UNEP

MAP

PRIORITY ACTIONS PROGRAMME

Coastal Landscapes of Tunisia with Special Focus on Cap Bon

A Proposed Landscape Character Assessment

Priority Actions Programme
February 2007

For bibliographic purposes this document may be cited as: Vogiatzakis, I.N. & Cassar, L.F. 2007. *Coastal Landscapes of Tunisia – A Proposed Landscape Character Assessment.* Split, Priority Actions Programme, 2007

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February 2007

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Acknowledgments

We are indebted to the Director of Agence dôAménagement et de Protection du Littoral (APAL) Mr. Abdelmalek for his support throughout this assignment. We would like to thank the personnel at APAL with whom we had the pleasure to work and who assisted us in no small manner. In particular we are grateful to Ms Sihem Slim, Ms Anissa Ksia, Mr. Fadhel Baccar from APAL Tunis and Mr. Aymen Kilani of the MedWetCoast project for providing access to literature as well as vital logistic support during fieldwork associated with this assignment. We would like to thank Prof. Bob Bunce at Alterra and Dr Marc Metzger at Wageningen University for providing the data on the Environmental Classification of Europe and Ms Elisabeth Conrad for discussing various sections of the manuscript. Finally we are grateful to Mr Ivica Trumbic Director of PAP-RAC UNEP for his confidence in assigning us this project and to Mr Marko Prem Deputy Director of PAP-RAC for the close cooperation as well as his invaluable comments on an earlier draft of this report.

1. Introduction

According to the Barcelona Convention "*Contracting Parties shall commit themselves to promote the integrated management of coastal zones, taking into account the protection of areas of ecological and landscape interest and the rational use of natural resources*ò Therefore, the Contracting Parties to the Barcelona Convention, at their Ordinary Meeting in Catania in 2003, adopted the recommendation 'to undertake thematic studies with a view to developing relevant guidelines and action plans on the issue of coastal land and sea environment and the utilisation of its resources' i.e. landscape management.

Despite the implicit reference of the document to landscape management, the coastal landscapes of the Mediterranean have never been studied or elaborated in the MAP projects per se. Landscape was taken into account only indirectly, through proposals of various documents (plans, strategies, programmes), in projects oriented to local level, such as Coastal Area Management Programme (CAMP), by using Integrated Coastal Area Management (ICAM) methodologies or by dealing with individual natural resources. Therefore, existing landscape-specific methodologies and concepts (such as landscape planning, vulnerability studies, and landscape characterisation) have not been introduced in ICAM.

The transformation of the Mediterranean landscapes has been a long process involving both natural and human induced processes (Ogrin 2005; Vogiatzakis *et al*. 2005) resulting in a complex landscape mosaic. After the Second World War this transformation was not only driven by agriculture, fire, grazing but also by imperatives (national or global) that bear little relation to the local and regional contexts in which settlements and agriculture have developed over millennia. Further anthropogenic pressures have been described by Naveh and Lieberman (1994) as the cause of ñeo-technological landscape degradationò The forces of population growth and industrialisation have stimulated considerable land-use change, especially agricultural intensification, with associated impacts including soil erosion, eutrophication and industrial and power-plant construction. These processes now threaten landscape integrity and diversity in the region altering a fine grained and multifunctional landscape.

The idea for landscape conservation was initiated by the IUCN (IUCN 1994). In Europe over the last 10 years ñlandscapesòhave received increasing attention from policy makers (Council of Europe 1992; PEBLDS 1995; ELC 2000) and researchers both at the national and international level (Vogiatzakis *et al*. 2005; Mazzoleni *et al*. 2004; Makhzoumi and Pungettti 1999). This reflects a new paradigm shift in natural resources management that recognizes the importance of landscape functions and values. The landscape is the fabric that integrates settlement, agriculture and ecology and offers a spatial unit for sustainable land management through the integration of sectoral activities (Naveh 1995) and with which stakeholders can resonate. During the 20th century the rapid change and the growing concern about the impacts of these changes on the landscape led to an increased interest in the inventory of land cover and lands use as well as the mapping and understanding of the landscapes. There is growing realisation that new approaches are necessary for the protection and management of all landscapes in holistic manner rather than focussing on the most òvaluableòand beautiful.

The physiognomy of the coastal landscape is created by geological, geomorphological and biological factors greatly modified by human activity. Many different kinds of classification have been applied to coasts in attempts to characterize dominant features in terms of physical or biological properties, modes of evolution, or geographic occurrence (Fairbridge 2004; Finkl

2004; EUCC 1998; LOICZ 1998). The increased availability of spatial data in digital format and the advances in Geographical Information Systems and other disciplines provided the opportunity for more comprehensive study of the coastal environment in an integrated and systematic manner.

Landscape character is defined as a distinct, recognisable and consistent pattern of elements in the landscape. Landscape Character Assessment (LCA) is a set of techniques and procedures to map differences between landscapes, based on their historical evolution and physical characteristics (Griffiths ***et al.*** 2004). LCA provides a common spatial framework as the foundation for integrating a variety of data from multiple sources that fulfils the needs for conservation, recreation and agriculture in the rural environment. Some of the most common applications that LCA can be employed for include:

- the development of indicators of ecological quality for monitoring the conservation status of the wider countryside;
- the identification of priority areas that are especially rich in wildlife interest;
- the identification of areas that provide the best opportunities to link, expand or buffer existing nature reserves and other protected sites;
- increasing understanding of the relationship between economic, social, and cultural factors and biodiversity;
- assisting with planning and landscape management applications and raising public awareness on landscape integrity;
- ways to achieve long-term sustainable change in the landscape whilst protecting wildlife.

Despite the wide use of Landscape Character Assessment (LCA) as a tool for landscape planning and management in NW Europe, there are few examples of its application in the Mediterranean as part of either a national mapping strategy or ICAM plans

Tunisian Coastal Landscapes

Tunisia (Figure1) has a great variety of coastal landscapes that reflect differences in biophysical conditions, and cultural heritage. The northern coast has an undulating coastline while the immediate hinterland consists of a wooded range of hills and mountains. Agricultural coastal plains can be found in the area of Cap Bon. The south is dominated by the low lying coastlines of the Sahel with dotted settlement pattern and flat steppic terrain further inland. Some of the most characteristic landscapes of Tunisia comprise coastal wetlands and semi-mobile landscapes of dunes. Some of the towns have exerted more their influence on the surrounding landscapes than others. Examples include Mahdia and Kairouan which have given rise to distinct cultural landscapes. The major threats to the coastal landscapes of Tunisia, are common along the Mediterranean coastal zone, and related to uncontrolled development, urbanization, increasing national and international tourism, land-based pollution, and unplanned or over-exploitation of natural resources, in particular freshwater. The strongest among these pressures, following the general trends in the South Mediterranean coast, are population increase and animal husbandry. As in the majority of Mediterranean countries an assessment of landscape character and associated pressures on specific landscape types has never being realised in Tunisia. The Cap Bon peninsula, located at the north-eastern tip of Tunisia was selected for a more detailed landscape study. The selection of the area followed consultation

with the PAP/RAC Focal Point, and it was due to its significance in terms of biodiversity and the range of pressures affecting its landscapes.

1.1 Project Aims and Objectives

The aim of this project is to prepare a landscape character assessment for the coastal landscape of Tunisia. The specific objectives are the following:

- identify current landscape management practices in the coastal zone of Tunisia and associated pressures and changes;
- illustrate the Landscape Character Assessment methodology;
- present a Landscape Typology for Tunisian coastal landscapes with emphasis on the Cap Bon Peninsula;
- provide recommendations for landscape-based management and on interventions that are deemed to have an impact on coastal landscapes;
- engage local authorities active in ICAM activities with landscape management and assessment practices.

This report describes the steps taken to address these objectives. In particular it sets out the development of a LCA methodology that could be employed, and provides with an example of its application based on real spatial data for Tunisia and the Cap Bon peninsula.

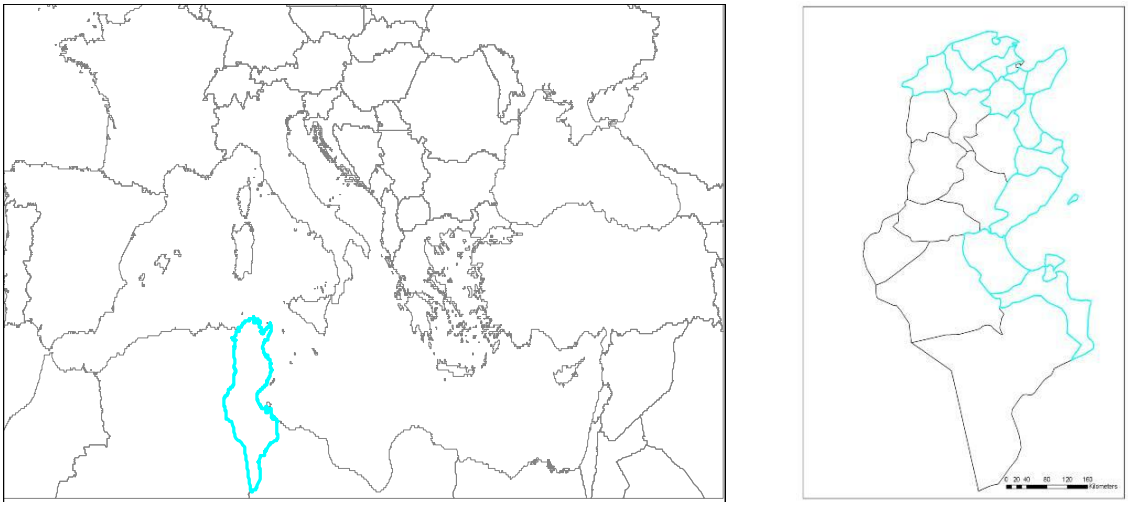

Figure 1: Location of Tunisia in the Mediterranean Basin and its coastal area

2. Coastal landscapes in the Mediterranean

2.1 Background

The formation of the Mediterranean was characterized by a series of extraordinary geo-tectonic and geographical events that occurred over a wide range of spatial and temporal scales. Often cited as the cradle of civilization, the Mediterranean Basin has provided a base to some of the worldôs oldest cultures. Over the centuries, the region served as a crossroads to various peoples and societies. Today, the region is a melting pot of different cultures and the regional identity of the Basinôs diverse societies is strong, shaped by the often austere environment in which people lived, and by centuries of commerce, as well as conflict. Despite the diversity, the peoples inhabiting the shores of the Mediterranean have much in common; they not only share the sea itself but also the physical environment around its shores. Following centuries of exploitation of the regionôs resources, resulting largely from the demands of ever-growing populations as well as from the multitude of conflicts that laid waste a once productive land, the countries that share a Mediterranean coastline now face common environmental challenges.

There are serious questions today about the Mediterranean regionôs environmental ability to support its growing human population in the medium term. In the thousands of years during which humans have lived in the Mediterranean Basin, and in particular during the past few decades of exceptionally fast development, civilization has profoundly influenced the regionôs ecology and degraded the environment. In ancient times, for instance, thick forests often extended down to the shore. Today, forests have been largely replaced by dense scrub vegetation and even lower succession formations. Depletion and degradation of resources, including freshwater, forests, coastal areas, and marine fisheries, is a growing concern, as is pollution within the region itself.

One need only visit the Mediterranean Basin briefly to realize the uniqueness of the region. Its landscapes and topography, as well as the habitats and biota, all contribute towards the regionôs richness and diversity. The Mediterranean possesses some remarkably interesting ecosystems, which are important both biologically and socio-economically. A growing and increasingly consumptive population, whose greatest demand is land area to develop for both urbanization and industry, is subjecting remaining pristine areas to intensified pressures. Thus, biodiversity within the Mediterranean Basin is increasingly at risk since mounting pressures on natural areas often lead to change in land-use patterns; such escalation may also lead to demands on ecological resources within the region that are unsustainable. Conversely, economic activities such as agriculture and tourism, which depend to a large extent on the vitality of ecosystems, will suffer if haphazard development region-wide is not contained.

Population expansion has already had a notable negative influence on numerous Mediterranean coastal locations, in particular, areas subject to urban sprawl and sites of major tourist attraction, as well as industrial projects and complexes. Projections indicate that the pressure is expected to intensify, with coastal populations likely to more than double by the year 2025, reaching levels of between 150 and 170 million. The population of coastal states of the Mediterranean was 246 million in 1960, 380 million in 1990 and 450 million in 1997. Blue Plan estimates that population will rise to 520-570 million by the year 2025 and is expected to reach approximately 600 million by 2050 and possibly as much as 700 million at the end of the 21st century (European Environment Agency/UNEP 1999; Benoit and Comeau 2005). According to Blue Plan scenarios, the number of tourists in Mediterranean countries will increase from 260

million in the 1990s to 440-655 million in 2025. At the same time, the number of tourists in the Mediterranean coastal region will increase from 135 million in 1990 to 235-355 million in 2025. It is expected that the majority of these tourists will be of European origin (European Environment Agency 1999). Already some 9000 km of coastline (circa 19%) are occupied by tourist complexes, road networks and related infrastructure, while many more similar projects are being planned on either side of the Mediterranean coast.

As Mediterranean landscapes are modified and converted, the biodiversity of the region is adversely affected. The richness and diversity of the flora and fauna of the region, much dependent on the maintenance of stable and functioning marine and terrestrial ecosystems, has diminished. As a consequence of anthropic disturbance, biotopes are degraded, food chains disrupted and entire ecosystems irreversibly damaged. The destruction of Mediterranean Basin ecosystems can have serious and far-reaching effects, notably, the loss of essential functions in the balance of ecosystems, reduction in goods and services provided, and species extinction.

2.2 The formation of natural and cultural landscapes within the Basin

The very formation of the Mediterranean, its landform and topography, coupled with its geographical location at the intersection of two major land masses of the Eastern Hemisphere, has resulted in the emergence of a particular climatic regime and ecological context. All these elements have created conditions conducive to the complex and dynamic development of the region's biota. The intricate blend of extant biotic elements, derived as a result of in situ evolution, and colonizer species from surrounding as well as distant regions, make up the Basin's exceptionally rich biodiversity. According to Blondel and Aronson (1999) there are four factors that are responsible for this richness in diversity: geology, biogeography, ecology and history.

In view of its physical location between three continental masses, that is, Europe, Asia Minor and northern Africa, the Mediterranean Basin has served as a point of convergence for numerous species of varying origins. Through the course of history the region experienced events that periodically modified the climate and environment, sometimes quite radically. Modern-day flora and fauna of the Mediterranean have been greatly altered, nevertheless, showing an astonishing diversity that characterizes the region's landscapes. Increasingly, semi-aridity and climatic bi-seasonality as well as anthropic activities, have thoroughly influenced the region's biotopes and biotic elements, especially the vegetation. Formerly a quasi-unbroken continuum of evergreen vegetation, the Mediterranean now consists of a landscape mosaic that includes outcrops, dunes, rain shadows, semi-deserts, mattoral formations, wooded patches, cliff formations and a suite of semi-natural and anthropic habitats. As a result of this complexity, largely governed by the Mediterranean climatic regime and a diverse topography, the Basin is exceptionally rich in endemics, both on the regional and local scales, and at the levels of genera, species and subspecies. In particular, wherever geographic barriers brought about ecological insularity or the isolation of a population or community (e.g., islands, high mountain peaks, oases, isolated woodland formations), this has over time led to a high degree of endemism, which vastly exceeds that found in any other part of Europe.

The Mediterranean area includes more than 25000 species of flowering plants and, as a consequence, it is one of the richest in the Old World (Quézel 1985); this figure represents about 10% of known plant species on Earth. It is estimated that more than half are endemic, and some 80% of all European plant endemics originate from the Mediterranean (Gomez-Campo 1985). Moreover, it is when such a figure is compared to the 6000 species of vascular

plants that are found in the rest of Europe (outside the Mediterranean area), an area some four times greater in size, that one starts to appreciate the ecological importance of the region.

Numerous Mediterranean elements that one would encounter today, such as *Olea, Myrtus, Phillyrea, Cistus, Quercus* cf. *ilex, Pinus* spp. *Abies, Cedrus*, etc., began to appear during the late Miocene and throughout the Pliocene. However, the current organization of the vegetation structures within the Basin is a direct consequence of the climatic upheavals that followed throughout the Quaternary and the subsequent modifications to the landscape by the human agency, which had a profound bearing on the natural ecological equilibrium since the upsurge of Neolithic society comprising herders and farmers. Modern-day Mediterranean landscapes and supporting vegetation structures, therefore, are the result of both climatic changes that took place over some twelve millennia together with more recent weather patterns, and anthromorphic elements. In a sense, geomorphology, temperature and precipitation played a crucial role, directly and indirectly, in shaping arboreal groupings together with their derivative assemblages, the shrublands and herbaceous scrublands.

The ósustainable balanceôthat had been attained as a way of life in previous millennia, changed radically in the space of the last two millennia, as the intensive increase in grazing and large-scale farming led to far-reaching modifications in the landscape, not least, a massive reduction of forest cover. Closer to date, the dramatic economic and social transformations that took place during the 20th century have led to further demographic increase and, in some instances, to a consequential displacement of certain populations (notably, a destitution-induced south-north emigration), an exacerbation of the exploitation of natural resources (including biodiversity and those within landscapes), a marked abandonment of productively low agricultural land, and the accelerated speculation of land for urbanization, industrial development and tourism purposes.

This rapid growth of urban and tourism development over such a short span of time, essentially the last four decades, is wholly responsible for a discernable loss of biodiversity and habitats of high ecological value. This has much been the case with regard to many Mediterranean locations, where biotopes have become fragmented and isolated (pocketed), often relegated to restricted refugia around which conflicting land-uses abound. In such a highly ó anthropizedô environment as one encounters throughout the Mediterranean Basin, natural communities often interface with disturbed habitats supporting weedy species or secondary succession vegetation colonizing abandoned agricultural land.

Mediterranean ecosystems are intricately linked to human affairs. The lands of the Mediterranean region have, over the millennia, been the focus of continual colonization by different peoples and cultures. Resulting conflicts initiated a process of population displacement in certain sub-regions; on the other hand, political stability and trade opportunities brought about demographic growth. As the regionôs population grew and became less sustainable in its manner, more pressures were exerted on the natural local environment and its resources. With the advent of mass tourism to the region, the last three decades or so have witnessed a greater demand on natural resources and, consequently, considerable land-use conflict. Therefore the conservation of biological diversity and its habitats should be seen from a holistic dimension, thus, bringing together other important components ï economic, social and political ï that constitute a challenge for the decades ahead, notably, that of promoting successful sustainable development strategies.

2.3 Engaging coastal management through the landscape approach

Within the Mediterranean setting, as outlined in the sections above, ecosystems are on the one hand, intrinsically linked to human affairs, and on the other, severely threatened by them. In the plurality inherent in the concept of landscape lie both the strength and the weakness as a setting for conservation. It is apparent that the term ólandscapeô means different things to different people, notwithstanding common elements. Hence, the term has a plurality of meaning and association. Despite the multitude of definitions put forth, there are three aspects that make landscapes much more than simply passive features in peopleôs everyday lives. One is that the impact of landscape is felt through all the senses. Secondly, landscape has a two-way relationship with people, with the power to shape and reinforce values, to inspire, to calm and to reinforce a sense of identity. Thirdly, landscape embodies past record of human land-use and ancestry. Landscape hence constitutes a meeting ground between nature and people, past and present, tangible and intangible values. As a result, landscape is increasingly being recognized as particularly relevant to the quest for more sustainable ways of living. It has several characteristics which echo concepts of sustainable development, such as its universality, its dynamicity and the fact that it is holistic yet hierarchical. By this implication, landscape is not merely an environmental resource in its own right, but also a means through which to pursue sustainable development (Phillips 2005).

Since landscapes are multifunctional, encompassing numerous facets, and because they can be identified with easily, providing as they do a backdrop to peopleôs everyday life, they provide an ideal arena for conservation efforts. Landscapes also provide an ideal scale for conservation efforts from an ecological perspective, evidence of which is the growth of the field of landscape ecology. In contrast one may argue that landscapes are cultural constructs, often contested. Where one individual may see a vacant plot suitable for development, another may see a valuable natural space. Moreover, landscape also has a range of often-unquantifiable values, ranging from pragmatic economic values to ecological, recreational, health-related and spiritual values. In a place like the Mediterranean, where landscapes are at times required to accommodate multiple, often conflicting, uses, changes are very often inextricably linked to social and cultural forces. Real-life examples include the case of economic situations triggering urbanization in rural areas or agricultural intensification and resultant ecological and visual impacts on the landscape. Such situations are commonplace in the Mediterranean. Linked to a rich and interesting past, the regionôs landscape has been subjected to extraordinary changes ï primarily through topographic modification to accommodate agricultural practice and the denudation of the sclerophyllous (woodland) cover for fuels and cultivation.

3. Landscape Character Assessment

3.1 Background and Rationale

The process of *characterization* comprises the identification of areas of distinct character, the classification and mapping of those areas and the description and explanation of their character. Landscape character is defined as a distinct, recognizable and consistent pattern of elements in the landscape. It is a functional hierarchy of abiotic, biotic and cultural components (Mücher *et al*. 2003). Landscape Character Assessment is a set of techniques and procedures used to classify, describe and understand the evolution and physical and cultural characteristics of landscape.

The rationale behind landscape character mapping is that particular combinations of physical and cultural factors occurring in different areas result in similar landscapes. The approach is based on a series of natural (i.e. landform, geology, soils) and cultural factors (i.e. land use, settlement pattern) that are used to describe the variability in the landscape at various spatial scales depending on the research scope. The data sources may include existing published sources, field survey information and the input of stakeholders to identify and describe areas of common character. LCA can operate at a range of scales from continental to national and regional.

The stages of a Landscape Character Assessment include:

- defining the scope of the study;
- undertaking a desk study to identify areas of common character;
- carrying out a field survey to gather further information about the landscape;
- classification and description to define and communicate landscape character types and areas.

3.2 Methodology

The methodology employed in this study is based on the approach developed by Griffiths et al. (2004) also proposed in a recent report by PAP/RAC (Vogiatzakis *et al*. 2005). However, some modifications were necessary to account for differences of the Tunisian coastal landscapes. The system is hierarchical (Figure 2), based upon the successive sub-division of the mapped attributes. The landscape is divided first into physiographic units from contour and geological data. The resulting units are then further sub-divided by soil type and finally by cultural patterns to derive the building blocks of the system, the Landscape Description Unit (LDU). Figure 3 illustrates the general approach and shows how he physical and cultural attributes are successively combined to derive the LDUs. These units are subsequently amalgamated into Landscape Types (Figure 2) with similar physical and cultural attributes using cluster analysis (e.g. TWINSPAN) (Hill 1979).

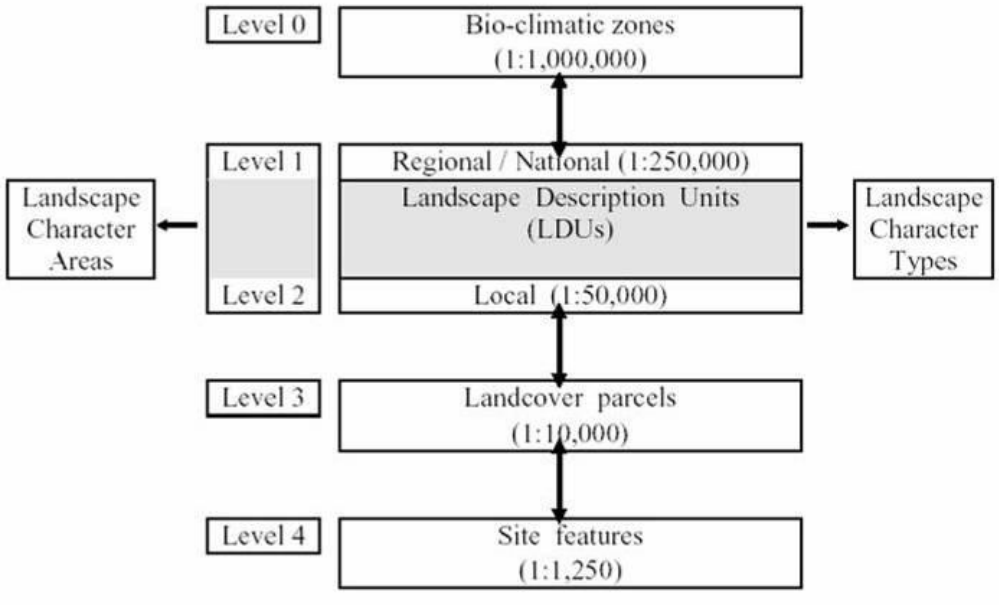

Figure 2: The landscape Description Unit Spatial Framework (Griffiths et al. 2004)

3.3 Developing the Typology

A distinction is made between a landscape typology and the application of that typology to generate a classification. The classification is the result of using the typology to map the area of interest, in this case the Mediterranean coast. In some cases, mapping can be achieved manually, based upon an interpretation of the mapped variables. Increasingly this kind of mapping is undertaken within a GIS environment, based upon visual interpretation of digital map layers using a technique called ôon-screenôdigitising, although alternative more computer intensive methods have been used (Mücher 2003).

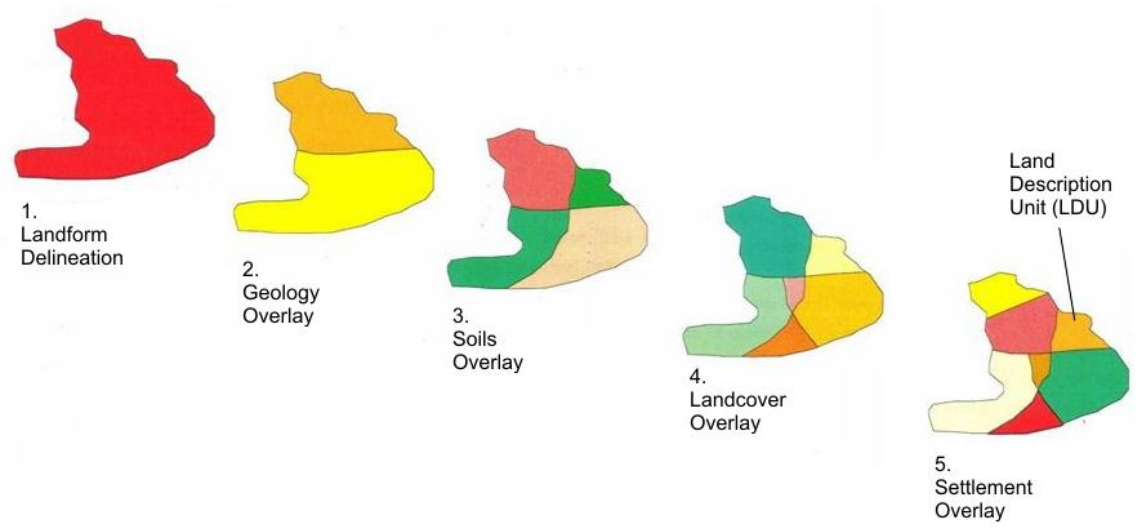

Figure 3: Schematic diagram of the overlay procedure during desktop mapping

An important component of this study is to develop a specifically coastal landscape typology for Tunisia that can be applied at a wide range of spatial scales from national to local. The development of the typology should follow the territorial limit of local coastal administrative units (UNEP/MAP 2005). Some of the most common variables employed more often in LCA include climate, landform, geology and land-cover (see review in Vogiatzakis *et al.* 2005).

The data for these attributes are stored in a database within a GIS software (e.g. ArcGIS). This is then followed by the overlay and subsequent subdivision of these variables into discrete homogeneous units. This operation can be carried out ñmanuallyò or automatically. Although the first approach can be time consuming for large datasets, it allows the user greater control over the process enabling decisions over the subdivisions e.g. by following natural breaklines for landform delineation or by amalgamating very small polygons of a geological attribute. In the second approach decision rules can be derived to extract the information needed from the individual variablesôlayers which can be then simply overlaid automatically within the GIS. This is generally faster but the presence of tiny polygons (slivers) which can be propagated along the process result in an unnecessary and not always meaningful number of polygons which then have to be filtered out from the final output.

The next step is the use of statistical procedures to determine the rules to decide between classes in order to produce repeatable results with minimal personal bias. Clustering techniques have been also applied at the global level for developing coastal typologies (LOICZ 1995; 1998). Therefore in this study the data can be analysed using TWINSPAN analysis (Hill 1979), a polythetic divisive classification technique, in PC-Ord (McCune and Mefford 1999). Although initially developed for the classification of species data TWINSPAN is also appropriate for landscape classification because it uses sample composition, in this case physical and cultural attributes, and the strength of affiliation of the attributes to different sample groups (Griffiths *et al.* 2004). TWINSPAN is also generally regarded as a robust analysis for data where there are many zeros in the data set. This generates groups of landscapes with similar attributes that will form the proposed coastal landscape types.

3.4 Data Sources – Availability

Although it is commonly accepted that a scientifically sound typology should be based on detailed information on the distribution, quality and quantity of biophysical variables, in many cases such information may only be derived from heterogeneous data sets of differing quality (Table 2). Quality is compromised by, for example: modernity, spatial scale, and area coverage.

For mapping purposes the coastal zone was defined as the boundaries of the Tunisian administrative units bordering the coast (Figure 1). Before the process of mapping can begin all of the relevant, readily available information for the study area needs to be collated as a series of digital map layers within the GIS. A review of available datasets that can be employed for these studies in the Mediterranean are found in Table 1. It is proposed that the typology developed for Tunisia can be based on the following variables:

- **Climate:** Climate zones may be defined using precipitation and temperature data.
- **Landform** - the relative relief and shape of the land surface as derived from interpretation of a Digital Elevation Model or topographic map. Classes may include valleys, rolling lowland, plateau, high hills.

- **Geological structure**: A simplified geological base map showing Geologyï structure/age is prepared first from Geological Maps. Geology-structure refers both to geological Period and to broad differences in lithology.
- **Land use**: the broad pattern of primary land use at the landscape scale as derived from existing land use maps.

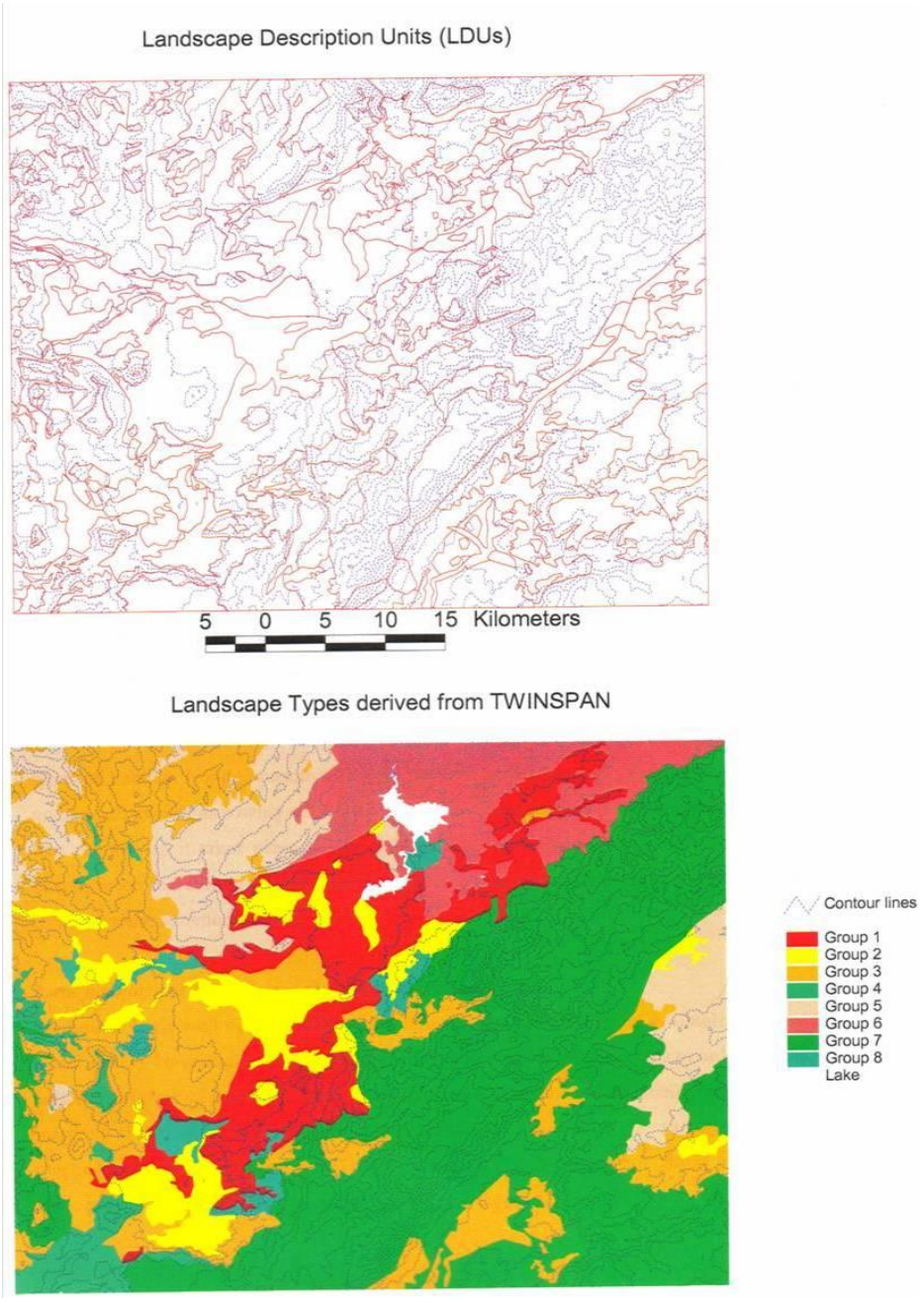

Figure 4: From Landscape Description Units to Landscape Types

Table 1: Potential Datasets for Landscape Character Assessment

	Source	Description
Climate	UEA, UK	The Climate Research Unit (CRU) at University of East Anglia offers several high-resolution global datasets. These include precipitation, temperature, relative humidity etc. Averaged climate data at individual country level are also available (http://www.cru.uea.ac.uk/cru/data/hrg.htm).
Topography	USGS	U.S. Geological Survey (USGS) is distributing elevation data from the Shuttle Radar Topography Mission (SRTM). The SRTM data were collected specifically with a technique known as interferometry, Data available to the geospatial data user community include 1-arc-second (approximately 30-meter) resolution data over the United States, and 3-arc-second (approximately 90-meter) data over non-U.S.territory (http://erg.usgs.gov/isb/pubs/factsheets/fs07103.html).
	USGS	GTOPO30 is a global digital elevation model (DEM) available by the USGS. Within this dataset elevation is regularly spaced at 30-arc seconds (c. 1km). The DEM is based on data from 8 different sources of elevation. The co-ordinate system is decimal degrees of latitude and longitude referenced in WGS84 (http://edcdaac.usgs.gov/gtopo30/README.asp). From this DEM other parameters can be derived such as slope and aspect.
Geology and Soils	ESB	The Soil Geographical Database of Europe at scale 1: 1,000,000 managed by the European Soil Bureau (ESB). A rasterised map with a grid resolution of 10km x 10km cell is available. The ESDB only includes the European countries of the Mediterranean.
	FAO-UNESCO	The Digital Soil Map of the World is a compendium of information on the distribution of soils in the world. The scale of the original map (and the vector-formatted data) is 1:5,000,000. The cell size of the raster data is 5 x 5 arc-minute http://www.fao.org/ag/agl/agll/dsmw.htm).
Land Use – Land Cover	CORINE	EU programme to provide information on the status of and changes to the environment. This database was derived from visual interpretation of Landsat satellite imagery in combination with ancillary information. It does not cover the Former Republic of Yugoslavia and Albania but it includes Tunisia and Morocco.
	PELCOM	A 1 km spatial resolution Pan-European Land Cover database which contains 16 classes and extends to Turkey, and part of the Syrian coast. This dataset does not cover any of the North African Countries (http://www.geo-informatie.nl/projects/pelcom/).
	GLC2000	The GVM unit of the JRC has produced a new global landcover classification for the year 2000 (GLC2000), in collaboration with over 30 research teams from around the world. Access is provided through registration.
	FAO:	The purpose of the AFRICOVER project is to establish a digital geo-referenced database on land cover for the whole of Africa (http://www.africover.org/webmap.htm). The Multipurpose Africover Database for the Environmental Resources (MADE) is produced at a 1:200,000 scale (1:100,000 for small countries and specific areas). Of the African Countries that boarder the Mediterranean there are data currently only for Egypt.
Geomorphology		No consistent Mediterranean or European geomorphological map exist. However, detailed digital elevation models (DEMs) are available, which convey a high proportion of the information required, i.e. altitude and slope. These data act as surrogates for geomorphological information. The best dataset available is the United States Geological Survey (USGS) HYDRO1k global digital elevation model, with a resolution of 1 km^2 (http://edcdaac.usgs.gov/gtopo30/hydro/).
GIS Global Datasets Products	AGI - ESRI	A compilation of geologic, hydrologic, elevation, land cover and other thematic datasets organized by regions of the world. The dataset comprises relatively small scale data (1:1 million scale or 1 Km resolution).

4. Landscape Character Assessment for Tunisia

4.1 The Tunisian coast – a historic overview

Tunisiaôs landscapes have been influenced by humankind for millennia. The first trace of human presence, within the land area that comprises present-day Tunisia, dates back to about half a million years BP. Peoples originating from the Sahara mingled with those originating from the northern and eastern regions long before this land, later to become known as Tunisia, was colonized by people of diverse origins, including Phoenician, Greek, Roman, Vandal, Byzantine, Arab, Norse, Spanish, Turkish and French.

Evidence exists of Phoenician trading posts along the Tunisian coast, as early as the 12th Century BC. These trading outposts, which later developed into maritime fortified towns, and subsequently became important coastal urban areas, exerted pressures on coastal landscapes as their populations grew and their domestic and economic activities became more diverse. Various colonizers utilized the coast and its often bountiful resources. Kerkouane, a former Punic settlement, with the status of a city, on the Cap Bon Peninsula, was founded in the 5th-6th century B.C. Utique, some thirty kilometres north of Tunis had been one of the most important ports in Africa. It was founded around 300 years prior to Carthage.

Carthage, a world power of the time, was founded in 814 B.C., and needs no introduction. Vast tracts of terrain to the north, south and inland of the city served to fuel Carthage with the resources it required. In particular, immense plains, former wetlands and natural grasslands, were transformed into agricultural land for an ever-growing and prosperous civilization. Carthage was destined to be later destroyed by the Romans and subsequently redeveloped by Julius Caesar. Further tracts of land were transformed into arable farmland extending into the hills in the hinterland, where freshwater from mountainous regions, such as those of Djebel Zghouan, was conveyed via impressive aqueducts to coastal regions such as Carthage. Remnants of the 132 km long Roman aqueduct that ran across the Wadi Miliane to the Bardo still stand today.

Following inter-religious conflict during the 10th century, Mahdia was developed on a promontory north of the Gulf of Gabes as a capital of the fatimide caliphate. The 10th century Great Mosque which still stands in this coastal locality in the vicinity of Borj el-Kebir, together with a fairly dense surrounding conurbation made up of habitations of varying age, is testimony of how coastal areas that were deemed to have defensible attributes were developed over time and according to the social, political and economic needs of the time. Another classic example is the former Berber town known as Oppidum Tunicense, later to become known as Tunis, the present-day capital, which was developed on the rocky isthmus which stretches between the Sebkhet es-Sedjoumi (great salt lake) and the bay of Tunis, an immense lagoon-like embayment overlooking the Mediterranean.

In addition to being landscape features of considerable magnitude, the various lakes near the capital are immensely important from the hydrological point of view as also from the conservation standpoint. These include the Lac de Bizerte, covering some 11,000 hectares, which flows into the adjoining Lac Ichkeul (8,500 hectares) during the dry season. The latter, a declared UNESCO (natural) World Heritage Site, is considered to be an exceedingly important wetland site for wintering waterfowl and the largest fresh water body in the Maghreb. The Lac de Ghar el-Melh, which covers approximately 3,000 hectares, also forms part of the system and is fed by the Medjerda, the only perennial river system in Tunisia. In historic times, its delta served as a strategic anchorage for the galleys of Barbary corsairs, as has also the partially navigable Lac de Tunis.

The Gulf of Tunis, in particular the area between the capital proper (Tunis) and the surrounding coastal suburbs, to the north including La Goulette, Carthage, Sidi Bou Said and La Marsa, and to the southeast Rades and Hammam-Lif, became exceedingly popular for up-market housing. Coastal landscapes were, in some instances, dramatically altered to accommodate necessary changes, such as a marina at Sidi Bou Said together with beach nourishment adjacent to it and the modification of the terrain at La Marsa so as to ensure appropriate alignment for construction of housing units on the immediate coast.

The strategic importance of La Goulette, translated from the Arabic Halk al-Wad (river mouth), was recognised as early as the sixteenth century when various conflicts ensued for its control between Barbarossaôs corsairs, the Spaniards and the Ottomans. Its location on a sandy isthmus between the Lac and the open sea made it militarily valuable. Economic prosperity and political stability of recent times transformed La Goulette into a coastal attraction and various infrastructural projects, over the years, aimed at embellishing this locality and at making it more accessible, contributed towards urban and infrastructural consolidation of this section of the coast and perhaps also to changes in the dynamics at large of the area. The Lac road which stretches across the shallow water to link La Goulette and Tunis is a case in point. The same can be said for the urban growth of coastal areas such as Hammam-Lif at the foot of Djebel Bou-Kornine and Soliman. In both locations, various alterations were made to the coastline, in particular, with regards to the construction of extensive wave-braking mechanisms immediately offshore. In the case of the latter, the coastal town is sandwiched directly between the shoreline and the coastal plain where wetlands occur.

Colossal changes in the terrain for strategic purposes are said to have occurred at Bizerte, often described as the Venice of Africa. For centuries Bizerte had been utilized as a trading post, port of call or strategic base, but, it is said, the military improvements that took place during recent colonization drastically changed its thousand year old appearance.

The northern coast between Cap Roux to Cap Zebib is characterized by a diverse landscape and seascape, comprising largely an undulating coastline with numerous capes and large embayments or small gulfs. Some of the various coves served over the centuries as indispensable ports of call and as bases for various activities relating to the maritime industry, including the infamous corsair events of High and post-Medieval age that wreaked havoc within entire coastal regions throughout the Mediterranean Basin, as well as economic benefit through the direct exploitation of marine resources. In particular, Cap Negro was utilized as a base for commercial coral fishing by French companies as early as the sixteenth century.

Of note is the harbour at Tabarka, located between Cap Roux and Cap Serrat, where a former island (immediately offshore) that had been joined to the mainland, in antiquity, via an existing sandbar offers adequate shelter to the Tabarka fishing fleet. Again, in view of the commercial importance vis-à-vis coral fishing around the rocky barren coast of Tabarka, the Genoese, after having acquired the land from Charles V, constructed a large imposing fortress on the crest of the hilly isthmus (former island), with commanding views of the Tabarka port; little in terms of landscape change, other than the further construction of a lighthouse by the French naval command in 1881, took place until recent times.

In recent years numerous housing units have been constructed on the mainland promontory opposite the isthmus, while a ótourist villageô, essentially consisting of numerous beachside hotels, complexes, beach clubs, golf courses and large plantations on extensive stretch of coast east of Tabarka, was constructed towards the area of Oued Bouterfess. Thus, new

developments during the last decades extended the urban footprint considerably on this part of the Tunisian coast, significantly altering the landscape fabric. This can also be said for other locations where golf courses have been constructed, such as along the eastern coast at Port El Kantaoui, where an entire tourist town was constructed from scratch, at Hammamet and as far south as Jerba (another former island that was linked via a thoroughfare to the mainland), not to mention golf courses beyond the coast in hyper-arid desert regions such as at Tozeur.

The northwest coast

The immediate hinterland of the north-western coast consists of a wooded range of hills and mountains, known locally as the Khroumiria, part of the Atlas range that extends westwards throughout northern Algeria all the way to Morocco. The vegetation comprises vast Cork oak forests accompanied by Mediterranean Evergreen oak-dominated woodland together with maquis-type assemblages as well as extensive plantations. The understory carpeting these areas mostly comprises myrtle, heather and *cistus* species. This woodland-dominated landscape extends across political boundaries of Maghrebian states as well as to locations close to the northwest coast, imparting a true sense of wilderness. The area is considered a refuge for wildlife including large mammals, so much so that the last Atlas Lion within Tunisian territory was shot here in 1943.

The Tell, which extends from this region, consists of a series of hills and ridges that form an undulating landscape which characterizes the northern aspect of the country. In particular the northern Tell is significantly hillier since this forms part of the foothills adjacent to the Atlas range. The north-eastern Tell and Cap Bon comprises lush plains, mostly used for cultivation. The Cap Bon promontory stretches out for ninety kilometres into the Mediterranean, bound by the Gulf of Tunis to the north and the Gulf of Hammamet in the south.

Cap Bon

The Cap Bon coast, which measures some 200 kilometres is largely rocky, ranging from low rocky coast to sheer cliffs, but also supports various sandy enclaves. The fertile soils of the hinterland are exploited to the full, through the establishment of orchards with numerous varieties of trees and cultivars, as well as large-scale garden-type farmland for the cultivation of cash crops. In some areas within the Cap Bon promontory, agricultural land-use occupies the terrain practically all the way to the sea. This part of the coast has also long been marketed for recreation purposes, primarily associated with sea-sports, bathing and relaxation, and, as a result, infrastructure and development have encroached upon the Cap Bon promontory coastline considerably.

The Sidi Raïs beach and coastal dunes, for example, have been, to a large extent, encroached upon by small-scale developments that have nonetheless had a significant impact on dune-field development, primarily interrupting beach nourishment through longshore drift, thus creating disequilibrium between beach-foredune sediment dynamics. In other localities along the Cap Bon coast various developments that often contrast with the rural character of the region may be encountered, but which nonetheless are exceedingly important from the socio-economic point of view. The constructed fishing port that protrudes seawards from the coastline and its associated tuna canneries at Sidi Daoud, south of El Haouaria, is a case in point.

Large-scale construction and development along the littoral has taken place at both Kelibia and Hammamet, as well as along significant stretches of coast between these two east-facing key conurbations, for example around Nabeul. In the case of Kelibia, urbanization spread from the nucleic 12th century A.D., borj that comprises a rocky spur on which a Punic citadel had

originally been built in the 5th century B.C., (later to be reconstructed and reinforced during the Arabization of the Maghreb; this fortress is considered the most important Moslem fortress in existence in Tunisia). The original fishing port was, in recent years, enlarged to cater not only for the needs of a modern fishing fleet but also for pleasure craft that sail the eastern coast of Cap Bon and beyond. The town grew both perpendicularly as well as parallel to the coast, with "Petit Parisô being constructed around the pocket El Mansourah beach, although most of the urban spread occurs in inland direction, across the plain.

Another large conurbation, Hammamet, lies at the foot of the Cap Bon promontory, and north of the Gulf of Hammamet, one finds a largely sandy environment that was quick to draw the crowds and compete for tourists, both international and domestic; Hammamet was launched as a resort town in 1920. Notwithstanding its present-day urban footprint, town planners have ensured that building height regulations, especially on the waterfront, remain within stipulated limits, while a large variety of trees (mainly eucalyptus and cypress) and other shrubbery has been introduced within the townscape in abundance. Like most coastal areas that have been inhabited for centuries, a fortified medina with accompanying Great Mosque, ramparts and fortress stand out, but while these may have characterized the coastal landscape at Hammamet up to a century or so ago, it is the whitewashed resorts and villas interrupted by "curtainsôof shrubbery that now dominate the landscape-seascape. The early nineties saw the construction of a mega yachting harbour with full ancillary facilities that cater for the international tourist market. The integrated resort of Yasmine Hammamet spreads over more than two hundred and eighty hectares and is flanked by extensive sandy beaches. The immediate hinterland of Hammamet has been converted from a terrain once supporting semi-natural and natural habitats as well as parcels of land used for pasture and cultivation, to one that now boasts some of the more attractive golf courses in the Mediterranean. The natural aspect of the landscape was incorporated into the design, while wide-scale planting was integrated into a massive landscaping scheme that produced numerous copses of trees and shrubs across the vast terrain.

From the conservation standpoint Cap Bon, or more specifically El Haouaria and its environs, is exceedingly important for avian migration across the central Mediterranean. During the spring passage, the promontory attracts as many as forty thousand raptors (birds of prey) that converge on the Darchichou region at the base of the Cap Bon promontory, and then soar towards El Haouaria over Djebel Abiod (393m), which forms the tip of this stretch of land (known as Ras Addar), and out onto the Mediterranean towards Pantelleria and subsequently towards Monte Ciccia in Sicily. The stretch of open sea between Djebel Abiod and Sicily is of a distance of one hundred forty kilometres, with the island of Pantelleria lying just over 80 kilometres from the coast of Kelibia on the Cap Bon promontory.

Historically, the coastline of Cap Bon has always provided a bridgehead for military incursions, such as the Agothoclesôexpedition in 310 B.C., that of Regulusôin 255 B.C., Caesarôs in 47-46 B.C., and others closer to date. For this reason the Cap Bon littoral boasts of various coastal fortifications such as the Ras ed-Drek Punic fortress and the Citadel at Kelibia, which, to a large extent, instigated large-scale modification of the coast so as to make these fortified areas strategically viable. Strategic considerations aside, the coastal areas of Cap Bon feature various other assets such as the hydropathic properties of natural spring-waters at Aïn Oktor and Korbus, where dedicated resorts have been constructed. Korbus had already been exploited as early as Roman times when wealthy inhabitants of the region visited the *Aquæ Calidæ Carpitanæ*.

The Sahel and the Gulf of Gabes

South of the city of Hammamet, commences the region known as the Sahel, which stretches south practically to the city of Sfax. In general, the coastline is relatively low-lying, dotted with a variety of towns and villages, many of which depend on fisheries, both domestic and commercial, as a way of life. The hinterland largely consists of open, flat steppic terrain that extends significantly inland. Coastal conurbations of significance comprise Sousse, Sfax, Monastir and Mahdia, while further inland one finds the city of Kairouan, an important holy centre for Islam. Indeed Kairouan, which is considered by many as the fourth Holy city of the Muslim world, has exerted its influence over time on surrounding landscapes. In particular, coastal defences were constructed around the port areas of Sousse, Sfax, Monastir and Mahdia with a view to afford a degree of protection to Kairouan.

One of the northern-most towns within the Sahel is that of Hergla, a relatively old town with a thriving community much dependent on fisheries and agriculture. A coastal thoroughfare dominates the shore region, as do the fishing port and cemetery. The lower regions are occupied by parcels of land that are cultivated while the slightly higher regions around the town support a vegetation assemblage that has been subjected to grazing pressures over the centuries. The town's 18th century mosque dominates the coastal town centre.

Much alike Yasmine Hammamet, Port el Kantaoui was constructed from scratch. It consists, essentially, of an immense coastal resort surrounded by an extensive hinterland of olive groves. In terms of landscape change, Port el Kantaoui altered the coastline considerably, with the establishment of a yachting harbour, various piers and jetties as well as breakwaters with acropods (to absorb the energy of onshore waves), extended beaches, large scale landscaping, including a 100 hectare golf course that extends from the hinterland to the sea, and a sprawl of holiday resorts.

The city of Sousse, one of the larger cities of the Sahel, has grown over the centuries both inland and along the littoral. Originally a walled coastal town with an 8th century ribat, the city was in recent times more associated with the tourism industry rather than coastal defence. When, in the seventies, Tunisia was identified as a potential tourist destination, Sousse was among the first coastal regions to be developed for this commercial endeavour. As a result, entire sandy tracts of beach were built upon to provide the newly founded industry at the time with space for commercial development. As in many other locations in the Mediterranean, little attention was paid towards environmental considerations, and the townscape ventured much too close to the shoreline.

Monastir is very much like Sousse in terms of intensive development of the coastal landscape, where 8th century ribats stand side-by-side with broad coastal thoroughfares, yachting harbours, artificially managed beaches, golf courses and holiday resorts. It is said that a chain of ribats, built by the aghlabites along the entire southern Mediterranean shoreline, communicated by means of light signals that enabled messages to travel between Sebta in Morocco and Alexandria in Egypt during the course of one night; such was the influence on the landscape by coastal defence structures along the Mediterranean during early Arab rule. Today, the leisure-oriented construction that takes place on the Monastir-Sousse-Port el Kantaoui coast as well as further north at Hammamet, is of such high calibre that, on the basis of design and amenity, it may compete with the some of the best resorts in the Mediterranean Basin. Significant alterations to the coastal landscape, particularly in Monastir, where extensive olive plantations occur, came about with the development and design of large golf courses on the immediate hinterland. The modification of the terrain, the intensive use of water resources, the radical land-use change and the planting of, often,

alien vegetation for embellishment purposes may pose questions of an ethical nature where sustainability considerations are concerned. Another area along the eastern littoral within the Sahel that is being developed into a resort centre is that of Bekalta, where touristic zones have been declared and subsequently developed on former agricultural and saltwort plains.

Further south, towards the Gulf of Gabes, extensive salt crystallizing basins may be found. Apart from characterizing the coastal landscape, these huge salt pans are an important staging point for numerous waterfowl including the elegant flamingos, which abound in this region. Not far is the fishing town of Mahdia. Developed largely on a promontory, Mahdia has spread along the adjoining littoral, where modern harbour facilities have been constructed. Thus, while enhancing the socio-economic fabric of the town and its environs, the new promenades abutting the port area have significantly altered the natural shape of the coastline. The country's second largest city is that of Sfax. Located on the northern tip of the gulf, Sfax is often referred to as the door of the Levant. Largely a sprawling coastal city in present times, Sfax was developed as an important part of a system of coastal defence towns in the region as early as the 10th century. In view of the prevailing aridity, many of those who cultivate the surrounding barren landscapes are also skilled fishermen and craftsmen, as a result of which, the coastal landscapes around Sfax are subjected to a multitude of uses. The harbour is characterized by vast commercial facilities and ancillary services, together with numerous industries of which some are deemed obnoxious. The vast hinterland comprises kilometres upon kilometres of olive plantations.

The Gulf of Gabes is located south of Sfax, where the shores of the embayment stretch for over five hundred and seventy-five kilometres, from Cap Kaboudia to the Libyan border. The gulf, formerly known as *Syrtis minor*, harbours within it a series of shoals, mudflats, rocky outcrops, islets and the island of Djerba. In the distant past, seafarers ventured into the seas of the embayment with trepidation due to the numerous shoals that made navigation difficult. As a consequence to the relatively poor soils, locals depend essentially on fisheries within the region's natural basin, although cultivation is nonetheless still practiced.

The coastal landscape within the gulf is characterized by a significant tidal range, unlike other locations within the Mediterranean (with the exception of some parts of the Adriatic). The formation of numerous mudflats is, therefore, very much in evidence within the Gulf of Gabes.

4.2 The Cap Bon peninsula

Cap Bon lies on the north-north-east segment of the country, forming an appendage that projects onto the central Mediterranean into what is geomorphologically known as the Siculo-Tunisian sill. The extent of the promontory's land-area measures some 2822km^2, which is approximately 1.8% of the total land-area of Tunisia. According to the census of 2004, some 650,300 persons inhabit the Cap Bon region, a figure that amounts to around 6.6% of the total population, with the largest conurbations occurring on the eastern coast at Kelibia, Hammamet, Nabeul, Dar Chaabane, Korba and Menzel Temime. Other smaller but nonetheless significant population centres on or near the coast occur at Soliman, Takelsa and Maamoura.

A simplistic appraisal of the promontory in terms of its landform demonstrates an extended massif that lies dorsally across the central segment of Cap Bon; this is known as Jebel Abderrahmen (637 m amsl at its highest point), which extends from the region north of Hammamet, across the middle of the promontory, towards Azmou in the north. Generally, this massif occupies much of the central segment of the Cap Bon promontory and is bound by coastal plains and other low-lying landforms in at least three main regions. These are:

- the relatively broad plain around Soliman, which extends from near the inland Zaouiet Jdidi to the Sebkha de Soliman on the coast;
- the extensive eastern coastal plain that stretches from Hammamet on the southeast to Hammam Laghzaz, just north of Kelibia, on the northeast coast; and
- the wide Dar Allouch plain that occupies much of the northern segment of the promontory and extends, in-part, down the northwest coast to the region occupied by the Forêt de Oued Lâabid.

Other smaller but nonetheless significant massifs that occur within the Cap Bon promontory are Jebel de Korbous and Jebel El Haouaria. The former lies on the coast, generally between Forêt de Oued Lâabid and Sebkha de Soliman on the western littoral of the promontory; the latter is located on the northern-most point of the promontory, just beyond the town of El Haouaria. A point worthy of mention is the fact that Jebel El Haouaria is a particularly important locality during spring avifaunal migration, primarily for raptors.

Many thousands of birds of prey, including eagles, buzzards, harriers and falcons, soar over Jebel El Haouaria in considerable number as they converge on Cap Bon every year during spring passage, before they undertake the seaward crossing towards Pantelleria and onto Monte Ciccia in Sicily during their northward journey. Thus, this locality is of regional, perhaps international, importance given the numbers of raptors that utilize this area for migration and any drastic changes on the landscape through, for example, (i) accelerated urbanization and increased urban footprint; (ii) large-scale open-pit mining; (iii) significant changes in the hydrology that may lead to changes in vegetation distribution patterns; or even (iv) considerable discernable disturbance (noise ï vibration ï emission) during peak migration, may have a dramatic negative influence on bird movement across this region.

As much as two thirds of Tunisia territory is cultivated and the same can be said for the Cap Bon peninsula, although it also harbours a great deal of tourism-related amenities, particularly on the coast. Indeed, the urban footprint is particularly dense in a number of locations along the littoral of the peninsula, in particular, in Hammamet, Nabeul, the coast between Beni Hkiar and Maamoura, as well as a number of other localities which were deemed conducive to tourism development. In general, the coastal landscape is quite varied, with extensive tracts of cultivated land together with considerable areas colonized by semi-natural assemblages and/or used for pasture. These, together with the cultural element that includes the contemporary urban footprint and the numerous historical monuments, form a mosaic that characterises the Cap Bon landscape.

Habitat-wise, a number of interesting elements occur throughout the peninsula as a result of a varied geomorphology and geology. Landforms at Cap Bon include an array of formations that range from sheer seacliffs and boulder scree formations to sloping rocky shores, shores comprising pebble and sandy formations, clay-dominated undulating hills and coastal plains, all of which provide habitat for a range of communities and assemblages. Some of the major biotopes that occur within the promontory include the various garrigues and low matorrals bearing various communities ï noteworthy amongst which are the Thermo-Mediterranean and pre-desert scrub assemblages (in particular, Palmetto brush: *Chamaerops humilis*-dominated formations and *Sarcopoterium spinosum* phryganas), the *Tetraclinis articulata* biotope and the oak and juniper dominated woodlands, among others. Various other specialised coastal biotopes and geomorphological entities of both scientific interest and importance occur within

the peninsula, which contribute towards the formation of the particular coastal landscape that occurs at Cap Bon. These include:

- coastal dune fields with accompanying pocket and linear beach formations (the latter formations function as órestingôzones for sand grains involved in aeolian processes, so crucial for foredune development and sustenance);
- perennial and seasonal *oued* systems, important not only as habitats in their own right, but as water run-off conduits and agents for sediment conveyance and deposition;
- offshore sandy/gravel formations such as sandbars, spits, tombolos and mudflats, some of which facilitate the creation of immense coastal lagoons;
- wetlands, including saline marshlands, transitional coastal wetlands and freshwater marshes.

Apart from the geology and the geomorphology, the formation of the landscape is also dependent on other factors, not least climate and hydrology. The climate of the Cap Bon region is, as expected, Mediterranean by its very nature, experiencing dry warm summers and mild wet winters. However, the promontory represents climatic variation that demonstrates substantial difference between different areas of the promontory. These micro-climatic regimes, which result from Cap Bonôs geographic orientation as a peninsula surrounded largely by the sea and the presence of the massif Jebel Abderrahmen, have, over time, helped shape the landscape of present-day Cap Bon. At least three micro-climates, and variations thereof, have been identified, these being humid, sub-humid and semi-arid.

As outlined above, a number of physical factors play a significant role in shaping the micro-climatic regimes throughout the promontory. As a consequence, the distribution of land-uses and the patterns these create within the landscape matrix are testimony of this. These factors include relief, prevailing onshore winds, geology and soils, as well as hydrology, that latter of which is discussed below. The watershed patterns of the promontory are largely determined by the Jebel Abderrahmen massif and its associated relief. At least 15 distinct catchment zones can be identified, draining an immense volume of run-off towards the littoral via the numerous *oued* systems that bisect the region. The principal systems that drain the promontory are Oued Bézikh, Oued Laâbid, Oued El Magaïez and Oued Tabouda on the western coast of Cap Bon, and Oued Hajjar, Oued Tafekhsit, Oued Lebna, Oued Chiba and Oued Bouliedin on the eastern coast, where a substantial number of sandy beaches, chotts and sebkhas occur.

Some of the more important biotopes that are closely associated with coastal watersheds are sand dune systems and wetlands. A number of these exist throughout the Cap Bon promontory, with the majority occurring on the eastern coastal plain. From the conservation point of view, these important coastal habitats should not be protected and managed in isolation, since they form part of a broad system of coastal conservation areas. Not only are they often physically connected through the dynamics that govern such geomorphological entities, but are also linked on a biogeographical landscape scale as a result of the linkages they form across the vast terrain comprising not just Cap Bon and the immediate Tunisian coast, but the very important biotopes that stretch across the Maghreb, such as Lac Ichkeul, Lac Tonga (El Kala) and others. This is precisely why it is crucial that biotopes and their immediate surroundings are not seen in isolation but rather as part of a landscape matrix that includes both natural and cultural dimensions, since people and their activities are very much part of the Mediterranean landscape and therefore part of the equation.

Some of the sites that were visited during the course of this present assignment exhibited characteristics typical of prime coastal habitats that require broad-scale conservation efforts

rather than piecemeal protection largely due to the interconnectedness of these coastal biotopes. These wetlands and dunes provide a system of wildlife corridors at varying landscape scale for a wide suite of different faunal forms, which could use these habitats and the cover they provide as staging points during migration as also, depending on species, for foraging, hunting and movement across the terrain. The various habitats perform the function of wildlife corridors and other such linkages, so badly needed in numerous areas throughout coastal regions where the human footprint has grown considerably; in order to serve as a medium for connectivity between existing pockets of ecologically important habitats and biota.

In ensuring connectivity it would be further envisaged that ecological linkages meet the needs of different movements (e.g. foraging strategies, seeking shelter, etc.), spanning different scales, of the various organisms that colonize a particular coastal landscape. In essence, it is crucial that physical linkages within such landscapes (which have been modified as a result of human activity) provide sufficient space and material assets for individual species to move and obtain what resources are required at different stages of their life cycle. Clearly there is a need to develop a better understanding on the use of connectivity at different scales by different species as a result of the complexity of the natural world and its associated ecological processes that operate at different spatial and temporal scales.

Some of the habitats encountered include the saline sebkha of Maamoura that is interconnected with the marshland at Tazerka and Korba; the latter comprises an extensive system of wetlands that occur immediately behind an exceedingly wide sandy beach that is backed by a series of embryo coastal dunes as well as what appears to be a dunal remnant. Such dunal remnants may be the result of decreasing sediment discharges by fluvial systems in the vicinity. Dunal biotopes of varying dimension may be noted in a number of localities throughout the promontory, as indicated earlier, especially on the eastern coast, and very often, these are associated with wetland habitats ranging from freshwater marshes to saline sebkhas. At Plage Menzel Horr, where a sizeable beach exists, the dune formation only supports a foredune colonized by the binder *Ammophila arenaria* (at the time of survey), a species typical of foredune formations, but no other species normally associated with this biotope were noted. Minor dunal formation is also present adjacent to Sebkha Dar Rebii and Sebkha de Bit El Assa, where the shoreline is characterized by mudflats and lagoon formations. Particularly large coastal dune formations, demonstrating high dune ridge development, are present at Hammam Laghzaz, where the dunes co-exist with a series of extensive sebkhas. These dunes are largely colonized by *Ammophila arenaria* on the foredune region, *Pancratium maritimum* and *Eryngium maritimum* on the subsequent ridges including the fixed dune, and *Retama raetam* and *Juniperus phoenicea* mostly on the consolidated dune region.

Another exceedingly large foredune formation occurs at Rtiba. This dunal component is, in relation to other dunes, quite mobile and is solely colonized by *Ammophila arenaria*. Its consolidated region further inland comprises a mix of planted species of trees and species of a remnant of the assemblage that once colonized the region. Species present at the time of survey included *Pinus halepensis*, *Pinus pinea*, *Acacia cyanophylla*, *Retama raetam*, *Myrtus communis*, *Pistacia lentiscus* and *Quercus coccifera*. The issue of planting trees on the consolidated dune, so close to the mobile foredune, impedes spatial inland development of the dune system. One positive feature of this particular dune system was the extensive *Posidonia* (seagrass) banquettes that formed on the strandline. These formations of washed-ashore seagrass remains act as barriers against wave surges; they absorb the energy of the force of the sea, thus reducing erosion and, as a consequence, protect the beach from losing sediment and retreating inland. In

comparison to the Rtiba dunes, the Oued Lâabid dunes do not attain the same height but are far better vegetated with *Ammophila arenaria* as a result of less mobility of the foredune; these dunes extend quite a distance inland and, in places within dune slacks, support humid zones.

One other most significant factor that has determined the shaping of the landscape over time is the anthropic element. The anthropogenic environment is another facet that requires serious consideration since the numerous artificial habitats that were created as a result of human intervention over time within the Cap Bon littoral and, indeed, throughout the promontory, are of paramount importance landscape-wise.

4.3 Developing a Typology for Tunisia and Cap Bon

The availability and accessibility of various datasets was evaluated during a meeting with the local management authority (APAL). In the absence of national widely digital datasets, the analysis has employed õfreelyòavailable spatial information using the methodology described in Section 3 to develop a typology. For geology, therefore, land-cover the GIS Africa product of AGI-ESRI are used while elevation data were derived from the SRTM-USGS (see Table 2). Data on climate at the national level was taken from the European Environmental Stratification (Metzger *et al*. 2005). The framework divides Europe into 84 classes based on topographic and climatic variables at 1 km^2 resolution. Finally the issue of scale remains an important challenge. Therefore, it is necessary that the developed framework is hierarchical. This will allow studies to be undertaken and comparisons to be made at different spatial scales in a way that for example local field data can be placed in the Mediterranean context. The system described herein is developed in a way that can be scaled up or down according to need.

Table 2: Attributes employed for Coastal Landscape Mapping in Tunisia and Cap Bon

	Climate[1,5]	Landform[2]	Geology[3]	Land Cover[4]
Tunisia	Medit. South 6 Medit. South 7 Medit. South 8 Medit. South 9	Lowlands Undulating (hilly) terrain Montane terrain	Quaternary recent deposits Pleistocene Tertiary (Oligocene-Miocene)	Urban Areas Cropland Pastureland Semi-Natural Areas Desert
Cap Bon	Semi-Arid Sub-Humid Humid inferior	Lowlands Undulating (hilly) terrain Montane terrain	Pleistocene Quaternary Upper Miocene Lower Miocene Calcareous deposits	Agricultural areas Semi-natural areas Coastal wetlands Mosaic

[1]*According to Metzger et al 2005; In ascending order the numbers indicate higher July mean maximum temperature,* [2]*From USGS-SRTM* [3,4] *From the AGI-ESRI © Dataset* [5] *According to MedWetCoast (UNDP/GEF 2004)*

Based on the attributes described in Table 2 a series of maps were produced for the Tunisian Coastal Zone (Figure 5) According to these maps the Tunisian coastal zone can be characterized as follows:

1. Urban coastal landscapes on quaternary deposits as, for example, in the region of Tunis.
2. Lowland coastal arable landscapes on Tertiary deposits as in the regions of Bizerte and Ariana
3. Undulating coastal landscapes on Tertiary deposits as in the regions of Jendouba and Beja
4. Mosaic coastal landscapes on Quaternary deposits as for example in the area of Cap Bon
5. Lowland pastoral landscapes on Tertiary deposits in more arid areas such as Sfax and Medenine

A more detailed characterization and mapping took place for the Cap Bon peninsula. For this purpose the climate, geological and land-cover data were based on the Geological Map of Tunisia (1:500,000 scale), the Bioclimatic Map of Tunisia and the MEDGEOBASE respectively as provided in the MedWetCoast project report (UNDP/GEF 2004). These maps were geo-referenced and digitized with ArcGIS. For landform the study relied on the STRM data. As a result the following Landscape Types were identified (see also Table 3.):

1. Undulating semi-natural landscapes: Found on rolling hills of Miocene geology these landscapes are dominated by semi-natural vegetation.
2. Undulating mosaic landscape: These units are found on rolling hills, calcareous substrate characterized by patchy semi-natural vegetation and agriculture.
3. Montane mosaic landscapes: Found on montane terrain these landscapes, which occur on calcareous and Lower Miocene geology, characterized by patchy semi-natural vegetation and agriculture.
4. Montane semi-natural landscapes: These units are found on montane terrain, on Miocene rocks, dominated by semi-natural vegetation.
5. Undulating agricultural landscapes: These units are on rolling hills over upper-Miocene rocks where agricultural practices are predominant.
6. Lowland agricultural coastal landscapes: Lowland pleistocene deposits where intensive agriculture dominates.

6a. Lowland semi-arid agricultural coastal landscapes Lowland pleistocene deposits where intensive agriculture dominates and where the climate is semi-arid rather than sub-humid as in Type 6.

7. Lowland semi-natural landscapes: Lowland pleistocene deposits where semi-natural vegetation is dominant.
8. Lowland agricultural coastal landscapes on Miocene rocks: Dominated by agriculture these units are found on upper Miocene rocks.
9. Coastal wetlands: Lowland landscapes on pleistocene deposits dominated by wetlands.
10. Semi-mobile coastal landscapes: Lowland landscapes on pleistocene deposits dominated by sand dunes.

Table 3: Main Coastal Landscape Types in Cap Bon their main components and patterns

	Landscape Type	Location	Components & Patterns
1	Undulating semi-natural landscapes	Jebel El Haouaria, Korbous	Sclerophyllous and other semi-natural vegetation dominant, some agriculture
2	Undulating mosaic landscapes	West of Soliman	Mosaic with agriculture and sclerophyllous vegetation, discontinuous urban fabric
3	Montane mosaic landscapes	West of Grombalia	Mosaic with agriculture, sclerophyllous vegetation and forests
4	Montane semi-natural landscapes	The plateau of Sidi Abderrahmane	Predominantly forested landscapes
5	Undulating agricultural landscapes	Takelsa	Hilly landscapes dominated by agriculture, discontinuous urban fabric
6	Lowland agricultural coastal landscapes	Kelibia, Dar Allouch	Agriculture dominated, Discontinuous urban fabric, wetlands
6a	Lowland semi-arid agricultural coastal landscapes	Grombalia, Korba, Tazarka, Maamoura	Agriculture dominated, Discontinuous urban fabric, wetlands
7	Lowland semi-natural landscapes	Oued Laabid	Forests and coastal sand dunes
8	Lowland agricultural coastal landscapes on Miocene rocks	Douar Ez Zedine	Agriculture dominated, Discontinuous urban fabric
9	Coastal wetlands	Extended from Maamoura to Kelibia	Includes marshes, transitional coastal wetlands, freshwater marsh and sebkhas
10	Semi-mobile coastal landscapes	Oued Laabid, Dar Chichou	Extensive dune fields

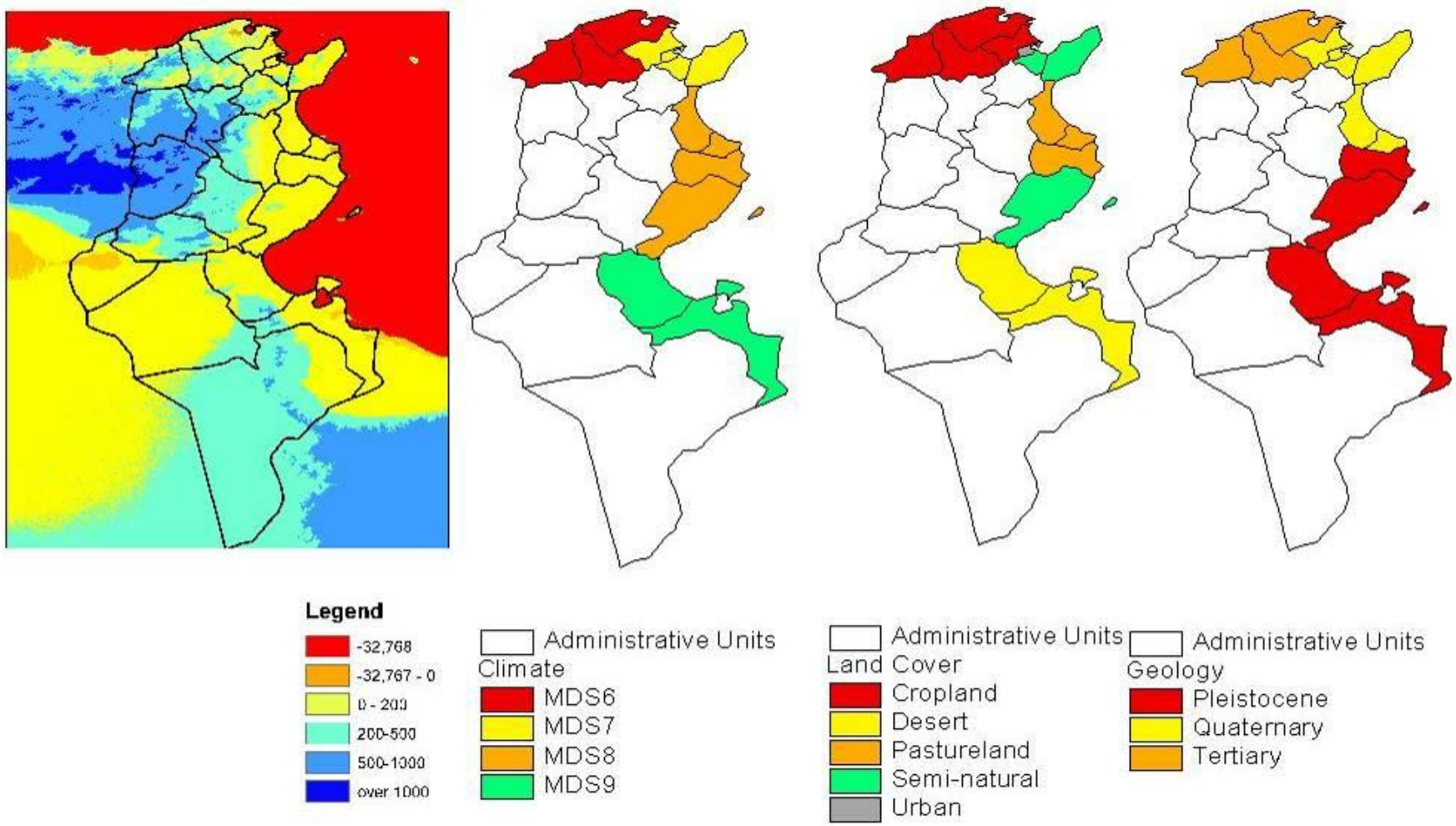

Figure 5: The character of the administrative units bordering the coast in terms of landform, climate, geology and landuse. These maps of variables can be used for developing a landscape Typology (see Table 2)

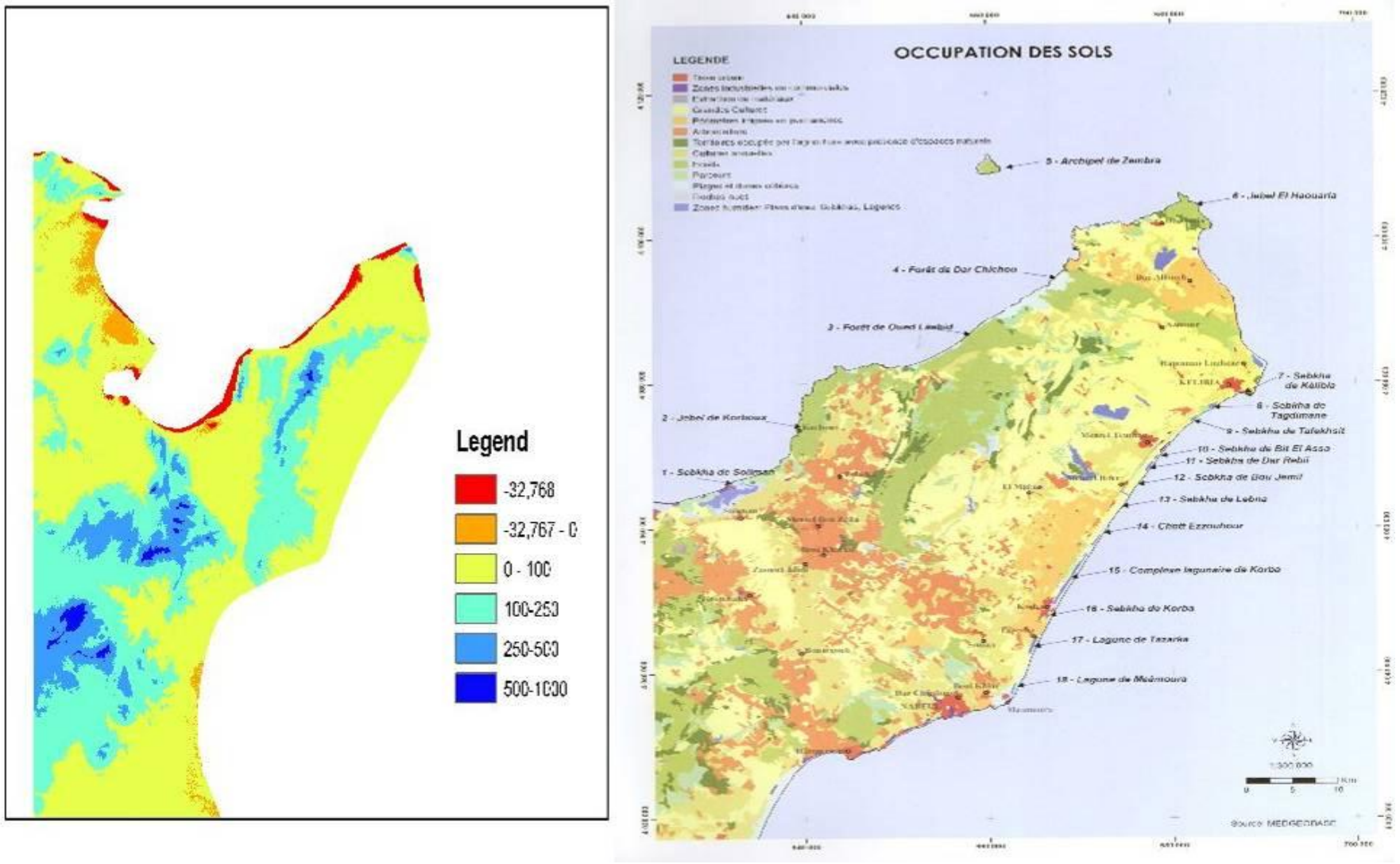

Figure 6: Landform and Land-cover units in the Cap Bon peninsula. Land-cover source MedWetCoast (UNDP/GEF 2004)

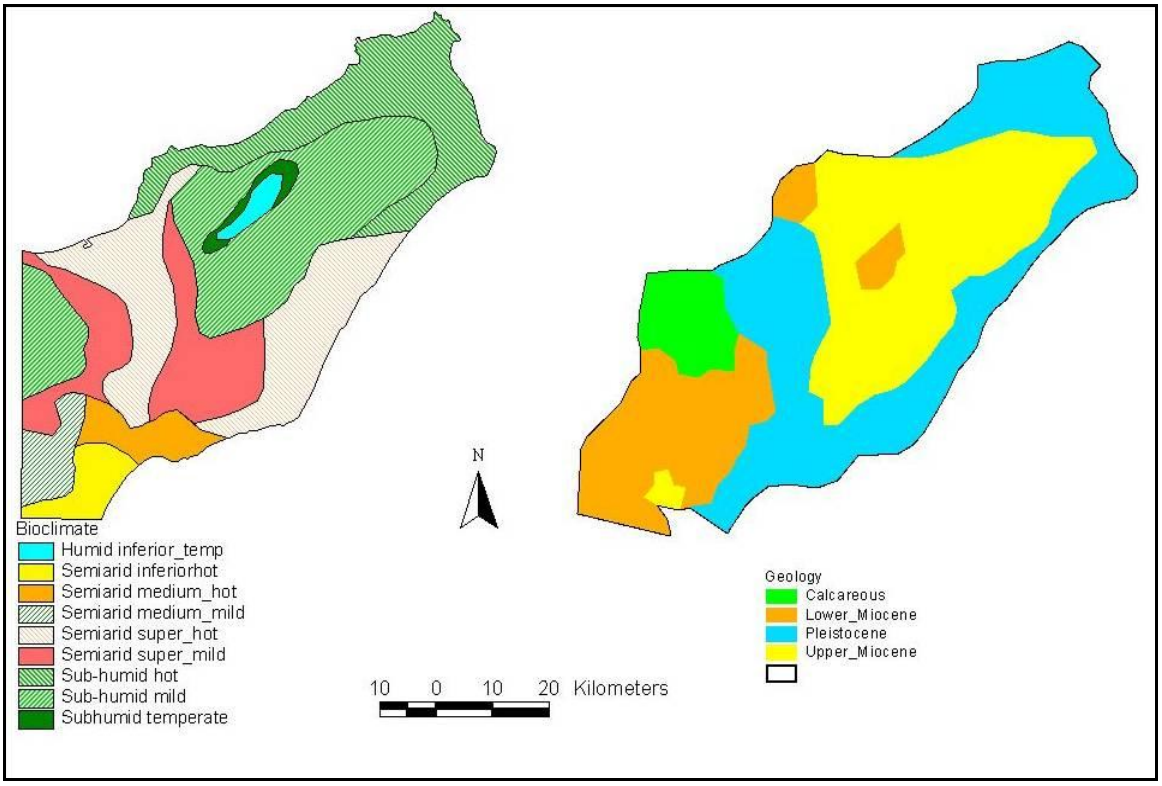

Figure 7: Bioclimate and Geology units in the Cap Bon peninsula. Modified from MedWetCoast (UNDP/GEF 2004)

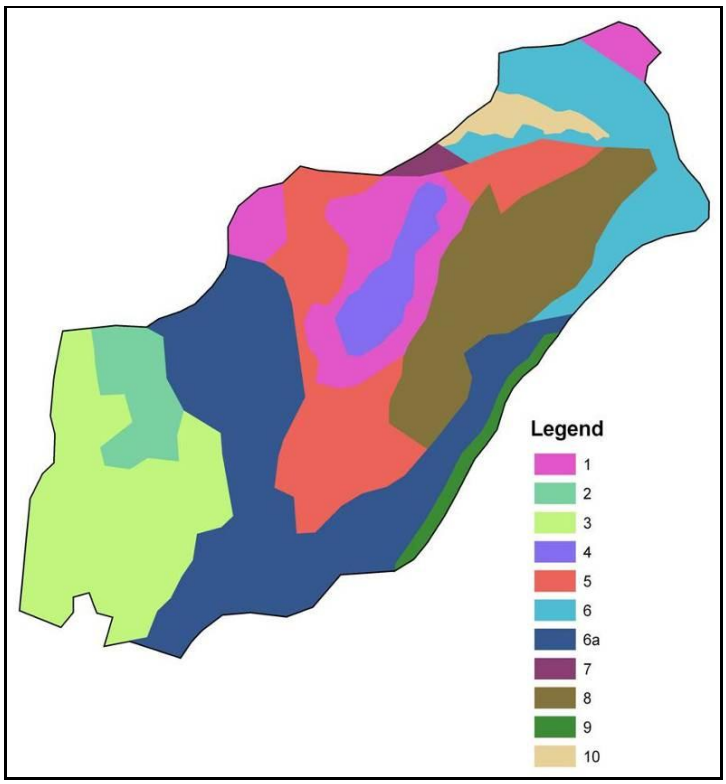

Figure 8: Landscape Types in the Cap Bon peninsula. Legend numbers follow Table 3

4.4 Pressures, impacts and risk

One of the more significant aspects of human actions, in terms of induced landscape modification, is dam construction. The construction of dams across perennial *oued* systems not only alters the hydrology and drainage configuration of an entire region, but also the pattern of water infiltration and the distribution of vegetation, as also changes in sediment conveyance and deposition. The latter will, more often than not, result in a dramatic decrease in sediment loads, which will subsequently negatively influence aeolian process on the strandline.

The fact that sediment gets entrapped behind dam constructions essentially equates with less material reaching the coast via *oued* systems that act as water run-off conduits. Thus, the offshore zone, where sand material gathers before longshore drift conveys suspended sand grains to the strandline, will become depleted of sand over the short-term. As less sand accumulates on the strandline the beach sediment budget will experience a prolonged phase of attenuation, which will consequently influence the rate of foredune build-up that is expected to decrease over time.

Long-term negative beach and dunal budgets will hence result in sediment loss and an overall sustained deficit, which will trigger off a variety of processes that will lead to accelerated erosion of coastal sands. Every beach and dunal component will experience sediment losses demonstrated by a severe loss of mass, blow-out formation and dune ridge deflation. As dunal sand is eroded away, stenotopic vegetation that thrives on this specialised environment will find survival difficult as a result of exposed root systems and will therefore begin to decline spatially along the dune lines. As floral cover decreases, more sand is blown away by the wind as stolons and other rooting systems, known for their sand stabilizing properties, wither away. Dunal vegetation is of vital importance in coastal dune formation, as plants that are adapted to thrive in these austere maritime conditions not only function to stabilize sand grains within the formation with their elaborate rooting system, but also act as an interception medium for *saltating* grains as well as those grains moving across the dune surface by *surface creep*. As this vicious circle of events comes about, more and more sand is lost consequent to accelerated erosion.

A sustained absence of terrestrial material, which would have been subsequently re-worked by marine processes and conveyed to the strandline via longshore drift, will eventually lead to beach-line retreat and dune-field attenuation. The coastal landscape will thus experience considerable physical change due to an overall collapse of morphological processes as the system becomes less dynamic; a continued lack of sand will lead to deflation of dune ridges, a change in the micro-hydrology of individual dune ridges, and, subsequently, to the consolidation of the sand, which will induce a suite of ruderal flora to colonize entire tracts in place of dunal vegetation. As this takes place, essentially two processes, independent of one another, are expected to get underway: one is that of accelerated erosion, and the other is that of rapid degradation of ecological assemblages. As indicated above, such drastic change in the dynamics of aeolian processes will bring about not only changes in the coastal landscape but also issues of a socio-economic nature as, for example, enhanced erosion of the coastline causes the abandonment of housing units constructed on sandy substrate (see below).

In addition to induced landscape change brought about by processes outlined above, dam construction itself generates two most significant changes in the landscape with which a number of pressures are associated. The first is the visual aspect through the large-scale use of reinforced concrete across perennial *oued* systems. The dam *per se* together with its ancillary

facilities and infrastructure, including the introduction of shrubbery (often using fast-growing alien species or indigenous species that are planted outside their ecological context) for landscaping and embellishment purposes, creates an immense impact upon the vista. Whereas the landscape, prior construction of the dam, would have consisted of a rural/semi-natural mosaic, the abrupt presence of a massive concrete structure jars somewhat with the surroundings. Although the dam would have been constructed for the common good of local communities, in order to provide water for domestic and agricultural uses, people living in close proximity to where the dam had been installed would have developed, over generations, a sense of belonging with which they have close, often emotional, association. Therefore, any sudden drastic modification of the terrain would, indeed, have a negative socio-cultural impact on those who have developed ‘ethnicôties with the landscape surrounding their homes.

The second major change to the landscape is the creation of an artificial body of water following completion of the dam, which, more often than not, inundates huge tracts of land, converting it into a freshwater reservoir not unlike a lake. The impact of such an undertaking is colossal and comprises an overall influence that has bearing on socio-economic aspects (due to the loss of land and sometimes housing); on the hydrology (as a result of seepage); on ecological resources (through the total obliteration of habitats and biota as a result of inundation); and, on the landscape matrix *per se* (due to a change in land-cover and land-uses). A number of such dams occur on the Cap Bon promontory.

Other major alterations and modifications to the coastal landscape occur that one can ill-afford to ignore. In particular, these include the construction of saltpans and salinas; excavation of water canals across the terrain to convey waste or excess waters to the sea as at Sebkha de Bit El Assa where a water conduit carries freshwater in addition to waste water from village to the sea; and, the formation of temporary ponds and wetlands following excavations of the land, as a result of which, ponding occurs due to the accumulation of water run-off or inundations consequent to storm surges. Of course, one should not fail to mention the immense transformation of the landscape following large-scale conversion of vast tracts into cultivated land during historical times. Perhaps the biggest land-cover change of all times was brought about by the practice of agriculture, a revolution, so to speak, that commenced some ten to twelve millennia ago and that, to some extent, is still on-going, either in terms of cultivation or pasture. As rural Third World populations grew, so did the human footprint as people sought to increase levels of production in order to feed more mouths.

In the case of Cap Bon, agriculture is predominant even if the tourism sector has grown enormously during the last decades (see below) along the littoral of the promontory. Much of the interior of Cap Bon is either agricultural (where the terrain permits such practice) or natural/semi-natural, primarily where the topography is rugged. However, some of the rolling terrain around El Haouaria is, in places, stepped (not terraced). The coast, on the other hand, comprises a mosaic of land-uses together with a number of biotopes typical of coastal regions. Depending on the topography, a substantial portion has been converted to cultivated land or developed; largish areas that are not appropriate for cultivation are utilized for pasture. Large, flat plains are mostly cultivated for cereal or extensive olive plantations; more manageable parcels of land are utilized for kitchen crops and orchards. A case in point is the coastal stretch between Nabeul and Beni Hkiar, which is quite rural in character and mainly cultivated with olives and kitchen crops. In the region between Chaabeni and Menzel Horr, where the terrain comprises a mix of terra and loamy soils, and the landscape is mostly undulating, grazing appears to be common. Evidence of grazing pressures by sheep and cattle is manifested in the

manner by which the numerous fig trees (*Ficus carica*) present are cropped at the base of the trunk and by the presence of a suite of ruderal species, notably *Diplotaxis erucoides*, among other species, which form carpets across vast tracts of trampled and grazed terrain. Areas nearby where these pressures tend to abate include the halophytic Chatt Ezzouhour, a seaward plain colonized by *Arthrocnemum macrostachyum.*

An apparent pressure on the coastal areas of the promontory is development, which manifests itself both in privately owned dwellings and extensive complexes for recreation and leisure; the latter industry is well established in Tunisia. Evidence of high density tourism development as well as closely packed domestic development close to the strandline occurs at various localities along the Cap Bon littoral. At Yasmine Hammamet, for example, an entire ócityô was erected along the sea-front. This up-market development caters mainly for the discerning European market and not only comprises 5-star arrangements for accommodation but also boasts artificial beaches and yacht marina. The sand required for nourishing the beaches was acquired from the seabed when excavation works were being carried out during the construction phase of the marine. During fieldwork related to this present assignment, it was noted that the sand had experienced consolidation (owing to the fact that its presence in the locality was only due to the intervention of human agency), as a result of a lack of aeolian dynamics, and *Cynodon dactylon* was colonizing areas were sand had eroded away and formed shallow depressions, where ponding was evident.

In Hammamet proper, where culture, fishing, habitation (both ancient and recent), tourism and embellishment-related landscaping brush shoulders, certain safe-guards are adopted, although some domestic housing units along the seafront have been constructed rather close to the shoreline. Planning considerations and policies impose minimum distance requirements of 25 metres in urban areas and 100 metres in rural regions. However, given the lie of the land in some parts of the coast, for example, where low-lying sandy pockets predominate, such policy is rendered ineffective and construction on sandy substrate will interfere with the dynamics of deposition (not to mention problems of structural instability). Such circumstances are not limited to one town or another, but are relatively quite widespread. The coast between Hammamet and Nabeul, for instance, is somewhat homogenous where coastal tourism development is concerned, as is the coastal region between Beni Hkiar and Maamoura.

Other implications, with far-reaching consequences, include the influence of climatic change that is expected to manifest itself in sea level rise, among other. According to the latest IPCC (Intergovernmental Panel on Climate Change) report, the sea level is estimated to rise between 28 centimetres and 43 centimetres (even if previous estimates anticipated a rise of up to a metre). Sea level rise will in actual fact threaten low-lying areas of the Mediterranean and all those regions within Cap Bon that have, over the last decades, experienced construction close to shore, primarily on sandy areas and wetlands (as is evidenced in Soliman and its surroundings), will be among the first to be subjected to the influence of accelerated erosion by the sea.

Another human activity which exerts a negative impact upon the landscape, both visually and for physical reasons outlined below, is the disposal of domestic waste and building debris. Undoubtedly, the footprint of a specific site used for waste disposal encroaches upon coastal habitats, replacing ecological communities and geomorphological entities with homogenised and generally unstable substrate that does little to sustain complex ecological assemblages. As the waste footprint increases, further obliteration and/or degradation and displacement of species occurs as it promotes the replacement of equilibrium communities dominated by K-

strategists by transient, labile and relatively less diverse floral assemblages dominated by r-strategists. The pre-existing coastal landscape thus becomes a mosaic of remnant patches and fringes interspersed with mounds of debris colonized by weedy species. Hence, the ecotones at the boundary between mounds of domestic waste and other debris and remaining surrounding biotopes become superimposed by an opportunistic flora largely associated with disturbance and biotope degradation. Such areas and mounds of debris and waste may function as sources for colonization by invasive species, as degraded areas promote the establishment of propagule banks; adjacent relatively stable areas that harbour remnant communities of the original biotope may thus function as a relative sink.

Unconsolidated substrates and waste materials are known to generate fugitive emissions, including fine particulates that are subject to wind and water assisted transport. Although particulate emissions are expected to contribute little to landscape change, their indirect impact on adjacent habitats and agricultural land may play a role in changing the patterns of natural vegetation and land-use. As particulates enter adjacent habitats, this may induce alterations of soil *p*H levels, which in turn may influence the solubility of various nutrients and the rate at which these are absorbed by vegetation. Increased fallout of particulates may coat the photosynthetic organs of plants leading to reduced incidence of light on plant surfaces, with subsequent reductions in photosynthetic efficiency. Moreover, the inherent instability of unconsolidated material promotes high sediment loads in surface water runoff following heavy precipitation. The terminal sinks for redistributed particulates by surface runoff include the surrounding biotopes, agricultural land and the marine environment. Likewise, leaching of soluble materials contained within domestic waste sites would be expected to disperse various chemicals throughout adjacent environments, including the marine environment. As outlined above, such emissions may contribute towards changing patterns of natural and semi-natural vegetation as well as potentially lead to agricultural land abandonment, all of which will result in landscape change of one form or other.

Another form of human activity, often related to the disposal of waste, which has the potential of inducing changes in the landscape matrix, is fire. Apart from the generation of various pollutants arising from combustion and the generation of particulate and gaseous emissions that would lead to the deterioration of air quality downstream, torching of extensive tracts of terrain will destroy vegetation as well as any immobile or slow-moving fauna. Fires would also displace mobile fauna due to localised increase in temperature and decrease in oxygen concentrations, as well as generate ash deposits that may influence soil quality.

Associated with waste, but generated from ships, is the issue of flotsam. Ship-generated garbage, consisting mostly of plastics and other synthetic materials (including bits of nylon rope and polystyrene) in addition to naphtha, is another element that requires careful consideration both in terms of visual impact and direct harm to fauna at sea and on the coast. Marine turtles in particular are frequent victims (through entanglement with fishing lines and nylon ropes or by swallowing polythene bags that are mistaken for food sources), while numerous species of vertebrates and invertebrates foraging on beaches and coastal dunes are known to become entrapped in plastic containers washed ashore. Although the presence of flotsam was not observed to be acute along the Cap Bon coastal region during the time of survey, other locations in Tunisia, such as Zouaraa and Berkoukech, on the north-eastern coast, are extensively affected. These sites are subject to on-going beach-dune erosion research and have been visited on a regular basis for the last seven years, where it was noted that ship-generated waste, regrettably, forms part of the coastal landscape of these areas in view of the

vast quantity of plastics washed ashore and carried considerable distances inland by storm surges.

Another human activity that has led to a change in the landscape is afforestation, that is, the establishment of plantations of varying dimension across tracts of terrain throughout the country. The Cap Bon promontory has not been spared in this regard and much of the area known as Dar Chichou has been planted extensively mainly with eucalyptus trees, pines and cypress trees. As indicated above, Dar Chichou is rather important as a staging point during the annual spring avian passage, as raptors among other groups converge on the promontory prior to cross the Siculo-Tunisian Channel towards Monte Ciccia in Sicily. From that point of view, therefore, there is no doubt that the planted woodland is of little importance. However, in view of the fact that many of the species used are either not indigenous or have not been planted in ecological context, the presence of such species of trees is expected to have an impact on the terrain, both on the micro-scale and on the landscape scale. In particular, as these trees shed their resinous leaves, the chemical properties of the surrounding top soil are expected to alter, consequently inhibiting the growth of any native understory vegetation and the natural development and regeneration of appropriate local biotopes that would have colonized the landscapes in the region.

4.5 Recommendations

This section provides with recommendations for the protection and development of the specific landscape types as identified in this report and summarised in Table 3. It is important to recognise that these recommendations deal with landscape components that are inter-linked and inter-related. Recommendations relating to one landscape component may have impacts on other landscape elements. Thus, for instance, allowing the abandonment of agricultural land in order to provide areas for re-colonisation by indigenous species and habitat restoration, may have impacts in terms of displaced rural populations and hence, urbanisation due to resettlement in urban areas. The recommendations below should therefore be holistically addressed and implemented through strategic planning at a regional or national level, with subsequent plans at the local scale.

4.5.1 Grazing (Landscape Types 1, 7, 8,10)

- Grazing is an integral part of the Mediterranean landscape, and has been a key element in the formation of cultural landscapes over time. It is also of considerable socio-economic significance in certain areas, even today. Any restrictions on grazing should therefore be accompanied by adequate measures at the strategic level to ensure minimal social, economic and cultural impacts, notwithstanding that such initiatives would be difficult to implement. Such measures could include the provision of alternative economic incentives or the provision of alternate sources of income and resources.
- Designate appropriate areas where grazing may be permitted through specific zoning plans coupled with a two-pronged effort that focuses on environmental education and surveillance/enforcement. Such zoning plan would delineate areas of ecological/cultural importance where grazing activity should be restricted and other areas of lesser importance where grazing may be permitted but its effects monitored.

4.5.2 Urbanisation *(Landscape Types 2, 6)*

- Conduct a baseline study to identify ecologically important biotopes as well as any areas that may harbour assets of cultural significance and determine how best such resources may be

protected and conserved through the setting up of appropriate policies that ensure long-term adherence of conservation measures.

- Control excessive construction and restrict such activity to those areas designated for development according to existing coastal management/local plan policies to ensure the conservation of coastal biotopes such as wetlands and sand dunes, as well as their adjoining landscapes which, more often than not, harbour cultural assets that include ancient fishing ports, coastal fortifications, walled cities including medinas and other coastal settlements, marabouts, amongst others.
- Develop a conservation-friendly culture through environmental education, which would promote a view of land as more than an economic resource to be developed, but as a holistic entity, the Mediterranean landscape, which is also important for a variety of non-economic purposes, not least a better quality of life for local inhabitants and an attraction typical of the region for visitors.
- Where constructions in undeveloped areas cannot be avoided for social and infrastructural reasons, all efforts should be made to ensure that such development has as restricted a footprint as possible and a contained negative influence on its surrounding landscapes, is constructed in a sensitive manner and seeks to mitigate all negative impacts.
- Efforts should be made to safeguard against the development of shanty towns and other slum settlements, given that due to inadequate infrastructure including waste disposal facilities, these have a disproportionate negative impact on the natural and cultural landscape, as well as considerable negative social and cultural impacts. Shanty towns may also have significant spill-over effects on surrounding areas.

4.5.3 Agriculture (Landscape Types 6, 7, 8, 10)

- Agriculture in the Mediterranean region is characterised by two contrasting trends: intensification of agricultural production, particularly in areas of population growth, and land abandonment in more marginal areas. The former is often accompanied by increased use of agricultural chemicals, including herbicides, pesticides and fertilisers. These have extensive and proven impacts on a variety of ecological components (to the detriment of some species and to the advantage of others), on hydrological systems (both freshwater and marine), and on human health. Wherever possible, the increased use of chemicals should be discouraged and more organic forms of agriculture promoted, if necessary through strategic incentives and disincentives.
- Agricultural intensification may also lead to freshwater pollution through over-abstraction of water for irrigation. In coastal areas this may lead to intrusion of saline water into freshwater aquifers, leading to an often irreversible decline in water quality. Water abstraction should therefore be strictly controlled and monitored while all necessary measures to ensure efficient use of water should be implemented. In particular, losses through evaporation and runoff should be minimised. Water quality in freshwater aquifers should also be regularly monitored.
- Land abandonment in more marginal areas may be seen as having both positive and negative impacts. On the one hand, it leads to degradation of distinctive cultural landscapes with aesthetic, social and cultural impacts, often accompanied by environmental impacts including soil erosion, rilling and gullying. On the other hand, the abandonment of cultivation allows regeneration and secondary succession to take place, providing valuable areas of semi-natural habitats. A strategy to address land abandonment must therefore be based on

a holistic assessment aimed at identifying areas where abandonment should be discouraged (through a suite of incentives) in order to ensure the preservation of cultural landscapes and livelihoods, and other areas, particularly those close to adjoining natural habitats, where abandoned land can be colonised by a variety of species and assemblages. In the latter case, initiatives may also include the promotion of habitat restoration and re-creation through the use of indigenous species planted in ecological context. Species utilised should include those that form a canopy as well as those that form an accompanying understorey floral stratum.

4.5.4 Landfill (Landscape Types 6a, 9)

- The impacts of landfills are several and include: i) land-take and visual impacts, ii) contamination of environmental components, including soil, air, and water resources (notably perched aquifers, wetlands and seas as well as leachates into aquifers and contaminated runoff). Landfills are generally also unsustainable in terms of resource use and may lead to the proliferation of invasive weedy flora and vermin. It is therefore recommended that a general strategy be developed to encourage waste reduction, reuse and recycling, and to ensure that waste disposal facilities have minimal impacts on landscape and the environment in general. Where landfills cannot be avoided, these should be stringently managed and engineered to ensure that contaminants are contained and that impacts are hence restricted to the landfill site. The visual aspects of landfills can be addressed, to some degree, through sensitive landscaping and screening. The use of indigenous vegetation is therefore recommended to ensure blending with the environmental context.

4.5.5 Tourism (Landscape Type 6a)

- Whilst it is recognised that tourism is vital to the economy of many Mediterranean nations, the industry also has several conspicuous impacts on landscape. The construction of facilities and infrastructure in particular, has been a key component of coastal urbanisation, and recent trends towards addressing specific tourism niches (such as golf-related tourism), have resulted in considerable negative impacts on the cultural Mediterranean landscape (together with a suite of negative environmental impacts). Achieving a balance between the economic necessity of tourism for many countries, and the safeguarding of resources which attract tourists in the first place, is no mean feat and necessitates strategic planning at the national level. This should be based on a philosophy that sees the safeguarding of resources and the growth of tourism as complementary rather than contradictory. Any tourism development that is not based on a sustainable view of resource use will inevitably have a limited life-time and will not be financially viable in the long term. This is particularly the case given shifts in tourism flows at an international level and the opening up of markets in other areas of the world which are now competing with the traditional ósun, sea and sandô tourism of the Mediterranean region. If the tourism product in the Mediterranean is degraded due to unsustainable resource use, the tourist now has alternative markets which can accommodate oneôs demands. Mediterranean countries must therefore seek to diversify their tourism product and to market elements which are specifically related to the Mediterranean, such as the considerable and unique natural and cultural heritage of the region. Moves towards eco-tourism, nature tourism and cultural tourism are therefore important in this regard and should be actively encouraged. The development of a master

plan at a national level is therefore recommended. Furthermore, such a master plan should be part of a regionally coordinated strategy across the Mediterranean basin.

- All tourism-related infrastructure and activities should be developed in a manner that is sensitive to the cultural and natural context. The proliferation of tourism-related constructions that have no link with a country's identity (and that could effectively be located anywhere in the world) is of great concern, and in the long run, serves to undermine the viability of the tourism product. Similarly, the promulgation of activities which result in degradation of natural resources, or which are insensitive to the cultural context, will inevitably be short-lived, either due to the degradation of the product being marketed, or due to antagonistic relations with local inhabitants. Any tourism developments should therefore be rigorously assessed and subject to environmental impact assessments (EIAs) and social impact assessments (SIAs), which should, amongst other things, identify exhaustive mitigation measures for any negative impacts identified. The refusal of permission for tourism developments (zero-option) should also be actively considered in particularly cases, particularly where such developments will impact more pristine areas or where they may lead to sprawl and the growth of resorts that would lead to the further degradation of coastal landscapes. It should also be borne in mind that some categories of tourists actively seek out more remote areas of a country and that the development of resorts and tourist complexes, whilst possibly attracting some groups of tourists, will also result in the loss of other groups. The growth of such resort areas should also be contained due to the variety of negative impacts that these have on landscapes and the environment in general.

*4.5.6 **Recreational activities** (Landscape Type 9)*

- Some recreational activities, particularly those based around natural resources, can have considerable impacts on coastal landscapes. In the Cap Bon area, these include bathing and sea-sports, with associated facilities and infrastructure, as is common in most Mediterranean coastal regions. The recommendations made above with regard to tourism facilities and infrastructure are also relevant to other recreational facilities. Furthermore, specific coastal areas of particular value (such as wetlands) should be safeguarded from recreational activities. Alternatively, limited recreational activities may be allowed provided that these are not accompanied by the widespread development of facilities and infrastructure. Any facilities developed in protected areas should be limited in footprint and impact, and should as far as possible be completely reversible.

*4.5.7 **Fire** (Landscape Type 10)*

- Fire has a long history in Mediterranean landscapes and may be considered to be an integral process in the evolution of cultural landscapes. Fires occur naturally in the Mediterranean climate. Aside from naturally occurring fires, however, fire may also result from a variety of anthropogenic activities/processes, such as landfills, burning of vegetation for agricultural purposes, and deliberate actions such as arson. Particularly given climate change and predictions that the Mediterranean region will become drier, fire is increasingly a threat and deliberately set fires may easily spread out of control and result in the destruction of expanses of natural vegetation. Recommendations therefore include the strict control of activities that may lead to fire, primarily during drier months in areas where seasonal vegetation (e.g. grasses) is dry and prone to fire. This should also be accompanied by widespread educational campaigns and strict monitoring and surveillance.

4.5.8 Planting of/displacement by alien species *(Landscape Type 9)*

- The concept of õMediterraneanismô has for centuries been conceptually linked to an identity based on particular floral species such as the olive (*Olea europaea*) and the lentisk (*Pistacia lentiscus*). Whilst such species are still widespread in the Mediterranean (e.g. *Olea europaea* in the Sahel region of Tunisia), a number of alien species are increasingly becoming dominant elements in the landscape. Some of these were deliberately introduced/are deliberately planted due to specific properties they harbour, whilst others were accidentally introduced or were introduced as ornamental species which subsequently escaped into the wild. An example of the former is the use of *Acacia* species in much of Tunisia; its properties as a relatively fast-growing species have resulted in its use in kilns for the generation of charcoal, and thus to the widespread planting of *Acacia* in several rural areas. Such plantations inevitably occupy a footprint that would otherwise be utilised by native indigenous species. At the same time, however, *Acacia* cannot be easily replaced by indigenous species, and it serves an important social and economic function. It is therefore recommended that areas of such plantations are contained, particularly in ecologically sensitive areas. Plantations can also be surrounded by a band of indigenous species, to ensure better blending with the ecological and landscape context.

4.5.9 Dune destruction *(Landscape Types 9, 10)*

- Coastal dunes represent one of the most threatened habitats in the Mediterranean. Sand dune systems in the region also form an integral part of the Mediterranean coastal landscape. They are severely limited in extent and harbour species, many of which are threatened, which are not found in other ecosystems in view of their specialist nature. Dune dynamics are also dependent on sediment systems across large watersheds, and the health of dunal ecosystems is therefore linked to activities occurring in areas much larger than the limits of the dunal habitat. This latter fact has been the prime cause of dunal degradation, as activities in the hinterland have increasingly limited water and sediment flows from inland to marine areas, resulting in less sediment being available for dunal processes and thus to negative sediment budgets and ultimately to beach erosion. Damming of river systems, in particular, has had a significant impact on dunal systems, as sediment is trapped behind dams and processes of siltation occur; not only is less sediment available for dunal systems, but water with a lower sediment load is also generally more erosive. The mitigation of such impacts is difficult, particularly where dams are large scale and of great importance for water harvesting and storage. Wherever it is possible to develop engineering measures to allow for the flow of sediments through dams, these should be implemented. Furthermore, the importance and vulnerability of dunal ecosystems should be recognised and these should be protected; protection should extend beyond the immediate boundaries of the dunal area to incorporate the watershed influencing dunal dynamics.

5. The need for a coastal landscape conservation strategy

5.1 Developing a policy framework – the notion of protected landscapes

There is widespread recognition regarding the necessity to extend the reserve-based approach to enhance conservation through the management of the whole landscape, since the maintenance of ecological processes does not depend solely on tracts of land dedicated to conservation, but also on surrounding areas. An integrated landscape approach is appropriate in situations where protected areas are spatially sparse or relatively small and therefore inadequate in guaranteeing effective long-term conservation. This is particularly relevant where human population density is high, where land-use is dominated by urbanization and agriculture, and where the pressures on already dwindling natural habitats are intense. In such a scenario, conservation will essentially depend on the capacity to afford protection to species within cultural environments. The challenge, therefore, is to integrate biodiversity conservation with the sustainable management of land and its resources. Planning at broad spatial scales for conservation is an essential aspect of an integrated landscape approach since the principle goal is to achieve conservation aims within the context of a mosaic of land-uses. The imposition of a planning regime will bring about a strategic, forward-looking approach to conservation, as opposed to the reactive response to managing land-use. A broad landscape-scale perspective is fundamental for the planning process to take into account the wider ecological and cultural processes that shape and alter the environment in a given area such as Cap Bon and other similar location in the Mediterranean.

In order to deal with the various constraints that arise from the loss and fragmentation of landscapes and habitats, a number of actions may be considered, essentially as a response to restore connectivity (linkages through aspects of wildlife corridors) and enhance nature conservation, principally through the notion of protected landscapes. The issue pertaining to the role of connectivity in conservation planning and strategy is central to the concept of protected landscapes and needs to be addressed at policy framework level. The recommended responses below primarily aim to improve the conservation potential of individual habitats without, however, straying from the significance of utilising linkages within a concept of protected landscapes. These are:

- *Enlarge the extent and range of protected areas and declare and/or restore other adjoining or nearby tracts with existing potential. Substantially larger tracts of habitat are more likely to support self-sustaining populations of flora and fauna (Bennett 1999).* Increased habitat extent also enables an area to maintain greater species richness, support fuller assemblages and communities, and sustain ecological processes (Forman 1995). Protected areas should not be isolated from their surrounding landscapes, nor from surrounding land-uses. Indeed, one should be promoting protected landscapes that form an integral part of a wider matrix that includes nature, a semi-natural topography and a significant cultural dimension, which harbours activities that are both conducive to conservation, like some aspects of agricultural activities, e.g., retaining terraces and rubble walls, planting of archaeophytes, organic farming, etc., and some undeniably quite harmful, such as activities and development which lead to fragmentation, quarrying, uncontrolled use of pesticides, hunting and trapping, grazing, etc.

  Sites that are declared conservation areas are subject to a suite of pressures and impacts from their surroundings because of the spill-over effects of human activities. Moreover,

protected areas rarely provide a balanced representation of ecological assets within a region. It is often argued that such areas were only set aside because, in the past, these were found or perceived to be least productive agriculturally or for some reason inaccessible for other economic or domestic activities. Hence, it is crucial to designate or design linkages that permit connectivity that is physical and as direct as possible between different important habitats and adjacent areas that serve as buffers, and, where this is not viable, restore or create habitat that would, as a minimum, provide a stepping stone effect within the landscape matrix.

- *Enhance the quality of existing habitats by allowing natural processes to go on, concurrently ensuring adequate protection measures accompanied by satisfactory enforcement.* It is an accepted reality within the Mediterranean Basin that semi-natural landscapes are, more often than not, subjected to multiple uses, where nature conservation objectives need to be weighed against other, often conflicting, land-use intentions. Controls on land-uses to minimize environmental degradation are a necessity, especially where anthropic activities threaten to irreversibly alter a landscape or reduce its sustainability. In such cases, consideration of trade-offs may sometimes be necessary.
- *Contain anthropogenic impacts from surrounding areas and land-uses.* Anthropic activities are a source of major impact on ecological assets, especially where landscapes are heavily fragmented. A range of actions such as **micro-scale zoning** to control certain activities and land-uses near important habitats and communities as well as the setting up of **buffer zones** to minimize impacts and pressures from external factors, coupled by **management and monitoring programmes**, would help counter some of the effects caused by external disturbances.
- *Promote and maintain connectivity to counter the influence of habitat isolation.* The benefits of linkages are numerous since these assist movement and dispersal *(a)* during migration and for everyday life cycle requirements; *(b)* between fragments across inhospitable environments; and *(c)* that create opportunities for re-colonization following local extinction. Connectivity also assists in the maintenance of biological processes, in particular those that depend on animal vectors such as seed dispersal, pollination and predation. The concept of a linked system of habitats and landscapes should be seen in the context of an integrated approach to nature protection since multiple tracts of habitat that function as an interacting system are a more effective means of conservation than a similar but isolated set of habitat tracts (Bennett 1999).

In summary, the conventional approach to conservation has, for years, been based on the selection and management of sites as protected areas of one form or other. These areas normally fall within categories in which the conservation of nature is given high priority or in which conservation aims need to be balanced with various forms of land-use, on occasion even incompatible with conservation. Typically, the pattern of such protected areas is that of stand-alone, very often scattered, land parcels that represent a range of different communities and ecosystems. There has been a growing concern among conservation biologists that, on its own, protected area-based strategy will not suffice to ensure long-term conservation needs of biota and their habitats. The way forward, therefore, should be three-pronged:

- to increase the number and spatial extent of protected areas;
- to recognise the urgency to extend conservation boundaries with a view to include entire landscapes, embracing both natural/semi-natural and cultural elements; and

- to ensure connectivity through a system of linked habitats and, where this is impractical due to distance or fragmentation, then restoration and/or habitat creation may need to be considered so as to secure some form of linkage.

Such strategy applies wherever human pressures have negatively impacted landscapes and the environment in general. Finally, it is augured that the concept of protected landscapes emerges as an ideal management framework; this is due to the fact that this management approach includes the human dimension as an essential part of an integrated system, with socio-economic and cultural concerns placed on a level footing with biodiversity conservation. The notion of protected landscapes brings conservation into the social arena because it specifically allows for human uses. In line with changes in the paradigm of protected areas, protected landscapes aim to protect ófor ô and ówith ôpeople. As a result, the concept offers a middle ground between conservation and development, providing a means for protecting biodiversity elements within a setting which also provides for sustainable livelihoods.

6. Conclusions

The coastal landscapes of Tunisia are faced with increasing human-induced pressures including population increase, overgrazing and tourism development, as demonstrated by the review presented herein. These problems, combined with lack of public awareness, political commitment (demonstrated by inadequacy of legislation and/or ineffective enforcement) and inter-sectoral co-operation, hinder the protection and sustainable planning of natural and cultural landscapes. In Europe an analysis of the existing monitoring programmes at national level shows that Landscape Character Assessment (LCA) has become an important tool for conceptualising and integrating spatially a range of factors that influence the state and trend of terrestrial ecosystems. LCA is a set of tools considered to be scientifically sound, region-specific and stakeholder-orientated, and designed to describe landscape character. The development of landscape typologies provides the spatial framework for monitoring ecological processes but also for the derivation of sustainability indicators.

An important question to address in landscape planning is how a landscape can accommodate change. Some landscapes are inherently sensitive whilst others may only be sensitive to a specific external pressure. Landscape typology allows the assessment of the sensitivity of the landscape to a particular type of change or development. The use of GIS technology enables data integration, increasing detail and efficiency in environmental resource inventory and analysis. Landscape typology provides the spatial framework for making judgements about the relative sensitivity of different types of landscape, their current condition and their vulnerability to change. This includes historical and aesthetic properties of a landscape as well as ecological characteristics.

National or regional policy objectives, which might be relevant for the use of LCA span a range of sectors such as agriculture, tourism, landscape protection etc. For example, in agriculture, the preservation of landscape character can be achieved through improving land-use or through promoting better practices that take into account the natural and cultural environment. Spatial and rural development planning should take into account regional identities and should limit expansion of settlements where necessary.

The success of an LCA depends on the quality of the datasets available. A previous study on Mediterranean landscapes (Vogiatzakis *et al*. 2005) has confirmed the lack of truly Mediterranean datasets. In the case of Tunisia, the datasets used exhibit high diversity in terms of quality and resolution. The preliminary research in Tunisia revealed that (free-readily accessible) thematic data resources with a high spatial accuracy are not widely available. However, and despite the difficulties in using these data, the need for clearly demonstrating (as this is a demonstration project-knowledge transfer) the LCA methodology to Tunisian partners overrides such concerns. When better digital datasets become available they can be used following the suggested methodology to improve landscape typology and mapping. Landscape Character Assessment as demonstrated herein is a powerful tool that can provide an important strategic overview within which to develop policies for a multifunctional landscape in which the conflicting demands of agriculture, development, recreation and nature conservation need to be resolved.

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Annex: Photos

Section A: Landscapes

(i) Examples of coastal Tunisian landscapes

Photo 1: Dunal landscape at Berkoukech.

Photo 2: General view of the dune field at Berkoukech on the north-west coast of Tunisia, illustrating dunal re-orientation as a result of changes in sediment fluxes.

Photo 3: Coastal mosaic on the north-west coast of Tunisia at Bouterfess, illustrating perennial fluvial source, consolidated dune, estuary and pasture.

(ii) Coastal landscapes at Cap Bon

Photo 4: Coastal landscape north of El Haouaria.

Photo 5: Rural landscape at El Haouaria comprising fallow agricultural land used for pasture, with palmetto brush community dominated by *Chamaerops humilis* on the outcrop in the background.

Photo 6: The coastal medina at Hammamet, a locality of cultural value constructed in historic times.

Photo 7: General view of Yasmin Hammamet: an upmarket large-scale development on the coast.

Photo 8: One of the numerous ecologically important wetland areas on the Cap Bon promontory. Such wetlands are important for avifauna, such as this wintering flock of flamingoes.

Photo 9: Agricultural landscape north of Nabeul, extending virtually to the shoreline.

Photo 10: Coastal mosaic: a landscape comprising sandy beach and dunes, semi-natural maquis, and planted pines, with pasture in the foreground.


Photo 11: Cultural heritage - ancient rural units alongside a culturally important grove of *Olea europaea oleaster*.


Photo 12: General landscape view of the coastal area at Korbus.


Photo 13: Extensive coastal dune landscape at Rtiba. A large plantation occurs on the consolidated region of this dune, which makes dunal development inland improbable.

Photo 14: Rural landscapes with high technology: wind farms installed on agricultural land at Cap Bon.

Photo 15: A view of the foredune at Hammam Laghzaz, where large dune formations occur, along with a series of extensive sebkhas.

Section B: Pressures, Impacts and Risks

(i) General Examples

Photo 16: Using brushwood to stabilize sand. The practice increases the risk of fire and also changes the microclimate on dune crests, apart from impeding the natural movement of sand.

Photo 17: Loss of agricultural land as a result of an artificial floodplain created following the construction of a dam at Zouaraa.

Photo 18: Acacia plantation on the consolidated dunes at Zouraa (north-west Tunisia).

Photo 19: Ship-generated waste: flotsam beached at Berkoukech (left) and Zouaraa (right).

Photo 20: *Carpobrotus edulis*, a prolific alien that is known to displace indigenous dunal vegetation on this important biotope.

Photo 21: The effects of accelerated beach erosion at Zouaraa, leading to strandline retreat and loss of sand material throughout the system, including beach and dunes.

(ii) Pressures, impacts and risk at Cap Bon

Photo 22: Upmarket tourist destination at Yasmin Hammamet. Note the promenade abutting the beach, and the close proximity of urban development immediately adjacent. The impacts on beach dynamics are evident.

Photo 23: Housing units constructed on the dunes. Not an uncommon sight throughout the coastal region between Hammamet and Korba. Apart from structural instability, this practice impedes dunal development.

Photo 24: Urbanisation encroaching upon the beach zone. This is a relatively common occurrence throughout the Cap Bon promontory. The use of the invasive *Agave* in this locality is evident.

Photo 25: Threat to wetlands. Urban dwellings encroaching upon the immediate banks of coastal wetlands on the Cap Bon promontory.

Photo 26: Expanding urban footprint around the coastal citadel of Kelibia, steadily encroaching upon agricultural land.

Photo 27: Hard landscaping, housing and infrastructure encroaching upon much of the coastal region at Kelibia.

Photo 28: Urban footprint encroaching on the shoreline and practically surrounding the coastal marsh at Kelibia. No doubt the ever-growing urban footprint will have a negative impact on the watershed of the wetland.

Photo 29: Urban belt around the foot of the Citadel of Kelibia. The urban footprint is increasingly spreading laterally along the coast, particularly given that the land area between the citadel and the shore is limited.

Photo 30: Hard landscaping on sandy substrates, a common occurrence in and around the coastal town of Soliman.

Photo 31: What future? Erosion collapse and instability of sandy substrates, where housing units were constructed on beaches at Soliman.

Photo 32: As the urban footprint expands at Soliman, dunal and wetland features decline. Much of the town that stands immediately adjacent to the strandline has been constructed on marshes and sandy beaches.

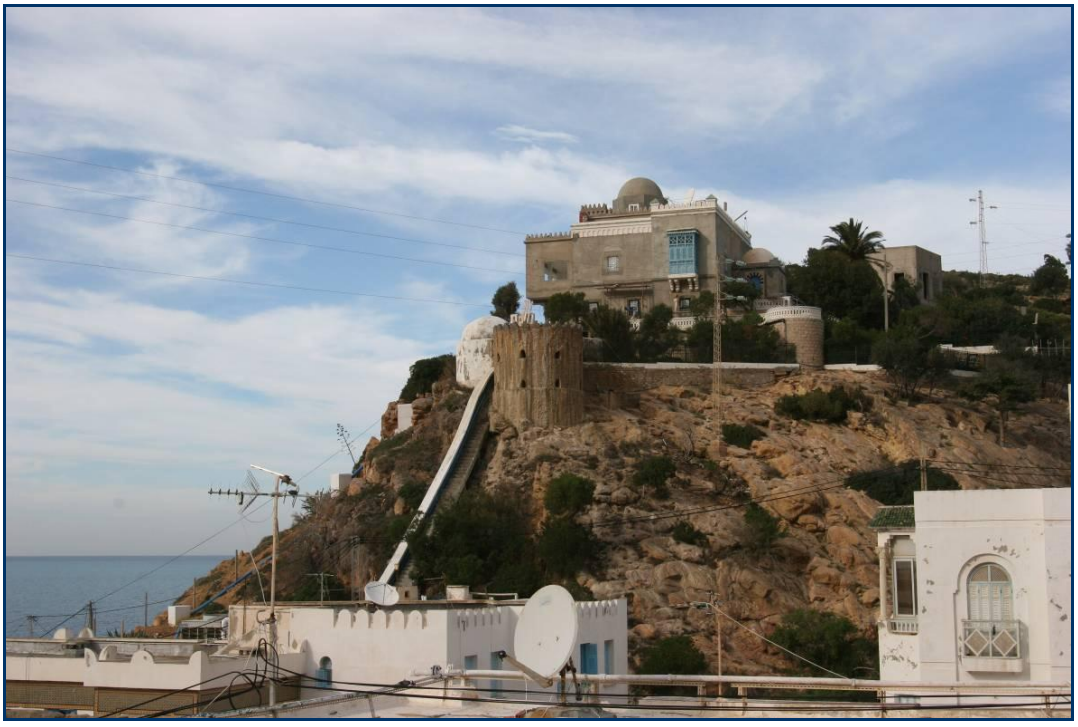

Photo 33: Extensive use of concrete in coastal localities near Korbus.

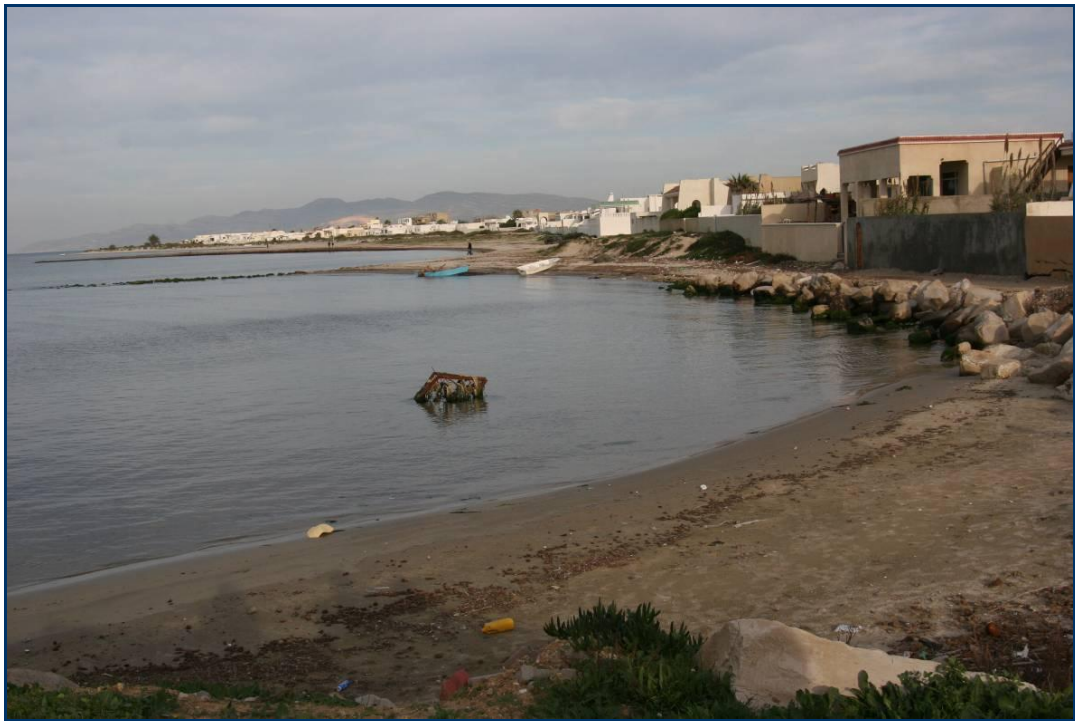

Photo 34: The effect of beach erosion: housing units practically on the waterôs edge as a result of accelerated erosion.

Photo 35: Land take: competition between coastal urban development and agriculture.