MEDITERRANEAN COASTAL LANDSCAPES

Management Practices, Typology and Sustainability

FINAL REPORT

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Executive Summary

During the last twenty years there has been recognition that a landscape scale approach is fundamental to the understanding of ecological processes. The landscape scale is considered to be the appropriate spatial framework for the analysis of sustainability. As a result landscape approaches have been adopted by international and national organisations to summarise pressures and threats and develop policies for sustainability.

This shift towards these approaches has prompted the development of landscape typologies at the regional, national and European scales. Despite the widespread development and application of landscape typologies in a number of European countries, there has been no specific attempt to develop a methodology specifically for the Mediterranean region.

Mediterranean coastal landscapes are ecologically and culturally diverse, characterised by a wider range of natural environments and historical influences. As a result, many of these landscapes are extremely sensitive and vulnerable to a range of pressures, especially the infrastructure development associated with modern tourism. The result is that the long-term sustainability of many coastal Mediterranean areas cannot be assured, requiring the development of techniques and policies that can provide the framework for conservation and sustainability efforts in these landscapes.

The aim of the project is to establish a typology of Mediterranean coastal landscapes based upon the available spatial environmental data. It is intended that the resulting typology will provide the context for the derivation of sustainability indicators (SIs) in coastal landscapes.

This report presents the overall approach, including a description of the available data sets and techniques to develop a typology of Mediterranean coastal landscapes. The results demonstrate that spatial environmental data can be used to group Mediterranean coastal landscapes into discrete, landscape types based on both natural and cultural attributes. The report evaluates the proposed methodology, assessing its value for providing the spatial context within which to derive sustainability indicators.

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1. Introduction

The Mediterranean

The Mediterranean sea is one of the world's largest semi-enclosed seas covering an area of 2,542,000 km^2 with a coastline of 46,000km (Grennon and Batiste 1989). The Mediterranean Basin is a tectonically active area which lies in the collision zone between Africa and Europe (Figure 1) and can be separated into two major basins, the eastern and western (Dardis and Smith 1997). The Mediterranean Basin has been a crossroad and confrontation of phylogenetic lines and cultures through the centuries, resulting in great spatial and temporal heterogeneity (Di Castri, 1981). It is marked by young orogenic systems exhibiting high, rugged and faulted mountains. The Mediterranean climate is characterised by hot dry summers and mild winters which give rise to a typical evergreen sclerophyllous vegetation on predominantly young limestone rocks. The area is characterised by a striking floristic, faunistic and landscape diversity, as well as scenic attractiveness. The Mediterranean region has one of the world's highest number of plant species and levels of endemism. Mediterranean landscapes have been shaped by natural disturbance and intense human impacts from early times to the present (Allen 2003). This has resulted in a wide diversity of landscapes along a gradient of human impacts from relatively untouched and natural to highly modified and threatened.

The coastal zone of the Mediterranean, in particular, suffers from increasing pressure. Many major cities and ports are located along the coast with much industrial and tourist development taking place. It is estimated that 50-70% of the population in Mediterranean countries live within 60 km of the coast and this proportion is increasing (Caffyn *et al*. 2002). Other pressures that have become more intense in recent years include intensification of agriculture, pollution and the introduction of alien species (Grenon & Batisse 1989; Di Castri *et al.* 1990). The latter carries great risks to natural ecosystems and resources. In particular, afforestation with alien species has caused problems to dune habitats.

What is a coastal landscape?

In the last 20 years there has been a paradigm shift from site-based wildlife conservation to a recognition that effective protection needs to operate at the broader landscape scale. Organisations such as UNESCO, IUCN, Council of Europe (Council of Europe et al. 1996; 2000) have been advocating either directly or indirectly, the adoption of such an approach worldwide. Landscape as defined by Forman and Godron (1986) is a mosaic of "interacting ecosystems". However, the term has many components including visual, political, socio-economic and cultural. Therefore, the broad concept of 'landscape', encompasses both natural and cultural elements i.e. the natural landscape is the fabric that integrates settlement, agriculture and ecology.

The term coastal landscape implies a relationship between land and sea. Some units in these landscapes such as beaches or rocky islands are defined by both sea and land while others such as mud flats and salt marshes exist somewhere between land and sea. Therefore, in order to adequately define coastal landscapes, we must define the complex elements that give this specific physiognomy to the zone where land and sea interact. The recent draft ICAM protocol (UNEP/MAP 2005) defines as coastal zone:

> *"……. the geomorphological area either side of the seashore in which the interaction between the maritime and land parts occurs in the form of complex ecological systems made up of biotic and abiotic components, living space for human communities and their socio-economic activities;"*

Coastal Mediterranean Landscapes

There is no commonly accepted delineation of the Mediterranean region. Various delineations have been used in the past depending on the nature of the study involved. For example, the *Blue Plan* delineation was based on administrative territorial units located by the coast (Grenon & Batisse 1989).

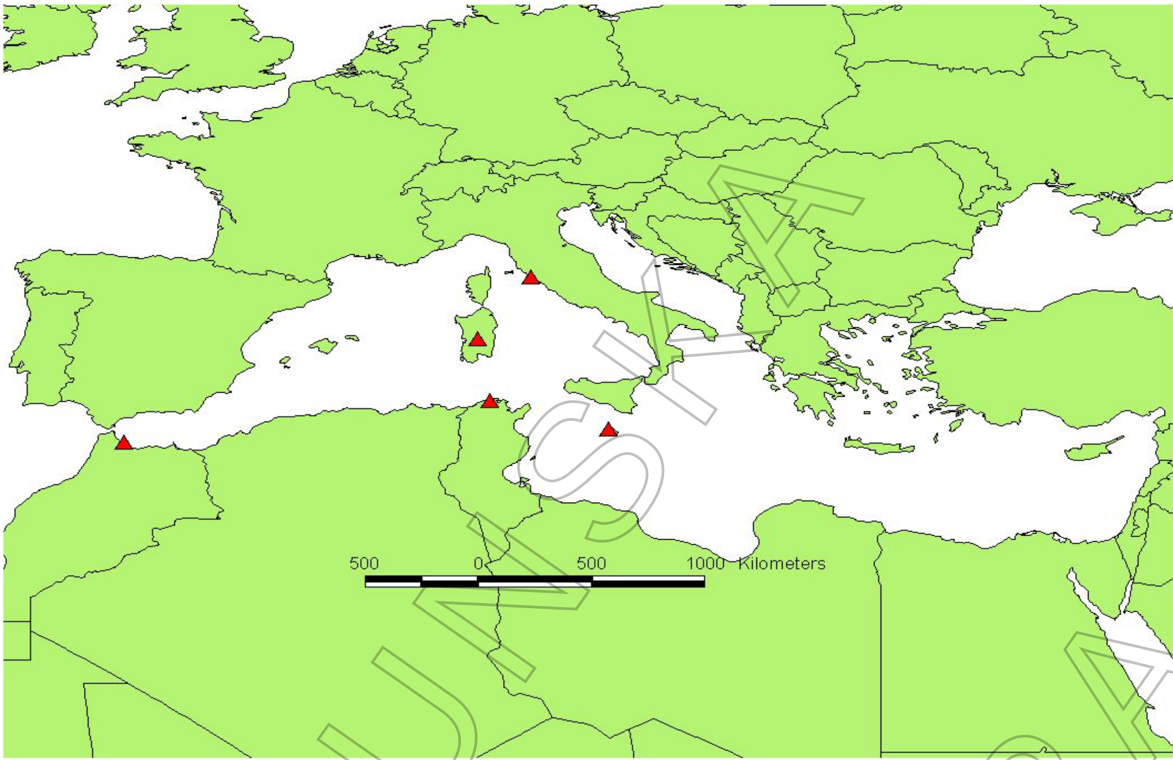


Figure 1. The Mediterranean Basins and the study sites described in this document

Nevertheless, it is known that 70 to 75 percent of the Mediterranean coastline is rocky (Dardis and Smith 1997) and displays a high diversity of habitats including sandy beaches, sekhbas, salt marshes, coastal plains, deltas but also the cultural imprint of former civilisations such as Greek, Roman and Arabic (UNEP/MAP/PAP 2001).

Since beaches are the recipients of much human pressure throughout the history of the Mediterranean, they have traditionally been the focus of scientific research. However, the notion of a coastal landscape goes beyond the limits of the coast. Coastal zones usually comprise a combination of high human population density, overlapping sectors and different interests, with intensive use of space and natural resources. These zones are influenced by inland processes, often at the scale of the river catchment, for example the Aswan High Dam which has affected the coastal region near Alexandria, Egypt. In addition the influence of activities/management goes beyond these zones affecting directly or indirectly the marine environment and its biodiversity. Therefore, they are extremely sensitive and subject to an increased degree of threat. Coastal landscapes throughout the Mediterranean are an important cultural and economic resource. They represent the wealth of natural and human history and, as such, are a cultural artefact worthy of preservation.

According to the draft ICAM protocol (UNEP/MAP 2005) there are two limits of the coastal zone:

(a) the seaward limit of the coastal zone shall be the external limit of the territorial waters of States Parties;
(b) the landward limit of the coastal zone shall be the territorial limit of local coastal administrative units.

Nevertheless, the protocol leaves lots of flexibility to the Mediterranean Countries for the delineation of those zones (UNEP/MAP 2005):

"If, within the confines of its jurisdiction, a State Party decides to establish limits different from those envisaged in paragraph 1 of this Article, it shall communicate a declaration to the

Depositary at the time of the deposit of its instrument of ratification, acceptance, approval of, or accession to this Protocol, or at any other subsequent time, where:

(c) *the seaward limit is closer to the shore;*
(d) *the landward limit is different, either more or less than the territorial limits of local coastal administrative units based on pertinent reasons such as the ecosystem approach, the economic and social zones or the specific situation of islands.*

The landscape approach is consistent with recent changes in policy and legislation at the European level (e.g. the Pan-European Biological and Landscape Diversity Strategy and the European Landscape Convention). One further reason for advocating landscape scale conservation approaches is the impact of climate change. As the climate changes, related research has demonstrated there will be shifts in suitable climate space for individual species at various spatial scales over the coming decades which, inevitably, will affect the structure and function of Mediterranean ecosystems (IPCC, 2001; Cheddadi et al., 2001; Mooney et al., 2001). Moreover, since the Mediterranean Basin is characterised by a high level of human activity and a low level of undisturbed areas the designation of protected areas that fall under the IUCN categories V (established for landscape protection) and VI (for the sustainability of natural resources) has often been advocated as the best adapted to the Mediterranean environmental reality and its conservation needs (Council of Europe & UNEP 2004).

Therefore there is a need to develop tools that will improve our understanding of the processes that operate at the scale of the coastal landscape. In particular we need to:

- *define the spatial boundaries of coastal landscapes*
- *identify the critical variables to develop a typology*
- *understand the link between landscape types and sustainability*
- *develop suitable indicators of sustainability (not just a matter of 'what they are' but also 'how' these are best developed)*

Each of the questions interact – spatial scale will also influence a vision of sustainability and the indicators necessary to track progress (or lack of it) towards that vision. The management of the Mediterranean coastal zone is a multidisciplinary, and cross-national problem that spans a wide range of spatial scales. This complexity is probably the reason why the coastal landscapes of the Mediterranean have never been comprehensively studied and that landscape-specific methodologies and concepts have not been developed. Currently there is inadequacy in our level of knowledge of the landscape typology, i.e. variety of landscapes, but also the main processes and forces influencing their transformation in the region. The development of a coastal typology is a necessary basis for coastal zone management and a prerequisite for the evaluation and risk assessment of losses or changes to coastal related resources.

Project Aims and Objectives

The aim of this project is to identify current landscape management practices in the Mediterranean and the main landscape types in order to gain an overview of Mediterranean coastal landscapes. The specific objectives of this project are to:

1. Identify current landscape management practices in the Mediterranean and associated problems, pressures, changes and impacts related to coastal landscapes;
2. Identify the main landscape types and landscape patterns (typology) at the regional level, illustrated with a case study
3. Propose sustainability indicators.

This reports describes the preliminary steps taken to address these three objectives. In particular it sets out the development of a methodology that could be employed, and provides with an example of its application based on real spatial data.

2. Prevailing issues & constraints within Mediterranean coastal landscapes: an expression of considerable land-use conflict

The birth and initial formation of the Mediterranean may be described as a dramatic phenomenon, 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 globe's oldest cultures. Archaeological evidence of early settlers in the region dates back at least one million years. Fossil remains dated at 400,000 years B.P., indicate that humans colonized various locations around the semi-enclosed Sea on a long-term basis, albeit a nomadic existence, and exploited available resources that occurred in the region, notably animal and plant life. Closer to-date, with the advent of the agricultural revolution some twelve thousand years ago and, as a consequence, food surplus, permanent settlements began to form around the Mediterranean. 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 base to three monolithic religions, co-existing, not without difficulty, for aeons.

The regional identity of the Basin's diverse societies, shaped by an often austere environment in which they lived, and by centuries of commerce and, not least, conflict, is strong. 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 region's resources, resulting largely from the demands of ever-growing populations as well as the multitude of conflicts that laid waste a once productive land, the countries, which share a Mediterranean coastline, face common environmental challenges. In this context, neighbouring countries have much to gain from a cooperative approach to solving them. As pollution problems worsen and as the pressure on resources increases, trans-national issues will multiply, thus heightening this need for joint action towards conservation by the states bordering this semi-enclosed sea.

There are serious questions today about the Mediterranean region's environmental ability to support its swiftly 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 region's landscapes 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 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 realise the uniqueness of the region. Its landscapes and topography, as well as the habitats and biota, all contribute towards the region's richness and diversity. Mediterranean coastal landscapes possess some remarkably interesting ecosystems, which are important both biologically (primarily as a result of the abundance of endemism) and socio-economically. Notwithstanding, numerous important areas are not adequately protected and various are under threat, mainly from development. An ever-increasing 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. Moreover, a further loss of species will diminish the aesthetic value of the region, which may have an unquantifiable effect on future generations (Cassar, 2001).

Population expansion has already had a notable negative influence on numerous Mediterranean coastal landscapes, 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 number of tourists is expected to reach 260 million per annum. Already some 9000km of coastline (*c*. 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. The island of Mallorca, for example, has already had 48% of its coastline irreversibly ‘artificialized’ in this manner while tourism-related developments dominate some 35% of Maltese coasts.

As Mediterranean landscapes are modified and converted, the biodiversity of the region would be adversely affected. The richness and diversity of the flora and fauna of the region, much dependent on maintaining stable and functioning marine and terrestrial ecosystems, would thus diminish. As a consequence to 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.

Sustainable development in a region as congested as the Mediterranean entails the harmonization of environmental and socio-economic goals, so that the processes required to reach them may converge rather than confront. The path towards sustainable development should imply policies and strategies whereby the quality of life results from a balance between the pursuit of responsible economic aspirations and objectives, and the conservation of the region’s natural and cultural heritage. For their own benefit, our Mediterranean ancestors showed, for a time, both prudence and foresight in the exploitation of resources in order to ensure a steady but sustained yield, thus harmonizing the ecological and developmental perspectives. This practice was in itself a lesson in the sustainability of resource use. Regrettably however, present-day trends of waste-generation and degradation have led to diminished regenerative capacities of natural coastal systems, that is, the capacity of the Mediterranean ecosystems to replenish resources and absorb waste, will eventually be outpaced by population growth and accompanying activities, constraining future economic growth and development in the region. Thus, the cradle of civilization has, in a span of less than half a century, been potentially transformed into the grave of the environment.

Climatic improvements following the last glacial created conditions that were both conducive to the development of present-day vegetation assemblages and the consequential population explosion in the region, which has had a negative influence on land resources. The ‘sustainable balance’ that 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, a consequential displacement of certain populations (notably, a destitution-induced south-north emigration); an exacerbation of the use of natural resources within landscapes; a marked abandonment of productively low agricultural land; and, the accelerated speculation of land for urbanization, industrial development and tourism purposes. The continuous population increase in the urban centres of the coastal zone, particularly in the South, have raised concerns about the quality of life and the function of urban and peri-urban landscapes for improving this quality. Therefore, in recent years there have been attempts to achieve this goal through appropriate design and planning. For example, ecological approaches to urban landscape design such as greenways and ecological networks have been developed in order to reintroduce nature to cities as a means to improve quality of life (Makhzoumi and Pungetti 1999).

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 discerning loss of biodiversity and habitats of high ecological value. This has much been the case in many Mediterranean locations, where biotopes have become pocketed and often relegated to restricted refugia around which conflicting land-uses abound. Frequently, the only physical connections between these patches of natural and semi-natural habitats are plots of agricultural land intersected by a myriad of crisscrossing dry stone rubble walls and a network of freshwater conduits or courses that bisect entire stretches of landscape.

Mediterranean landscapes are intricately linked to human affairs. Therefore the conservation of biological diversity and its habitats should be seen from a holistic dimension, thus, bringing together other important components - economic, social and political - that constitute a challenge for the decades ahead; notably, that of promoting sustainable development strategies with success.

2. 1 A changing landscape - issues and malpractice:

2.1.1. Agriculture

The most significant factor that has influenced the land-cover within the Mediterranean littoral has been agricultural practice. This singular activity, which has stretched over thousands of years and is still ongoing, has dramatically modified the terrain into the landscapes of the Mediterranean we come across today. Considerable tracts of territory were transformed from natural habitat into arable land; entire hills and sloping ground were stepped and terraced; colossal amounts of soil were shifted around and modified; major fluvial systems were diverted and channelled across kilometres of territory; and, vast quantities of groundwater were and are still extracted from freshwater aquifers. In more recent times, traditional agriculture makes way for greenhouses and tons of poly-tunnels. In terms of change, agricultural activity has altered the face of the Mediterranean, transforming the landscape into one that is predominately rural in character, consequently, with strong human interaction. Landscape change commenced in antiquity when vast tracts of woodland were felled to make way for agriculture and for use as fuels. As Mediterranean populations grew and became less sustainable in their manner, more and more land was reclaimed for cultivation putting colossal pressure on resources. As a result, Mediterranean environment and society, over time, merged to produce the cultural landscapes that are characteristic of the Region. Traditional agricultural systems comprising small plot mixed type farming, e.g. the *dehesas* and *montados* of the Iberian peninsula, terrace cultivation, in Greece and Italy and enclosed fields with dry stones walls in North Sardinia, are all testimonies of different more sustainable practices of the past. These systems were the result of "management practices optimising the typical annual fluctuations in productivity without causing ecological degradation" (Naveh and Lieberman 1994). However, during recent decades these habitats have been subject to irreversible deterioration through intensification, extensification and land abandonment.

Agricultural land abandonment: Changes in lifestyle, a better income and an all-round improvement in social benefits meant that more and more young people opted for employment within the service sector, rather than cultivate the land as their predecessors had done relentlessly. The effect that abandonment has on landscapes varies according to a number of factors, not least topographic characteristics, soil type and the availability of water resources. Certain features within a given tract of land may in time have an influence over landscape structure and function, much in the same way that natural watercourses may, over a prolonged period of time, alter their course by carving new conduits through soft terrain. With the cessation of agriculture, natural and semi-natural assemblages would soon form part of the secondary succession. The rate at which natural plant development takes place depends on factors outlined above as also on whether there is an existing plant cover or only bare soil with but a seed-bank, or whether colonization is left exclusively to floral resources on surrounding areas. As time goes by, environmental conditions, notably climatic and edaphic factors, will have a bearing on how assemblages will evolve.

Changes in land-use leading to abandonment highlight the need for a better understanding of the patterns and processes underlying colonization and early succession. Much more important however, are policy decisions concerning the future of abandoned agricultural land. With abandonment taking place at an increased rate, for different reasons, the issue poses a question of an ethical nature, that is, what should the environmental management response to accelerated abandonment be? One may argue in favour of parks or, alternatively, even land speculation for rural development or enlargement of urban margins. However, the answer lies with restoration ecology. Vast tracts of land could be tactfully and strategically restored into public parks, conservation areas or landscape corridors to link important ecological sites. The decision as to which option should be considered depends largely on site characteristics, geographical location and land-use priorities, but also on long-term conservation policy, commitment towards nature protection, and foresight.

Alien flora & invasive species on coastal landscapes: Much stress is made by conservationists on the distinction between indigenous species, towards which conservation efforts are directed, and introduced or alien species, which often create considerable problems (Sutherland, 2000), not least through competition for space. It is an established fact that one of the principal causes of biodiversity loss, and, as a consequence, a loss of landscape integrity, is through the effect of species introduced beyond their native range. In addition to competition, alien species may replace native flora and fauna through predation or parasitism, and may alter the dynamics of system function (Meffe et al., 1997), thus, having a profound effect on even at landscape scale. The success of alien species' survival and, indeed, rapid distribution spread are dependent on numerous factors. Some of these include a high reproductive rate coupled by high dispersal rates, a wide range of tolerance to environmental variables (euryoecious) and a high genetic variability. Very often, species may originate from distant regions with similar climatic regimes, as is the case of South Africa and the Mediterranean region. Some examples particularly affecting the coastal landscapes include *Oxalis pes-caprae, Arundo donax, Carpobrotus edulis* and *Vitis vinifera.* Other species, like the various *Acacia* and *Eucalyptus* species, used extensively throughout the Mediterranean littoral, are quite a serious threat to native biotopes and local soils, both from the point of view of water intake and displacement of indigenous species as a result of allelopathy. Moreover, these trees reduce the aesthetic value of Mediterranean landscapes considerably in view of their atypical aspect where local landscape character is concerned. Although a native species to the Mediterranean, *Pinus halepensis* has been invading in abandoned land, altering landscape structure and increasing combustibility in an already fire susceptible region.

Grazing and Herding: The effect of grazing pressures is much in evidence in numerous coastal localities around the Mediterranean, especially where sheep flock and goat herd densities are notably high. Grazing and browsing activity influences vegetation distribution patterns significantly, which consequently have a bearing on landscape characteristics and dynamics.

Freshwater extraction: illegal bore-holes: In view of recent technological advancement, bringing with it the availability of portable rock-boring equipment, bore-hole drilling for groundwater extraction has become more frequent and widespread across the region. The drilling of illegal bore-holes in coastal areas not only leads to saline intrusion, since the freshwater lens in aquifers is usually thinnest nearer the coast, but transforms otherwise arid landscapes into irrigated systems as extracted water is used liberally on agricultural land. Apart from the environmental considerations that stem from this activity, often illegal, the aesthetic transformation is dramatic, where traditionally dry farming systems within Mediterranean rural landscapes are converted into water-intensive agricultural zones over a short span of time.

Human Induced Fires: Fires, which mar the landscape long-term, are started for a variety of reasons in the Mediterranean. Land clearance, arson as well as for hunting purposes are among the reasons. Man-induced fires tend to kill off the natural vegetation, including both canopy and understory vegetation, creating niche space for invasive species. Alike grazing, this activity very often leads to accelerated erosion especially on sloping areas since weedy flora is, more often than not, seasonal, with the consequence that entire hillsides very frequently lose their substratum due to the formation of rills and gullies. In certain cases, landslides may occur, which create permanent scars in the landscape.

Effluents from Farms: Farmyard waste can have a detrimental effect on landscapes, particularly in the short-term. This is especially relevant where catchment areas, freshwater courses, slow-flowing streams and placid coastal waters are concerned. Concentrations of farm bio-solid waste and other slurries originating from livestock farms, as well as fertiliser and pesticide residues, may alter the composition of ecological communities and encourage the growth of algal blooms and a suite of nitrophilous species, further harming associated ecosystems and, thus, altering the character of the landscape.

Damming of Fluvial Sources: The construction of dams, normally for agricultural purposes, can have devastating effects on coastal landscapes, especially were sandy substrate environments are concerned. Aeolian dynamics, i.e., the transport and deposition of sand particles on sandy beaches and dunes, are much dependent on a variety of other elements and factors, namely the conveyance of sediment to sea by fluvial systems. Damming of such systems will cause much needed sediment to silt up behind anthropogenically installed catchments, thus depriving beaches and dunes from the process of natural nourishment. This will, in the short-term, lead to massive erosion of the beach and eventually the dune-field, which will have wider and far-reaching consequences on the coastal system, including its ecological, geomorphological, landscape and socio-economic facets.

2.1.2 Development

After the multitude of impacts that stem from agriculture and its related ancillary activities, human impact that has influenced Mediterranean coastal landscapes most, particularly during the last four decades, has been urban, infrastructural development and associated activity. This includes:

- coastal urbanisation schemes
- infrastructure and industrial estates in coastal areas
- massing of tourism development on the littoral
- coastal road and promenade construction
- hard-landscaped car-parks
- camp sites
- inappropriate landscaping and afforestation schemes
- long-term sand fixing operations through tree planting
- mushrooming of illegal coastal shanty towns
- open-pit quarrying
- domestic waste land-fills
- open sewerage systems
- recreational activities such as off-roading

Experience has shown that all of the above-listed activities can have a severe impact on coastal landscapes, both by way of obliteration of previously existing features as well as aesthetically. People may argue that some of these are necessary evils and that once it has been decided to expand urban schemes towards the coast, then a fair deal of infrastructural development, together with embellishment and landscaping, will also need to be acknowledged as part of the package. Once there is an established acceptance for urbanisation, then other opportunities and facets of development will emerge; little by little, the coastal landscape is recklessly transformed into, very often, an incoherent urban mass. In addition, other activities are usually instigated as a result of demographic and urban expansion, which also have a most negative impact on coastal landscapes. Notable among these open-pit quarries, domestic waste/building debris land-fills, shanty town development with no sanitary facilities, illegal dumping sites and uncontrolled open-sewer canals, whose presence within formerly pristine landscapes may be deemed obnoxious.

The main issue hinges upon integrated planning and the need to manage resources holistically. So, rather than develop coastal areas piecemeal, as has been the case so far in practically every corner of the Mediterranean, coastal landscapes and associated resources should be subject to the scrutiny of technical and professional personnel, guided by approved coastal subject plans and management plans. Integrated coastal area management plans seek to address issues such as responsibility for management, maintenance and upkeep, interpretation facilities, organization of land-uses and identification of conflicts of use/incompatible uses, monitoring of assets for change and understanding pressures, risks and impacts. These prevailing issues and constraints within representative Mediterranean coastal landscapes are demonstrated by the case studies below

2.3 Case-study 1: the influence of afforestation and dam construction on coastal landscapes – the state of affairs at Zouaraa[1].

Background: Chatt el-Zouaraa lies on the coastal plain east of Tabarka, on the northwestern Tunisian littoral. Its watershed extends a considerable distance inland, in the general direction of Beja, to and beyond the surrounding mountain range that includes Jbel Abiod, Jbel Msid, Jbel Kreroufa and Jbel Sidi Mhammed. The case-study proper forms part of a series of beaches and embayments, which occurs between Tabarka and Cap Negro, aligned in a northwest-facing direction.

Infrastructural development in the Chatt el-Zouaraa region, including the construction of a dam relatively close to the coast, aimed to harvest water run-off upstream of the Zouaraa dune-field, has led to significant changes in the hydrological regime and, as a result, to the sediment dynamics of the coast. In recent years, an overtly apparent transformation was registered along the beach and foredune zone at Zouaraa beach, as a result of a marked decreased in sediment fluxes.

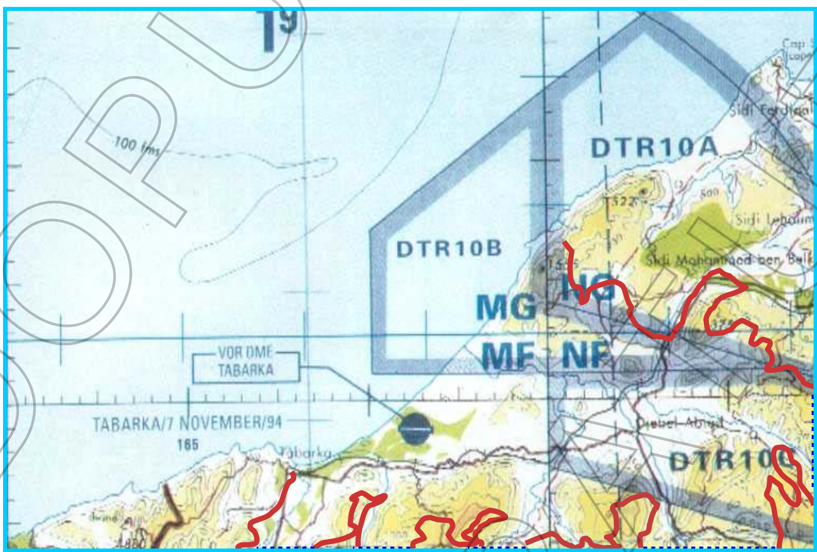


Figure 2. Zouaraa on the northwestern Tunisian littoral and its extensive watershed (indicated in red).

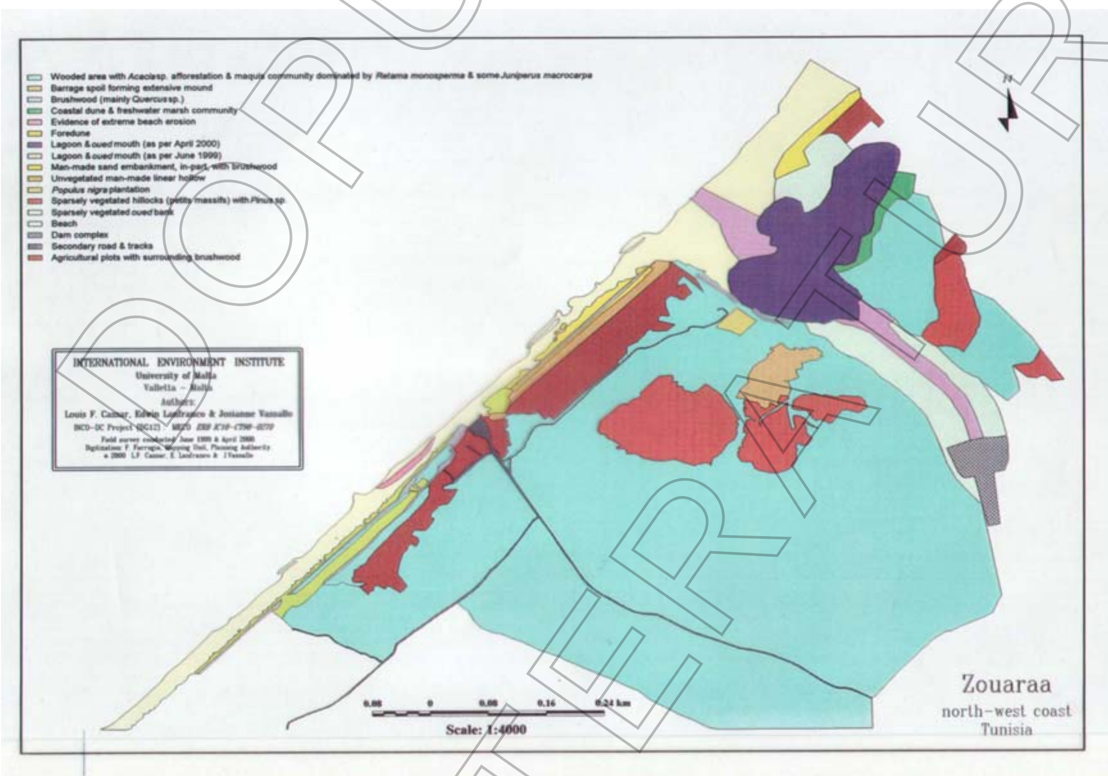
Characterization: The immediate coastal sector of Zouaraa-Nefza comprises a beach zone and accompanying dune field, in parallel to the shoreline with dune ridges generally trending northeast to southwest; the entire area is set in a large natural embayment. At the waterfront, the length of the beach is approximately 15 kilometers. The coastal dunes originally stretched back from the foredune/back-beach deposit zone quite some distance inland, where these converged onto an area of higher consolidated dune deposits. It is assumed that aeolian depositional processes influenced the landscape for a number of kilometers inland in the past, certainly before any human intervention to stabilize the region with woodland, but possibly also during a different climatic regime. Evidence of past aeolian development can be seen as far inland as twelve kilometers or so. An extensive *oued* system (Oued Zouaraa), now dammed, used to discharge into the sea towards the northeastern end of the beach; other small discharge channels, which act as seasonal run-off conduits, also occur in the area. With regard to vegetation, the Zouaraa dune includes most of the typical Mediterranean dune

[1] *This case-study was adapted from:* Cassar, L.F., Lanfranco, E., Vassallo, J., Gatt, P. & Anderson E.W. (2002).

species, however the pre-dune assemblage is highly impoverished. Some dune species, which are generally common in most Mediterranean dunes, are rare, as in the case of *Cakile maritima* and *Elytrigia juncea.* The dominant species on the dune crest is *Ammophila littoralis,* others being *Eryngium maritimum* and *Euphorbia paralias*. The fixed dune has been stabilized by plantations of *Acacia saligna* and *Acacia retinoides.* The dune crest has been topped by a mass of brushwood, possibly to prevent the sand from creeping onto the wooded area. Originally there must have been a large population of *Retama raetam*, remnants of which still exist within the *Acacia* planting as well as in the estuarine area and the pinewood undergrowth.

Where the watercourse opens into the sea, an estuarine habitat has been created with mixed vegetation including both dune species and some marsh species. Thus, there is the characteristic Mediterranean watercourse community with *Nerium oleander, Tamarix* sp. and *Vitex agnus-castus* as well as typical marsh species such as *Juncus rigidus* and *Holoschoenus vulgaris.* The area further inland from the dune has been wooded with pines, particularly Stone Pine (*Pinus pinea*), and Maritime Pine (*Pinus pinaster*). Prior to being wooded this landscape must have originally supported a typical maquis formation of fixed dunes as evidenced by the persistence of typical species of this formation such as *Juniperus macrocarpa.* The undergrowth includes both dune species and maquis species. Thus most species occurring in the dune proper are also found here, together with other dune species such as *Cyperus mucronatus.* Maquis species include some *Cistus* spp., *Halimum halimifolium, Quercus coccifera, Quercus ilex* and *Olea europaea*.

Figure 3. Landcover map of the Zouaraa coastal landscape



The cultural aspects of the landscape comprise relatively large tracts of agricultural land, albeit seemingly low-quality, pine wood and acacia plantations, fairly open parcels of land for grazing and herding, make-shift clay-based charcoal kilns and small-scale habitation. The recently constructed dam, a landscape feature in its own right, also forms part of the anthropic landscape. Its construction has constituted significant changes in the landscape, not least, the creation of an artificial flood-plain that has inundated vast tracts of previously cultivated and inhabited areas. The artificial lake is nowadays used for irrigation purposes in the Zouaraa-Nefza region. From a socio-economic point of view, it has provided freshwater for agriculture and domestic use in a previously arid zone.

Rapid transformation of the coastal landscape: The coastal area at Zouaraa consists of a wide embayment, not unlike a linear beach setting. The study-area constitutes a beach zone, a dune field, a *oued* system developing into a perennial watercourse (since the river is now dammed), and a hinterland, which extends some twelve kilometres inland towards the Zouaraa-Nefza thoroughfare.

It is widely acknowledged that an active dune field is highly dependent on the interaction between a number of key elements required for coastal dune development. Typically, an active dune field would consist of a sediment bank located in an *offshore* or *foreshore zone*; the wet/dry transitional beach boundary, and an active foredune area, known as the *transit zone*; and, a *resting zone*, which comprises the stable dune area. For these entities to occur, an ample supply of sediment is required together with the principal agents or geomorphological processes involving aeolian sand transport and deposition, and, a characteristic vegetation.

Sediment supply occurs as a result of longshore drift from eroding headlands, cliffs and other coastal formations (including other beach zones and dune systems), as well as by fluvial sources such as rivers and valleys, and directly via the seabed. In locations experiencing a positive alongshore sediment budget, coastal foredune assemblages would tend to develop in a sequence that is related to the gradient of alongshore sediment supply.

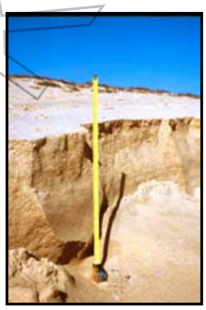
Figure 4. A general view of *Zouaraa*.

In the case of Zouaraa, it is largely assumed that the prevailing situation vis-à-vis the foredunes, i.e., the most rapid accelerated erosion along the entire strandline, is due to the interruption of sediment, both in a spatial and temporal context, as a consequence of the new dam construction, amongst other minor factors. Long-term erosion of the foredune assemblage in any dune system often leads to the initial enlargement of the dune proper. However, prolongment of this phenomenon due to alterations in sediment fluxes (as a result of fluctuation in fluvial discharge at the coast) may subsequently lead to deflation of the main dune ridge structure.

Before the dam was constructed, the Zouaraa coastal sand dune system may have been described as a *fluvial delta sediment system,* whereby the source of sediment was, indeed, the system of *oueds* that eventually culminated in the river downstream, which flowed out into the sea at Zouaraa beach. In the Zouaraa case, the spatial association began adjacent to the sediment source (river mouth) where a highly positive beach budget and low dune budget occurred. Longshore drift gradient would have shown a decreasing beach budget accompanied by an increasing dune budget. This morphological sequence of events would lead to a very low foredune at the point adjacent to the fluvial source and increasing in dimension in the longshore direction due to an enhanced dune budget. This was indeed the case at Zouaraa. However, with the relatively recent damming of the fluvial source and consequent decrease in sediment supply, the foredune experienced a sustained loss of its accumulated mass.

In 1999 it was predicted that should erosion continue at a steady pace, and, as the beach budget deficit grows, it is likely that the foredune would continue to lose mass. Under a prolonged negative budget, it was felt at the time that the foredune would eventually decrease in size and subsequently undergo morphological changes such as deflation of the ridge structure. It was further envisaged that in the long-term the dune might experience a sequence of attenuation stages that will lead to a ‘permanent’ loss of foredune structure coherence. If this predicament for Zouaraa was correct, then the dunal system, at least, that adjacent to the river mouth, was considered to be exceedingly vulnerable. Such interpretation was based on the fact that some of the foredunes appeared to have become quite flat-ridged due to an evident loss in aeolian dynamism and, as a result, a number of blow-out formations (excessive wind erosion and lack of sand material input) and gullies had formed on and around the foredunes.

a. Evidence of strandline erosion (1999)



b. Detail of strandline erosion (1999).

c. Significant sediment loss over a span of a mere ten months (2000).

d. Permanent structures used as baseline for measuring erosion (2000).

e & f. Accelerated erosion as a result of the disruption of aeolian processes; note loss of material on beach surface (L); and, collapse of permanent structures (2001).

Figure 5 Changes in Zouaraa Coastal Landscape

In a relatively short time-span the extensive Zouaraa coastal landscape, dominated by a linear beach and a sequence of foredunes, became less stable and it soon became evident that dunal vegetation would find it harder to establish itself with success. Degradation was observed to rapidly set in and within a span of just over two years, the entire coastline suffered severe erosion. This was largely due to a number of factors, namely the significant decrease in sediment supply coupled by a lack of adequate vegetation cover to effectively stabilize the dune face and to act as an interception medium for descending saltating sand grains; higher rates of sand transport and low deposition levels often result from the latter. The presence of dune vegetation increases the amount of humus and other detrital material resulting in better soil conditions and water retention capabilities. In the case of the Zouaraa dunes, the situation was likely to worsen since a considerable section of the foredune has already begun to lose much of its vegetation cover.

Assessing and monitoring landscape change: If change is anticipated on geomorphological systems and topography, it is considered critical to obtain measurements of current landforms and an assessment of the causes leading to degradation, particularly, of vegetation and, more specifically of the beach and dunal profiles at Zouaraa. In each case, detailed profiles and field measurements were deemed necessary. More accurate larger scale maps would allow identification of the main landscape features such as storm wave swash bars. Changes in landscape features can then be monitored by re-profiling.

Apart from these basic characteristics, potentially significant factors such as (i) vegetation types (biotopes and ecotones), (ii) sediment compaction, and, (iii) the occurrence of debris along these transects would be required. Field investigations on the status of the vegetation/habitat-types and the dunal systems would need to be conducted by way of standard searches, belt transects and direct measurement using field equipment such as prismatic compass, clinometer and measuring tape. The entire foredune sector will need to be measured [physical dimensions; angles of slope; dune hollows] and its physical relationship with other components of the beach/dune field assessed.

Having established a baseline on a number of components that make up the Zouaraa system, monitoring was identified as the only short-term option prior to proposing any intervention plans. Long-standing observations of the dune system, the beach and the river mouth zone would be necessary. The beach would thus require monitoring in terms of depositional sand budgets on its surface; where the material was likely to be moving and subsequently deposited; and, whether the trends of beach-line erosion are continuing in the future, at current rates. In the long-term, it would be important to establish whether there is any evident retreat of the present shoreline and any significant build-out of sand bars offshore. Furthermore, the foredune zone would need to be monitored in terms of vegetation coverage, morphology and coherence. In no uncertain terms, the beach (both shoreline and surface) eroded severely at a fantastic rate, as a result of which the foredune was also negatively influenced due to a prolonged negative beach/dune sediment budget and experienced deflation of its general structure. In the case of the river mouth zone, considerable change was also noted to have occurred. From an initial dune/marsh habitat, the area was fast transformed, first into an estuarine then a lagoon-type environment. No doubt, these dramatic topographic and habitat changes, which the landscape at Zouaraa experienced in a short span of time, will have had a negative impact on the characteristics and biota of the area, and shall continue doing so until the rapid rate of induced change ceases and the landscape becomes stable once again.

Figure 6. Fluvial discharge: the river mouth at the coast (1999) (L). The same river mouth following the construction of the dam, with water and sediment supply radically reduced (R) (2001).

Environmental issues and impacts: The Zouaraa site is, in many respects, of significant scientific interest and a most interesting Mediterranean cultural landscape. From the ecological and geomorphological viewpoints, Zouaraa is an ideal location for investigating its respective dynamic coastal system, particularly suitable for studying dune morphology in relation to human intervention; it also lends itself suitably for environmental education purposes.

With regard to threats and impacts, the site appears to be under a significant amount of risk as a result of human activity, primarily, but not exclusively, from impacts following the construction of the dam across Oued Zouaraa. In this regard, sediment fluxes have been negatively impaired with serious consequence to the dunes but also to the entire coastline. The beach and adjacent foredunes are also under severe pressure in view of the fact that the area is utilized for recreational/bathing purposes during the summer season. Human presence, in this regard, has contributed to the degradation of the various elements that constitute the coastal belt at Zouaraa-Nefza. It is evident that land-uses that make up the cultural landscape aspect are very much in conflict with the natural elements of the landscape within the region as is also apparent from the list below of notable cultural elements, other than the dam, which contribute towards the further degradation of the coastal landscape at Zouaraa and its surroundings:

- the use of brushwood to 'stabilize' the sand. Apart from demonstrating poor management practice, brushwood, once dry, will increase the risk of fire. Moreover, it induces changes in the hydrological regime of the dune by reducing evaporation and thereby altering the characteristics of the dune ridge and slopes. It would also impede the active growth of dune vegetation so important to dune stabilization and development.

- use of heavy plant machinery for shifting of sand on dunal zone, which disrupts natural aeolian processes.

- use of alien species for afforestation or species that are planted out of context to the habitat-type in question.

- damage caused by agriculture-related activities such as reclamation of dunal areas for cultivation and the use of pesticides and fertilizers, concentrations of which would have an negative impact on the biota present and hydrological system of the area.

- the presence of permanent (concrete) and temporary (timber) constructions on the rear sector of the beach, which are detrimental to foredune development.

- trampling, disturbance and encroachment in general by visitors to the area.

With regard to other potential impacts, the site at Zouaraa would prove exceedingly vulnerable to increased human presence, particularly if this were to lead to large-scale development within the area for tourism and recreational activities. Any unplanned amenity and infrastructural development, including camping, would probably prove detrimental to the coastal landscape in general.

2.4 Case-study 2: The coastal landscapes of the Maremma: a focus on Collelungo within the *Parco della Maremma*[2].

The coastal landscapes Parco della Maremma offers a diverse array of landscape types that contrast in both spatial and temporal terms, and which include a number of landscape features that double as relatively important ecological habitats as well as cultural features. These include the Fiume Ombrone, which has an influence on coastal dynamics and sediment fluxes in the area (particularly on the sandy

[2] A*dapted from:* Cassar, L.F., Baccar, F., Ellul, A. & Xuereb, R. - "La gestione dei problemi multidisciplinari riguardanti l'ambiente costiero presso Collelungo (Parco della Maremma)" (in press).

beach and dunal systems) as well as an important source of freshwater for anthropic use; the beach and coastal dunes together with adjacent marshes, the former of which serves for recreation and bathing; the rocky vegetated foothills of the Monti dell' Uccellina and associated outcrops; and, the anthropic land-cover, which comprises an expanse of low-lying land afforested by pines, mainly *Pinus pinaster*; the canals whose prime purpose was to convey freshwater across tracts of reclaimed territory; and, the meadows on the coastal plain that serve as pasture grounds for the characteristic cattle and horses of the Maremma as well as for cultivation. In addition, the area attracts a vast number of visitors during varying parts of the year, primarily for recreational purposes, which notably include bathing, eco-tourism and trekking.

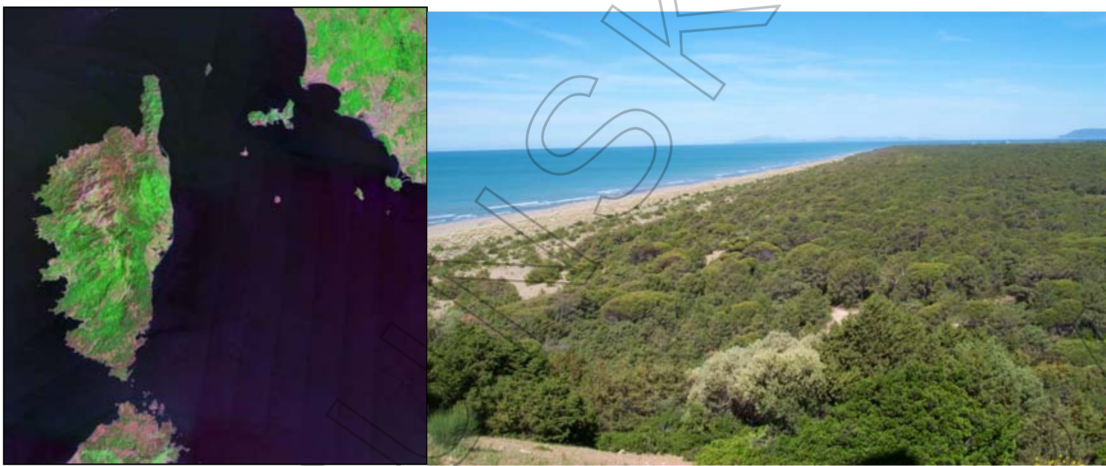


Figure 7: A satellite image of the Maremma, with the *arcipelago Toscano* just off its coast, and Corsica (L); and, the pine plantation dominating the landscape between the Ombrone river and *Torre di Collelungo* (R).

The extensive sandy littoral around Collelungo is enveloped between Bocca d'Ombrone and the eastward protrusions of the calcareous hills known as I Monti dell'Uccellina. Consequently, three major sediment sources are likely to play an important role in coastal dynamics:

1. Fluvial silt discharged into the sea by the Fiume Ombrone, and subsequently distributed beyond the river mouth by marine currents;

2. Silt carried by ephemeral surface water runoff from I Monti dell'Uccellina and deposited at the low-lying coast at Il Paduletto; and,

3. Sediment transported from other locations by marine currents, including: material eroded from sea-cliffs; displaced beach sand; offshore accumulations of sediment; and silt discharged into the sea by other nearby valley systems (*e.g.* at Cala di Forno).

These sediment inputs are intricately linked not only with the natural seaward progression of the Bocca d'Ombrone delta, but also to the formation of an extensive sandy beach that lines the entire coastal landscape. Ancillary transport and accumulation of deposited sand by aeolian forces has produced dynamic coastal dunes.

Historical records and more recent environmental monitoring schemes indicate that this process has been far from constant and has been profoundly affected (directly or indirectly) by various anthropogenic interventions both within the coastal zone and its Maremma hinterland, as well as throughout the far-ranging watershed of the Ombrone. In particular, relatively recent reclamation and afforestation projects have arrested much of the seaward discharge of terrestrial sediment. Other, more localised, interventions have also contributed directly to the shaping of the current coastal landscape, for example:

1. Site engineering operations on the immediate hinterland abutting the dunes between the Bocca d'Ombrone and Collelungo, for the purpose of marshland drainage, canalization and reclamation; and,

2. Tree planting (especially *Pinus* spp.) both within the mature and consolidated dunes proper and on their immediate surroundings, thereby stabilising the labile dunes and constraining their dynamic landward advancement, and also influencing their ecology and successional patterns.

Floral assemblages around Collelungo: The beach length from the Bocca d'Ombrone to its extremity towards Cala di Forno, measures approximately seven kilometres, however, not all the littoral within this stretch of beach is wholly composed of dry sand. The substrate of the area immediately adjacent to the river mouth consists of partially moist sediment, made up of fine silts and sand particles, while its extant vegetation is mostly halophytic. These assemblages, which lie on exceedingly low-lying terrain that becomes inundated from time to time, are essentially made up of *Inula crithmoides, Arthrocnemum macrostachyum, Halocnemum strobilaceum,* some thinly spread stands of *Phragmites australis* and *Juncus maritimus, Halimione portulacoides* and some *Limonium angustifolium.*

With regard to the vegetation within this marsh-dominated environment, as well as within the dune morphological sequence, plant communities do not have clear-cut boundaries, but rather merge into one another since communities are assembled primarily as a function of the individual species' environmental requirements. Variations in environmental variables can often lead to the presence of mosaics of different species assemblages. Moreover, natural phenomena (*e.g.* severe flooding) as well as intense human interference with natural habitats have also led to the introduction of alien elements, resulting in a 'mixing' of community types.

From previous studies carried out in the area, it transpires that at least three community-types of the **Salicornietalia** association have been identified from this habitat; these are *Salicornietum radicantis*, according to the authors the most prevalent, *Arthrocnemetum glauci* and *Halocnemetum strobilacei* (Arrigoni *et al*., 1985). Recent work in the area indicates that community composition within this biotope is more or less unaltered (Cassar *et al*., field survey 2003; in press). This does not mean to say that the area occupied by marshland habitat has, over time, not changed its extent.

Towards the east, marshland elements merge with maquis vegetation that colonizes, to a large extent, the low-lying area that was originally a tombolo formation. The flora of this marshy environment consists primarily of species that one would normally encounter in halophytic biotopes as well as freshwater marshes; dunal elements also occur as a result of aeolian formations nearby. Further to the ESE, the humid biotope merges gradually with the dry beach-surface environment, where aeolian development becomes progressively more noticeable. In fact, the presence of dry beach sands and sand dune formations becomes steadily more evident as one progresses along the coast in the direction of Torre di Collelungo. It is estimated that the sand dune biotope commences at approximately two and a half kilometres from the eastern banks of the Bocca d'Ombrone, although aeolian processes together with associated floral elements are evident, as indicated above, considerably closer. The dunal system, comprising the formation of a foredune and subsequent dune ridges, stretches as far as the sandy beach extends (in the direction of Cala di Forno) to the region that lies beneath Torre dell' Uccellina.

Among the principal assemblages within the dune biotope, one identifies: **Cakilo-Xanthietum italici; Ammophiletum arundinaceae; Crucianelletum maritimae; and, Sporoboletum arenariae.** These assemblages occur on the back-beach deposit (where embryo dunes form), the foredune and successive dune ridges, including a semi-consolidated region within the sequence. Interestingly, although traces of a Mediterranean fixed dune assemblage (Order **Helichryso-Crucianelletalia**) occurs within the dunal sequence (mostly beyond the second dune ridge, as one would expect), influence of the foredune assemblage (notably through the presence of *Ammophila littoralis*) may be observed right the way through much of the dune sequence.

Figures 8: A general view of the coastal landscape at Collelungo – the coastal sand dunes in the foreground with the *Monti dell'Uccellina*, colonised by maquis and woodland elements, in the background (L); and the pine plantations rapidly encroaching upon the tombolo and, consequently, the dunal area (R).

Although the continuity of the dune field along the Collelungo beach is interrupted by a sheer calcareous rocky promontory that abuts onto the beach at Collelungo, a remarkably mobile climbing dune formed mainly along the western face of the outcropping rock, and 'climbs' almost two-fifths of the way up its side. The assemblage that colonizes this aeolian formation is dominated by *Ammophila littoralis*, *Senecio cineraria*, *Xanthium italicum* and *Euphorbia paralias*, with *Helichrysum stoechas, Euphorbia peplis*, *Eryngium maritimum* and *Cakile maritima* in lesser number, on the more mobile sections of the dune formation. The more stable areas are characterized by *Juniperus oxycedrus* ssp. *macrocarpa*. The vegetation on the rock faces consists of *Anthyllis barba-jovis*, *Limonium multiforme*, *Erica multiflora*, *Senecio cineraria* as well as maquis and other woodland elements based broadly on the **Quercetalia ilicis** formation, assemblages of which colonize the calcareous hilly landscapes of the Park's hinterland.

Even from a cursory visit to the study site, one could deduce that sediment deficit has had a significant effect on the seven kilometre sandy coastal stretch between Bocca d'Ombrone and the region beneath Torre dell'Uccellina, as beach erosion over recent decades has been considerable. Clear evidence of severe erosion processes of coastal sands occurs predominantly at locations nearer the river mouth, for example at Marina d'Alberese, where the current maximum rate of strandline erosion is estimated at 11 metres per year (Pranzini & Cipriani, 1999). Since the mid-18th Century, around 800 metres of coast, comprising loose mobile substrates, is thought to have eroded at the apex of the Ombrone delta (Pranzini, 1994). Relatively close to this particular locality, remnants of man-made structures that had been constructed on the rear end of the beach can nowadays be seen lying a considerable distance offshore, while numerous dead trees (mainly pines) of the woodlot that occurred on the proximate inland area may now be seen on the strandline and its immediate vicinity (see figures below). The major causes for this accelerated erosion include river damming, mountainside re-afforestation, riverbed quarrying and reclamation of wetlands (Pranzini, 1995).

The influence of landscape change on the environment: It is evident that the biodiversity in the region has undergone change and is under pressure from activities and processes within it as well as outside. The biodiversity of the coastal landscapes at Collelungo is dominated by a number of biotopes that are affected by the human activities that have taken place, mainly, over the past two hundred years, and which now form an integral part of the cultural landscape that dominates the area. These include the introduction of the pine tree woodlot, take up of land for agriculture, recreational activities by numerous visitors, and other activities that have taken place outside the region but affect the beach and coastal dune system located within the littoral of Collelungo.

Impacts that lead to the alteration of environmental regimes, such as micro-climate, hydrology and species composition (especially through the introduction of anthropochore species or when species are not planted within their ecological context), are among major factors in land transformation and degradation since they disrupt the proper functioning of the ecosystem and are a threat to biodiversity. Such pressures on the natural biotopes were introduced whenever the landscape was transformed and reclaimed for agricultural purposes. This must have been especially evident when hundreds of acres of wetlands were altered to accommodate a soil cover for cultivation and pasture, thus completely obliterating the indigenous vegetation cover.

The planting of the *pineta* during the early 19th Century must also have had a severe effect on the landscape at large, and, on the delicate balance between elements of the cultural landscape and those of the natural coastal landscape. The comparatively high crown of the intensively planted pines forms a quasi-continuous canopy that reduces the amount of light that reaches the lower strata of the woodland. Direct competition for space with the Quercetalia ilicis maquis and woodland formation and its Erico-Rosmarinetum understory assemblage is also an issue, since it leads to the displacement of the indigenous vegetation cover by bigger regenerating pines. Moreover, propagation is quite significant on the coastal dunes, where numerous pine seedlings appear to be rapidly colonizing the dune-field. This is particularly widespread on the mature dune, where one would normally encounter the *Juniperus* formation, and, to a lesser extent, on the fixed dune. As a result, the pine plantation is gradually encroaching upon the coastal dunes, directly displacing the largely specialized dune flora as well as changing the micro-climate and soil chemistry of the dune surface, respectively, due to the somewhat large shadow cast by the cumbersome pines and to the shedding of their resinous needles. At the landscape scale, the visual change is considerable; from a low-lying maquis biotope to a pine woodland environment. At the cultural level, the pine plantation was and still is of considerable importance economically.

Annually, the national park within the area attracts approximately 75,000 to 80,000 visitors increasing to 200,000 in summer (Personal communication, administrator of il Parco della Maremma/Cassar et al. 2004). While tourism in the park is encouraged, it can still take its toll on the wildlife it supports since human activity can have an affect on fauna and flora, as well as landscapes, as a result of disturbance.

Human activities outside the park proper, such as river damming and riverbed quarrying, has had a considerable impact on the sandy landscape, which comprises the beach and coastal dunes at Collelungo, causing accelerated erosion of the strandline. This is mostly evident at Marina d'Alberese, where the remains of many dead trees lie on the sandy shore and its immediate environs. These tree remnants may either have formed part of the indigenous Quercetalia ilicis formation or else of the planted pine woodlot. In the event of continued strandline erosion at the current estimated maximum rate of 11 metres/year (Pranzini & Cipriani, 1999), it is predicted that a significant portion of the Collelungo beach would be lost in the medium-term. As a consequence, the beach, which is of immense importance geomorphologically, ecologically, as also socially, shall quite likely undergo further strandline retreat as well as lose its mass, which is so important for dune development, a predominant feature of the coastal landscape in the region. Culturally, accelerated erosion is resulting in seawater intrusion and, as a consequence, salinization of vast meadows currently utilised by the butteri (= indigenous horse-riding cattle herders) for their cattle and semi-wild horses as pasture. Thus, this negative impact is likely to have a dramatic effect on the cultural landscape *per se*, since changes in vegetation patterns (from pasture to marshland flora) are likely to cause the abandonment of vast territory by the butteri, which in their own right are an integral part of the cultural landscape of the Maremma.

As the beach surface continues to experience a negative sediment budget, dune ridge regression will eventually lead to a lack of dynamism across the entire dune system, which will result in the formation of more blow-outs, possible rilling and further consolidation. As a response to such changes in the dunal landscape, as dune regression persists, floral density and distribution may continue to degrade. This has already occurred on the 'fixed dune' formation, where the corresponding vegetation-type (the order Helichryso-Crucianelletalia), represented by *Helichrysum stoechas* and *Pancratium maritimum*, is highly limited within the dune sequence. Consolidation of the sand surface due to a prolonged lack of aeolian sediments may also initiate the advance of eurytopic species (flora that is capable of colonizing a wide range of environments, as opposed to stenotopic species) from inland areas and their subsequent colonization, to the detriment of the more specialized dune species, thus, altering the landscape almost permanently.

Figure 9: Pines encroaching onto the dunal area.

A cultural landscape dominated by agriculture: Fragmentation of the landscape within the coastal stretch of the Maremma has, over centuries of human use, occurred wherever natural biotopes were modified or altered. One of the clearest examples was the land reclamation (bonifica) that took place during the early decades of the previous century, where vast tracts of land were systematically converted from marshland to pasture and cultivated territory, markedly transforming the natural landscape into a cultural one. As a result, agricultural and other economic rural activity has forged a seemingly indelible mark upon the local landscape, separating parcels of land that to-date still support natural or semi-natural biotopes. The agricultural activity within the region is mainly dedicated to the rearing of animals and crop cultivation. Land is taken up for pasture for the cows (bovini maremmani) and wild horses, whereas olives, vines and other crops supply local produce. These areas of cultural landscape compete with land left for natural ecosystems to develop. Notwithstanding, those patches within the landscape that are utilized for cultivation and, more so, for grazing, may still be found to support interesting features. No doubt, those areas that manifest a less intensive pattern of land-use, with little human input, are places where ecological processes play an important role in relation to the composition of plant species and development of semi-natural assemblages that characterise the landscape. Although it may be said that these land parcels are highly anthropic and, in addition, may not support extensive ecological communities, they nonetheless perform an exceedingly important function, that of landscape linkages or wildlife corridors. Effectively, planted woodlots, cultivated land and excavated water canals, as in the *Parco della Maremma*, provide connectivity at a wide range of spatial scales. They provide species mobility across and between the fragments of a heterogenic landscape mosaic for a variety of purposes, including foraging, breeding/nesting, shelter and distribution. This is yet another example where there is synergy between natural and cultural assets, where nature benefits from cultural landscapes.

Areas that experience abandonment and subsequent re-establishment usually demonstrate a high degree of species diversity, often much richer than ecologically stable communities nearby. This results from the fact that in addition to the species which establish themselves as a consequence of dispersal and the regenerative natural spread of the adjacent stable community, weedy species made up of ruderal and adventive elements also find their way onto fallow or abandoned land due to the disturbed and degraded nature of the site. This is very much the case within the cultural landscapes of the Maremma, where slopes which experienced abandonment were noted to support a much fuller and richer flora than those slopes that supported the original biotope (pers. obs./comm. CASSAR/ARRIGONI, 2002). The reason for this is precisely because elements of the maquis biotope have spread, through regeneration, across the slopes and thrive together with opportunistic weedy species. As time goes by, environmental conditions, notably climatic and edaphic factors, will have a bearing on how such assemblages will evolve and how they will shape the coastal landscapes of this region.

Pressure to develop land for agro-tourism is still present and may represent a risk to natural areas and consequently bring about further landscape modification from natural to cultural. As more land is taken up for cultivation, the semi-natural area decreases. This issue becomes more relevant in the wider context of the local landscape, where a balance between cultural elements and the semi-natural environment seems to have existed for millennia. An exponential increase in agro-tourism, to accommodate visitor influxes into the region, should not be underestimated and its impacts on the balance natural and cultural landscapes need to be considered.

Figure 10: Severe beach erosion, with much of the beach having been eroded away, in places, all the way to the consolidated dune and pine plantation.

The present-day landscape: Whereas the predominant landscape features along the littoral of Collelungo are indeed cultural that include the semi-natural environment and the setting created in the last decades to accommodate agro-tourism, to be effective the region must be managed in the context of the broader landscape. The landscape is characterized by the complex formed by the *Monti dell'Uccellina*, the mouth of river Ombrone, the *Paludi della Trappola*, the sandy coast extending from *Principina a Mare* to *Talamone*, the anthropic land-cover, including the pine plantation, the canals, and the meadows on the coastal plain that serve as pasture as well as for cultivation. This diverse naturo-cultural terrain offers contrasts in both spatial and temporal terms, and may therefore be considered a very dynamic landscape. It varies seasonally, offering visitors a different experience in the summer and winter months where the landscape is more verdant during the latter. The landscape is affected by all the human activities that take place within the region, from the plantation of the pine woodland in the 19th century to the rapid erosion of the beach and the seasonal variation in visitor numbers.

The early transformation of the landscape occurred when hundreds of acres of wetlands were altered to accommodate a soil cover for cultivation and pasture. The planting of the pine trees with their green canopy is in sharp contrast to natural vegetation that occupied the area before it. The effect of the pine forest on the dune vegetation is also gradually altering the landscape since it is contributing to the eradication of certain dune flora and the advancement of the pines themselves. The sandy beach is eroding fast, especially in certain areas such as *Marina d'Alberese*, and dead trees stranded on the shore have become part of this dynamic coastal landscape. All these changes occur within the broader landscape of the *Monti dell'Uccellina* which provide a sensational backdrop to the activities within the Parco and which represent a less dynamic environment, visually.

Nevertheless, the cultural landscape that now overshadows the Maremma appears to have become the predominant overall feature of the region. Over the years, the landscape has become more rural in character, in contrast to the region's former naturalness. As an agro-tourism destination the region provides vast areas of cultivated land, pasture grounds and buildings to accommodate visitors. Other infrastructure such as roads has also been developed to render the area more accessible. Although most buildings are rural in character, some still impinge on the landscape and as pressures from the tourism sector increase, it is anticipated that the largest pressure will be to increase such facilities, thus altering the semi-natural landscape further.

The landscape is also affected by the visitors to the park that visit it primarily for recreational purposes; this includes bathing in summer and trekking and walking during the cooler months. Since the number of visitors is largest in summer and is focused on the coastal area, the impact on the landscape is greatest at this time where a high volume of motor vehicles stream in to the region, and visitors flood the *Marina d'Alberese* coastal stretch. Although the impact on the landscape may be temporary, the effect of the visitors on the coastal area in the long-term is still felt and should not be under-estimated.

2.5 Case-study 3: Smir Lagoon (North-western Mediterranean coast of Morocco) and its surroundings: the influence of dam construction on the landscape[3]

Background: The Mediterranean town of M'diq was, until the 1990s, a quiet and little-known village on the eastern coast of the Tetouan promontory, Northern Morocco. Economic prosperity generated by tourism-related development brought about demographic growth coupled with a surge of urban expansion, particularly along the littoral, and has led to significant changes in land-cover and conflicts of land-use, especially between the natural environment and the cultural elements of the region.

The region of Smir Lagoon comprises a patchwork of coastal habitats that include coastal dunes, saline marshes and watercourses. Recent development in the area has generated a shift in the dynamics of physical systems and ecological communities of the area. Much of the landscape change and its related environmental impact are derived from the construction of a dam at Oued Smir, the construction of residential and tourist accommodation on and close to the beach and dunal area, and from the discharge of wastewater into the sea. Sand dune systems on the Smir sea-front were subject to attrition and loss of foredune mass as a consequence of interception of sediment. This change in dunal dynamics is reflected in structural and compositional shifts in plant communities. Moreover, avifaunal diversity is relatively high, consistent with the function of the lagoon as a staging post along an important migration route.

Characterization of the area: The case-study area at M'diq comprises Smir Lagoon, Smir beach (the sandy beach located between M'diq and the area adjacent to Smir Lagoon), and the hinterland leading to a recently constructed dam and, as a result, an artificial lake, located at the headwaters of Oued Smir. Smir Lagoon lies a short distance from a sandy shoreline known as Smir beach, which forms part of an extensive linear beach that lies on the embayment that stretches between Sebta and Cabo Negro. Prior to construction of the dam, the lagoon's hydrology was dependent on water recharge

[3] *Adapted from:* Cassar, L.F., Gatt, P. Lanfranco, E., Lanfranco, S. & Mallia, A. (in press).

stemming from the uplands located westward of it. Thus, the lagoon and a significant sector of Smir beach and adjacent dunal area depended largely on fluvial fluxes that formed part of a complex hydrological system that originates on the Jbel Zemzem slopes. At one time, freshwater was channelled from the Jbel Zemzem catchment towards the coast, first via Oued Lil and Oued Jerjon, then onward into the Oued Smir conduit. The headwaters of the former valleys originate on either

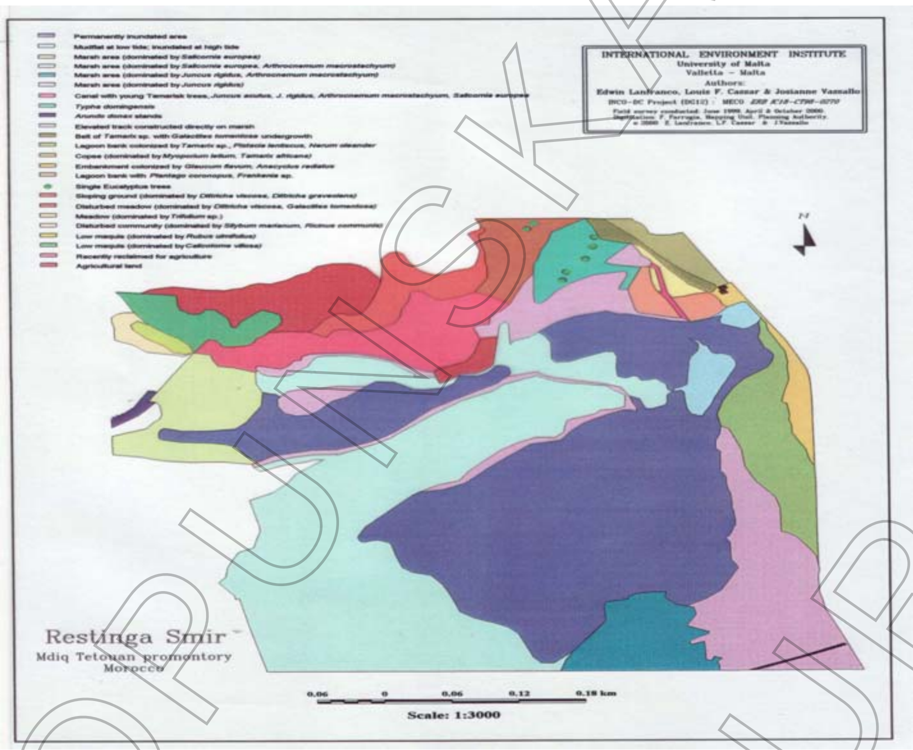


Figure 11: Vegetation distribution map of Smir Lagoon.

Figure 12: Human induced impacts. Kilns on the Smir Lagoon hinterland (L). Wood harvested for use as fuel (R).

extremity of the Zemzem foothills. From l'Oued Smir, water would then nourish the wetland areas inland of the lagoon and, subsequently, replenish the lagoon. Presently, the sediment-rich freshwater, which once flowed downstream towards Smir beach carrying large quantities of terrigenous material, important for beach and dune nourishment, is now entrapped within the artificial lake as a consequence to the dam. Moreover, following engineering works at beach level that created a link with the open sea at a point beneath the elevated thoroughfare that connects M'diq with Fnideq, the lagoon is now regularly inundated with seawater, especially at high-tide. As a result, both the lagoon's bathymetry and its chemistry have been significantly modified (Bayed & El Agbani, 2002). Currently, at high tide, the lagoon is confluent with a newly constructed marina at its mouth.

From the cultural point of view, many of these changes and alterations to the landscapes of the Smir/M'diq coastal area where and still are crucial for the well-being of the local population and the economy in general of the region. Additional amounts of freshwater are required to serve the growing needs of an ever-increasing population, one which is also augmented seasonally. Thus, apart from the need to service the domestic and agricultural sectors, freshwater is also needed in vast quantities to service the tourism sector (mostly, but not exclusively, domestic tourism), which flourishes within the littoral of Smir – M'diq. Furthermore, large up-market holiday complexes and hotels are being constructed all along the immediate coastline in an effort to attract foreign holiday-makers so as to diversify the holiday market. As to be expected, numerous land-use conflicts came to pass consequent to the mélange of uses, both traditional and more recent, and existing land-cover components.

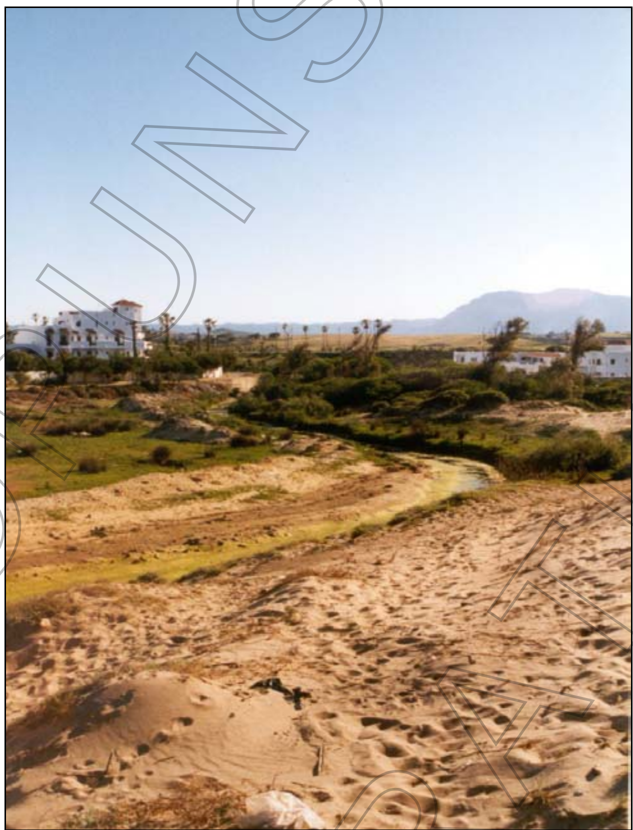


Figure 13. Channel in the sandy beach conveying eutrophic water to the sea.

Figure 14. Concrete wall beneath bridge originally intended to act as barrier between marina and lagoon; note demolished central portion.

Landscape elements within the area of Smir and human interaction: The area around the lagoon is largely flattish land dominated by marshes, coastal dunes and beaches. Further inland the landscape changes into a series of hillocks, most of which have been terraced for agriculture and related uses, eventually becoming hillier and, in places, almost mountainous. The dam construction has resulted in significant change, not least, in view of the formation of an artificial lake.

Biotopes: The vegetation immediately within the lagoon comprises marshland flora such as Arthrocnemum macrostachyum and Juncus spp. along the fringes of the lagoon and steppic communities further inland. The areas closer to the lagoon proper, characterized by longer hydroperiods and higher soil moisture content, are dominated by Arthrocnemum macrostachyum, often accompanied by A. fruticosum. Other species, including Salicornia europaea s.l. and Suaeda maritima occur in lower abundance. Regions away from the edge of the lagoon, where hydroperiods are shorter and soil moisture content lower, the dominant species is Juncus acutus.

Further inland, wherever watercourses criss-cross the terrain, plant communities consist of a water-fringe cane-bed assemblages, characterized by a thick belts of *Typha domingensis* and *Arundo donax*, along the sides of which grows a broad cover of *Juncus rigidus* (becoming more extensive closer to the lagoon), together with *Dittrichia viscosa* and *Gomphocarpus fruticosus*. Areas of higher ground (with consequently lower levels of soil moisture) comprise extensive cover of *Dittrichia viscosa* associated with *Tamarix* sp. and *Limonium ferulaceum*.

Vegetation assemblages further inland of the lagoon consist of species generally considered indicative of disturbed environments interspersed with species of dry calcareous steppe, including *Avena barbata* s.l., *Aster* sp., *Dittrichia viscosa*, *Convolvulus arvensis*, *Verbena* sp., *Polygonum ?aviculare*, *Lythrum hyssopifolia* and *Dittrichia graveolens.* Bramble thickets (*Rubus ulmifolius*), which may represent a remnant of a previously more extensive **Quercetea-ilicis** assemblage, occur throughout the landscape inland of the lagoon. Further remnants of this presumed assemblage, including *Pistacia lentiscus* and *Quercus coccifera*, occur along the tracks that surround the lagoon. Other species present in this area include *Convolvulus althaeoides* and *Tamarix* sp. The disturbed area supports a vegetation cover generally considered typical of such environments, including *Ricinus communis*, *Dittrichia viscosa* and *Silybum marianum* together with planted/naturalised individuals of *Acacia karroo.*

Smir beach and coastal sand dunes: Like other sandy areas in the Mediterranean, Smir beach is subject to insensitive development, which has, over a relatively short span of time, degraded a previously extensive sand dune system. The original coastal dune system has been bisected by the main thoroughfare that links M'diq with Fnideq and encroached upon by a number of ad hoc car-parks, afforestation and constructions, ranging from hotels and tourist complexes to marina developments and private residences. Dune remnants on the lagoon side of the road have also been subject to various pressures, including planting of inappropriate species (such as Eucalyptus sp.), grazing (camels, donkeys and cattle) and trampling (vehicles, humans and animals). The foredunes and beach are further stressed by the passage of eutrophic water through a canal incised into the sandy substrate, approximately mid-way along the length of the beach.

Field observations suggest a general lack of coherence between the beach and the dune. Various human activities have contributed towards a decline in sand deposition, as recently built structures on the beach proper act as physical barriers that impede sediment transfer from the beach zone to the dunes. Presently, the dimensions of the foredune and the main dune ridge (consolidated dune) are clearly disparate; whereas remnant foredunes are mostly less than a metre high, the consolidated dune immediately adjacent to the foredune exceeds a height of five metres. Such circumstances suggest that the consolidated dune was, in the past, nourished by an active, indicatively larger foredune, which now appears to have lost a great deal of its mass. Permanent structures are known to have a negative impact on sediment transfer and depositional processes, since they act as sediment traps that hinder sand movement across the beach surface. As sustained depletion of sand material through erosion coupled by a continual impediment of sand nourishment processes continues, the foredune is likely to experience a marked loss of material that is expected to lead to long-term deflation of the dunal mass (Cassar & Stevens, 2002).

Anthropogenic modifications of the physical conditions of the coast and the landscape in general in the area of Smir have lead to accelerated ecological degradation of climax sand-dune communities. By and large, species composition tends to be depauperate relative to comparable dunes in other parts of the Mediterranean littoral. Habitat degradation in parts of the dune area was sufficiently severe to cause localised extirpation of characteristic dune vegetation with, in many cases, subsequent colonisation of the vacant habitat-space by invasive generalists, a trend that is consistent with the increasing popularity of the area with tourists.

Dam construction: The dam and reservoir upstream of Oued Smir have considerable influence on the downstream characteristics of Oued Smir and the water catchment draining into Smir lagoon. Without a shadow of doubt, both entities are in themselves landscape features of socio-cultural value. The dam's construction has drastically reduced the flow of freshwater through the Oued and into the lagoon with consequent shifts in vegetation dynamics. The latter problem has been further compounded by the infiltration of seawater from the marina into the lagoon following a physical connection between the two. Further environmental impact in this area arises from the extensive reforestation that was undertaken on large tracts of the hinterland. The type of afforestation undertaken has not always been contextually appropriate and the species used (mainly Pinus pinaster) have the potential to alter the physico-chemical characteristics of the soil with consequent impact on the characteristic flora of the locality. Moreover, any large-scale regeneration of pines would displace indigenous flora consisting of maquis and accompanying understorey vegetation.

The Smir dam area, which includes the large stretch of open water formed by the artificial lake behind the dam proper, should attract open-water birds such as ducks and grebes, notwithstanding the lack of emergent vegetation. The uplands, dominated by Jbel Zemzem, are located quite close to the artificial lake and relatively close to the coast. The topography of this area appears decidedly suitable for soaring birds of prey, both for slope-lift and for the provision of thermals, as also to use the wooded areas on its slopes for roosting.

Potential benefits from eco-tourism: The region is geographically important for the bi-annual migration of birds across the Tetouan promontory to the Iberian Peninsula and vice versa. Overall, the area provides different biotopes, which have the potential of attracting and supporting numerous species of birds of various groups. In particular, if the lagoon area were to be appropriately managed and sensitively rehabilitated, it may provide an additional source of income to the local populace of M'diq, through eco-tourism, in particular, through bird watching. The Tetouan-Iberian Peninsula route is one of the major bi-annual migration paths of Old World passages and, like its eastern counterpart, the Bosphorus, offers good opportunities for observation and research. One advantage is that tourism infrastructure is already established, with several reasonably good hotels that provide accommodation nearby and roads that render the lagoon and its surrounding hinterland quite accessible; this would also diversify the tourist-product on offer, and, as a result, may extend the tourist season into the shoulder and winter months to coincide with birding schedules such as spring and autumn passages, and wintering species. Its coastal location, at the edge of the land-sea interface of the Mediterranean, is of importance to migrants during both seasons. in spring, it offers a last stopover on the African continent, where migrants may put on further fat before traversing the sea. Conversely, in autumn, it allows birds that have depleted their energy reserves during their southward flight and subsequent sea crossing, a possibility of resting and refuelling immediately on landfall. Furthermore, in winter, the lagoon also serves as a wintering site for discrete numbers of water birds. Thus, the coastal landscapes of the region have the potential of rendering much benefit to the local population if these are managed in a responsible manner. Apart from exploiting the natural resources of the region, such as freshwater for agriculture and domestic uses, the area has the prospect of providing a market for specialised tourism, given the sustainable management of resources by maintaining an overall balance between the elements that make up natural and cultural landscapes.

Sources of environmental impact on the coastal area at Smir – the conflict between natural and cultural landscapes: Coastal development and associated activity that affected the environment of the lagoon and its surroundings is significant; as a result, the magnitude of the impact is likewise expected to be considerable. Impacts that were observed or inferred include:

Construction of a marina on seaward side and subsequent linking of lagoon with the sea.	This induced a complete change in the physico-chemical characteristics of the lagoon, which, over a short span of time, became a salt-water pool. The rise in salinity has killed off less-resistant vegetation in the lagoon, including large stands of *Tamarix*.
Construction of main thoroughfare along the back of Smir beach.	Road construction has mainly impacted the dune area. However, its presence has also increased access in the lagoon area. The presence of the road increases pollution from SO_x, NO_x, CO_x and other volatile compounds emitted in car exhaust. Furthermore, this busy road has elevated noise levels in the area and introduced light disturbance from car headlamps at night, which can have an impact on the fauna, particularly birds, of this important wetland.
Construction activity on the marshland, the beach and coastal dunes, including the expansion of M'diq with consequent land take-up.	Some constructions are present in the marsh itself between the village of M'diq and the lagoon proper as well as directly on the beach and dunal areas. Apart from this, the expansion of the village of M'diq towards the marsh/lagoon system is poised to threaten these habitats, which have the potential to generate considerable interest in eco-tourism to the area.

Impacts from sewage overflow into the marshland and coastline.	The sewerage system of the village of M'diq does not seem to coping well with urban increase. This is resulting in sewage overflows into the marshland surrounding the lagoon as well as onto the beach zone and into the sea.
Dumping of construction and demolition waste on the marshland adjoining lagoon.	Several areas, especially to the west of the lagoon (near the village of M'diq) have suffered from considerable dumping of construction and demolition waste. This waste is used to form access tracks across the marshland. Apart from obliterating habitat and introducing alien materials, these dirt tracks are also interfering with the flow of water towards the lagoon.
Fly-tipping onto the lagoon and marshland.	Another chronic impact relates to the tipping of waste into the lagoon precincts, especially in areas within reach of the road circling the lagoon. Considerably more tipping is present along the roads skirting the hinterland side of the lagoon.
Conversion of marshland around the lagoon into agricultural land.	It is evident that there have been various attempts at converting tracts of marshland habitat around the lagoon into agricultural land. The agriculture practiced is dry farming and the crops grown appeared to consist of cereals.
Grazing activity by cattle and camels.	Grazing activity around the lagoon and marsh area, though not substantial, is appreciable. This results in the cropping of vegetation as well as the introduction of natural fertilisers into the area as a consequence to bio-solid waste.
Trampling.	This is a direct effect of the previous activity; while its effects are limited to grazing domestic animals as well as by humans, compaction of the soil, primarily in view of a possible increase in water-logging, should not be underestimated.
The effect of the dam and reservoir built upstream of the lagoon.	The effects of the dam and artificial lake on the downstream region of the Oued and the lagoon have led to the most notable impacts in the whole area. Considering that the construction of the dam was an important measure from an economic and social point of view, its environmental impacts are considerable. The major impacts can be summarised as follows: • a drastic reduction in the water flow through the Oued; • a radical change in humidity levels and physical characteristics of the Oued with a concomitant transformation of floral patterns within the Oued; • a quasi total "starvation" of the lagoon system of freshwater with the consequence that the lagoon became increasingly brackish; • a complete modification of the hydrology of the lagoon, dune and beach system; • a most notable reduction in the sediment load previously transported via the valley and, therefore, a reduction in beach replenishment.
Cutting down of the tamarisk thickets for use as firewood.	Most of the woody shrubs present in the area of the lagoon (predominantly *Tamarix*) are regularly cut for use presumably as firewood; a possible destination being the kilns present in the hinterland region of the lagoon.

Assessment of environmental risks and impacts on the coastal area: Various risks and impacts may be identified as a consequence to human activities within and beyond the immediate Smir Lagoon area. While it is acknowledged that the economic momentum attained, particularly from tourism, is maintained and even enhanced, every effort should be directed towards conserving the natural resources of the landscapes within the region. Apart from the immense aesthetic value of the coastal natural and cultural landscapes, the Smir Lagoon and its surroundings are potentially significant as staging point for migratory birds. Bearing in mind the importance of this western-most Old World major avian passage route (Cramp & Simmons, 1982), wetlands located within this geographical region would act as 'migrant trap' as birds converge upon the Tetouan promontory during migration, later fanning-out into the European or African interior (as the case may be).

Existing threats and impacts in the area are varied. Primarily, they stem from the construction of the dam at Oued Smir, an important man-made landscape feature that has altered the characteristics of the region in numerous ways. Apart from being features in their own right, the dam construction and the body of water that has collected behind it have led to a considerable depletion of sediment downstream of this infrastructure. As a consequence, sediment-free water flowing down-stream has led to scouring of the banks of Oued Smir. Moreover, a substantial decrease in sediment loads reaching the coast is expected to have a negative influence on beach/dune nourishment processes in the medium term. This will eventually lead to a sustained net deficit of beach sand and, subsequently, a loss of foredune mass due to a lack of sediment transport and deposition (Cassar & Stevens, 2002). The construction of hotel complexes and large private villas directly on the beach and on the coastal dunes as well as the discharge of wastewater into the sea are also the cause of significant direct negative impacts on the littoral.

Most of the impact at the coast and hinterland is related to the construction of the dam. This includes the beneficial impacts related with the development, that is, that of containing water for storage and more prolonged use for human activities. Depending on the actual construction of the reservoir, the slowing down of the water flow and storage may also help in aquifer recharge, as well as to reduce the erosive force of strong water flow downstream. Conversely, the reduction in seaward flow of freshwater has resulted in an inability to replenish the freshwater body in Smir Lagoon, while the recent breach that brought about a direct physical land-sea connection has had a notable effect. Primarily, the influence of tidal fluctuations has led to a striking rise in salinity levels within the lagoon and its surroundings, which will no doubt bring about a transformation in the biotic make-up of the area. It is expected that freshwater and halophytic vegetation will, in time, be wholly replaced by halophilic species. On a positive note, water-level fluctuations as a result of tidal cycles have led to an increase in the 'feeding edge' for wading birds, predominantly at low tide.

These modifications to the terrain, consequent to improvements in the infrastructural system to cope with increasing urbanization and other human activity, are expected to have a significant influence on the coastal semi-natural and natural landscapes at Smir. No doubt it is a question of balance and sustainable use of resources, however, abrupt, unplanned development shall always level pressures and lead to conflict between cultural elements within a landscape and natural and semi-natural assets of coastal Mediterranean landscapes.

3. Landscape Classification – Developing a Spatial Framework

3.1. Landscape Typology

A landscape typology and the subsequent classification into discrete landscape types, provides the *spatial framework* for the derivation of sustainability indicators. The typology is a recognition that past and future pressures vary enormously between landscape types and, therefore, the development of policies and measures to contain such threats and to restore ecosystem functioning and other landscape scale processes is directly related to the *character* of a landscape. In this context, spatial framework refers to distinct and mapped areas on the ground encompassing a particular set of landscape attributes. The rationale for the development of the typology is based upon an understanding of the factors, both natural and cultural, that determine the intrinsic 'character' of a landscape. For example, in a coastal context differences in climate, slope, substrate, tidal rage etc. combine with cultural factors that have shaped the evolution of the landscape over millennia, to create a recognisably distinct landscape type.

There are many techniques for the classification of landscapes. An early attempt by FAO to establish Agro-ecological zones (1996) is a good demonstration of a land classification technique at a global scale based on spatial environmental data. Examples of European level classification include the European Landscapes Map (Meuus 1995) and the work produced recently by Washer and Jongman (2003). Despite its wide use in NW Europe as a tool for landscape planning, the development of a landscape typology for Mediterranean countries has been limited. Exceptions include Portugal (Pinto-Correia et al. 2002), Spain (Mata and Sanz, 2003), Slovenia (Marušič and Jančič 1998) and Italy (Blasi et al. 2003).

An important distinction is made between landscape *typology* (the nomenclature) and landscape *classification* (application of the typology in map form). The typology necessarily precedes the classification, requiring the sampling of the whole range of landscape units to identify the attributes that discriminate between the full complement of landscape types. This is a complex task and is influenced by a whole range of factors, including:

- The objectives and scale of the project
- Scale, resolution and quality of the data
- The sampling scheme
- The diversity and complexity of the landscape types
- The techniques to classify the samples into a consistent typology

There is a close relationship between the scale and objectives of the project and the availability and quality of the input data. Quality issues relate to modernity and data availability in digital format, in addition to the level of detail – some individual countries, for example, will have soil maps at medium scales in digital format containing more detail than is available for all counties across the region. Thus, there are difficult decisions about which data to include given probable differences in quality and level of detail.

The sampling scheme is a critically important consideration in developing the typology. At the scale of the Mediterranean region, even if data are available at an appropriate level of detail, it is unfeasible to sample every landscape type. A sample design needs to be developed, based upon an initial stratification related, for example, to climate zones or broad geological types, within which to select a sample of points at which more detailed information on soil type, land cover etc. is collected. The level of sampling intensity is related to the complexity of landscape types, with more samples in areas of landscape diversity. Finally, the techniques used to classify the sample data into a robust and consistent classification that can be applied across the whole region of interest will determine the level of detail (number of divisions) in the typology and its applicability at a range of spatial scales.

Classification involves translation of the typology into mapped form – essentially the labelling of every landscape unit. GIS increasingly provides the tools to accomplish this, enabling the different layers of spatial data to be overlain and combined according and classified according to specific rules and thresholds identified in the typology. The development of landscape typologies has been facilitated by the use of GIS, enabling data-sets of different scales and, frequently, varying projections, to be integrated into a single digital database of geographic and attribute data. This technology provides significantly increased opportunities for more detailed environmental resource inventory and analysis in space and time and shows considerable promise for extensive use in nature conservation (Gergel and Turner 2001).

3.2 Coastal Typology

The physiognomy of a coastal landscape is created by geological, meteorological and biological factors, greatly modified over time by human activity. The physical factors include tide, currents and wave action interacting with climate to shape local landforms. The natural setting provides the context for the establishment of, in a coastal Mediterranean context, a wide range of ecosystems with associated plants and animals and an equally wide range of human uses of the local resources, both on and off-shore.

Depending on the scale of the typology and the approach used there are two types of analysis used in classifying coastal areas (LOICZ 1995; 1998):

- detailed analyses of restricted areas based on selected variables
- global approaches based on one or two types of data such as the distribution of ecosystem types or geomorphology (Table 1)

The tidal range of coastal waters is another important factor in describing the nature of coastal landscapes This is, for example, the case with attempts in the past such as the European Union for Coastal Conservation (EUCC) coastal typology which was based on predominant substrate, slope and tidal regime (EUCC, 1998). However the last parameter is less important in the Mediterranean context since it is recognised that the typically micro-tidal regime has had less impact on evolution of coastal landscapes and habitats. The European Typology developed by EUCC identifies five landscape types at the 1st level of classification (Table 1). Often for the purposes of management and planning, coastal landscapes are divided into two major groups: ‘cliffed’ and rocky coasts and coastal plains (Rigg et al. 1997). The landward boundary in these studies has been set by an elevation threshold above the mean tide level, by defining the inland boundary at a specified distance inland, on the bases of the major break in slope or by following the limits of the associated catchment.

Table 1. Examples of different scale coastal landscape related typologies

European coastal landscape typology[1]	Morphologic Forms of the Cretan Coastline[2]	Coastal Geomorphological Systems in the Mediterranean[3]
1a. Hard rock, cliffed coasts	Sandy beaches	Rocky coasts
1b. Hard rock coastal plains	Cobble rampant beaches	Alluvial Fans
2. Soft rock coasts	Low lying reefs	Deltas
3a. Tide-dominated sediment. Plains	High coast (including sea cliffs)	Beach Systems
3b. Wave-dominated sediment. Plains		

[1]Level 1 classification EUCC (1998); [2]Kelletat (1979) in Mayer (1995); [3]Dardis and Smith (1999)

3.3 Methodology

3.3.1 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.

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. Since the Mediterranean area extends over three continents there is a need to use complementary data sources in order to obtain information for whole region. These include:

Climate

High resolution climate data from the CRU at the University of East Anglia, UK

The Climate Research Unit (CRU) at East Anglia offers several high-resolution global datasets. Datasets 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- STRM Data 90m: The U.S. Geological Survey (USGS) is now distributing elevation data from the Shuttle Radar Topography Mission (SRTM). The SRTM data were collected specifically with a technique known as interferometry that allows image data from dual radar antennas to be processed for the extraction of ground heights. Data available to the geospatial data user community include 1-arc-second (approximately 30-meter) resolution data over the United States and its territories, and 3-arc-second (approximately 90-meter) data over non-U.S. territory (http://erg.usgs.gov/isb/pubs/factsheets/fs07103.html).

USGS - GTOPO30: GTOPO30 is a global digital elevation model (DEM) available by the United States Geological Survey (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

ESDB: The Soil Geographical Database of Europe at scale 1: 1000000 (CEC, 1985) is part of the European Soil Database managed by the European Soil Bureau (ESB). A rasterised (gridded or cell-based) map with a grid resolution of 10km x 10km cell is available. The ESDB only includes the European countries of the Mediterranean.

FAO-UNESCO Soil Map of the World: 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 and Land Cover

The **CORINE (CO-Ordination of Information on the Environment)** programme was initiated by the European Union 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. This dataset does not cover the Former Republic of Yugoslavia and Albania but it includes Tunisia and Morocco.

PELCOM: This is the 1km 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/).

AFRICOVER – FAO: The purpose of the Africover Project is to establish a digital georeferenced database on land cover and a geographic referential 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 data currently only for Egypt. The scale of the dataset is 1:200 000 for the country and 1:100 000 for the Nile Delta.

Geomorphology:
There is no consistent Mediterranean or even European geomorphological map. 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 1km2 (http://edcdaac.usgs.gov/gtopo30/hydro/). It was created by projecting the USGS GTOPO30 dataset, which has a 30'' resolution, onto an equal area Lambert Azimuthal projection. Slope, aspect, and flow properties were also calculated for the dataset.

Table 2 The most common variables employed in landscape classification

Variables	Description	Example Datasets
Climate	Physical - Abiotic	CRU, Univ. East Anglia
Soils	Physical - Abiotic	FAO UNESCO Soil Map European Soils Database
Geomorphology*	Physical - Abiotic	USGS TOPO30
Hydrology*	Physical - Abiotic	Not available
Vegetation	Physical - Biotic	Potential Nature Vegetation
Land use and Land cover	Cultural	CORINE, PELCOM
Landscape History	Cultural	Not available

Apart from these collective datasets presented above it has to be noted that there are also national datasets for some of these variables available, both for the countries that have carried out a landscape character assessment (see section 3.1), and in some countries with no landscape character assessment in place such as Greece. These datasets differ in terms of projection and collection standards, while their accessibility and copyright has to be investigated.

3.3.2 Coastal Landscape Typology Development

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 maps layers using a technique called 'on-screen' digitising. Alternatively, the classification is achieved by interpolation, frequently of gridded data at a specified spatial resolution depending upon data quality and availability. Interpolation is effectively a prediction of the landscape type for a grid point.

An important component of this study is to develop a specifically coastal Mediterranean landscape typology that can be applied at a wide range of spatial scales in the Mediterranean Basin (from the entire region to national and local scale). The landward limit of the coastal zone to follow for the development of the typology should be the territorial limit of local coastal administrative units

(UNEP/MAP 2005). We propose the use of four variables three biophysical, namely climate, landform, geology and one cultural i.e. land cover. The data for these attributes can be stored in a database with 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 "manually" 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 variables' layers 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 Case study: A coastal landscape typology for Sardinia

The methodology described in the previous section will be exemplified with a case study from the island of Sardinia, Italy. Sardinia, the second largest island in the Mediterranean has a variety of landscapes strongly linked to its geological history but also human influence. The costal zone of the island is characterised by wide variety of habitats such as dunes, estuaries, salt marshes, sea cliffs and coastal garigues. Although the landward limit of the coastal zone should be defined by the limit of the local coastal administrative units, these were not available in digital form for this case study. Therefore a 7km buffer from the coast was used instead to delineate the coastal zone. This distance is an average of the extent of the community units along the coast of Sardinia and in cases coincides with catchment areas. For the derivation of the typology in this study climate, landform, geology and land cover were employed (Table 3). **Climate** data were taken from the European Environmental Stratification (Metzger et al 2005). The framework divides Europe into 84 classes based on topographic and climatic variables at 1km^2 resolution. This dataset was employed herein to provide surrogate information on climate. Although 5 classes are found in Sardinia only 3 of them characterise the coastal zone (Table 3). **Landform,** the relative relief and shape of the land surface, was derived from interpretation of a DEM of Sardinia (USGS- STRM) with a pixel size of 90 x 90m. **Geology** was simplified into meaningful categories for landscape character assessment using the 1: 200 000 geological map of Sardinia. **Land cover** was taken from the CORINE land cover map of Sardinia (Marini et al. 1993). The land cover classes in the study area were amalgamated in order to reflect the broad pattern of primary land use at the landscape scale: agricultural areas, forested and semi-natural vegetation, humid zones, water bodies. All the maps used in this study form a co-registered spatial database.

The data were stored in ArcGIS where the successive sub-division of the mapped attributes took place. The climate zones were first divided into physiographic units from contour and geological data. The resulting units were then further sub-divided by land use patterns to derive the building blocks of the system, the Landscape Description Unit (LDU). These units were subsequently amalgamated into Landscape Types with similar attributes using TWINSPAN analysis (Hill 1979). The classification was stopped at the third level of division, resulting in 8 groups containing a sufficient number of units to characterize existing landscape types (Table 4). The results of the classification were then mapped into a GIS to produce a map of Landscape Types (Figure 16).

Table 3. Attributes employed for Coastal Landscape Mapping in Sardinia

Climate[1]	Landform[2]	Geology[3]	Land Cover[4]
Medit. South 2	Plains	Quaternary deposits	Artificial Terrain
Medit. South 3	Rolling hills	Sedimentary of Pliocene	Agricultural areas
Medit. South 5	Steep montane terrain	Volcanic Pliocene-Pleistocene	Forested and Semi-Natural Areas
		Marine and continental	Humid Zones
		Volcanic Oligocene, Miocene	Water Bodies
		Transitional and Marine of the Palaeocene, Eocene	
		Volcanic of Palaeozoic	
		Hercynian metamorphic	

[1]*According to Metzger et al 2005; In ascending order the numbers indicate higher July mean maximum temperature*
[2]*From USGS-STRM* [3]*From the Geological Map of Sardinia* [4]*From CORINE Land Cover map*

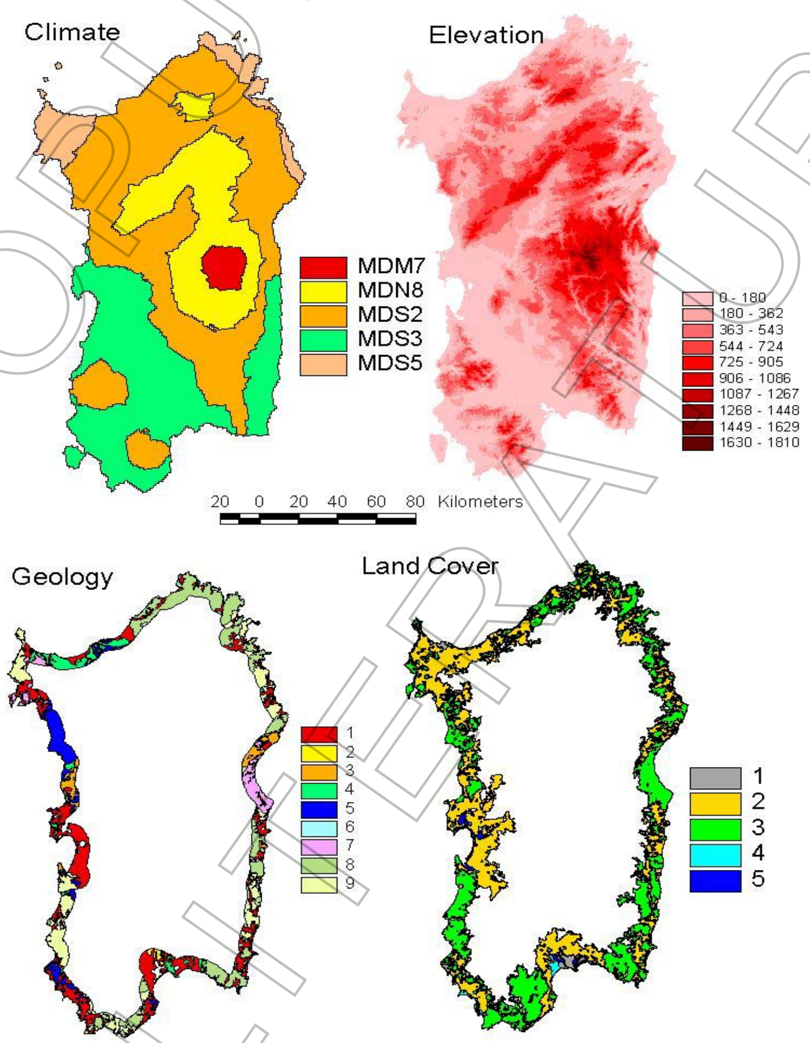


Figure 15. Maps of Variables used for Developing the Typology (for legend information see Table 3)

The main landscapes types identified are the following:

1. High coastal landscapes on hard rocks: These units are found on steep montane terrain, on volcanic rocks, dominated by semi-natural vegetation
2. Hilly agricultural coastal landscapes on hard rocks: These units are on rolling hills over volcanic rocks where agricultural practices are predominat.
3. Hilly coastal landscapes on hard rocks: Forests and semi-natural vegetation dominate on rolling hills over hard rocks. According to the classification a further distinction can be made between the northeast (3a) and southeast units (3b), the latter being drier.
4. Mosaic coastal landscapes on hard rocks: These landscapes, which occur on volcanic rocks, appear to be distinct due to the patchy nature of agriculture and semi-natural vegetation.
5. Urban coastal landscapes on recent deposits: Lowlands on quaternary deposits with continuous urban fabric.
6. Agricultural coastal plains on recent deposits: Lowland quaternary deposits where intensive agriculture dominates.
7. Lowland coastal landscapes on hard rocks: Low lying landscapes on hard hercynian rocks dominated by semi-natural vegetation in the most arid zones of the island.

Table 4. Coastal Landscape Types in Sardinia, their main components and patterns

	Landscape Types	Location	Components & Patterns
1	High coastal landscapes on hard rocks	Orosei, North of Bosa, Capo Marangiu	Forests and sclerophyllous vegetation dominate, limited agriculture, lack of urban fabric
2	Hilly agricultural coastal landscapes on hard rocks	Bosa to S. Caterina, Castelsardo, Vignola Mare	Agricultural fields, limited semi-natural vegetation, discontinuous urban fabric
3a	Hilly coastal landscapes on hard rocks	Rena Maiore, Costa Esmeralda, Porto S.Paolo, S. Teodoro	Sclerophyllous and other semi-natural vegetation dominant, some agriculture, discontinuous urban fabric
3b	Hilly coastal landscapes on hard rocks	Costa Paradiso, Costa Verde, Costa del Sud	Sclerophyllous vegetation dominant, with some agriculture, urban fabric sparse
4	Mosaic coastal landscapes on hard rocks	South of Arbatax, Bari Sardo, Portoscuso	Mosaic with agriculture and sclerophyllous vegetation, salt marshes, discontinuous urban fabric
5	Urban coastal landscapes	Cagliari and its surroundings	Continuous Urban fabric with limited agriculture, semi-natural vegetation, and salt pans
6	Agricultural coastal plains on recent deposits	Oristano, Porto Torres, Posada, Tratalias	Intensive agriculture, discontinuous urban fabric, salt marshes, coastal lagoons
7	Lowland coastal landscapes on hard rocks	North of Argentiera to Stintino	Sclerophyllous vegetation dominant, some agriculture, lack of urban fabric

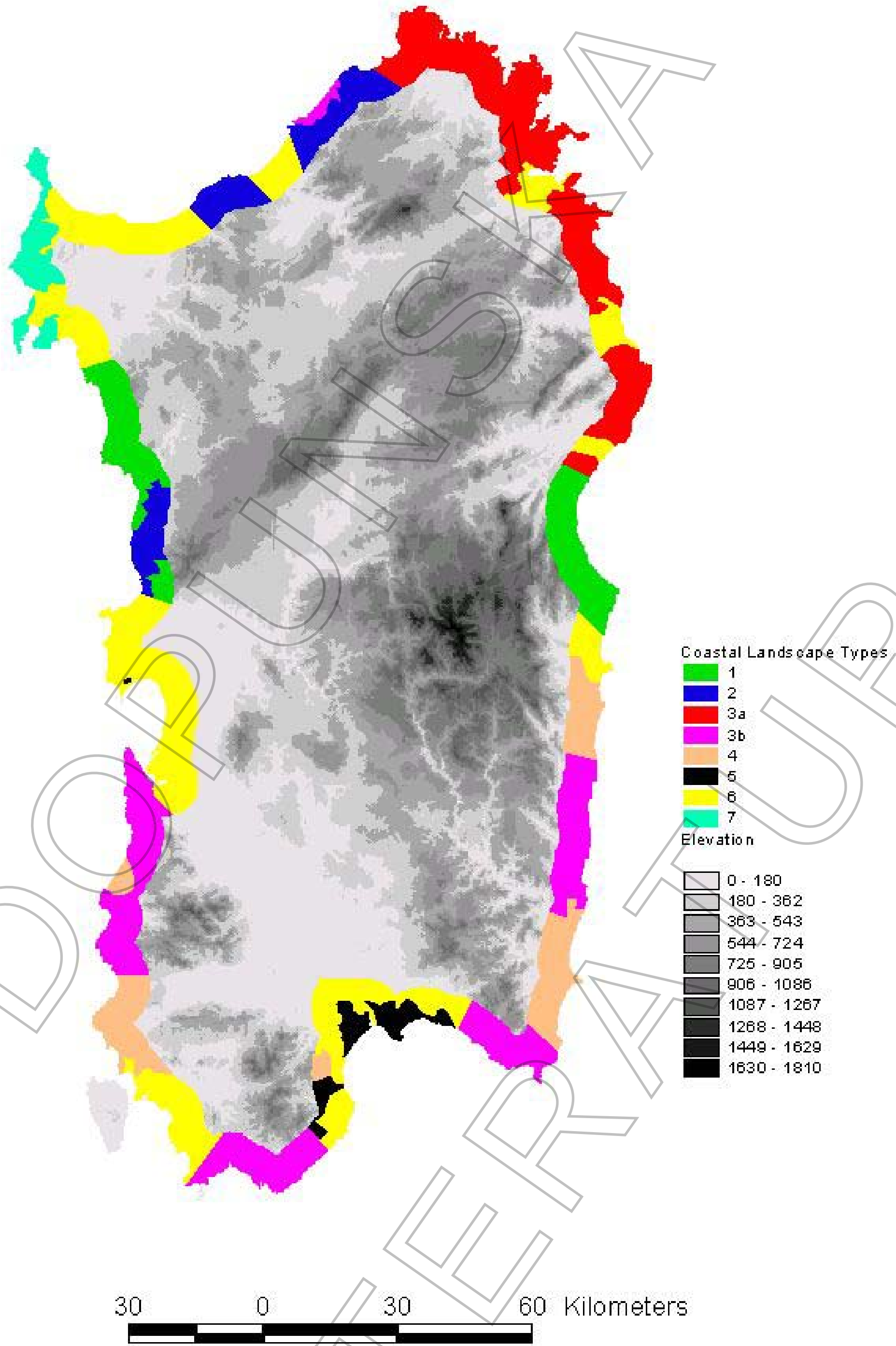


Figure 16. Coastal Landscape Types in Sardinia (for legend information see Table 4)

4. Sustainability Indicators

The island of Gozo: A case study

Sustainability is not a theoretical concept – it means nothing if it can't be implemented (Bell and Morse, 1999). As a result there has been a plethora of attempts to generate management tools to aid in its practical implementation, and one of the most popular of these is the use of indicators and indices (an index being an amalgam of indicators; Bell and Morse, 1999). Sustainability indicators and indices (SIs) have a long pedigree stretching back into component fields of environmental science, economics and community development, and indeed many published lists of SIs will have echoes of this history. Hence 'classic' environmental indicators such as those for biodiversity, toxic loading of pollutants or abundance of key indicator species, economic indicators such as GDP/capita and community development indicators such as poverty, human health or resource distribution find their way into lists of SIs (Morse, 2004). But sustainability is more than just the presentation of all this information it is about constructing a picture from the pieces. How does toxic loading impact on biodiversity and economic wealth and health? Questions such as this have resulted in numerous ideas as to how the separate information can be integrated into an holistic picture of the complex interactions which exist between human societies and the environment (Morse et al., 2001).

One popular approach has been to think in terms of pressure leading to changes which can impact on both human society and the environment. As a result humans respond to problems by making changes in their behaviour or perhaps through legislation. This is the classic and popular pressure-state-impact-response model of SIs. The popularity of the PSIR model rests in part on its inherent intuitive sense of cause-effect: *what we do will bring about negative or positive change*. However, one of the problems with the PSIR model or indeed any effort to capture sustainability is related to the spatial scale at which these tools are being applied. People would have a sense of their immediate neighbourhood but many of the pressures transcend that scale – perhaps operating at national or international scales. Setting the appropriate scale by which people can envision sustainability and measure change with SIs is not an easy task, not helped by the fact that different people will have different appreciations of the space which is important. If it is assumed that the 'landscape' is a convenient space for developing and measuring SIs given its visual apparency (but not withstanding the notion that landscape is also a constructed space in itself) then the challenge becomes how this could best be done?

The authors have been involved in a research project focused in Gozo, Malta, to achieve the marriage between SIs and landscape. In many ways Malta is a microcosm of the issues, pressures and threats which occur through the Mediterranean (MCSD, 2005). The Gozo research to date has not been focused on deriving SIs for landscapes. Instead the six-steps-to-sustainability (SS-2-S) process has been devised to identify areas of high ecological value, the pressures associated with those sites and the identification of SIs. The data are combined via a Geographic Information System. However, the intention is to add a new dimension to this process by repeating the steps for landscape units in Gozo.

The current SS-2-S process is as follows:

STEP 1. Creation of a list of criteria by which to judge ecological value. This is, in essence, an expert-driven task. For the Gozo research a range of criteria were employed including rarity (species listed in the Red Data Book), endemism, distinctiveness and richness/diversity. In this case ecological value represents what it is we wish to sustain

STEP 2. Mapping the state. Once the criteria for ecological value have been identified these are then mapped onto the island of Gozo. A key concern here, of course, is the inherently subjective judgment as to how the criteria should be aggregated into a single ecological value for a polygon. For this research it was decided to take the simplest approach possible - additive (Morse et al., 2001).

STEP 3. Identification of sites to protect or those most at threat. One ecological value has been determined for the island of Gozo it is then used to identify which places on the island have the highest value. Figure 17 is the resultant map for Gozo, with red representing the highest levels of ecological value.

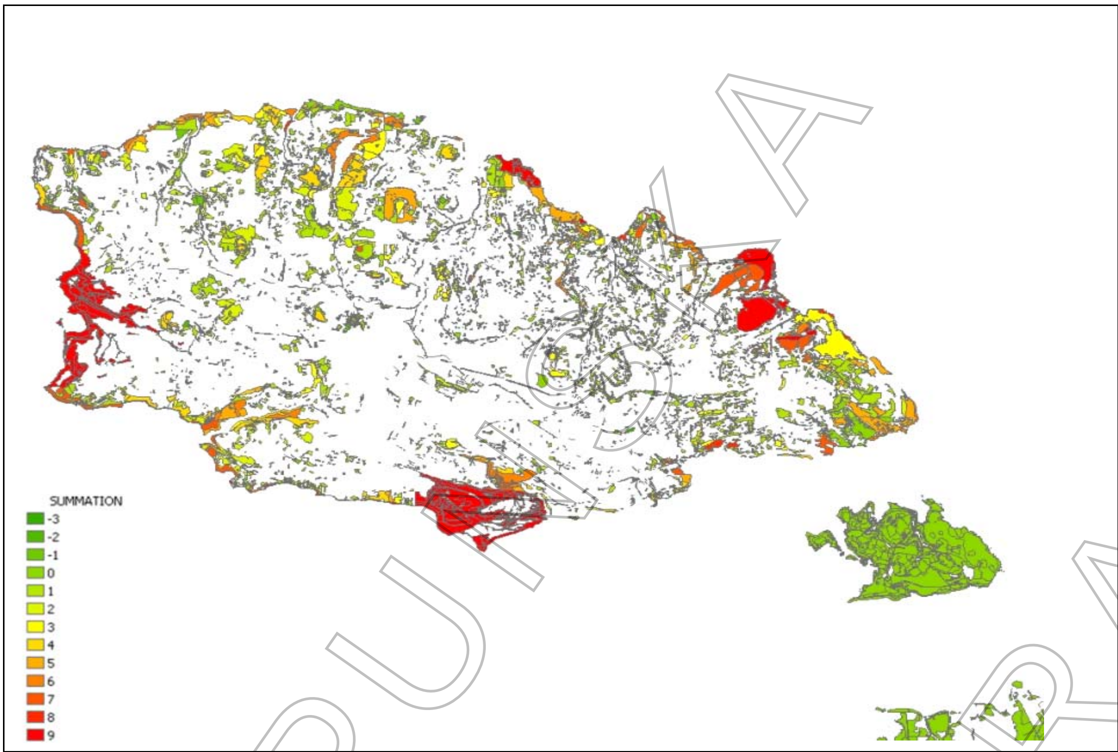


Figure 17 Ecological value for Gozo

STEP 4. Characterisation and confirmation. The sites identified in this way were then characterized in detail by taking a series of transects and identifying and counting the species present. In order to simplify the process as much as possible only plant macrophytes were included in the survey. The aim here is to provide confirmation that the sites are indeed of high ecological value.

STEP 5. Identifying pressures. This phase of the research seeks to identify the key human and natural pressures faced by the sites. Given the human pressures on Gozo it is these which inevitably will dominate the short to medium term thinking. The process adopted was a variation of the Systemic Sustainability Analysis (SSA; now used throughout the Mediterranean as SPSA), and is summarized as Figure 18.

In order to put the modified SSA into practice a week-long activity, entitled "*Landscape integrity assessment for sustainability in the coastal zone*", was held in Gozo with a view to discuss, identify and highlight issues pertaining to the conservation of Mediterranean semi-natural landscapes and their sustainability. The latter two days of the meeting were dedicated towards the SSA-based assessment of the sites selected for their high ecological value. Participants from various Mediterranean countries, together with Maltese and Gozitan counterparts, carried out cursory appraisals of the sites, following which they discussed key conservation issues and identified pressures adversely affecting the sites and their surrounding landscapes. The participants, sub-divided into working groups of between three and five persons per group, then produced rich pictures based on their observations and findings to describe key issues afflicting the sites. From this they were able to identify pressures and the tasks required to address them

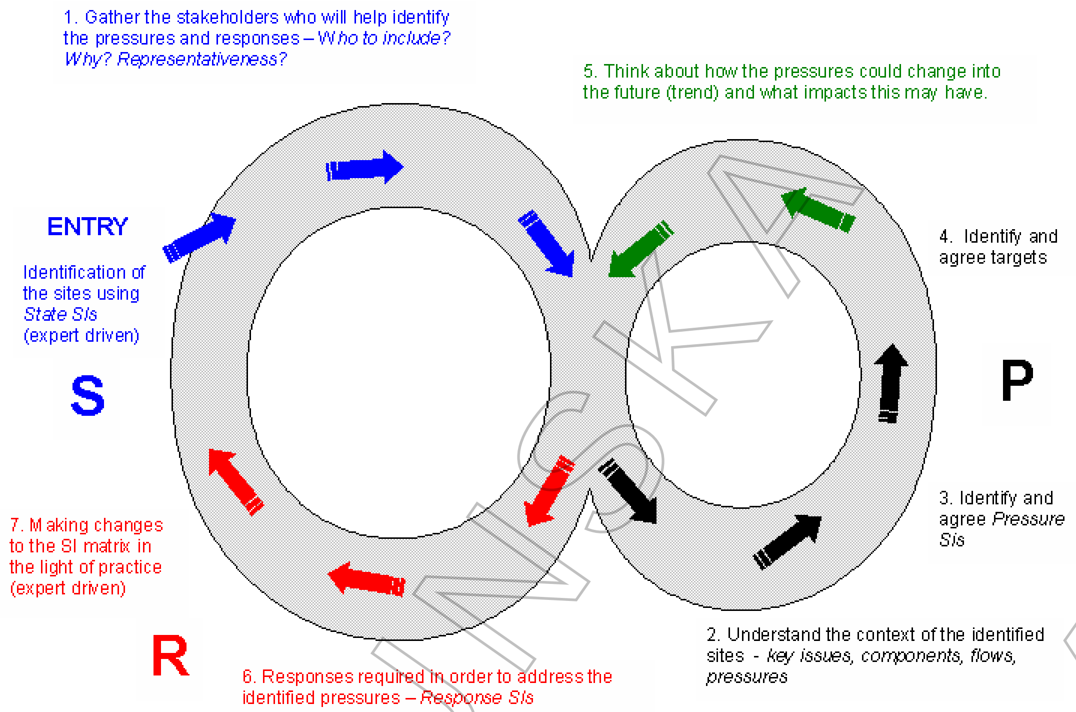


Figure 18. Summary of a modified SSA approach to the identification of pressures operating for selected sites of high ecological value in Gozo.

A second focus group seminar was held during the initial part of 2005, where a group of local planners were familiarized with the selected sites and their surrounding landscapes. Three work parties visited each of the sites and identified the key issues afflicting the sites. At a later phase, the planners created 'rich pictures' to describe pressures they had identified for each of the selected sites, subsequently deriving a list of the actions/solutions deemed necessary to tackle the issues. The group was introduced to the sites and their surrounding landscapes during a series of tutorials on landscape ecology following which, the group was sub-divided into three fieldwork parties with a view to analyze each site and identify the key issues and required actions. Subsequently, the planners, retaining the same group configuration they had in the field, created rich pictures to describe the environmental pressures they had identified for every one of the sites, later deriving a list of environmental issues and the action deemed necessary to tackle the matter.

In order to test the transferability of the modified SSA a similar exercise, but not in so much depth, was conducted in the Maremma, Italy, and for the north-west coast of Tunisia. The pressures identified from the SSA sessions for the sites in Gozo as well as in north-western Tunisia and in the Maremma are summarised as Table 5. Note how some of the pressures, such as agricultural pollution and illegal construction, are common across many of the sites while others are more limited in importance (e.g. landfill). With regard to the Gozo sites, it appears that bird hunting and trapping scored for every site. This is not surprising since such activity is deemed, practically, endemic within the context of the Maltese Islands. Also, in view of the rural character of the sites in question, coupled by their coastal location (ideal for incoming migratory birds), bird shooting and trapping is typically widespread.

Table 5. Pressures identified by key actors during the process of SSA.

PRESSURES / SITES:	Dwejra/ Qawra	Ghajn Barrani	Ghajn Damma	Ramla l-Hamra	Rdum S.Filep	Ta' Cenc	Ta' Magun	Ta' Tocc	Wied Sabbar	Maremma Tuscany	Berkoukech Tunisia
Quarrying	Ⓟ				Ⓟ		Ⓟ				
Illegal constructions	Ⓟ	Ⓟ	Ⓟ	Ⓟ	Ⓟ		Ⓟ	Ⓟ			Ⓟ
Hunting & trapping	Ⓟ	Ⓟ	Ⓟ	Ⓟ	Ⓟ	Ⓟ	Ⓟ	Ⓟ	Ⓟ		
Pollution from agriculture		Ⓟ	Ⓟ	Ⓟ	Ⓟ		Ⓟ	Ⓟ		Ⓟ	Ⓟ
Land abandonment	Ⓟ				Ⓟ	Ⓟ	Ⓟ	Ⓟ	Ⓟ		
Threat from development						Ⓟ			Ⓟ		Ⓟ
Visitor pressure	Ⓟ			Ⓟ						Ⓟ	
Unregulated camping	Ⓟ			Ⓟ							
Climbing & abseiling	Ⓟ										
Grazing	Ⓟ				Ⓟ		Ⓟ	Ⓟ			
Planting of / displacement by alien species	Ⓟ				Ⓟ		Ⓟ	Ⓟ		Ⓟ	
Landfill		Ⓟ	Ⓟ								
Recreational activities				Ⓟ		Ⓟ			Ⓟ	Ⓟ	
Land take-up through uncontrolled reclamation		Ⓟ	Ⓟ	Ⓟ	Ⓟ		Ⓟ	Ⓟ		Ⓟ	
Proximity of urbanization							Ⓟ	Ⓟ			

Pressure to construct illegal structures in the countryside and the prevalence of trampling also score highly in the local context, while the former is also prevalent on the Tunisian coast. Other pressures of some significance include the often illegal take-up of land for reclamation purposes, which results in the loss of semi-natural assemblages; the abandonment of agricultural land, which brings with it rubble-wall degradation and, as a result, accelerated erosion; and, the release of herbicides and pesticides into the environment, notably into the hydrological system. Other pressures, which do not appear to be widespread within the selected sites, but whose impact would do irreversible harm, include open pit quarrying; the spread of uncontrolled urban development; the use of and consequent displacement by alien species of indigenous flora; and, disturbance caused by recreational activities in ecologically sensitive areas.

STEP 6. Ranking pressures and finding SIs. Once pressures have been identified for the sites it is a relatively small step to rank the importance of the pressures at each site (including a variation in rank according to the different stakeholder groups) and to create SIs to gauge them alongside SIs of state and response. An example of a list of pressure SIs is provided as Table 6. Please note that these are only meant as examples – work is ongoing to set SIs that will be put to stakeholders in Gozo.

Table 6. Some example SIs that could be employed for the pressures identified as important in Gozo, the Maremma and North-West Tunisia

PRESSURES	POSSIBLE SIs
Quarrying	Area occupied by the quarry Rate of extraction from the quarry (quantity of rock per annum)
Illegal constructions	Number of illegal constructions within a 5 km radius of the site
Hunting & trapping	Number of trap sites
Pollution from agriculture	Quantities/type of fertilizer and pesticides applied to agricultural land (per area basis) Number of eutrophication incidences in local streams/rivers Biological Oxygen Demand of local streams/rivers Concentration of pesticides/nitrates/phosphates in local water systems
Land abandonment	Proportion of land abandoned per annum
Threat from development	Number of planning applications made in past year Number/type of developments that have occurred in past year Population density Loss of agricultural land to development
Visitor pressure	Number of tourists staying in vicinity (hotel records) Census of visitor pressure on certain days of the year
Unregulated camping	Number of incidences of unregulated camping in locality
Climbing & abseiling	Census of the number of climbers/abseilers on certain days of the year
Grazing	Incidence of damage through grazing Proportion of land area grazed
Planting of / displacement by alien species	Number of incidents along with the nature of the alien species
Landfill	Area occupied by landfill site Type/quantity of waste placed into site on an annual basis Incidences of pollution arising from the landfill
Recreational activities	Number of incidences on certain days of the year
Land take-up through uncontrolled reclamation	Proportion of land taken-up through uncontrolled reclamation
Proximity of urbanization	Distance to nearest dwellings Road density

A new dimension to SS-2-S: Extension of these ideas to landscape units.

As formulated here under steps 1 to 6 ecological value, pressures and SIs are specific to sites rather than landscapes. However, it would be relatively straightforward task to repeat the expert-participatory process using landscape as the spatial unit of assessment rather than 'sites'. What matters is that the stakeholder groups can resonate with the unit, and landscape provides a readily apparent and easily recognizable unit. For example, Gozo has the main landscape units shown in Figure 19.

Everyone living on the island or even visiting it would 'see' these units even though they will not know of their names or any formal classification. Differences between some of the units may be more noticeable and 'valued' than others, but the units would provide a convenient yet readily apparent basis for exploring value, pressures and SIs. This would be of marked contrast to the sites identified as being of high ecological value.

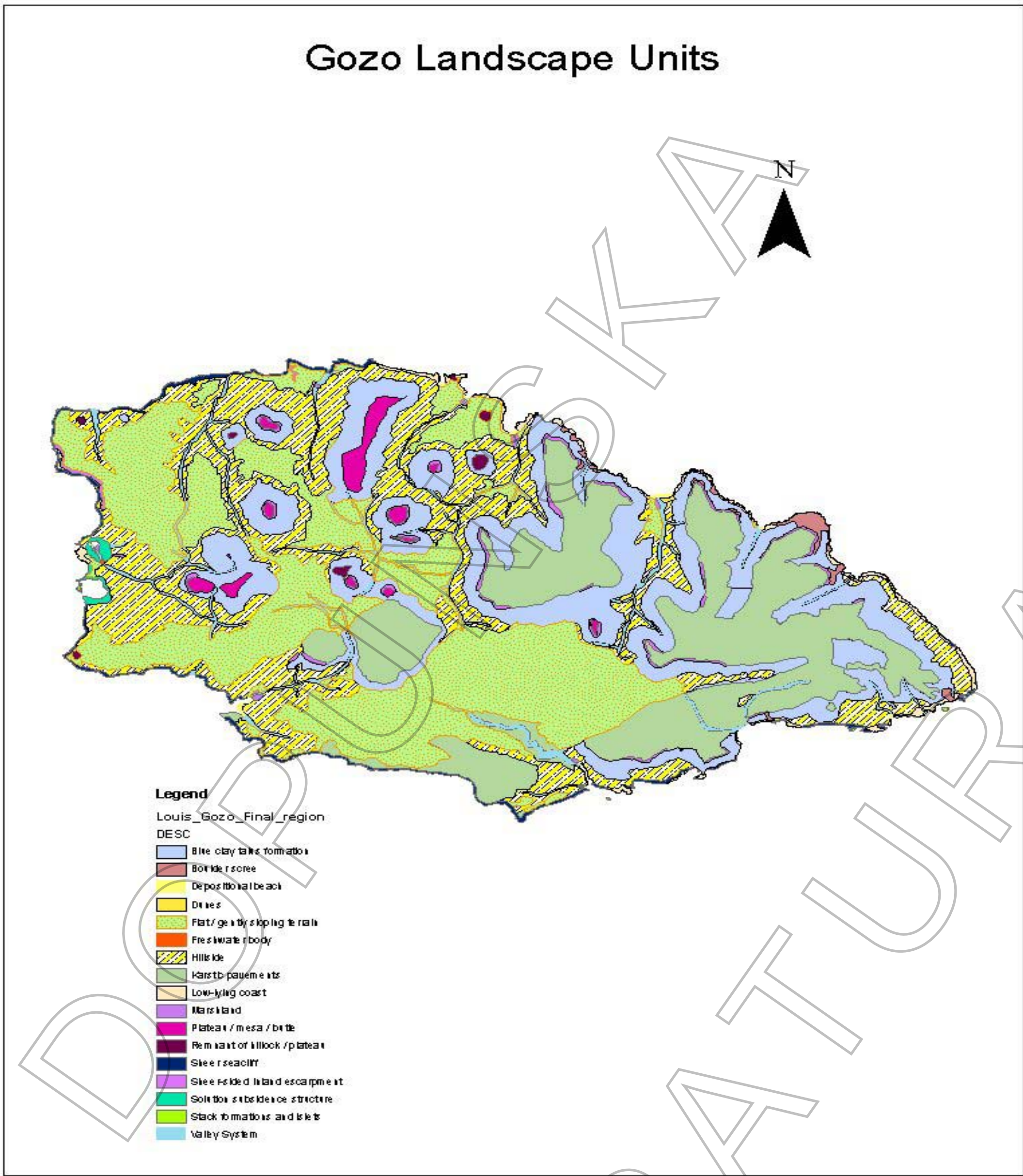


Figure 19. Main landscape units of Gozo

Rather than use just the concept of 'ecological value' it would be possible to combine landscape units with some notion of 'human value' either in terms of economic use, cultural benefit or even through something as subjective as 'attractiveness'. In 'hard' terms each of these units is associated with different 'uses' and activities, and hence will also have their own pressures which can be identified and SIs can be used to gauge them in the same way as for the sites of high ecological value. For example, it is likely that the landscape unit listed as 'blue clay' in Figure 19 (area shaded blue) would be associated with pressures arising from the use of powered bikes resulting in erosion of the slopes. Similarly the low-lying (green) areas of Figure 19 would be associated with pressures arising from agricultural activity and development.

It should be noted that the SS-2-S process as set out here is linear – it is run through once then ends. Clearly this is far from ideal when working with something as mutable as sustainability, and in reality the SS-2-S process needs to be repeated on a regular basis. Limitations of resource allocation will obviously be important here.

5. Conclusion and Future Work

Despite the great cultural and natural diversity of the Mediterranean, coastal landscapes throughout the Basin are faced with common threats including pollution, overgrazing, tourism development, as demonstrated by the case studies presented herein. These problems combined with lack of public awareness, political commitment (demonstrated with inadequacy of legislation or ineffective enforcement) and inter-sectoral co-operation, hinder the protection and sustainable planning of natural and cultural landscapes. What differs is the scale of these problems and the means/tools employed to solve them which reflect a clear divide between the countries of the North and South Mediterranean (Vogiatzakis et al. *in press*).

Landscape Character Assessment provides 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. The development of landscape typologies provides the spatial framework for monitoring ecological processes but also for the derivation of sustainability indicators. The report has demonstrated a method for aggregating Landscape Description Units with similar attributes into a system of Landscape Types. The use of GIS technology enables data integration, increasing detail and efficiency in landscape inventory and analysis. The methodology is robust, transparent and repeatable, based on consistent datasets and can potentially be developed in a pan-Mediterranean scale.

A potential obstacle in the development of a pan-Mediterranean scale coastal typology, as the preliminary research in this study confirmed, is the lack of truly Mediterranean datasets. The datasets identified so far exhibit high diversity in terms of quality, resolution, and coverage. Although high quality data are available for some limited areas or individual countries, such data are not applicable for the initial task of dividing the Mediterranean coastal landscapes into major regional units. However, and despite the difficulties in using this data from different sources, the need for pan-Mediterranean coverage overrides such concerns. During the development of the Mediterranean coastal landscape typology more data can be incorporated into the project as they become available.

The quality and availability of datasets was important to the development of a coastal landscape typology for Sardinia, used as a case study. For example, the use of the administrative boundaries for delineating the coastal zone of the island would allow more realistic/meaningful conclusions to be drawn. For a regional scale case study more detailed information on climate would be possibly required. Moreover, the use of up to date information on land cover is of utmost importance since it affects the accuracy of the classification. In this case the land cover map used, produced in 1993, did not account for recent changes in the landscape. Fieldwork is an important component of any landscape character assessment for the validation of the desktop study results and therefore improvement of the proposed scheme. This was not possible within the time and resources of this study. 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.

The adoption of a truly holistic landscape approach has been advocated as the link to sustainability in the Mediterranean region (Makhzoumi and Pungetti 1999). The commonly used Environmental Sustainability Index (Morse 2004) is a country level based index which, although useful for the construction of league tables of national performance, does not help with issues of sustainability operating at more site-specific levels. Given the advantages that landscape may have as a recognisable spatial unit for an analysis of sustainability it may be possible to link SIs to coastal landscape types in the Mediterranean. A first attempt of this kind was demonstrated herein for Gozo, but there is certainly more work needs to be done.

Towards a pan-Mediterranean Coastal Landscape Typology – The way forward
Based on its knowledge and experience on Mediterranean Landscapes, Landscape Character Assessment and Sustainability Indicators the working team suggest the following groups of activities for the development of a pan-Mediterranean Coastal Landscape Typology:

1. Establishment of a pan-Mediterranean cartographic database on cultural and physical attributes for the coastal area;
2. Development of a complete typology for the Coastal Mediterranean landscapes;
3. Application of typology to generate maps of coastal landscapes
4. Derivation of coastal landscape specific indicators of sustainability;
5. Apply the derived typology to address specific problems e.g. sensitivity to change

The main challenge, however for the continued development of a spatial framework for landscape planning, is the integration of disciplines and data to develop an increasingly holistic view of the landscape at multiple scales. The emerging Mediterranean framework needs to be capable of translating policies and targets from a pan-Mediterranean down to national and local level. There must also be sufficient flexibility to ensure that the Mediterranean spatial framework can be shaped by the results of local studies.

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