coral reefs could be destroyed within 30 to 50 years (Cury and Miserey, 2008). Otherwise, William and Victoria (2008) evaluate several approaches to discern the impact of ocean acidification on calcifying plankton, over basin scales. Finally, climate change also decreases the great movement of ocean waters, the global thermo-hyaline circulation, because it depends on water temperature and salinity (Cury and Morand, 2004).

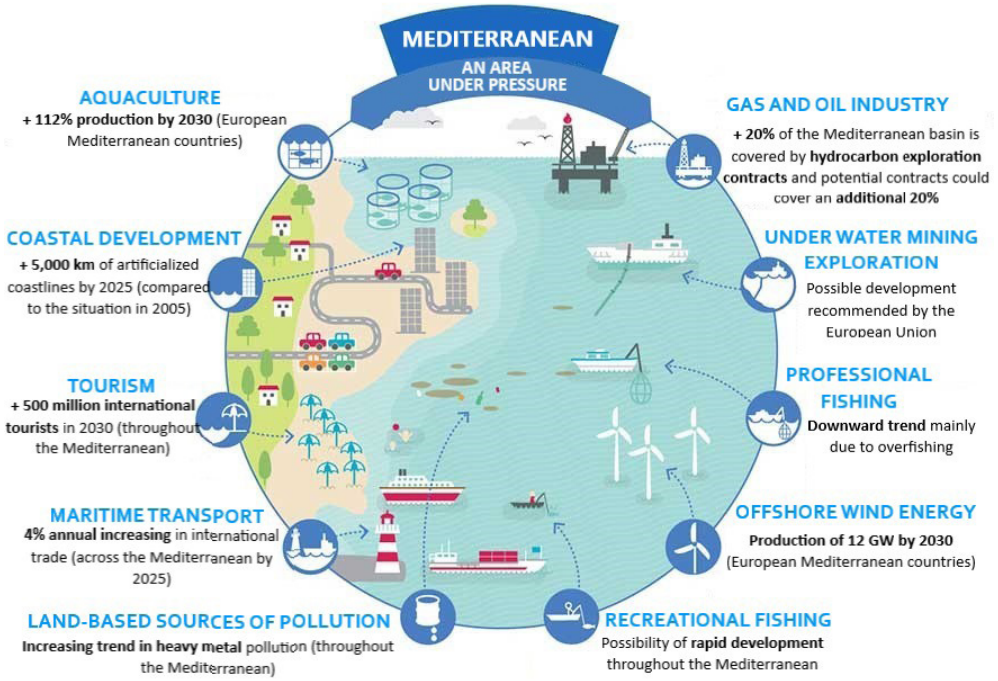

Figure 1. Human pressures on the sea (WWF, 2015)

III.3. Impact of the accumulation of these pressures

Human activities within an ecosystem often overlap and their impacts can be intensified as a result. Impacts can also increase over time. By looking at such cumulative effects (Fig. 2), it is possible to assess the total effect of various human actions on an ecosystem, as well as the capacity of the ecosystem to maintain the expected services (UNEP, 2015). The analysis of impacts regarding their causes enables a tailor-made management response to be provided. The set of management responses adopted within the framework of ecosystem-based management must be considered as a whole and may involve compromises when management choices overlap. Indeed, multiple-use management does not always lead to opportunities that are described as “win-win”: something can be lost when something else is gained, and this involves assessing the trade-offs between different uses. Planners can use spatial analyses to predict overlapping threats and to develop a better understanding of the effects and interactions of multiple stressors. For example, to consider cumulative effects, specialists may need to begin by building regulatory mechanisms that encourage or require goal setting and assessment in different sectors.

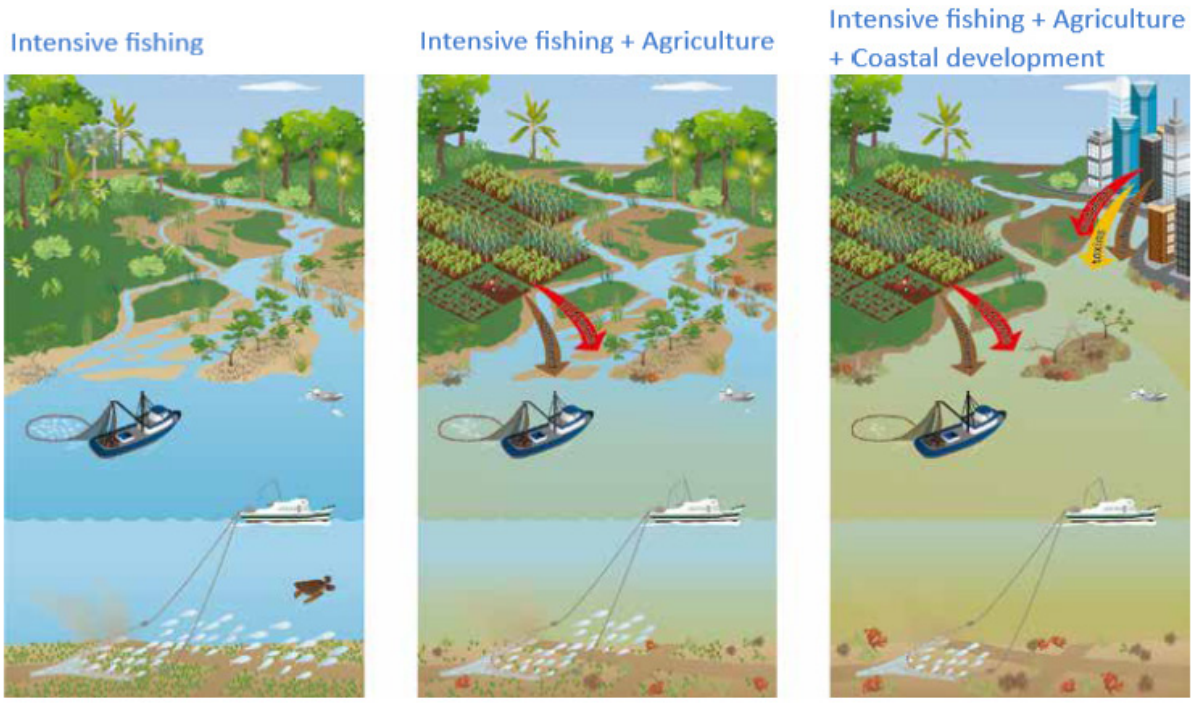

Figure 2. Cumulative pressures on the marine ecosystem (UNEP, 2015)

On the one hand, fishing is said to be intensive when fish and other marine species are caught at a faster rate than their reproductive rate, reducing fish stocks below an acceptable level. In severe cases, intensive fishing can alter the balance of ecosystems, lead to changes in food resources and make ecosystems more vulnerable to further disturbance. On the other hand, because of poor agricultural practices, sediments and

nutrients are carried away by runoff to rivers and the marine environment,leading to reduced water quality, microscopic algae blooms, macroscopic algae growth, and the decline of seagrass beds. Thus, the combination of intensive fishing and poorly managed agriculture can have a devastating impact on the nurseries of already weakened fish populations. Finally, coastal development and the artificialization of the coastline increase the runoff of pollutants such as sewage and chemical fertilizers into the ecosystem. The superimposition of new impacts can have unexpected and combined effects on ecosystem health. Comprehensive land-use planning, low-impact development and smart growth practices can help manage cumulative impacts by reducing impervious surfaces, preserving open space, and promoting the sustainability of coastal communities.

III.4. Tools for cumulative impact assessment in marine spatial planning

Assessing the cumulative impact of different human activities is a first step that requires access to sector-specific statistics. It requires an evaluation of the necessary duration of time and the coefficient of each pressure and their degree of effect. If the data can also be mapped, managers will have a first impression of where in the ecosystem the human footprint is the largest. Furthermore, the different human pressures shown in Fig. 2 could be assessed according to their impact on the 8 ecosystem components, namely: seabirds, cetaceans, seals, fish, biologically derived rock and reef habitats, coastal sedimentary habitats, continental shelf sedimentary habitats and deep-sea habitats (UNEP, 2015). This assessment tracks changes in status in response to these pressures and provides guidance on pressures for new or amended regulations.

In general, the state needs to work with a team of researchers or specialists to understand how to plan for and avoid these negative cumulative impacts. To do this, working methods begin with an understanding of the habitat vulnerability to each of its human uses. This means assessing which uses are compatible or incompatible with certain habitats, based on expert judgments and the best available scientific data. Indeed, the cumulative impact maps and scores provided by the experts allow planners to understand what future coastal activities can be considered and where they may be located. The research team and experts can develop a GIS (Geographic Information System) tool to model how different uses may affect habitats, giving state planners a way to predict impacts before permits are issued.

The evaluation criteria are multiple and may vary depending on the case. Smit and Spaling (1995) propose 6 criteria for assessing cumulative impacts, as follows:

- **Temporal accumulation:** occurs when the interval between one disturbance and the next is too short for the system or one of its components to assimilate or recover from the disturbance. The respect of this criterion thus supposes that the evaluation method can consider both the duration and the frequency of the disturbance. It should also be able to incorporate a long-time horizon to detect long-term induced changes, or delay effects.

- **Spatial accumulation:** effects occur when the spatial distance between disturbances is smaller than the distance required to remove or disperse the disturbances. An assessment method must be able to account for the geographical scale at which disturbances occur, allow the spatial boundaries of the study to be defined coherently, and allow the way in which disturbances and their effects are spatially differentiated to be represented. It must also be able to consider both flows/movements across boundaries on the same scale (*e.g.,* intra-regional) as well as between different scales (local to regional and then global). The ability to consider spatial distribution, especially surface distribution, is particularly important because the assessment of cumulative effects is often conducted in a regional context. Some methods are oriented towards one type of spatial distribution rather than another (punctual, linear, and surface).
- **The type of disturbance:** This criterion refers to the ability of the method to consider disturbances of various types or not. It must be able to consider:
  - disturbances from multiple sources and from the same source repeated in time or space,
  - actions that stimulate or propagate changes that will themselves trigger other types of disturbances.
- **Accumulation processes:** Result from the relationships that link cause and effect. A method must be able to account for specific processes of evolution, differentiate between additional and interactive processes, and integrate a technique that aggregates the effect of each one.
- **Functional effects:** Refer to the alteration of processes (*e.g.,* energy flow, nutrient cycling, and succession) or changes in functional properties (*e.g.,* assimilation capacity, transport capacity and thresholds). A method must be able to identify, analyze and evaluate the functional change in an environmental system, process or one of its components. In general, this criterion should consider evolutionary changes over time, accumulation over time, lagging effects or effects related to thresholds.
- **Structural effects:** Include population changes, habitat modification and alterations to geophysical resources (air, water, and soil). As with functional effects, a method must be able to identify, analyze and evaluate structural changes in the environmental system, one of its components or processes. This type of change is perceived as essentially spatial; it implies being able to consider spatial accumulation, fragmentation effects or flows between boundaries.

III.5. Ecosystem protection as a factor in sustainable tourism

The protection of marine ecosystems, in Tunisia or elsewhere, could be considered as a primary factor in the sustainable development of tourism. Indeed, the tourist community is always looking for a diversification of actions and programs (*e.g.,*excursions and leisure). This diversity could only be provided by varied ecosystems in good ecological condition.

Marine Protected Areas (MPAs) can be useful tools for implementing ecosystem-based management, by regulating the different human uses in each area. They can correspond to small, highly specialized areas (such as wilderness reserves protecting a fish species from overfishing), to large, complex areas with multiple uses. Generally, MPAs are used to protect species or habitats, maintain livelihoods, facilitate restoration, or control access to areas important for recreational, cultural, or historical reasons. Protected areas can enable managers to sustainably manage and conserve the areas.

Moreover, Integrated Coastal Zone Management (ICZM) is an approach and a tool for the governance of coastal territories aiming at sustainable development. It promises an integrated management with an ecosystem approach to space and resources that simultaneously considers terrestrial and marine, natural, economic, and social issues of a coastal zone defined as a coherent territory for reflection and action. The ICZM concept was concretized at the Rio de Janeiro Convention in 1992. Chapter 17, one of the most consequential chapters of Agenda 21, makes the ICZM concept the approach that should be favored to move towards the sustainable development of coastal zones. The novelty ICZM lies precisely in the organization of a governance system that combines regulations, policies, incentives, support actions and consultation processes in a project that promotes the sustainable development of the coastal zone and its uses. Finally, it is important to note that Tunisia has regulated in its legislation the creation of these coastal zones. Thus, the national strategy, based on the analysis of the existing situation, sets objectives, determines priorities, and justifies them, identifies coastal ecosystems requiring management and all the actors and processes involved, lists the measures to be taken, their cost as well as the institutional instruments and legal and financial means available, and sets a timetable for implementation".

Finally, Marine Spatial Planning (MSP) could be considered as a means of sustainable tourism development. Indeed, MSP makes it possible to provide an overview and localization of the use of marine resources and marine space, and to determine what can be done in different places with less impact and fewer conflicts of use. Smaller-scale, spatially explicit management measures such as zoning of multiple-use areas, designation of MPA networks, or individual protected areas can also be derived from marine spatial planning. One of the advantages of such planning is that it allows planners and managers to integrate information on the characteristics of the ecosystem, the impacts of human activities on it (and vice versa), and its linkages with other ecosystems (or the impacts of other uses). This information can then be mapped to form the basis for (a) spatialized sectoral regulations for specific uses, (b) plans for future research, monitoring, and assessment to fill information gaps, and/or (c) a comprehensive marine zoning plan. Coastal zone planners and marine resource managers have used a variety of marine spatial planning tools that differ in information content, scientific rigor and level of technology used.

IV. Analysis of trade-offs in ecosystem protection, aquaculture, fishing, and tourism sustainability

IV.1. Introduction and scope

In Tunisia, the protection of the public maritime domain and marine ecosystems is currently experiencing a certain revival of interest. This is because of the disastrous consequences of industrial establishment, abusive exploitation, and a strong attraction of an ever growing public for the coast, the sea and related leisure activities. However, such protection is subject to difficulties which arise mainly from the consideration of often contradictory concerns, between the general interest and particular interests, between industrialists, fishermen and yachtsmen and between coastal protection and the development of activities related to the sea. It is a delicate issue on which the effectiveness of the coastline protection and the public maritime domain depends.

Moreover, the range of coastal ecosystems, including the public maritime domain, is a territorial space requiring special development to limit its anarchic use that would facilitate violations and infringements. The control of coastal development also includes the control of the specific risk linked to the phenomenon of coastal retreat under the influence of marine erosion. Land use planning therefore goes through two stages which are: master development plans and urban development plans. These plans aim at protecting the territorial space concerned by the development and ensuring the organization of the use of space by guiding the implementation of the State programs, local public authorities, public establishments, and services and by working towards their coherence within the framework of economic and social development prospects, considering the impact of development on the environment (Law n° 94-122, art. 5).

This component will focus on the different threats of the Tunisian marine ecosystems as well as the possible interactions between the different sources of these threats, particularly fishing, aquaculture, and tourism. Therefore, a general definition of the Maritime Public Domain (DPM) and an introduction to the Agency for Coastal Protection and Development (APAL) and its objectives are given. In a second stage, the trade-offs between the protection of ecosystems, fisheries and aquaculture and the sustainability of tourism in Tunisia are analyzed.

The DPM is made up of all public goods belonging to public persons, which are assigned for public use, and which are located near the sea or implanted in the interest of maritime navigation, whether natural or artificial (Ben Cheik, 1996). Moreover, it has been accepted that the coastline is a wider space than the maritime public domain, defined by Law n° 95-72 of 24 July 1995 creating APAL, in its article 1 as being “the contact zone that concretizes the ecological, natural and biological relationship between land and sea and their direct and indirect interaction”. As for the shoreline, it is conceived as the meeting point between the coast and the maritime public domain, it is the part alternately covered by the tides, the leis and the relays of the sea and the dunes. It constitutes at the same time a part of the natural maritime public domain and a part of

the coastline. The coast is a less broad notion than that of maritime public domain.It is a point of contact between land and sea, which borders the continent. It is a border between the coast and the maritime public domain. It is a longitudinal line that follows the configuration of the maritime-land zone. In addition, the natural maritime public domain includes, on the seaside, the internal waters, territorial waters, soil, and subsoil of the continental shelf, as these spaces are delimited by the texts and bilateral agreements concerning the limits of the Tunisian maritime territory, the exclusive fishing zone, and the exclusive economic zone (Law No. 95-73, art. 2).

Finally, it is important to note that the coastline thus comprises, the natural components of the maritime public domain and “inland areas within variable limits according to the degree of climatic, natural and human interaction between them and the sea, such as coastal forests, estuaries, marine capes and coastal wetlands” (Fig. 3; Law n°95-72, art. 1).

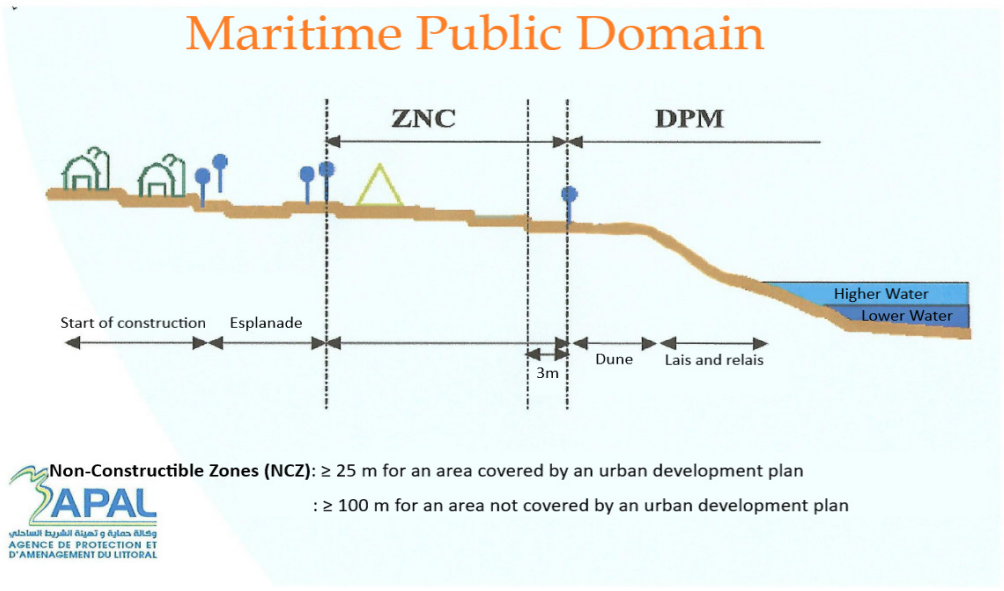

Figure 3. Maritime Public Domain

IV.2. Agency for the protection and the management of the coastline (APAL)

The Coastal Protection and Development Agency (APAL) is a non-administrative public establishment, created by law N°95-72 promulgated on 24/07/1995. APAL is called upon to implement the State's policy in the field of coastal protection and development, to protect the public maritime domain against encroachments and illegal occupations, and to give its approval to any development and equipment project on the coast before its execution and this, within the framework of consultation with the stakeholders. APAL is increasingly involved in the preservation of the resources necessary for the development of tourist activity. The management of the coastline and more precisely of the Maritime Public Domain is one of its major manifestations. Indeed, the State has defined a mode of management guaranteeing the preservation of sensitive natural environments and allowing the use of beaches that respects the environment and contributes to the improvement of the quality of life of citizens and the development of tourism. APAL oversees:

- The management of coastal areas in the public maritime domain and the monitoring of development operations as well as the monitoring of rules and standards set by the laws and regulations in force relating to the development of these areas, their use and occupation.
- The regularization and clearance of the land situations of buildings and constructions existing before the creation of the agency, in accordance with the legislation in force.
- The elaboration of expertise studies and research relating to the protection of the littoral and the development of natural areas and sensitive zones.
- The observation of the coastal ecosystems' evolution and the setting of an observatory system.
- The rehabilitation and management of natural coastal zones and sensitive areas (*e.g.,* wetlands, coastal forests, and islands).

IV.3. Fishing in Tunisia and interaction with marine ecosystem

In Tunisia, fishing is a very important and strategic sector for the national economy, and it is even considered as one of the pillars of agricultural development in the country. Indeed, this sector ensures food security by guaranteeing an income for many families and contributes to the national effort to export agricultural products. The Tunisian coasts are about 1290 km long (APAL and PNUD, 2012). The continental shelf is narrow in the north and widely extended in the south (the 60 m isobath is only reached around 110 km from the coast (Bradai*et al.* 1995). This shelf is dotted with seven islands and islets, namely, from north to south: Galite, Galiton, Zembra, Zembretta, Kuriates,

Kerkennah and Djerba. In addition, the Tunisian continent is also home to seven lakes and lagoons which are, from north to south: the lake of Bizerte, the lake Ichkeul, the lagoon of Ghar El Melh, the lake of Tunis, the lake of Kheneiss, the lagoon of Boughrara and the lagoon of El Bibène.

According to the latest statistics from the General Directorate of Fisheries and Aquaculture (DGPAq), the annual production of fishery products reached 133,972 tons in 2018 (Anonymous, 2018). In addition, the annual evolution of the fishing contributions during the last decade (Anonymous, 2008-2018) shows that since the year 2011, the national production of sea products has increased significantly and in a continuous manner. This trend of increase would be generated essentially by the contributions of aquaculture following the national strategy for the development of this activity. In addition, in 2018, Tunisian exports of fishery products reached 26,983 tons in quantity or 20.1% of total production for a value of 527.3 million dinars. During the same year, the Tunisian fishing fleet had 14,515 units of which 980 are non-active, or 6.8%. In terms of numbers, it appears that more than 92% of the Tunisian fishing fleet is made up of coastal boats, *i.e.*, 13,376 units including 6,139 motorized coastal boats (BCM) and 7237 non-motorized coastal boats (BCNM). The trawlers numbered 420 units, followed by sardine vessels with 412 boats and 39 tuna vessels. According to the regions, it appears that the southern region is home to more than 55% of the national fleet, all boats included. The activity of this fleet is supported and guaranteed by a developed port infrastructure. In total, 57 fishing ports are scattered along the Tunisian coast, including 12 deep-sea ports that can accommodate large fishing units such as trawlers, sardine, and tuna vessels (Tabarka, Bizerte, La Goulette, Kélibia, Sousse, Monastir, Téboulba, Mahdia, Chebba, Sfax, Gabès and Zarziss). The others are coastal ports that house the coastal fishing units and provide adequate services for this type of boat. In addition to this port infrastructure, there are several landing sites scattered all along the Tunisian coast, particularly in lagoons and areas with difficult access. In 2018, the fishing activity was carried out by 50,201 fishermen, 75% of whom are purely coastal fishermen and 50% are in the southern region, while the northern and eastern regions account for only 26% and 24% of the total workforce, respectively (Anonymous 2018). This population is distributed, according to the fishing mode practiced, as follows:

- 36,632 fishermen practice artisanal coastal fishing.
- 5,330 fishermen engage in trawling.
- 5,501 fishermen practice fire fishing (lamparos) for small pelagic species.
- 2,174 fishermen in lagoon fisheries, on foot and in aquaculture.
- 564 fishermen on board tuna vessels.

This activity can generate more than 36,000 indirect jobs in the country. In Tunisia, the fishing methods practiced are essentially of three types: coastal fishing, trawling and seine fishing. As a result, Tunisian fishermen use numerous fishing gears and techniques that differ according to the area, season, and targeted species and which range from simple fishing on foot, hooks and pots to the trawl and large purse seine

used by the tuna vessels, passing through the various coastal gears (*e.g.,* nets, fixed fisheries and longlines).

The negative effects of fishing activities on marine ecosystems, particularly coastal fisheries, are not to be demonstrated. In fact, these activities have caused the overexploitation of fishing resources, particularly benthic resources, and have degraded the quality of the coastal marine ecosystems. As an indication, the Posidonia meadow in the Gabès Gulf is in continuous decline and this is particularly due to the pollution by phosphates and damage caused by trawling in shallow waters areas. Moreover, the zones of shallow depths are silting up, more and more, consequently losing their biodiversity.

On the other hand, conflicts of interest between the different fleet segments (trawlers, seiners, and coastal boats) are increasingly observed. This often creates social problems and a lack of trust between fishers and all stakeholders in the sector. In addition, some activities, particularly inshore, interact negatively with some existing aquaculture activities.

The State, through the Ministry of Agriculture, Hydraulic Resources and Fisheries, has encouraged and initiated many projects for the installation of artificial protective reefs in shallow areas. The main objective of these reefs is the fight against anarchic fishing with towed nets.

Finally, it should be noted that fishing activity in Tunisia continues to suffer from many problems related to the scarcity of resources, the lack of regulations enforcement as well as the inadequacy of a strategic vision and institutions capable of responding to them.

IV.4. Aquaculture and regulatory measures taken in Tunisia

The procedures for setting up an aquaculture project are centralized at the level of the technical services of the General Directorate of Fisheries and Aquaculture (MARHP). In the field of aquaculture and at different levels (regional and central), multiple actors are involved, as varied and under different tutelage, including:

- The General Directorate of Fisheries and Aquaculture (DGPAq).
- The Aquaculture Technical Centre (CTA).
- The Inter-Professional Group for Fishing Products (GIPP).
- The National Institute of Marine Science and Technology (INSTM).
- The National Agronomic Institute of Tunis (INAT).
- The Higher Institute of Fisheries and Aquaculture of Bizerte (ISPAB).
- The Agency of Ports and Fishing Facilities (APIP).

- The Agricultural Investment Promotion Agency (APIA).
- The National Environmental Protection Agency (ANPE).
- The Tunisian Union of Agriculture and Fisheries (UTAP).
- The Coastal Protection and Development Agency (APAL).

It should be recalled that the role of APAL is to manage coastal areas and monitor development operations and their compliance with the rules and standards set by the laws and regulations in force (in this case the concessions granted to aquaculture projects).

Generally, and for onshore projects, the DGPAq grants an agreement in principle on the activity and the promoter submits its request to the APAL for the granting of a concession on the maritime public domain (DPM; Sigma Engineering, 2017). In a broader plan, APAL is involved in monitoring the coastline that is undergoing a strong environmental destruction either by aquaculture companies or by other factors that destroy the marine environment in the DPM (destructive fishing and tourism-related activities).

IV.5. Sustainable tourism

In Tunisia, before the promulgation of the town planning code in 1994, coastal management was based on the boundaries of the Public Maritime Domain established by decrees dating back to French colonization. This did not prevent the encroachment on the DPM by some tourist establishments. The determination of the 5 priority tourist zones (North Tunis, South Tunis, Hammamet-Nabeul, North Sousse, Djerba and Zarziss) by Decree 73162 of April 5, 1973, the elaboration of development plans relating to these zones and the specifications regulating the establishment of hotel units have set up guidelines for the protection of the coastline. However, these measures were insufficient to achieve this objective. In this context, the public authorities revised the old DPM boundaries by introducing new boundaries reinforced by the promulgation of the urban planning code in 1994. It imposed a setback from these boundaries, namely 25 m minimum in areas already covered by a development plan and 100m minimum for future areas to be developed. In this respect, the APAPL was created to ensure the application of these measures and to manage the coastline which is the main resource of the Tunisian tourism commodity (seaside tourism). The development of tourist activity has been mainly in the coastal areas with 95% of the hotel capacity being located on the coast and 92% of overnight stays in these areas.

Several environmental analyses of tourism development in the tourist regions of Tunisia have been made. The studies show, for example, that in the Tabarka region, whose exploitation started in 1992, hotels have been built in dune and pre-dune areas, which is normally prohibited by the laws relating to the respect of the Maritime Public Domain. In addition, commercial coral fishing has reduced the presence of corals from 30 to 100 m deep. A study carried out in Djerba, Sousse and El Kantaoui, shows a retreat of dune areas, poor vegetation cover and a retreat of beaches downstream of ports. Retreats of

25 to 35 m of beach have been observed in El Kantaoui since the late 1980s following the creation of the marina. In Djerba, hotels have sought to mitigate the phenomenon of erosion by riprap. Every year artificial recharging is necessary. However, this only shifted the problem, without solving it. The study conducted by the firm Engineering of Hydraulics, Equipment and Environment (IHEE), showed that the Tunisian coastline records 1,543 km which is stable while 127 km are coasts in decline, a rate of 7.6% of the coastline that is eroded. Moreover, tourism has made a major contribution to the achievement of Tunisia's objectives in terms of sustainable development through the interest given to the conservation and protection of the environment, the improvement of the living environment of the population, the assurance of a certain social equity and its important participation in the economic growth of the country.

Town and spatial planning (*e.g.,* Integrated Coastal Zone Management (ICZM), zoning of tourist activities, planning regulations and guidelines, development controls and especially the use of Environmental Impact Assessment (EIA) can thus be used to prevent potentially damaging development. To guide the development of its territory, the Tunisian State has various tools to promote spatial planning and a strategy to safeguard its coasts. In fact, as in other sectors, Tunisia's tourism development policy is supported by solid legislation protecting tourist sites and areas throughout the country, and by incentives for investment in these niches, thus providing a concrete example of evolution towards a real sustainable development of Tunisian tourism.

Regulatory mechanisms:

There are legislative and regulatory mechanisms in place. These mechanisms entrust the protection of the coastline or the DPM to certain bodies: The Agency for the Protection and Development of the Coastline (APAL), the National Agency for the Protection of the Environment (ANPE), the Land Agency for Tourism (AFT) and the Directorate of Land Use Planning (DAT). To take measures of the efforts made by the Tunisian State at the regulatory level, it is necessary to describe the means that have been made available to these bodies.

Elaboration of a strategy for the development of ecological tourism within marine and coastal protected areas (AMCP) in Tunisia:

The national program for marine and coastal protected areas has selected five sites which will be implemented in two phases: first, the creation of the Galite National Park, then the establishment of four other marine and coastal areas. The extension of the network of marine and coastal protected areas consists in the establishment of four other marine and coastal protected areas: in the Zembra and Zembretta Islands, the Kuriates Islands, the north-eastern part of Kerkennah and the coastline from Cape Negro to Cape Serrat. The effective and operational management of these MCPA is under the direction of APAL in collaboration with these different partners. Indeed, at the end of the creation and development stage of each MCPA, the management stage is based on the coordination of the different partners and donors.

Protected areas produce direct and indirect goods and services which include recreation, tourism, and exploitation of natural or cultural resources, hunting, fishing, and educational services. Indirect goods and services are those that do not result from visits to protected areas. The main activities carried out in AMCP are: (1) ecotourism and marine and land-based excursions, (2) nautical and underwater (diving) tourism, and (3) fishing tourism and sport fishing competitions. In addition, the establishment of a code of conduct for the rational management of these activities that can be established by consensus through workshops with all stakeholders such as: APAL, Ministries (Tourism, Interior, Agriculture and Hydraulic and Fishing Resources), tourist operators, diving clubs, *etc.* The regulations that be applied to the public maritime domain should also be applied in marine and coastal protected areas.

V. Establishment of guidelines to involve tourists in citizen sciences activities

V.1. Introduction and scope

In general, the relationship between science and society has evolved over time, depending on the changes observed in environmental and health issues and challenges.

In what follows, the definition of Citizen Science will be synthesized in general, and in the Mediterranean in particular. The main citizen science projects for monitoring the quality of marine ecosystems in Tunisia will be cited. In addition, special attention will be given to the possible methods and approaches to involve tourists in this monitoring.

V.2. History and definition of citizen science

Historically, the term "Citizen Science" was coined by Alan (1995). This author explained how knowledge about the environment can be accumulated from individual experiences reported by many people. Moreover, the concept of Citizen Science was born in the United States. It refers to the participation of the public in research (Rosner, 2013). In the past, through learned societies or research networks (cartography, weather, astronomy, *etc.*), goodwill was very often called upon to collect data of interest to scientific research throughout the planet. In astronomy, many amateurs contributed to the discovery of comets or variable stars. Prior to the 20th century, reference was often made to the work of amateurs who, although they did not benefit from an official scientific education, were considered great scientists. Moreover, it was only in the 19th century that the word "scientist" was used to refer to a person who was exclusively devoted to some kind of science (Rey, 1992). Moreover, and by way of example, mushroom or bird lovers have long shared their observations with researchers specialized in mycology or ornithology. There is also talk of a citizen's approach to characterizing procedures and methods for co-producing knowledge, technologies and solutions to concrete problems involving civil society movements with scientific institutions.

As proposed by Schneider (2002): "Citizen Science" can be defined as the participatory and combined effort of research, analysis and public education that strictly pursues, as a basic principle, the objective of collective well-being of present and future generations of human beings on the planet and in the biosphere. Otherwise, the French association "Fondation Sciences Citoyennes", created in April 2002, believes that citizen science should be based on citizen control of scientific research with political objectives. Thus, three axes of work are at the heart of its definition:

- Increasing the research and expertise capacities of civil society, of associative, consumerist, trade union and citizen forces.
- Stimulating freedom of expression and debate in the scientific world.
- Promoting the democratic elaboration of scientific and technical choices.

Moreover, among the fields of application of citizen science, often cited as an example, is the study of biodiversity, which involves a considerable amount of data to be collected in the field, on the scale of a given territory. However, it should be remembered that citizen science goes beyond the so-called participatory or collaborative science, since it leads to a politicization of the question of science and its orientations, and their links with the well-being of society. Indeed, the concept of Citizen Science obviously generates Citizen Scientists who are the people who intertwine work and citizenship, doing science differently, working with different people, making new connections, and helping to redefine what it means to be a scientist (Stilgoe, 2009).

The citizen scientist, through his or her research and analytical skills, must participate in protecting society against modes of development that place state or corporate interests' above collective benefit.

V.3. Concept of citizen science

In a rather general vision, citizens are encouraged to issue alerts when they consider that they are in danger and can thus request scientific expertise, which may or may not support their fears on certain subjects. Within this general concept, participants provide data and research locations, raise new questions, and collaborate with researchers to create a new scientific culture. While carrying out activities that are both interesting and useful, these "volunteer researchers" acquire new knowledge and skills, as well as a better understanding of scientific work. In addition, these networked, open, and transdisciplinary practices improve science-society-policy interactions and foster more democratic research, where decision-making is based on research results (Fig. 4). In general, and in the field of biodiversity and ecosystem studies, this type of participatory science can also be a means for citizens to regain or maintain contact with the fauna and flora around them, while contributing to their restoration and protection (Miller, 2006). There are three main types of citizen science programs:

- Programs initiated by scientists, who need volunteer citizens (experts, specialists, amateurs, or neophytes in the scientific field concerned) to help them collect a large amount of data, or data over a vast territory or over a long period of time.
- Citizen initiative projects, in which scientists or scientific teams are associated and integrated.
- Programs initially built between scientists and citizens interested in the same subject of study or objective.

In all cases, citizen volunteers can, by following a protocol prepared or validated by scientists, carry out observations, measurements, sampling or counting and transmit these data (raw or prepared) for processing and analysis by scientists. As an example, in 2010, about 200,000 people contributed to monitoring rivers near their homes for "World Water Monitoring Day".

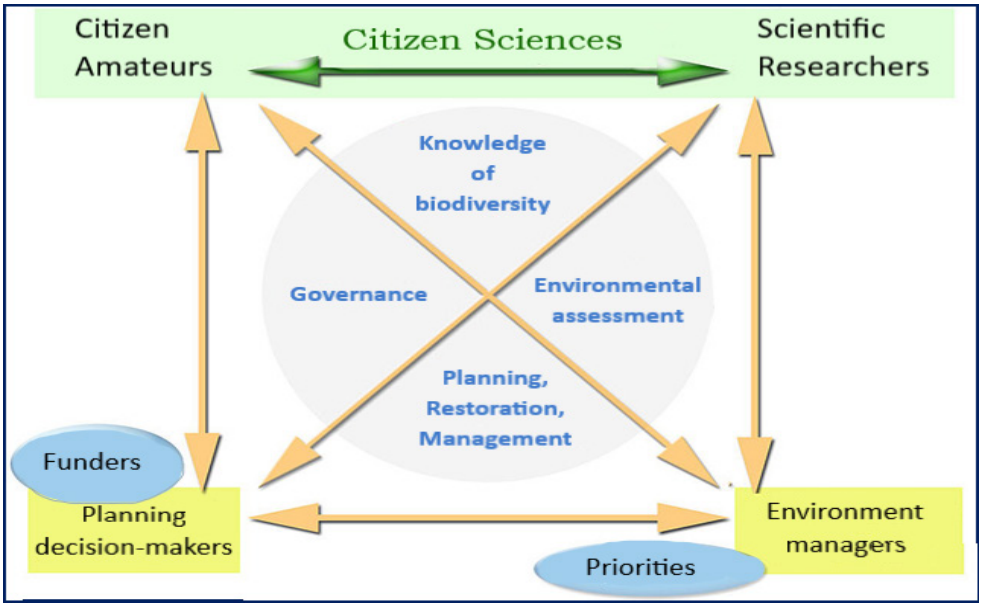

Figure 4. Concept of citizen science

V.4. Interest of citizen science

The contribution of citizen science appears indispensable for the advancement of knowledge. There are several major interests of citizen science.

- Citizen science makes it possible to obtain data over vast geographical areas and long periods of time, which is particularly important in the natural sciences (*e.g.,*ecology, population biology and conservation biology).
- Citizen science programs are often more economically viable because they are more resilient to the vagaries of research funding programs.
- Citizens represent an important work force and a significant source of skills.
- Citizens can contribute to the development of research and enrich scientific knowledge. In return, scientists share their results with them.
- The collaborative research contributes to an accumulation of knowledge for all types of actors, such as local authorities, nature reserves and associations. This knowledge is then mobilized to set up targeted protection actions (Guihéneuf, 2012).
- When scientists are active, citizen science programs are privileged scientific mediation processes, bringing citizens closer to scientists, and inviting them to understand the issues related to the theme of the studies in which they participate.
- Citizen science makes it possible to improve biodiversity monitoring at a lower cost for states that increasingly rely on volunteer naturalists in addition to scientists and consulting firms (Harold *et al.* 2010).

- The motivation of the volunteers and their number, as well as their wide distribution in the field, compensates for and limits the risk of bias. For example, to collect the same type of information (indicators for assessing biodiversity in Europe), teams are made up of 83% volunteers on average in Germany and there are no volunteers in the teams made in Poland (Schmelleret *al.* 2009).

V.5. Citizen Science and the Tunisian Context

In Tunisia, the concept of citizen science is still vague and ambiguous. In fact, there is little understanding of this concept by Tunisian members with the total absence of a legal and institutional framework, although participatory science has become a reality that is imposed for all. Thus, the country is called, first, to revise its legal framework to introduce in these regulatory texts a clear and specific legal instrument that defines the concept of citizen science and the involvement of tourists in various scientific activities without, however, touching the sovereignty of the state and without threatening the ethics of science. Once examined, the legal framework of the draft law dedicated that citizen science should take into consideration a lightening of administrative processes, adapted training, and a more sustained pace of implementation of strategies, while drawing inspiration from international best practices. In addition, Tunisia has developed a legal and institutional arsenal which is interested in a tourist activity close to the concept of citizen and participatory science, namely ecotourism. Indeed, ecotourism is commonly defined as a component of sustainable tourism. It refers to forms of tourism whose main motivation is the observation and enjoyment of nature and traditional cultures. This considers the integration of the educational and interpretative characteristics of the environment, for small groups organized by specialized and local tour operators. This form of sustainable tourism minimizes negative impacts on the natural and socio-cultural environment. This would contribute to the protection of natural areas, while at the same time creating jobs for local communities and raising the awareness of residents and tourists of the need to protect the natural and cultural heritage (OMT, 2002). This definition goes beyond the limit of ecological tourism (respect for the environment and customs without changing anything) because it includes the components of sustainable development: economic development, social progress, and environmental protection (IUCN, 2011).

Finally, it is important to note that in Tunisia, participatory science helps to overcome the lack of human resources among scientists, financial means and allows covering wider geographical areas. For certain themes, this is even essential, as amateurs can bring new species or invasive species to the attention of scientists, which is becoming one of the major threats to Mediterranean and Tunisian biodiversity.

V.6. Citizen science projects for monitoring the quality of coastal ecosystems

The ideal cooperation, according to a participatory approach, between research projects and civil associations will result, in most cases, in gathering reliable and complementary data on the ecosystem to understand its complexity and measure its level of erosion.

In recent decades, human activities have disrupted the global environment, leading to a major biodiversity crisis; the result of the phenomenal development of societies which has been based on the unsustainable exploitation of living organisms. Nowadays, collecting data on the ecosystem to grasp its complexity and measure and understand its destruction must be achieved by associating this collection of information by citizens with a research project. Indeed, the conservation of biodiversity and ecosystems is rarely considered to be the responsibility of the citizen. However, participatory science allows citizens to take part individually in this collective management, by participating in data collection, studying the results, and implementing management actions that can generate measurable positive effects (Cooper *et al.* 2007). By the same authors, participatory science projects thus have a twofold objective: to collect as much data as possible and at the same time to raise awareness of biodiversity issues. They also contribute to improving society's perception of science. When knowledge is shared, it facilitates a sense of ownership by the individual. Collective and shared management of biodiversity is, or will be, a major asset in supporting public policies and evaluating their implementation (Couvet*et al.* 2008). Moreover, citizen science can improve the monitoring of biodiversity (Julliard *et al.* 2004) at a lower cost for states that increasingly rely on volunteer naturalists in addition to scientists and consulting firms.

V.7. In Tunisia

Before citing examples of projects in Tunisia and elsewhere, no participatory science program on the marine environment on the southern shore of the Mediterranean has been set up to date. This is because this type of activity is terribly handicapped by legislative and administrative constraints in addition to the political and cultural context which is different from that in Europe and North America (Kundasamy, 2014). The countries on the southern shore of the Mediterranean are currently developing programs to raise awareness of marine environmental issues. Some associations have the aim of developing participatory science programs, but these will only be implemented once the populations have been made aware of them (Kundasamy, 2014).

In the case of Tunisia, if it refers to the simplified definition of participatory science which describes it as the participation of citizens in a research program, it realizes that these are mostly initiatives from civil society. Indeed, associations are the most numerous to propose participatory science programs. By this way, they propose to citizens to participate in a research program, but it also means that they link up with research organizations to propose the participatory science tool and thus act as an interface.

The public institutions, public research institutes and university laboratories, which employ scientists, are less likely to propose this type of program and therefore less likely to propose by themselves this direct link between scientists and citizens.

The following are rare attempts to involve Tunisian citizens in scientific projects to monitor the quality of marine ecosystems in Tunisia.

National Stranding Network (RNE):

The Tunisian National Stranding Network (RNE), established by government in 2004, should urgently respond to all reports of dead or alive stranding of marine turtles and cetaceans. With the aim to provide rescue and the maximum amount of biological and ecological data and information on the causes of mortality. This network is based on the regular search for individuals of these species stranded on the Tunisian coast (Fig. 5). It invites citizens, according to their abilities and knowledge, to register and participate in the various surveys and other monitoring programs. The RNE network has developed a collaborative tool: an online information system, dealing with the reporting of observed stranding of the following species: dolphins, whales, and marine turtles. It also allows citizens involved in this network to transmit plausible data.

Project ADMIR Gabès:

The project was established to act against the Degradation of the Environment and the Resources in the governorate of Gabès. This project is an example of citizens' initiative to support the role of civil society actors, professional organizations of artisanal fishers, and public actors in the governance and co-management of marine and coastal natural resources in the Governorate of Gabès. Indeed, it has raised the awareness of different actors such as civil society, local populations, and public authorities on the importance of sustainable use of marine and coastal natural resources. Indeed, the region of Gabès, with a surface area of 7,175 Km^2, is populated by about 376,000 inhabitants. The main economic activities of the region are agriculture, fishing, tourism, and industry. From an environmental point of view, the region has a particular character because of its biodiversity, its fisheries richness,and the presence of a maritime oasis. However, the activity of the industries established in the Gulf of Gabès, especially the "Tunisian chemical group" contributes to environmental degradation and probably impacts on human health. In fact, the Gulf of Gabès is considered by the United Nations Environment Program (UNEP) in the framework of its strategic action program as one of the "pollution hotspots" in the Mediterranean, and it is retained as one of the priority sites of the Euro-Mediterranean Horizon 2020 initiative aiming at the de-pollution of the Mediterranean. Despite the actions undertaken, the situation remains worrying, particularly because regional actors (industry and civil society) have not been sufficiently involved in proposing and implementing adequate solutions. It is in this general context that the ADMIR Gabès project was established and implemented within the framework of the financing agreement between the European Union (EU) and the Government of the Republic of Tunisia. The main objectives of this project are:

- To support the role of civil society actors, professional organizations, artisanal fishers, women clam collectors and public actors in the governance and co-management of marine and coastal natural resources in the Governorate of Gabès;
- To promote the increase and diversification of incomes of vulnerable groups by facilitating access to markets and local services, and by involving the private sector.
- To improve the methods of intervention of public authorities and civil society organizations which are active in the key areas of the project involved in artisanal fisheries and local sustainable development.

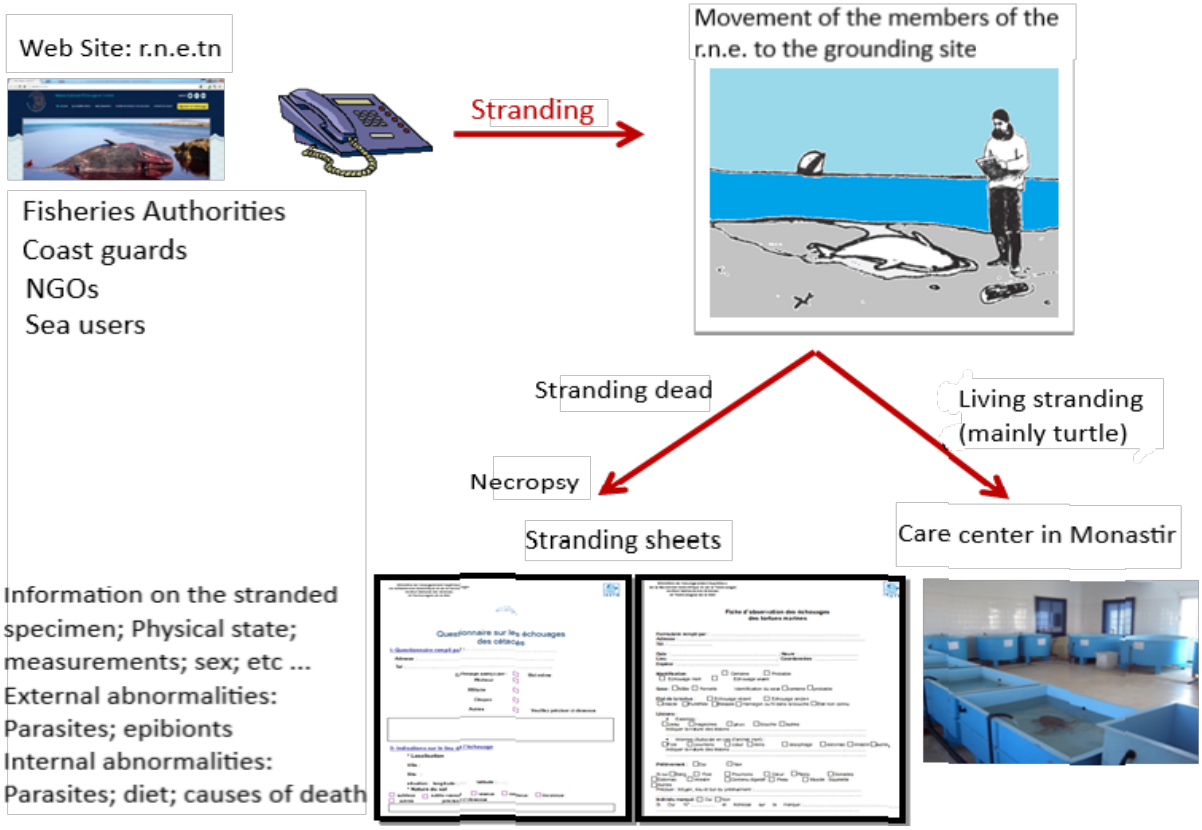

Figure 5. National Stranding Network of marine turtles and cetaceans in Tunisian coasts

V.8. Projects in other Mediterranean regions

The following are brief mentions of some citizen scientific projects for the monitoring of the quality of coastal ecosystems:

- **Vigie-Nature Project:** Founded and supported by the National Museum of Natural History (France).
- **GEIR project:** Group of Invasive Species of La Réunion, (Groupe Espèces Invasives), France".
- **BIOLIT Project:** The observers of the coastline (Les observateurs du Littoral), France.
- **BioObs Project:** Basis for the Inventory of Underwater Observations (Base pour l'Inventaire des Observations Subaquatiques).

V.9. How to Involve Tourists in Monitoring Ecosystem Quality?

For many countries, including Tunisia, tourist activity is a godsend for employment and foreign currency resources. However, in recent years, this activity has demonstrated its limitations on many levels (Abdennadher, 2014). To move away from the traditional modes of massive productivity in this sector, new branches can be envisaged to diversify the modes of attraction, such as the involvement of tourists in citizen scientific activities which could represent an asset for integrating sustainability in the tourism sector. It is an authentic model of tourism that respects the environment, also qualified as responsible tourism, even ethical. Tourists, as voluntary citizens, can, by respecting a protocol prepared or validated by scientists, make observations, measurements, sampling or counting and transmit these data (raw or prepared) to be processed and analyzed by scientists.

Monitoring of habitats, species or ecosystems via indicators that mostly seem to indicate a declining situation (Butchart *et al.* 2010) needs to be done on a large scale, especially to assess the path that remains to be taken to achieve the UN biodiversity targets (De Heer *et al.* 2005). Some indicators concerning fish or birds (Gregory *et al.* 2005) also provide information on the phonological impact of climate change (Julliaret *al.* 2004). Often long temporal monitoring and over large areas are necessary. Scientists can then be assisted, including by the public or associations. The motivation of these actors can be a determining factor for the scope and quality of certain studies (Neil *et al.* 2010).

The “Para-taxonomists” is sometimes used to describe people with no scientific training but employed as research assistants in the field. Examples of para-taxonomists are students, tourists, eco-volunteers, or members of local populations who assist researchers in their tasks. Depending on the case, they may or may not be trained, or may receive a small initial training. They are mainly used in areas that are frequented to inventory the biodiversity of an ecosystem that is particularly rich while specialists capable of determining these species are rare. Indeed, the involvement of eco-volunteer tourists in scientific activities focused on the preservation of an ecosystem can take many forms, such as:

- Creating an interactive website that asks people to help them request the required information and map it. This series of participatory research can involve citizens in the research, especially tourists.
- Organizing large-scale data acquisition surveys involving many tourists, encouraged by improved telecommunications. These surveys will provide thousands of trained citizens to be integrated into monitoring projects. Science remains the same, while a very small part of the fieldwork is outsourced to ordinary people who really bring their own expertise. But as concerns grew about biodiversity issues, amateur naturalists have gradually become increasingly recognized as experts on territories and species, working with specialized scientists.

VI. Conclusions

The Tunisian coastline, which is home to 76% of the population, 87% of the industrial activity and 80% of the tourism activity, is subject to strong pressures that jeopardize the rational management of its natural resources and therefore its sustainability. Added to this are the risks related to climate change and more particularly the accelerated rise in sea level.

Tunisia has become aware and has developed tools to promote the implementation of Integrated Coastal Zone Management (ICZM), both at the institutional and legal levels and the development of knowledge in relation to the challenges involved. However, limitations are nowadays hindering an effective application of this integrated management in the field. A fundamental reason for the limitation in the application of the ICZM approach is the fact that ICZM plans, although prepared according to a participatory approach, do not have the force of an obligation to be applied by other sectors at the national level.

The other aspect on which efforts should be doubled concerns the awareness of sectorial actors and the population at large of the major challenges and risks incurred by the coastline if development continues with the same trend in the future. Also, the popularization and sharing of good practices in terms of actions to adapt the coast to climate change are essential to move rapidly towards integrated and sustainable management of coastal areas. This can only encourage the sustainable development of the tourism sector in Tunisia, which remains a major source of income for the country.

Finally, to better formulate clear and practical opinions and recommendations, this first work of synthesis of the current situation regarding the protection of coastal ecosystems and the sustainable development of tourism in Tunisia, must be reinforced and supplemented by an important work of identification of valid criteria to better judge this situation and propose adequate measures to reconcile coastal ecosystems and the sustainable development of tourism in Tunisia.

VII. References

Abdennadher M., 2014. Étude Taxonomique & Écophysiologique des dinoflagellés toxiques du Golfe de Gabès: *Alexandriumminutum*, *Prorocentrum lima*, *Coolia*spp. et*Ostreopsisovata*. Thèse de doctorat Faculté des Sciences de Sfax, 372.

Alan I., 1995. A Study of People, Expertise and Sustainable Development, Psychology Press, 1995.

Anonyme, 2018. Annuaire statistique de la Direction Générale de la Pêche et de l'Aquaculture (DGPA) de l'année 2018.

Anonymous, 2000-2018. Annuaires Statistiques de la Direction Générale de la Pêche et de l'Aquaculture (DGPA) des années 2000 à 2018.

APAL, 2014. Système d'Information et d'Aide à la Décision SIAD: Contexte, acquis et perspectives. Présentation.

APAL and PNUD, 2012. Etude de la carte de la vulnérabilité du littoral tunisien à l'élévation du niveau de la mer due aux changements climatiques. Rapport de la Phase 2.

Ben Cheikh Ahmed-Dellagi H, 1996. Le domaine publique maritime, Mémoire DEA, FDSPT, 1995-1996, 105.

Bradai M.N., Ghorbel M., Bouain, A., 1995. Aperçu sur l'activité de pêche dans le gouvernorat de Sfax. Cahier CERES Série géographique, 1: 211-236.

Butchart S.H.M., *et al.* 2010. Global biodiversity indicators of recent decline. Science, 328: 5982.

Cooper C.B., Dickinson J., Philips T., Bonney R., 2007. Citizen science as a tool for conservation in residential ecosystems, Ecology and Society, 11.

Couvet D., Jiguet F., Julliard R., Levrel H., Teyssedre A., 2008. Enhancingcitizen contributions to biodiversity science and public policy, Interdisciplinary Science Reviews, 33: 95-102..

Cury P., Miserey Y., 2008. Une mer sans poissons, Paris, Calmann-Lévy, 284.

Cury P., Morand S., 2004. Biodiversité marine et changements globaux : dynamique d'interactions où l'humain est partie prenante. Paris, éditions ADPF, 50-68.

De Heer M., Kapos V., B.J.E., Brink, 2005. Biodiversity trends in Europe: development and testing of a species trend indicator for evaluating the progress towards the 2010 target. PPhilosophical Transactions of the Royal Society B, 360: 297-308.

Gregory R., Van Strien A., *et al.* 2005. Developing indicators for European birds. Philosophical Transactions of the Royal Society B, 360: 269-288.

Guihéneuf P.Y., 2012. La propriété des données dans les programmes de science participative : état des lieux des pratiques et du droit , Note de travail établie pour l'association Planète Mer avec l'appui de la Fondation de France, 10.

Halpern B.S., Walbridge S., Selkoe K.A., Kappel C.V., Micheli F., D'Agrosa C., Bruno J.F., Casey K.S., Ebert C., Fox H.E., Fujita R., Heinemann D., Lenihan H.S., Madin E.M., Perry M.T., Selig E.R., Spalding M., Steneck R., Watson R., 2008. A global map of human impact on marine ecosystems. Science. 319:948-52.

Harold L., Fontaine B., Henry Piquet F., Julliard R., Kerbiriou C., Couvet D., 2010. Balancing state and volunteer investment in biodiversity monitoring for the implementation of CBD indicators: A French example.EcologicalEconomics, 69: 1580-1586.

IUCN, 2011. Evaluation du cadre juridique et institutionnel relatif à l'écotourisme et aux aires protégées en Tunisie par le professeur de droit Wahid Ferchichi. Union Internationale pour la Conservation de la Nature Tunis. www.switchmed.eu:http://bit.ly/2otmtbU

Julliard R., Jiguet F., Couvet D., 2004. Common birds facing global changes: what makes a species at risk? Global Change Biology, 10: 148-154.

Kundasamy L., 2014. Sciences participatives sur la biodiversité marine : Etat des lieux et perspectives de développement en Méditerranée. Planètemer – France.

Miller JR., 2006. Restoration, reconciliation, and reconnecting with nature nearby. Biological Conservation, Elsevier. 3: 256-361.

Neil D., DanielsenF., BurgessPer M., Pirhofer-WalzlJ.K., 2010. Environmental monitoring: The scale and speed of implementation varies according to the degree of people's involvement. Journal of AppliedEcology, 47 : 1166-1168.

OMT (Organisation Mondiale du Tourisme), 2002. Définition de l'écotourisme de l'OMT. https://bit.ly/2KKclVv

PAP and PFN, 2011. Plan d'Action pour la mise en œuvre du Protocol GIZC en Méditerranée 2012 – 2019.

Rey A., 1992. Dictionnaire historique de la langue française, p. 1895, article «Science», édité par les dictionnaires le Robert.

Rosner H., 2013. Dataownings. Scientific American, 308: 68-73.

Schmeller D.S., Henry P.Y., Julliard R., Clobert J., Gruber B., Dziock F., Lengyel S., Nowicki P., Déri E., Budrys E., Kull T., Tali K., Bauch B., Settele J., van Swaay C., Kobler A., Babij V., Papastergiadou E., Henle K., 2009. Advantages of volunteer-based biodiversity monitoring in Europe. Conservation Biology 23: 307-316.

Schneider M., 2002. De l'expertise indépendante à la science citoyenne, Mars 2002, Contribution au séminaire «Expertise et principe de précaution», de l'AITEC (Association Internationale de Techniciens, Experts et Chercheurs), Global Chance et SOLAGRAL, le 5 mars 2002 à Paris.

SIGMA Engineering, 2017. Etude de marché des produits aquacoles mains en Tunisie, cas: Loup et Daurade. Phase 1: Diagnostic, analyse critique de la situation actuelle du marché national et international des produits aquacoles: Loup et Daurade. Activité 1: Diagnostic et analyse de la situation actuelle du marché national et international des produits aquacoles: loup et daurade. Activité 1.2: Recueil et analyse des données socio-économiques. 173.

Smit B., Spaling H., 1995. Methods for Cumulative Effects Assessment. Environmental Impact AssessmentReview, 15: 81-106.

Stilgoe J., 2009. - Scientifiques citoyens reconnecter les sciences à la société civile. Livre provient du Projet STACS. Science, Technology and Civil Society, 86.

UNEP, 2007. Guide introductif. UNEP Regional Seas Reports and Studies No. 189.

UNEP, 2015. Vers une gestion écosystémique des zones marines et côtières.

William M.B., Victoria J.F., 2008. Ocean acidification: documenting its impacts on calcifying phytoplankton at basin scales. Marine Ecology Progress Series. 373: 239-247.

WWF-France, 2015. Croissance bleue: la Méditerranée face au défi du bon état écologique.

DISCLAIMER

The present document has been produced with the financial assistance of the European Union under the ENI CBC Med Program. The contents of this document are the sole responsibility of *National Institute of Marine Sciences and Technologies* and*National Agency for Environment Protection*.In addition, under no circumstances it could be regarded as reflecting the European Union position of the programme management structures.

PARTNERS

ASSOCIATES PARTNERS

Bs partage 95 05 05 15
Design and Editing