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Training Package

Integrated Coastal Area Management

Part one: Training Manual

UNIDO ICS 2001

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INTERNATIONAL CENTRE
FOR SCIENCE AND HIGH TECHNOLOGY

Training Package

Integrated Coastal Area Management

Part one: Training Manual

Version 1.0, February 2001

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Preface

Each one of the subprogrammes, that make up the Earth, Environmental and Marine Sciences and Technologies Programme at ICS-UNIDO places much emphasis on the training aspect of environmental management. For some time now, the Coastal Zone Management subprogramme has focused on human resource capacity building, giving considerable importance to the preparation of didactic material on the interdisciplinary aspects of coastal management and planning.

It gives me great pleasure to note that one of the major goals of the Coastal Zone Management subprogramme for this year, that is, the preparation of this Training Package, has come to fruition. I trust that it will be put to good use during the initial years of the new millennium, when it will be necessary to translate sustainable development goals into reality.

Gennaro Longo
Programme Officer
Area of Earth, Environmental and Marine Sciences and Technologies, ICS-UNIDO

The Training Package on Integrated Coastal Area Management has two parts. Part one, which contains 10 modules, consists of lecture notes on various aspects of coastal area management. Part two contains the visual aids that accompany each of the 10 modules.

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Not least, I am exceedingly grateful to my wife, Lucienne M. Bugeja, for her unceasing support, extraordinary patience and constant encouragement throughout the time I spent working on this assignment both in Trieste and, at home, in Malta.

Louis F. Cassar
Hal-Lija, Malta, December 1999

Overview*

Decades of neglect and overexploitation, conflicts over resource use and a lack of stakeholder participation in decision-making brought about a need, which essentially stemmed from a change in the prevailing mentality, for a greater environmental awareness. Various local and international initiatives, over the years, provided the platform for enhanced international collaboration on one end of the scale and public communication and involvement on the other. The last three decades saw the setting up of a number of specialized bodies, within the ambit of both international and intergovernmental organizations, particularly through the initiative of the United Nations. To a large extent, these entities, together with a host of non-governmental organizations, have sought to slow down the process of degradation and, indeed, reverse current trends of resource exploitation. In this respect, a number of landmark events have since been held, following the Stockholm Conference of 1972, each one contributing further to the evolution and fine-tuning of interdisciplinary concepts such as environmental management and sustainability. More importantly, these environmental milestones set the scene for a better understanding of the need to tackle *development* and *conservation* in a holistic manner.

Whereas in the past, the approach to planning and management of coastal resources was traditionally sectoral, nowadays, it is oriented towards strategic planning and integrated management. This methodological shift in favour of multidisciplinarity does not quite substitute for the notion of targeting economic activities, but rather complements the manner in which resources in coastal areas are managed.

Although this training package focuses on the Mediterranean region per se, the concepts, issues and examples highlighted within most modules may readily be "imported" into other coastal regions, where similar scenarios no doubt exist, and adapted to local circumstances. In a sense, this training package seeks to complement similar works on the subject, but may also be utilized separately to conduct, for example, a training course on aspects of integrated coastal area management (ICAM). Moreover, each module is designed as a stand-alone set of lecture notes, which render the manual more flexible and versatile in its use. Each module is a complete course, thus allowing trainers to choose and mix modules according to training needs and requirements. Some capacity-building exercises may necessitate the utilization of all modules of this ICAM training package, while others may only require partial utilization. Whichever the scenario, it is vital that coastal area management is seen as a proactive mechanism, which requires a long-term, holistic and incremental approach to environmental planning and management.

*General scientific editor of training package Louis F. Cassar, Director of the International Environment Institute at the Foundation for International Studies, University of Malta, and Scientific Adviser on Coastal Zone Management at the International Centre for Science and High Technology (ICS-UNIDO).

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Explanatory notes

CBA	cost-benefit analysis
CEA	cumulative environmental assessment
CED	cross-elasticity of deman
CFC	chloroflurocarbon
CVM	contingent value method
DSS	decision support system
EIA	environmental impact assessment
GDP	gross domestic product
GDSS	group decision support system
GEF	Global Environment Facility
GIS	geographical information system
GNP	gross national product
ICAM	integrated coastal area management
ICPM	integrated coastal master plan
ICZM	integrated coastal zone management
LGMP	Local Government Management Board
MCA	multi criteria analysis
MCE	multi criteria evaluation
MIS	management information system
OECD	Organisation for Economic Cooperation and Development
PSR	pressure-state response
psu	practical salinity units
RDI	real disposable income
REA	regional environmental assessment
SEA	strategic environmental assessment
SIA	social impact assessment
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientic and Cultural Organization
WHO	World Health Organization
WTA	willingness to accept
WTP	willingness to pay

Introduction

Introduction

It has often been said that there is, probably, no other region on the planet that has attracted more attention than the coastal zone. One may argue that the littoral is no more important than any other environment, yet no other geomorphological entity on earth has had so much concern expressed, funds directed towards it and its related issues, and action taken with the aim of protecting it and the resources found within it.

From time immemorial the coast has been instrumental in providing human beings with countless benefits; the marine environment, in particular, has for centuries been depended upon by local populations for their subsistence as also for economic purposes. Urban centres have been established near the sea since the earliest of times. From around the high Middle Ages to more recent times, in particular during the past 150 years, more and more people moved closer to the coast. The reasons for this may be attributed to commerce and trade opportunities. However, improvements in social well-being and societal structures during the last 80 years or so and, closer still, with the advent of affordable travel possibilities (which seems to have had a catalytic effect since the 1950s) are seen to be largely responsible for the pressures exerted on the littoral.

According to a recent estimate, some 66 per cent of the globe's population lives within a few kilometres of the coast and, as a result, pressures stemming from human activity—urban sprawl, food production (mainly agriculture), industry, communications, transport and recreation—are concentrated in the region. A series of other impacts, consequent on human activities further afield, are a constant occurrence. Some examples include the conveyance of sewage from inland urban locations to the coast and the discharge of industrial effluent into fluvial systems reaching the sea. This is yet another case in point of how much the coastal zone and adjoining marine habitats are potential sites of extreme resource conflict.

In recent decades, the *riviera* became the in-place for the masses with sea-sports becoming increasingly popular and, as the years went by, more diverse. Meanwhile, shore-based activities such as beachside camping, barbecues and beach picnics became more appealing, thus resulting in increased round-the-clock disturbance. These reasons and others have led to mass tourism, and worse still, to a trend of "sun, sea and sand" holiday-making, which, in broad terms, often results in indiscriminate development on the littoral.

The degradation experienced in coastal regions such as the Mediterranean, is largely due to insensitive development and an attitude of securing a quick source of income. This was particularly prevalent during the post-war period when the tendency to industrialize at the quickest rate possible was much in evidence. The unsustainable use of land and other natural resources, as though these were infinite, was at an exceptional high, principally during the 1950s and 1960s following the deprivation experienced during the 1940s. In the case of recreation-oriented development, privately owned seaside dwellings belonging to the affluent few and which once stood uncontested and relatively undisturbed, began to make way for, or rub shoulders with, resorts and holiday complexes in many regions within the Mediterranean basin.

As years went by, one-time pristine sites became suffocated with motorways and concrete conurbations, domestic waste and ever-growing transitional populations and accompanying ancillary facilities, including industry. Whereas during past centuries, it was agriculture-related activities and, to a much lesser extent, coastal fortifications which caused significant damage to coastal communities and habitats, nowadays it is industry and urbanization of sorts that pose a serious threat to coastal ecosystems. In fact, apart from encroachment through unplanned development and urban disarray, the coastal zone has yet another malady to cope with, in the form of environmentally hazardous technology. Heavy industry, dockyards, power stations, waste treatment plants, marinas and even aquaculture projects are largely responsible for adversely affecting marine and coastal biota, and for applying added pressures to the littoral, leading to increased sea/land-use conflict.

Since the cause of environmental degradation (whether directly through habitat modification and destruction, or indirectly through lack of planning) is primarily man-induced, the human factor, or, more accurately the social fabric, has to be accounted for when appraising the state of the environment, especially in densely populated regions such as the Mediterranean.

A. Human pressures on Mediterranean coastal ecosystems

One need only visit the Mediterranean basin briefly to realize the uniqueness of the region. Its landscapes and topography, as well as the habitats and biota, all contribute towards the basin's richness and diversity. The Mediterranean possesses some exceedingly interesting ecosystems, which are of importance both biologically—in view of the abundance of endemism, amongst others—and economically.

Notwithstanding, many important sites are still not adequately protected and a number are under threat. In addition, biodiversity is increasingly at risk. A burgeoning population, whose greatest demand is land area to develop for urbanization and industry, is subjecting remaining areas of pristine beauty to intensified pressures.

Evidence shows that population expansion and increased industrialization has already had a notable effect on the coastal area of numerous countries. Moreover, projections indicate that human pressure is expected to intensify, with coastal populations likely to more than double by the year 2025, while the number of visitors to the region, according to an estimate of the United Nations Environment Programme (UNEP), is expected to reach 260 million per year.

As the coastal zone is modified, the biodiversity of the region is adversely affected. The richness and diversity of the flora and fauna of the Mediterranean, much dependent on maintaining stability of marine and terrestrial ecosystems, would thus diminish. As a result of human-initiated disturbance, habitats are degraded, food chains disrupted and entire ecosystems irreversibly damaged. Severe degradation of Mediterranean basin ecosystems can have serious and far-reaching effects, leading to the loss of essential life-support components, reduction in goods and services provided, and species extinction.

Increasing pressures on natural areas can lead to a change in land-use patterns, and make demands on the ecological resources of the area that are unsustainable. Diminished regenerative capacities, that is, the system's capability of replenishing resources and absorbing waste, may eventually be outpaced by population growth and accompanying activities, constraining future economic growth and development in the region.

Economic activities, like agriculture and tourism as well as certain elements of industry, which depend on the vitality of ecosystems, will suffer if haphazard development is not contained. For instance, the destruction of habitats such as seagrass beds, a vital element in the life-cycle of many species of fishes and crustaceans, may have significant repercussions on the fisheries industry if continued damage is not curtailed. Further loss of species in the area will diminish the aesthetic value of the region and have an unquantifiable effect on future generations.

B. Applying the concept of sustainability through integrated coastal area management

The general notion of sustainability in a region such as the Mediterranean is not an easy one to embrace across the board. The reason being, primarily, that the politico-socio-economic frameworks of various countries fringing the Mediterranean are so dissimilar and, to some degree, almost incompatible. Prior to manifesting a rationale for sustainability, it must be borne in mind that societal structures are, principally, so diverse—with some societies experiencing a western-style way of life, while others are still struggling for basic sanitary facilities.

While it is commendable that every nation aspires to a better quality of life, it is a known fact that developed nations produce more domestic waste, emissions etc. In a sense, therefore, the very concept of sustainability and the desire to progress is paradoxical, since the use of some technologies may well bring about increased negative impacts within the country concerned as also in the region as a whole.

The way to proceed, in terms of managing coastal resources as well as related technology exchange, would be to implement plans strategically and in an integrated manner, taking into consideration the environmental, social and economic factors concerned. Unfortunately, not all components of the coastal zone can be quantified or valued. A "price tag", for example, may be given to fish catches and prime land earmarked for the development of industry and urbanization. However, the effect of pollution and secondary impacts as a result of industrial activity is not easily quantifiable. Nor can one venture to cost biodiversity, since, even if this may not have any apparent economic use at present, it may well become important to, for example, the pharmaceutical industry in the future. Another sphere of considerable difficulty is landscape valuation. Areas of intrinsic natural beauty fall within the sphere of subjectivity; again, it is better to err on the side of caution and take into account its possible future potential.

In considering sustainable development options, quite often, the question of carrying capacity arises. As with everything else, this concept should be seen in context; for example, calculating the carrying capacity of a historic walled city is a world apart from the threshold value of an ecosystem. In the case of the walled city scenario, once beyond its carrying capacity, it is likely that higher levels of noise, congestion and a general lack of tranquillity will result. On the other hand, exceeding the carrying capacity of a coastal ecosystem, particularly one that is sensitive and economically important, may lead to an equivocal state of affairs. In any circumstance, it is at no time advisable to verge upon the threshold level of an ecosystem or any of its components. As the term implies, carrying capacity is the uppermost or furthest limit that may be endured, following which, in the case of species, adaptation or extinction is most likely to occur.

In sum, sustainability is not about restoring ecosystem productivity for further exploitation. It should be regarded as a measure to rehabilitate an affected area with a view to restoring the system, and all that is influenced by it. Firstly, by ensuring that the dynamic equilibrium, on which all the components (such as communities and populations) that make up the system greatly depend, is restored; and, secondly, to ensure that the benefits which may be derived by future generations are safeguarded.

C. The Future

The need to instil a strong attitude of belonging (not merely coexistence but one of conjoint accountability) among decision and policy-makers of the Mediterranean basin, as also the public at large, is strongly felt. In time, this should bring about a common positive outlook towards environmental matters and hopefully an attitude to act and take decisions with responsibility and with respect towards present and future generations. In view of the interdisciplinarity of coastal management as well as the complexity of governance among states, it is crucial that international efforts, in the field of environmental protection and conservation, are harmonized so as to derive full benefit.

Today, it may be acknowledged that much has been done by international agencies and national governments, in their endeavours to halt and even reverse current levels of degradation. Notwithstanding, it is also evident that certain ecosystems in the Mediterranean have sustained much damage over the last decades.

In taking stock of the general picture, the ensuing constraints by, for example, demographic pressures along the littoral show that some of the problems identified as early as the initial part of the 1970s, despite the ongoing efforts by many, still persist unabated. The very fact that a number of hot spots have been identified in recent years, from various areas of the Mediterranean, is testimony of this.

Difficulties also arise, in the field of environmental management, from the fact that other constraints exist. Some of these include:

- ❐ A lack of streamlining among national environmental and planning agencies;
- ❐ A lack of communication between industry, policymakers and the general public;
- ❐ An inadequate flow of information due to weak public awareness systems and lack of consultation;
- ❐ Failure to incorporate sustainable planning strategies into industrial development policies;
- ❐ A serious lack of involvement of key stakeholders in decision-making processes;
- ❐ Inadequate legal instruments coupled with ineffective enforcement;
- ❐ *Environmental education* receives too low a priority;
- ❐ Human resources not adequately trained or too thinly spread with overload of responsibility;
- ❐ The inability to measure and analyse certain risks holistically.

One of the major constraints faced by national governments is the lack of adequately trained staff. Very often technical and professional staff are thinly spread and are, on occasion, expected to perform functions beyond their technical remit. For this reason, it is important that *human resource capacity-building* in the area of environmental management (including management of coastal resources) is given high priority. Well-trained personnel would be an invaluable asset to any agency dealing with environmental protection and conservation.

The proper understanding of such multidisciplinary fields would also bring about a better awareness of the problem and the real magnitude of risk involved. Adequately trained staff are indeed most effective where inter-sectoral coordination, directly relevant to coastal management and industrial development, is concerned. Moreover, it is likewise important that some synergies also prevail between the different facets or levels, namely regional, national and local. This should bring environmental issues into focus for more stakeholders and ensure their participation in decision-making.

It is anticipated that this training package, with its individual modules, will serve to bridge some of the training needs of key stakeholders and further complement other similar works, thereby increasing the capacity building opportunities in the Mediterranean region. Some of the stakeholder groups that readily come to mind include: members of staff of environmental and planning agencies, wardens within local government, conservation area managers, environmental non-governmental organizations and, of course, facilitators of training courses and seminars on coastal area management.

2

Mediterranean coastal habitats and biota

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1 Geopolitics: linkages between the physical setting and use of resources on the Mediterranean coast

1.1. Introduction

1.1.1. Rationale

The overarching determinant for integrated coastal area management (ICAM) is geopolitics. Before any decisions can be made, the geopolitics of the environment, from the macro-scale to the micro-scale, must be considered. The geopolitics of the physical setting, whether it be the eastern Mediterranean or one pocket beach in Malta, will exercise a profound influence on the use which can be made of resources.

Geopolitics is essentially the interplay of geography and politics; more tangibly, it is the use of geography to illuminate political decisions before they are made. Geography provides the "real world" evidence in the light of which such decisions are taken. It should be stressed that, in the modern use of the term, geopolitics takes into account a full inventory of geography—political, social, economic and physical—at the location in question.

Despite the fact that research in the early part of the twentieth century concentrated upon global dimensions, geopolitics is, currently, not regarded as scale-specific. Obviously, the physical setting can be taken to imply geography on any scale from the international to the local, but similarly, political decision-making occurs at all levels, from the international to the national, the regional and the local. International policy cascades downwards and influences local events. For example, during 1999, a large part of the coastal area of the eastern Adriatic has been dominated by North Atlantic Treaty Organization (NATO) decisions on Kosovo and the neighbouring areas. In contrast, the effects of local geopolitics are likely to remain significant only at the local level, although there may be in some instances a ripple effect to the regional, national or even international level. Local decisions on the safety of water traffic in the vicinity of Istanbul have been fed into the national policy for the Turkish Straits, which seeks to limit tanker traffic and therefore influences petroleum development in the Caspian Sea basin.

The use of resources in the Mediterranean coastal area implies political decision-making at all levels. Furthermore, what is considered a resource may encompass the coastline itself and also specific resources ranging from conservation areas to salt or sand within the coastal area. The coastal area may also be influential in that it gives access to resources inland or, more commonly, seawards.

1.1.2. Geopolitical change

Both interacting elements of geopolitics are subject to change. However, as with the contrast between cascading and ripple effects, significant change in the case of geography and politics (the physical setting and its use) is initiated at opposite ends of the scale. In geography, with few exceptions, changes are local and it is the sum total of such local changes which alters the entire character of the coastline. In politics, key decisions are made at a high level and set the pattern within which local politics operate. This distinction needs to be borne in mind in any examination of geopolitical change.

The physical setting of the coastal zone depends ultimately upon the balance between the forces of erosion and weathering acting against the resistance of the surface materials, predominantly rocks. The continual removal, transport and deposition of surficial debris constantly changes the form of the landscape.

This is most apparent along the coastline which is the most active of all the geomorphological environments. River floods may cause extreme landscape changes, but major floods are rare occurrences and for all but a few days in most years, the fluvial environment is quiescent and stable. In contrast, the coastal environment, although most severely influenced by storms, is one of constant change.

The coastline itself can be characterized as advancing or retreating, depending upon the balance between erosion, deposition and sea level change. Erosional and depositional changes can be more sudden, but are limited in their effects. Sea level change is gradual, almost imperceptible, but can have a more far-reaching influence. Submergence and erosion result in coastline retreat, while emergence and deposition produce an advancing coastline. For the Mediterranean, the balance between erosion and deposition can alter over short distances. In this, there is a significant difference between the northern shore with its marginal seas and fretted coastline and the southern shore which is far simpler in form and considerably less serrated. Sea level change, since the Mediterranean is one coherent water body, affects the entire coastline, although the evidence for such change varies from place to place. Along the northern coastline of Tunisia, there are several extensive areas of coastal sand dunes which indicate the continuing pre-eminence of emergence. In the Gulf of Gabes, spits and other depositional features now drowned show that submergence is dominant.

The forces for change originate mostly from the maritime environment, but are supplemented by those from landward. The predominant controls are waves and currents; the former through corrosion, the pressure of water and attrition break down the coastal rocks, consolidated and unconsolidated, while currents transport the material away as longshore drift. Tides govern the zone of such activity. Given the limited tidal range of the Mediterranean Sea, erosion tends to be concentrated on a very narrow belt and is therefore more effective than in areas with a greater tidal variation. On a smaller scale, erosion and weathering are abetted by flora and fauna, but particularly wetting and drying in a saline environment.

The main landward forces affecting the coastline result from fluvial action, mass movement and weathering. The effects of wind in deflating unconsolidated material can be felt from seaward or landward.

The resistance of consolidated rock to erosion depends upon lithology, together with the attitude and form of the rocks. Lithology comprises most importantly hardness, permeability and the presence of specific structures. Attitude and form refer to stratification, jointing and faulting. Broadly speaking, the more resistant the rocks, the more slowly they are eroded. Resistant areas remain as headland whereas less resistant are eroded into bays.

As a result of the combined action of maritime and landward forces, coastlines can be classified as erosional, depositional or compound. Additionally, where other factors predominate, such as fluvial deposition in deltas or volcanic outpouring in lava flows, the coastline is categorized as neutral. The other variable which may produce modifications in the erosional and depositional landforms is the height of the coastline. Highland and lowland coastlines display an overlapping, but different array of pictures.

On the more local scale than headlands and bays, the main landforms indicating erosion are the cliff and the associated wave-cut or shoreline platform. In the retreat of the cliff and the development of the platform, other features such as caves, stacks, stumps and arches may be formed. The predominant depositional feature is the beach, which can be classified according to its size, position or material. Beaches commonly comprise sand, shingle, silt or clay, or a mixture of any of the four. Particularly on long lowland coastlines, the beach may be shaped into a spit, an offshore bar, a bay bar or a tombolo. These landforms are categorized predominantly by their degree of attachment to the land.

As this brief summary indicates, the physical aspects of the coastal area are changeable and provide varying constraints on the use of resources. For example, there is likely to be greater accessibility for tourists along a lowland rather than a highland coastline. On the other hand, steeply shelving bays on a highland coastline offer better protection for vessels than do gently sloping lowland bays. However, more fundamental limitations on the use of resources are dictated by the use or interplay of the physical setting and politics.

While change in the physical setting is, for the most part, slow but continuous, geopolitical change on the global scale has been nothing short of momentous. With the fall of the Berlin Wall in 1989 and the disintegration of the Soviet Union in 1991, the all-pervading confrontation between NATO and the Warsaw Pact ended. The world moved from stable bipolarity to an increasingly volatile unipolarity or perhaps multipolarity. For the Mediterranean basin, however, these cataclysmic events were more muted. Geographically peripheral to Europe, the great diversity within the region and the long history of many of its problems both militated against any abrupt change. Differences at a local and regional level had been overshadowed rather than eliminated by the cold war.

One obvious effect of the ending of the cold war was the replacement of a fracture zone between East and West by one between North and South, the line of which passes along the centre of the Mediterranean. Furthermore, while East-West differences were largely externally induced, North-South contrasts represent real deeply engrained differences. Thus, unlike the East-West division, that between North and South will not be removed as a result of decisions and circumstances external to the Mediterranean area.

The demise of the bipolar world has diminished the possibility of global conflict, but greatly increased the probability of regional and local crises. This has been particularly significant for the Mediterranean, which, in the number of potential geopolitical flashpoints, rivals any other region of comparable size. Problems such as the Arab-Israeli conflict, the Cyprus question, the Yugoslav issue, the confrontation between Greece and Turkey, the external policies of radical States, terrorism, militant fundamentalism and South-to-North migration are all unrelated to the cold war. Therefore, more than at any time in the recent past, geopolitical events are likely to influence the linkage between the physical setting and the use of resources. The use of resources is governed by politics. Indeed, it is not unreasonable to suggest that politics itself has developed quite largely as a result of the basic need to apportion resources.

1.2. Political considerations and patterns of resource use

1.2.1. Resources

So far the module has focused upon geopolitics, the physical setting and the changes which have occurred and are occurring in both. As employed in the study of economics, the term "resource" is extremely wide-ranging. For example, the resources of the coastal area include the people who live there, all the components of the physical geography and all aspects of the access to the maritime environment which is provided. Since it is the activities of people which are controlled by politics, it is reasonable to classify resources according to the use that has been made of space by people within the coastal area. The interplay of the physical resources available and the political decisions governing their use is encapsulated in the land-use pattern.

Land-use can be divided into those elements of the pattern which could occur anywhere and those which are coastal area-specific. In the first category are: residential occupation with all its attendant services, agriculture, forestry, industry, military installations, tourism and recreation, quarrying, dumping and waste disposal and conservation and research. Those elements of land-use, specific to the coastal area include all aspects of fishing, ports and port industries, desalination and salt production. Such a simple classification requires some degree of modification. For example, for most countries the coastal area is the main focus of tourism and possibly also of recreation. Military installations connected with the navy are likely to be predominantly in the coastal area. In many parts of the southern Mediterranean, agriculture in the coastal region is, for climatic reasons, significantly different from that inland.

Consideration of resources specific to the coastal area raises the issue of what comprises the coastal area. In terms of management, the term "coastal zone" refers to the land-sea interface, and covers some distance on either side of the shoreline. The terrestrial sector stretches as far inland as is dominated by maritime influences. The "area", on the other hand, includes terrestrial components, often topographical or geomorphological, which do not necessarily form part of the coastal belt, but have some chief influence on the coast. Whatever the terminology, the coverage must, in some way or other, interact with or have some influence on some major aspect of the coast. Perceptions of the coastal zone are likely to vary considerably from country to country, particularly according to the size of the national territory. If the width of the coastal zone of Spain or the Libyan Arab Jamahiriya were taken as standard, then the whole of Malta would be coastal zone.

The identification of the coastal zone to landward can be related to any of the following:

- Geomorphological features
- Land-use
- Vegetation change
- Climatic effects
- Legal constraints
- Convention

To seaward, there are of course defined zones such as the territorial sea and the exclusive economic zone (EEZ). There is then the question of the baseline from which these distances are measured. Suffice it to say that different countries claim different widths of territorial sea. One result is that the Strait of Gibraltar comprises exclusively territorial seas of Spain and Morocco.

The coastal survey of Malta, completed in 1989, provides a detailed case study on a manageable scale of the delimitation of the coastal zone. With a coastline which is partly highland and party lowland and which is, in many areas, dominated by urban development, a variety of possible lines is presented.

The most clear-cut division on the landward side was according to any or all of the following:

- Obvious breaks of slope, principally at the landward edge of the shoreline platform
- The limit of areas of tourist use by maritime-orientated tourists
- The occurrence of a bio-marker plant species: *Inula crithmoides*

1.2.2. Scale considerations

It is apparent from the foregoing sections of the module that scale is a major variable when considering the linkage between the physical setting and the use of resources. It has already been shown that the focus for the study of the physical setting, including the land-use, is likely to be on a local or at least very restricted scale. For research on larger scales, physical aspects can be considered in almost all cases to be aggregations of those found on the local scale. In contrast, the focus for geopolitics is upon the large scale and the effects of political actions cascade downwards to influence events on the local scale.

Theoretically, any number of scales could be employed, but in practice it is convenient to use four:

- Macro-political: on which events are on the global scale
- National: on which events are on the inter-State level
- Regional: on which events are on the sub-State level
- Sub-regional: on which events are on the local scale

1.2.2.1. Macro-political scale

Events on the macro-political scale are those which could affect the whole of the Mediterranean basin. They may be generated within the Mediterranean basin itself or imposed from external global sources. The results are to impose either general or specific constraints upon the use of resources in the coastal area.

A major constraint can result from globalization which can be equated with the increasing projection of United States control and culture. With its overwhelming military and economic global dominance, together with its effective involvement within the realms of governance of the World Bank, the International Monetary Fund (IMF), NATO and the Security Council, the United States has worldwide influence. The most obvious examples of the sanitizing of whole coastal areas by United States actions have been war in Kosovo and the sanctions imposed against the Libyan Arab Jamahiriya. In more general terms, economic perturbations in both consumer and supplier countries exercise a profound influence upon Mediterranean tourism.

More specifically, the continuing collapse of the Russian Federation has already led to the enhancement of criminality throughout the region. Examples are seen in the movements of refugees from north Africa and Albania to more economically advanced countries and the flow of drugs from Beirut and eastern Turkey.

Closely related is terrorism, some State-sponsored, in the littoral States of the Mediterranean Sea. There has been terrorism on land, in the air and at sea. Furthermore, the growth of arms trafficking and the spread of weapons of mass destruction have particularly endangered the eastern Mediterranean. As a nuclear power, Israel poses a particular threat to stability.

Other macro-political scale threats include those resulting from the collapse of Yugoslavia and the continuing Arab-Israel confrontation. Religious extremism, particularly in the Maghreb, is another potentially destabilizing factor. It is clear that there is a wide range of geopolitical events on a macro-political scale which can affect the development and use of coastal area resources in the Mediterranean.

1.2.2.2. National scale

The potential for constraints on resource development as a result of inter-State geopolitical problems is well exemplified by the case of Greece and Turkey. Sea-bed exploitation is at present almost entirely prohibited as a result of confrontation between the two countries over the maritime boundary in the Aegean Sea. This issue also presents problems for tourism, fishing and trade and dominates the area of the eastern Mediterranean.

While spillover from the continuing conflicts in the Balkans and the Levant is on a macro-political scale, inter-State relations influence tourism, agriculture, industry, services and water provision. This is seen clearly in the developing relationship between Israel and Palestine. In the Balkans, services had all been developed in common during the existence of Yugoslavia. With fragmentation, there are endless transboundary problems between the neighbouring States. However, the most acute have occurred following the war in Kosovo and concern the forced movements of both Albanians and Serbs.

There are many other inter-State issues, but at the western end of the Mediterranean, the cases of Spain and Gibraltar and the Spanish enclaves in Morocco are worthy of mention. In both cases, tourism, industry, fishing, trade and travel are affected. Thus, it can be seen that inter-State tensions can exert a major influence on the use of resources in both the landward and the seaward sides of the coastal area.

1.2.2.3. Regional scale

The term "regional" is taken to characterize those events which occur at a sub-State level, but which are significant on a greater scale than local events. A good example is provided by eastern Turkey, an area with coastal zone potential not only for tourism, but also for other forms of exploitation. It is already the exit point for oil pipelines from Iraq and the provision of water to northern Cyprus and Israel. The continuing conflict with the Kurdish population has affected not only tourism, but has obviously endangered pipelines and constrained investment.

Equally devastating has been the effect of religious extremism and terrorism in Algeria. Most of the northern part of the country is affected, but the coastal area in particular has been the scene of violence. Clearly, any use of the area for tourism, industry, agriculture or trade is greatly conditioned by the continuing conflict.

In a different way, the development of Cyprus has been limited by the effects of partition. Continuing instability and the presence of the United Kingdom of Great Britain and Northern Ireland sovereign bases have discouraged tourism and investment. With its location and climate, Cyprus was, all year round, a major destination for visitors.

Similarly, the economy of Egypt has been ravaged by the effects of terrorism on tourism. Although a large part of Egyptian tourism is to upper Egypt, the coastal area and in particular Alexandria have always been of significance.

At the sub-State level, it is clear that the use of resources in the coastal area can be hindered by geopolitical events. Furthermore, such events may influence development in neighbouring countries. Perceptions of violence in Algeria undoubtedly affect the use of the coastal area in both Morocco and Tunisia.

1.2.2.4. Sub-regional scale

The emphasis for events on this scale is at the local level and can be seen most easily in land-use competition. Obviously, there are many variables, some specific to one area, which control the development of the various types of land-use. However, three key dichotomies exercise the major influence upon the competitive ability of a particular form of land-use. These are:

- Flexible/inflexible
- High investment returns/low investment returns
- Good access requirements/access of minor importance

When these have been appropriately attributed to each type of land-use, the possibilities for competition can be identified.

The coastal zone survey of Malta completed in 1989 provides good examples of land-use competition. The coastal zone was delimited and the following land-use types which provided total coverage were mapped: tourism, maritime functions, vegetated areas (green all the year round), accessible shore, open land, agriculture, polluted areas, services, industry, historical sites and domestic occupation. One hundred map sheets on a scale of 1:2,500 were completed, covering the entire coastal zone of Malta, Gozo and Comino. Having mapped the total land-use pattern, it was possible to identify areas of current and potential land-use competition.

Major current sources of friction included competition between agricultural land and domestic occupation. As a result, limits to coastal zone building were suggested. Potential competition between land-use and sea-use was also examined. As a result, it was possible to define maritime conservation areas which appeared compatible with the land-use in the neighbouring coastal zone.

Land-use competition in the coastal zone represents the interrelationship of local level geopolitics. However, certain events which are by global standards local, produce ripples which are of global significance.

The continuing dispute over the designation of the Gulf of Sirte is a local flashpoint which has been drawn to the attention of the world. The Libyan Arab Jamahiriya claims that the water in the Gulf of Sirte out to latitude 32° 30′ N is internal water. By regularly sailing warships into the Gulf, the United States has attempted to demonstrate that the Gulf cannot be considered historic waters.

While the Gulf of Sirte represents a long-running local level geopolitical flashpoint, even more significant in its effect upon the use of the coastal area was the attack launched by NATO against Yugoslavia in Kosovo.

The arbitration at the International Court of Justice (ICJ) over the maritime boundary between Tunisia and the Libyan Arab Jamahiriya resulted in the identification of an even more limited area of geopolitical significance.

The Greco bank is a sponge bank located immediately north of the terminal point of the land boundary between the two countries, Ras Ajdir. During the period of Italian occupation, sponge fishermen, other than those from the Libyan Arab Jamahiriya, were ejected from the bank and this set a precedent. The issue was then to locate the bank with pinpoint accuracy for the International Court of Justice. Using a Libyan harbour vessel, in the presence of assessors, the exact location was identified on charts which were subsequently presented to the Court and, it is reported, exercised an influence on the alignment of the agreed maritime boundary.

1.3. Conclusion

The use of resources in the coastal area is constrained by the physical setting, but more importantly by political decision-making. The interplay of geography and politics, encapsulated in this issue, defines geopolitics. Geopolitics can be operational on a number of scales and the effects of the macro-political, national, regional and sub-regional upon geopolitical events has been demonstrated. It must be repeated that, before any aspect of integrated coastal zone management can be contemplated, the geopolitical environment needs to be examined.

2

Mediterranean coastal habitats and biota

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2 Mediterranean coastal habitats and biota

2.1. Introduction

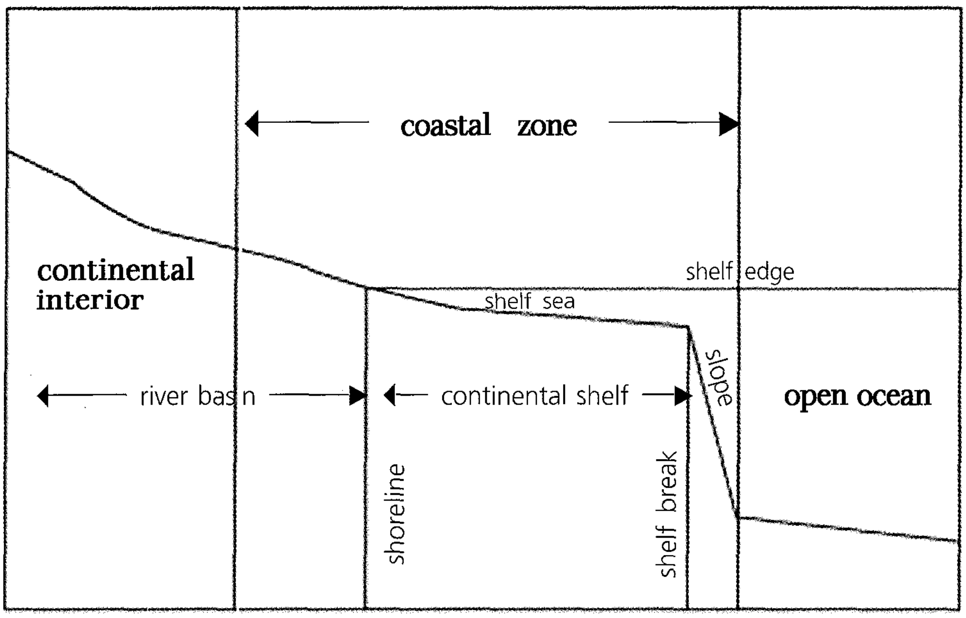
2.1.1. Rationale

The coastal zone is the transitional area between land and sea. In the spatial context, it consists of a band (rather than a line), the width of which varies from place to place and is determined by the interaction of marine and terrestrial coastal processes.

There is a great diversity of views as to what constitutes the coastal zone, both between and within disciplines. Thus, ecologists, geomorphologists and economists, for example, all have different ideas of the limits of the coastal zone.

Ecologically, the coastal zone can be regarded as that zone in which the marine environment influences the terrestrial environment, and vice-versa. In practical terms this means that the coastal zone extends from the region of terrestrial maritime vegetation (that subjected to the effect of wind-blown salt or seawater) to the edge of the continental shelf (more or less at a depth of 200 metres).

Figure 2.1. Coastal zone

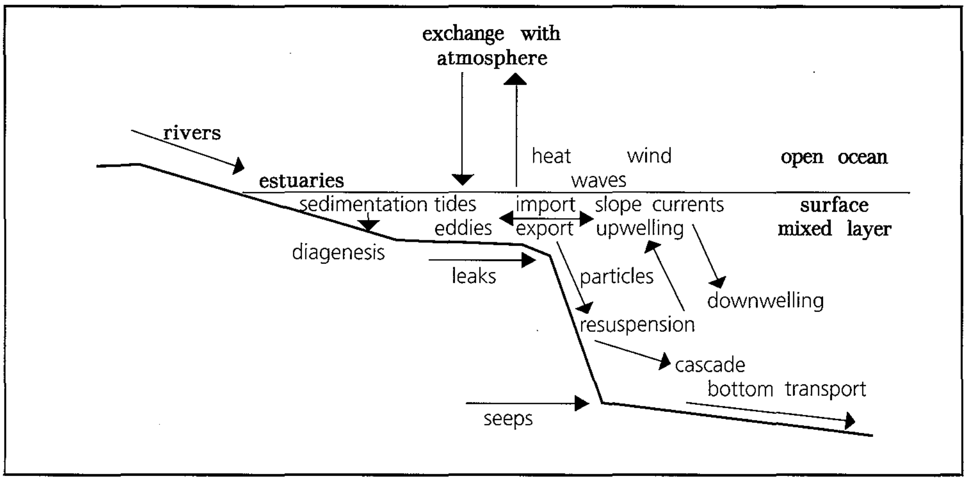


The coastal zone is subject to various natural processes, which may be of a physical, chemical or biological nature. Gradual, seasonal or stochastic changes in these processes may lead to a variety of impacts on the appearance, functions and (potential) uses of the coastal zone.

Examples of such variable natural processes and resulting impacts are:

- Coastal currents and sediment flows leading to coastal erosion or accretion
- Storm and wave conditions affecting coastal profiles
- Dispersion, degradation, adsorption and sedimentation processes affecting water and sediment quality
- Ecological succession leading to changes in habitat types and biodiversity
- Energy and material cycles affecting biological productivity

Figure 2.2. Physical processes in the coastal zone



2.1.2. *Major subdivisions of marine organisms*

Plankton

Plankton are those forms that drift with currents and are unable to swim against a current. Most plankton do have a limited ability to move and can migrate vertically through the water from day to night. Plankton is very important as it occupies the first two or three links in marine food chains. Plankton may be divided into:

(a) Phytoplankton: mostly microscopic single-celled algae

(b) Zooplankton: tiny animals, micro- or macroscopic, unicellular or multicellular

Nekton

Nekton are free-living organisms that are able to swim against currents; use fins, jets of water, flukes and flippers to swim through the water.

Benthos

Benthos are organisms that reside primarily in or on the substratum and do not swim or drift for extended periods as adults. They are either motile (burrow, crawl, walk) or are sessile (permanently or semi-permanently affixed to the substratum). Benthic organisms that live on the bottom are epibiotic and those living within are endobiotic.

Demersal

Demersal organisms are those that alternate between swimming and resting on the bottom (e.g. some flatfish).

2.1.3. Factors affecting coastal organisms

Abiotic factors

These are physical features of the environment that interact with organisms to produce both opportunities and constraints. These include temperature; salinity; light; waves, currents and tides; substratum; oxygen; and availability of nutrients.

Biotic factors

These are biological features of the environment, including predators; competitors (intraspecific and interspecific competition); symbionts (symbiosis means simply "living together'; it does not imply a mutually beneficial relationship) and pathogens (disease-causing organisms)

2.1.4. Characteristics of coastal benthic ecosystems

The shallow water (there are no stagnant depths as in deep open water) prevents loss of nutrients to lower layers hence increasing productivity. Light availability throughout the water body (due to shallowness of the water) accounts for more energy input per unit volume when compared to offshore areas, hence increasing productivity. Increased productivity is accounted for also by input of nutrients from land. High productivity and continued disturbance (sea-level fluctuations, changes in salinity, silt deposition in estuaries etc.) account for high diversity. Non-continuous introduction of nutrients and disturbance also causes cycles of population, with prey species populations increasing rapidly on input of nutrients (or with consequent increase in prey population at lower trophic levels), then crashing with predation (and with the crash of prey populations at lower trophic levels).

2.1.5. Mediterranean Sea at a glance

The Mediterranean is a sea with many unique features. It is a complex environment consisting of many interacting bodies of water that are sensitive to climatic and meteorological events. It is characterized by strong gradients in physical factors. These cause the ecology of the Mediterranean to vary from west to east. The Mediterranean is Atlantic in character towards the west, becoming wholly indigenous Mediterranean towards the east. The Mediterranean is located between three large land masses: Europe to the north, Asia Minor to the east and Africa to the south. The Mediterranean is completely surrounded by land except for a narrow passage to the north-east Atlantic through the Straits of Gibraltar, a connection to the Black Sea by way of the Bosphorus, and a connection to the Red Sea by way of the man-made Suez Canal.

2.2. Physical characteristics of the Mediterranean Sea

2.2.1. Geographical overview

Vital statistics

Maximum length	ca. 4000 km (Gibraltar to Syrian Arab Republic)
Maximum breadth	ca. 900 km (coast of France to Algeria)
Area	2.523 million km^2 (not including Black Sea which has an area of 0.4 million km^2)
Shelf area (<200 m)	550,000 km^2

Constituent seas

The Mediterranean Sea is subdivided into a number of smaller seas:

West basin	*East basin*
Alboran Sea	Adriatic Sea
Balearic Sea	Ionian Sea
Ligurian Sea	Aegean Sea
Tyrrhenian Sea	Sea of Marmara

Islands

The Mediterranean basin is characterized by numerous islands, varying in size from relatively large and to exceedingly small islands:

Large islands	*Small islands*
Sicily	Most numerous in Aegean and Ionian seas
Sardinia	
Cyprus	
Corsica	
Crete	

River input

Four principal rivers empty into the Mediterranean:

Rhone	On northern shores of western Mediterranean (France)
Ebro	On northern shores of western Mediterranean (Spain)
Po	Into northern Adriatic
Nile	On southern shores of eastern Mediterranean (Egypt)

In all, some 13 major rivers drain into the Mediterranean. "Russian" rivers empty into the Black Sea and their waters reach the Mediterranean by way of the Bosphorus.

2.2.2. Mediterranean climate

The dynamics of the Mediterranean Sea and the ecology of the Mediterranean are mainly linked with the climate. The Mediterranean climate is of the Mediterranean Climate type (also found in other parts of the world—western margins of continents in the temperate zones). This is characterized by hot dry sunny summers and warm, moist winters.

However, there is much regional diversification within the Mediterranean. Arid environments occupy a large part of the eastern region and the southern perimeter whilst the north-western Mediterranean lands are, in part, wooded and somewhat humid.

Climate within the region also depends on distance from the Atlantic. In summer, the Azores subtropical anticyclone (a pressure "high") advances towards western Europe while in winter depressions (low pressure systems) from the North Atlantic sweep across the Mediterranean from west to east. These cause particularly heavy precipitation on west-facing coasts and lead to violent north-westerly or northerly winds.

A characteristic of Mediterranean climate is the presence of small-scale but very violent weather phenomena, mainly very strong winds and intense precipitation episodes that are sudden and short.

The latter have important implications for the ecology of the coastal zone as they lead to pulses of water laden with solid material discharged from rivers and valley systems. Quite often, this not only results in erosional and sedimentation processes in the nearshore region, but also leads to coupling of coastal waters with deeper waters due to turbidity currents (currents laden with sediment that move at high speed for distances of tens of kilometres and transport sedimentary material to the deep seabed).

Precipitation

This varies considerably from place to place in the Mediterranean, but in general there is a gradual decrease in rainfall from west to east and from north to south. Rainfall varies from more than 1,500 mm per year along the eastern coastline of the Adriatic to less than 100 mm per year along large parts of the North African coast. The combined catchment area of all rivers draining into the Mediterranean totals 4 million square kilometres.

Rivers whose catchment lies partially outside the Mediterranean climatic region have a more regular flow than those whose catchment is wholly in the Mediterranean region, the reason being that they are fed by melting snow of mountain ranges (e.g. Ebro, fed by meltwater from the Pyrenees; Rhone and Po, fed by meltwater from the Alps).

The Nile is geographically an extra-Mediterranean river (fed by the abundant rains of tropical Africa), however it behaves more like a typical Mediterranean river[1] and its flow is quite irregular—now more so since it is largely controlled by dams!

There is a large imbalance between the run-off drained along the northern shores of the Mediterranean and that drained along the southern shores. The northern shores contribute 92 per cent of the runoff and the southern shores the remaining 8 per cent. This is due to the different precipitation regimes on the two shores, since the size of the drainage area is similar.

The area that receives most river input in the Mediterranean is the Adriatic Sea, accounting for 70 per cent of all river input into the Mediterranean. The Aegean, Tyrrhenian and Ionian basins together receive approximately 20 per cent of this input whilst the north African coast receives the remaining 10 per cent.

Solar radiation

Solar radiation in the Mediterranean varies between 400 kJ/cm^2/year and 840 kJ/cm^2/year and increases from west to east and from north to south. The average is 660 kJ/cm^2/year for the west basin and 682 kJ/cm^2/year for the east basin. Due to the high solar elevation and the increased day-length, the total solar radiation reaching the Mediterranean latitudes during summer is higher than in the tropics.

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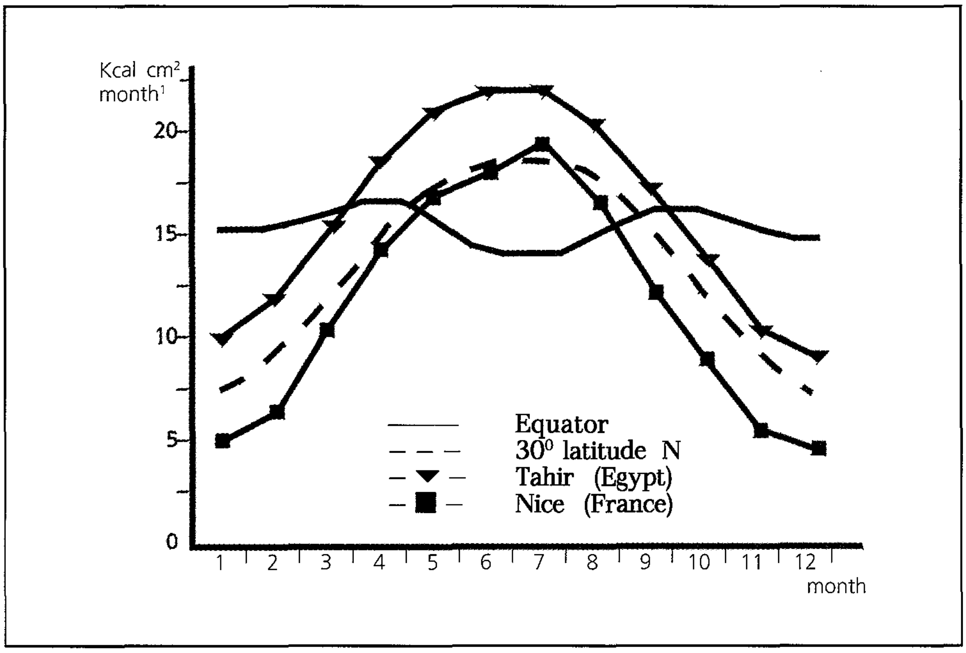
[1]Mediterranean rivers typically have very irregular flows in the sense that the volume changes with season: large flows during the wet season and reduced flows (in some cases very reduced) during the dry season.

Figure 2.3. Solar radiation at various latitudes (adapted from Béthoux, 1977).



2.3. Unique features of the Mediterranean

The Mediterranean Sea is characterized by several unique features, as follows:

- It is surrounded by land and greatly influenced by terrestrial conditions especially the climate. It therefore behaves more like a large lake than a sea;
- The continental shelf (mean sea level to a depth of ca. 200 m) is narrow, with an average width of ca. 16 km (compared to world average of 68 km). Two exceptions to this generalization are the Adriatic and Gulf of Gabes (east coast of Tunisia);
- The climate is strongly biseasonal: hot dry sunny summers and warm, moist winters. The shift from dry to wet season is rather abrupt and associated with short and intense storms;
- Very high solar radiation input—the total radiation reaching the Mediterranean region in the summer solstice is one of the highest in the world: 92 kJ/cm^2 per month on the southern shores of the east Mediterranean and 75 kJ/cm^2 per month in the north-west Mediterranean;
- The Mediterranean is microtidal. The average tidal range is only 0.3 m (compare to world average of 3 m). Two exceptions to this generalization are the Adriatic (tidal range ca. 1 m) and the Gulf of Gabes (tidal range ca. 2 m). Both are shores bounded by large shallow zones that allow amplification of a weak astronomical tide;
- Meteorological oscillations (i.e. due to barometric pressure oscillations and to winds) in sea-level ("meteorological tides") are much more important than astronomical tides on most Mediterranean shores. These may cause fluctuations of up to ca. 1 m vertical height. These differ from astronomical tides in being neither cyclical nor predictable. Shores bordered by shallows open to large fetches of strong winds may experience storm surges (e.g. Venice up to ca. 2 m);
- The Mediterranean is a warm sea even at depth. Water temperatures in the Mediterranean are summarized in table 2.1 below:

Table 2.1. Water temperatures in the Mediterranean

	Surface water temperatures (°C)		Deep water temperatures (°C)	
	Min.	*Max.*	*Min.*	*Max.*
West basin	12	16-20	12.5	13.5
East basin	16	29	13.5	15
Adriatic	12	15	—	—

(Compare Atlantic deep water (>2000 m) temperature = ca. 4°C)

- The Mediterranean is a very saline sea. The average surface salinity for the whole Mediterranean is ca. 38.5 psu (psu = practical salinity units) (second only to the Red Sea in salinity = 40 psu; compared to Atlantic average surface salinity ca. 35.5 psu). The salinity at the surface ranges from ca. 36.2 psu at the Straits of Gibraltar to ca. 39.5 psu in the Levantine Sea;
- The Mediterranean Sea is well oxygenated even at depth (due to strong exchange between surface and deep waters). Exceptions are regions with a high biological oxygen demand (BOD), usually due to the discharge of raw sewage;
- The Mediterranean is an oligotrophic sea (low concentrations of dissolved nutrients[2]). Phosphorus is usually the most limiting—the concentration of phosphorus (as phosphate) at depth is ca. 6 mg/m^3 (compared to average for world ocean = 72 mg/m^3). This concentration decreases to practically nil at the surface;
- Nitrogen is the second most limiting nutrient. The concentration (as nitrate) in Mediterranean deep water varies from 70 to 150/mg/m^3 falling to very low levels at the surface;
- The concentration of nutrients at the surface decreases from west to east, and this affects primary production. Overall, productivity of the Mediterranean is one of the lowest in the world, comparable to that in the central oceanic gyres. The average annual productivity of the Mediterranean is ca. 50 g carbon/m^2/year (compared to average for world ocean = ca. 100 g carbon/m^2/year).
- Productivity[3] decreases from west to east and is summarized in table 2.2 below:

Table 2.2. Mediterranean productivity

	Productivity (g carbon/m^2/year)	
	Open water	*Coastal water*
West basin	50	75
East basin	25	50

[2]Nutrients are compounds necessary for growth of producers, such as plankton. By far the most important nutrients are nitrogen (mainly in the form of nitrate, NO_3^-) and phosphorus (mainly in the form of phosphate. PO_4^{3-}). Other ions such as silicon (as silicate) and calcium are also important to the development of phytoplankton. Nutrients are intimately linked to almost all ecological processes, for example as limiting factors for producers, consumers and decomposers. They are also electron donors for microbial decomposers. There are many kinds of organisms that fix nutrients into organic compounds, but the many species of phytoplankton may contribute to 93 per cent of marine primary production. (Seagrasses, macroscopic algae are very efficient primary producers but they are restricted to coastal zones that are relatively rare in the marine environment).

[3]Producers are autotrophs, that is, they manufacture the organic compounds they use as sources of energy and nutrients through the process of photosynthesis. In the marine environment most producers are microscopic and macroscopic algae, although green plants are important producers in such environments as the terrestrial maritime fringe, salt marshes and sea-grass beds.

- Production is highest in those regions where there is high light intensity and a mechanism for a constant supply of nutrients. One such region is the coastal zone, due to:

  Nutrients from terrestrial run-off:
  - Freshwater discharges (especially important in enclosed harbours and bays)
  - River discharge (e.g. Adriatic fed by Po—productivity ca. 90 g carbon/m^2/year)
  - Temporary run-off due to storms (especially important in arid regions)
  - Local enrichment (e.g. sewage outfalls)

  The bottom is close to the surface hence nutrients are easily replenished especially where currents and storms stir up water to the very bottom;

  Large plants (macroalgae and sea grass) can anchor;

- Input of nutrients into the Mediterranean depends greatly on terrestrial run-off. This may account for up to 33 per cent of new production (e.g. in Tyrrhenian Sea).

2.4. Divisions of the marine realm

The marine environment may be divided as follows:

Pelagic: Neritic (over continental shelf)
- Planktonic (floating)
- Nektonic (swimming)

Oceanic (in deep open sea)
- Planktonic (floating)
- Nektonic (swimming)

Benthic: Hard substrata
- Epibiotic (on the substratum)
- Endobiotic (in the substratum)

Soft substrata
- Epibiotic (on the substratum)
- Endobiotic (in the substratum)

Division of the substratum into "hard" and "soft" is too simplistic because a whole range of types exist from mud to sand to shingle to boulders. Additionally, some substrata are not formed by geological factors alone but also have a biotic component: e.g. salt marshes; sea grass meadows and maerl beds.

2.4.1. Origins and affinities of the Mediterranean marine flora and fauna

The present-day flora and fauna of the Mediterranean is composed of four elements:

- A large number of Mediterranean species (ca. 62 per cent) which are also found in the east Atlantic. Biogeographically, the Atlantic and the Mediterranean form one unit known as the Atlanto-Mediterranean province;
- A number of species (ca. 29 per cent) are endemic to the Mediterranean, that is, they are only found in this sea;

- A few (ca. 13 per cent) are cosmopolitan, that is, they are found in most of the world's oceans;
- A small number (ca. 5 per cent) are Indo-Pacific.

This mix of species is a result of the evolutionary history of the Mediterranean. Some 65 million years ago the Mediterranean (or what was to become the Mediterranean) was part of a stretch of ocean called the Tethys Sea which connected the Atlantic to the Indo-Pacific. The Tethys Sea was populated by a rich subtropical biota of Indo-Pacific affinity. When the palaeomediterranean (the forerunner of the present day Mediterranean) became totally cut off from both the Atlantic and the Red Sea about 6 million years ago, climatic changes caused it to partially or totally dry up resulting in the mass destruction of nearly all the original marine biota, an event known as the Messinian Salinity Crisis. Subsequently, further tectonic movements re-established a connection with the Atlantic at the Straits of Gibraltar around 5 million years ago and the Mediterranean was repopulated by Atlantic species, this being the reason why the bulk of the present day Mediterranean species are also found in the east Atlantic.

In very recent times (1869), a link with the Red Sea was re-established via the Suez Canal and this has resulted in a number of species migrating from the Red Sea into the eastern Mediterranean, a process which has been called Lessepsian migration after the French engineer Ferdinand de Lesseps who was largely responsible for the development of the Suez Canal. The present day Indo-Pacific element of the Mediterranean is mainly represented by these recent immigrants, however, a few species may be relicts from the days of the Tethys Sea, for example, Neptune Grass *Posidonia oceanica.*

2.4.2. Species distribution patterns

The Mediterranean is divided into two great basins, the west basin and the east basin, separated by a shallow sill (the Siculo-Tunisian sill) with a maximum depth of ca. 430 m running from Sicily to Tunisia. There is a pronounced difference between the two Mediterranean basins in floral and faunal diversity: the number of species (species richness) is much lower in the eastern than in the western Mediterranean, the most impoverished region being the south-eastern corner (the Levantine Sea).

Species abundance also falls from west to east. This is probably because the warmer and more saline eastern Mediterranean is inhospitable to the majority of Atlantic-derived species. Many west basin species reach their easternmost limit of distribution in the Central Mediterranean, for example, the mussel *Mytilus galloprovincialis* and the precious coral *Corallum rubrum.*

There are also some differences in species richness and abundance from north to south: the northern waters of the Mediterranean generally being richer than southern waters, again, probably an effect of increasing temperature as one proceeds south. On the other hand, some species common in the eastern Mediterranean are very rare or not found at all in the west basin. Examples include the starfish *Hacelia attenuata* and the long-spined sea-urchin *Centrostephanus longispinus.* Others are found only along the southern shores. An example is the stony coral *Astroides calycularis.*

Some of the recent Lessepsian immigrants from the Red Sea, finding the warm saline and underpopulated Levantine Sea a suitable environment, have established themselves there and are slowly spreading westwards. One example is the sea grass *Halophila stipulacea* which entered the Levantine Sea soon after the Suez Canal was opened (it was first recorded from the Mediterranean in 1885) and has since progressively colonized the east basin and has reached the central Mediterranean (Maltese islands and Sicily in 1971).

2.5. Mediterranean coastal communities

2.5.1. *Phytal system*

From the biological point of view, the Mediterranean coastal environment may be divided into several zones depending on the relative contributions of two key physical factors: light and wetness.

The first region of the coastal zone is the adlittoral—that part of the terrestrial environment that is under some maritime influence from wind-blown salt and spray.

The next region is the supralittoral—that zone on the shore which is permanently exposed to the air except for occasional wetting by sea spray and the highest waves.

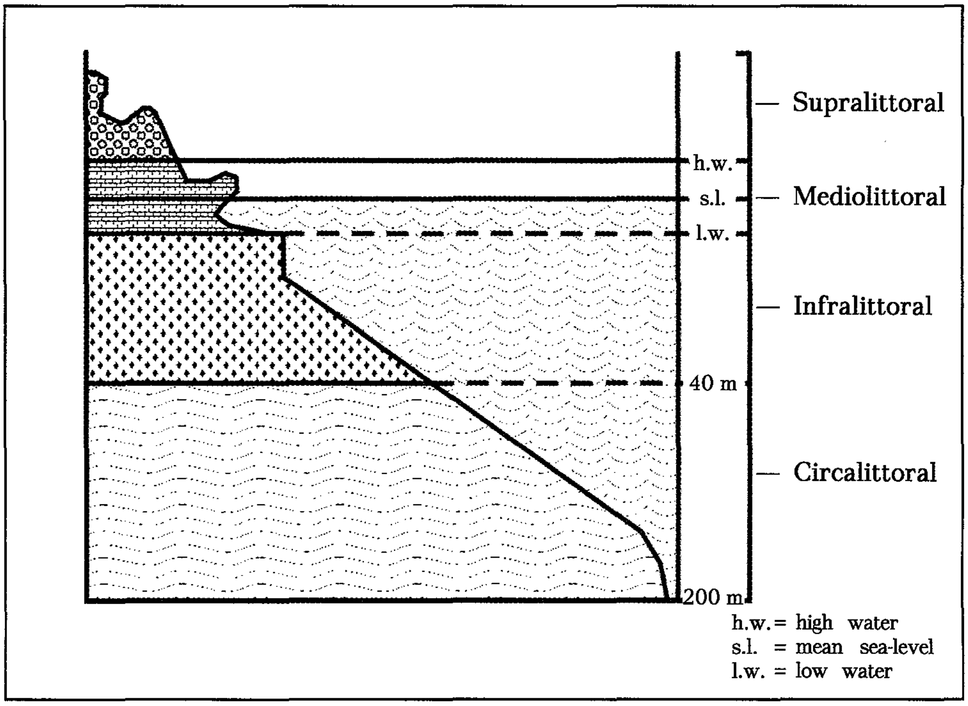
Next comes the mediolittoral—that zone which is regularly exposed and submerged, mainly due to wave action. This zone corresponds to the intertidal zone of tidal shores, however, in most of the Mediterranean, the tidal range is very small and changes in sea level brought about by wave action and atmospheric conditions are far more important.

The next zone, the infralittoral, extends from the lower limit of the Mediolittoral, which is never (or hardly ever) exposed, down to the lowest limit where sea grasses and photophilic algae can live. The lower limit of this zone depends largely on light penetration, but on average lies at ca. 40 m depth.

Next comes the circalittoral which extends from the lower limit of the Infralittoral down to the maximum depth at which plant life of any sort can live, in practice about 200 m.

All these zones collectively make up the phytal or littoral system. Below this is the aphytal or deep water system, poorly known in the Mediterranean. Within each zone of the phytal system, a number of subdivisions exist characterized by differences in ecological factors such as water agitation, salinity fluctuations, temperature, and the nature of the substratum. Of these, perhaps the most important is the last, giving for each zone two distinct assemblages of biotic communities: soft substratum communities and hard substratum communities.

Figure 2.4. Mediterranean phytal system



2.5.2. *The adlittoral zone*

Adlittoral habitats are ecotones[4], occurring at the interface of marine environments and coastal inland habitats. As such, some of these environments are essentially terrestrial in general character whilst others are aquatic, but all are modified by significant maritime influence.

Habitats of the Mediterranean adlittoral

There is considerable habitat diversity within the Mediterranean adlittoral. The habitat types which occur at any given locality are a function of distance from the coast, of specific coastal topography and geomorphology, and of human land-uses of the area.

River deltas

Deltas are formed at the mouths of rivers where sediments transported by running water are deposited in a low-energy environment, forming new wedges of land. The principal deltaic areas of the Mediterranean region are the Ebro delta, the Rhone delta and the Po delta on the northern coasts and the Nile delta on the south-eastern coast. Typical deltas comprise a wide range of habitats ranging from sand banks and shingle banks to marshes and pools. All these habitats are characterized by decreasing salinity with increasing distance from the shore. Most deltas in the Mediterranean are ancient, dating to the immediate post-glacial period. However, some of these areas are of comparatively recent origin, having been formed following deforestation upstream of the delta. When such deforestation occurs within the catchment area of a river, unconsolidated soil from the affected region is carried towards the sea by running water and subsequently deposited to form a new delta. One such delta is that of the Ebro, which has originated within the past one thousand years. Some deltaic environments are colonized by remnants of former riverine forests including species such as poplar (*Populus* spp.), alder (*Alnus* spp.) and willow (*Salix alba*). These forests would have previously occupied large tracts of floodplain surrounding Mediterranean rivers but are now restricted to small areas around the Nestos delta, Rhone delta and Po delta.

Coastal lagoons

These habitats are generally characteristic of low coastal plains and are frequently associated with river deltas. The formation of coastal lagoons is related to the transport of sediment by rivers. When rivers reach the sea, their sediment load is deposited as marine and freshwater currents cancel each other out. This promotes the formation of sand-spits running parallel to the shoreline. Lagoons form behind such spits. They would generally not be entirely cut off from the sea, but connections with the marine environment are nevertheless reduced. As the sand-spits grow, some lagoons may be completely isolated from the sea and would eventually develop into a brackish water or freshwater environment. The lagoons of the Mediterranean occupy an area that has been estimated at 7000 km^2, with the largest being Lake Maryut, with an area of 1670 km^2. Such lagoons are areas of high productivity and several, such as the Etang de Thau, in the Camargue, are of considerable commercial importance in the context of fish catches.

One of the principal factors regulating the productivity of a lagoons is salinity. In lagoons on the Adriatic coast of Italy, productivity (in terms of fish catch) increases

[4]Ecotones are zones of transition where adjacent ecosystems overlap.

from 3-12 kg/ha in the oligohaline[5] lagoons (low salinity; 0.5-5 psu) to 70-197 kg/ha in polyhaline[6] lagoons (high salinity; 20-35 psu) where the salinity approaches that of seawater. This compares with values of 3-14 kg/ha calculated for the Mediterranean as a whole or for the area of continental shelf.

Saline marshlands

Saline marshlands occur along the interface of aquatic and terrestrial habitats, generally on coastal and deltaic plains. The distinctive feature of Mediterranean saline marshlands is their flooding regime. Within the Mediterranean basin, most marshlands are flooded seasonally. Marshes would be flooded during the wet season and desiccated throughout the dry season. This places severe stresses on the vegetation of these habitats, and the only plants that colonize these habitats are those capable of tolerating a continuous drought which may persist for several months. The origin of the water supply of marshes differs from marshland to marshland. Most marshlands are supplied, to varying extents, by direct precipitation and runoff. In addition, marshlands in the vicinity of rivers may be supplied by flooding of the river above its banks whilst coastal marshes may be supplied by wave action. Other marshes may be flooded by rising groundwater. In all cases, however, the proximity of fresh and saline sources of water promotes the formation of a brackish-water environment, colonized by a suite of species characteristic of such habitats.

Such marshlands are also inhabited by a wide range of animals including wild boar, foxes, wild bulls and wild horses. Marshlands provide ideal nesting and feeding grounds for many species of birds and the principal asset of these wetlands (in economic terms) is often their avifauna. The vegetation of marshlands is diverse. The parts of marshlands which only hold water for part of the year are colonized by hydrophytes such as *Damasonium* spp., and *Ranunculus* spp. and *Potamogeton* spp. Patches characterized by a saline substratum are colonized by halophytic species such as *Juncus* spp., *Limonium* spp., *Arthrocnemum* spp. and *Salicornia* spp. amongst others. Margins with more or less permanent water and shallow depth and colonized by the lesser reed *Phragmites australis* provide an important source of shelter for waterfowl. This species tends to be invasive and is therefore subject to regular control through grazing, burning or hydrological management. The very high productivity of marshlands is the source of their high biodiversity.

Intertidal wetlands

Much of the Mediterranean is essentially tideless and large areas of intertidal mudflats are therefore relatively scarce. Such habitats are limited to regions with a significant tidal range: an area covering roughly 200 km between the Gulf of Gabes and the Kneiss islands, in Tunisia and another area along the coasts of the Upper Adriatic. The presence of large and diverse populations of invertebrates in the sediments of these tidal flats attracts wading waterfowl, which therefore add to the biological and economic significance of these areas.

Sand dune systems

Sand dune ecosystems are a characteristic feature of the backshore environment of many Mediterranean coastal areas. Unlike desert dunes, coastal dunes are built and

[5]Oligohaline: a low salinity environment.

[6]Polyhaline: a high-salinity environment.

maintained by vegetation, mainly dune-building grasses such as Marram Grass (*Ammophila* spp.). Backshore vegetation is responsible for dune construction by ensuring a net accumulation of sand. Vegetation therefore represents an obstacle which traps wind blown sand in its immediate vicinity. Coastal dunes are frequently perceived as being of value in coastal protection, as reserve defences against encroachment by the sea. Much of the vegetation that colonizes sand-dune ecosystems is unique to these environments and any loss of habitat results in a reduction of the diversity and range of distribution of these species.

Rocky coasts

Low-lying rocky shores in the Mediterranean are frequently karstified and as a consequence, the fresh and brackish-water habitats of these environments are fragmented. Rocky shores are characterized by several ecological gradients and are therefore rich in species. The parts of the habitat nearest the shore are subject to higher salinities and more intense disturbances from wave action than are the more landward parts of the habitat. In general, much of the perennial vegetation of rocky coastlines is halophilic although reduced influence of salt and wave action would provide suitable habitat-space for relatively unspecialized annual species along the upper reaches of these habitats.

The part of the shore closest to the sea is usually devoid of any large terrestrial plants and is largely characterized by exposed rock and seawater rockpools. These seawater rockpools are of an exceedingly temporary nature. Water input is derived from wave action and if a pool is situated more than a few metres up the shore, then its supply of water may not be consistent enough to prevent rapid desiccation. Alternatively, if a pool is close enough to the shore, occasional heavy waves would tend to flush its contents completely. In some parts of the Mediterranean, wave action may lead to the accumulation of large heaps of Neptune Grass (*Posidonia oceanica*) on the shore. Such *Posidonia* banquettes are rich habitats in their own right, being colonized by a variety of invertebrate organisms. These complex ecosystems are rarely long-lived since the banquettes are usually removed in order to clear beaches for bathers. Further up the shore, where intensity of wave action is diminished, soil would be shielded in very small, sheltered hollows, no more than a few centimetres across. These sporadic accumulations of soil support the specialist flora characteristic of these parts of the shore. At distances of several tens of metres from the shoreline, greater environmental stability and reduced maritime influence permit the retention of more extensive patches of soil in shielded rocky hollows. In this part of the habitat, the natural community would be open to competition from less specialized species. At greater perpendicular distances from the shoreline, the soil patches become confluent and provide a continuous substrate for colonization.

Salinas

The sizes and forms of Mediterranean salinas vary, but most are a combination of shallow lagoons and pans, established on the sites of natural saline lagoons. Although essentially anthropogenic in origin and application, coastal salinas are nevertheless rich wetland habitats characterized by high biological diversity. Such habitats provide a relatively undisturbed aquatic environment which is colonized by a wide variety of cyanobacteria, invertebrates, macrophytes, fish and waterfowl.

Current and former salinas are almost the only regular habitat for flamingos in the Mediterranean. With this in mind, conversion of a wetland into a salina is often perceived as a change of wetland-use rather than as a permanent loss of wetland. The biological richness of salinas is also a consequence of the physico-chemical gradients which are characteristic of these habitats. The pans closest to the coast would be characterized by salinities which are comparable to that of the surrounding habitat whilst pans further inland would be much more saline. As such, the less saline pans would be colonized by halophytes and fish, whilst the most saline pans would only support brine shrimp (*Artemia* spp.) and some specialized insects.

2.5.3. Threats to habitats of the adlittoral zone

Drainage and reclamation

Mediterranean wetlands have been subject to intermittent drainage throughout historical times. In past centuries, the principal objective of draining coastal wetlands was the provision of land which could be exploited for agricultural purposes. Another, often parallel, objective of draining wetlands concerned minimization of the spread of insect-borne diseases. Removing lentic aquatic habitats reduced the available breeding areas for insects such as mosquitoes, which may act as vectors for various diseases, including malaria. One such case in point is the draining of the Marsa wetland in Malta, as part of a systematic programme aimed at the eradication of malaria. Drainage of coastal wetlands persists, although the objectives are somewhat different. Increasing populations mean that much drainage of wetlands is now concerned with generating fresh building space in order to accommodate coastal housing, industry and, especially, tourism.

Tourism

The significance of the Mediterranean as a prime destination for tourists has resulted in loss of wetland space which has been converted into tourist facilities. Such activities also lead to the fragmentation of coastal wetlands and few remain in a natural state. The requirements of the tourist industry have led to the commercialization of many wetlands, now perceived as a potential source of considerable income. All this is done at the expense of the natural ecological processes of these wetlands. Although tourism is a source of income, it is also a source of extensive disturbance from vehicles, pollution and littering. National parks, such as the Camargue in southern France, are visited by a large volume of tourists throughout the summer months. Under such circumstances, pristine habitats would only persist in restricted core areas which would be off-limits to most visitors. Exploitation of sand-dune ecosystems as recreational areas results in degradation of these habitats. Much of the damage being caused to these habitats originates from use of off-road vehicles, horse-riding and trampling by hikers.

Eutrophication

The high population density along the coast of the Mediterranean generates a considerable amount of pollution, mainly from sewage, much of which is released into wetlands such as lagoons. The relatively calm, warm water of these lagoons promotes eutrophication leading to the growth of algal and bacterial blooms and consequent depletion of oxygen within these water bodies. The high biochemical oxygen demand characteristic of eutrophic waters promotes anoxic conditions within them leading to massive mortality of fish, molluscs (such as shellfish) and aquatic plants.

This problem is becoming more and more acute. There are more than fifty cities with a population size in excess of 10^5 along the Mediterranean coast, and this figure swells considerably throughout the summer months due to the seasonal influx of tourists. The sewage generated by these resident and transient populations is consequently one of the major threats for coastal wetlands. Run-off from agricultural activity is also an important source of nutrients which may cause eutrophication. This problem is particularly evident where the water-body receiving the nutrients is semi-enclosed (as lagoons or deltas).

Exploitation

The increasing population pressure along the coast of the Mediterranean has been reflected in increased exploitation of coastal habitats for hunting, fishing and aquaculture. Many coastal wetlands, such as marshes, lagoons and salinas are colonized by birds and are consequently visited by hunters. Bird-shooting is responsible for the annual destruction of millions of waterfowl in the coastal wetlands of the Mediterranean. Apart from depletion of avifaunal diversity, hunting activity also results in the accumulation of large volumes of spent lead shot in the sediments of these wetlands, possibly increasing the toxicity of the water. Lead is accumulated by living organisms and tends to be amplified in its passage through food chains, leading to high (and toxic) concentrations in top predators such as waterfowl.

Damage caused to coastal wetlands by fishing is principally the result of improved capture technologies, leading to unsustainable levels of harvest and subsequent reduction of fish populations in lagoons. Trawling in coastal areas is also very destructive for meadows of the sea grass, *Posidonia oceanica.*

Aquaculture within coastal waters or in the adlittoral is another form of exploitation that may damage these habitats. Intensive aquaculture generates significant volumes of excretory products which add to the nutrient load (and hence the biochemical oxygen demand) in coastal wetlands and which consequently promote eutrophication. Moreover, escapes of farmed non-native fish may disrupt pre-existing ecological equilibria, leading to depletion of stocks of native fish. Sediment loads generated by fish farms are another important source of pollution and may increase water turbidity.

Alteration of hydrological regime

An increase in agricultural activity along the coast generates a demand for freshwater for irrigation. In many cases, this water is obtained from the groundwater reserves beneath wetlands. These aquifers play a very important role in maintenance of water levels in such coastal wetlands and depletion of their water content results in severe degradation of the wetlands which are partially dependent on them. Alteration of the hydrological regime in order to favour agriculture has other repercussions on coastal wetlands. The extensive irrigation of rice crops on the Camargue, in southern France, has led to input of fresh irrigation water into the Étang de Vaccares. This lagoon is now less saline and more permanent than previously, leading to pronounced changes in species composition.

Demand for hydroelectric power can also modify the hydrological patterns in these coastal habitats. The construction of dams upstream of coastal wetlands intercepts sediment loads and consequently results in deltaic retreat. This problem is particularly evident in the Nile delta and in the Rhone delta amongst others.

Moreover, discharge of freshwater into lagoons from hydroelectric plants can lead to reduced salinity and consequent changes in species composition with possible loss of important fisheries. In many lagoons, the salinity is dependent on the maintenance of canals leading to the open sea. Silting up of these canals, associated with freshwater inputs from agriculture and hydroelectric plants, is another factor leading to reduced salinities in coastal lagoons.

2.5.4. Supralittoral zone

The supralittoral zone is characterized by organisms that require some wetting with seawater but not immersion.

On rocky shores the main species include:

- Various maritime lichens, mainly species of *Verrucaria* which are adapted to live in this extreme environment;
- Microscopic algae which live on or in the rock and give it a characteristic blackish-brown colour;
- Two species of periwinkle, of which the commonest is *Melarhaphe* (= *Littorina*) *neritoides;*
- The isopod *Ligia italica.*

On sandy shores, the supralittoral zone is dominated by animals that burrow in the sand, mainly sandhoppers or amphipods (for example, *Talitrus saltator*) but also several terrestrial forms, such as beetles and woodlice. A visible subzone on most sandy shores is the strand-line—the highest point reached by waves. This area collects stranded material called beach wrack which provides a cool, moist environment for small invertebrates, both terrestrial and marine (flies, beetles, centipedes, spiders, isopods, amphipods, gastropods). Gulls and other shore birds scavenge here. In the Mediterranean, the banks of sea grass leaves and seaweed debris deposited on sandy shores by winter storms support an interesting community of terrestrial and marine species including amphipods (e.g. *Orchestia*), snails (e.g. *Ovatella*), spiders (mainly lycosids or wolf-spiders), beetles (mainly staphylinids or rove-beetles), flies and others.

2.5.5. Mediolittoral zone

The mediolittoral zone is colonized by organisms that tolerate more or less regular immersion in seawater but not continuous submersion.

Characteristics of life in the mediolittoral zone

Organisms colonizing this zone are characterized by vertical zonation (i.e. the occurrence of dominant species in distinct horizontal bands). Continual alternation between a marine and terrestrial habitat causes problems of heat stress, desiccation, oxygen shortage and reduced feeding opportunities. Fresh water inputs from the land and evaporation cause variations in salinity due to the very shallow depth of the water. Activity of several organisms is related to fluctuations in water level (e.g. some organisms prone to desiccation/heat stress migrate to deeper water during sea-level lows; others become active only when covered with water). Water movements during rough weather cause wave shock that can cause physical damage to organisms due to abrasion, hydrostatic pressure and pressure drag. Local communities may be prone to seasonal influxes of predators (e.g. migratory shore birds) that can have devastating effects (an example of biological disturbance). Hence the development of behavioural and structural defences by many mediolittoral species. Species composition in this zone is often determined by physical and biological disturbance.

On rocky shores, the upper reaches of this zone are characterized by:

- Barnacles of which there are three species; *Euraphia depressa* occurs in the highest levels and *Chthamalus stellatus* further down. The third species *Chthamalus montagui* occurs at intermediate levels on some shores;

- At the lower limit of the barnacle zone occur the limpets (species of *Patella*, mainly *Patella ulyssiponensis* on the upper shore and further down *Patella caerulea*; on some shores, a third species of limpet—*Patella rustica*—occurs);
- Within the limpet zone also occurs the chiton *Lepidochitona corrugata;*
- Close to sea level the shore is dominated by the attached snail *Dendropoma petraeum* in exposed parts, while another attached snail *Vermetus triquiter* occurs in sheltered microhabitats. On some shores, the shells of *Dendropoma* are embedded in encrustations of the calcareous alga *Neogoniolithon notarisii* to form characteristic platforms known as "trottoirs" or "vermetid rims";
- The vagile top-shells *Monodonta turbinata* and *Monodonta articulata* occur throughout the mediolittoral during calm weather but seek the shelter of pits and grooves in the lower reaches of the shore during rough seas;
- In the mid-mediolittoral, macroalgae (large algae) become evident. Different shores have different suites of species, depending on geographical location, exposure, nature of the substratum and other factors. On the moderately exposed calcareous shores of the central Mediterranean for example, there is a fringe of red algae (mainly *Polysiphonia setulariodes*) followed by fringes of *Polysiphonia opaca, Ceramium ciliatum* and *Laurencia papillosa*, with encrusting coralline algae becoming dominant in the lowermost reaches of the mediolittoral.

Endobenthos on soft-substratum shores

The mediolitoral zone of sandy shores is a harsh environment. Since it is periodically covered and uncovered by water, it absorbs the direct assault of waves whilst sand is mobile and prone to shift, grinding organisms within it.

The surface remains wet at low tide from capillary action. Therefore, interstitial organisms thrive near the surface of the sand. These include bacteria, worms of various types and copepods. Their bodies are generally long and thin to enable them to move easily among the grains; many have adhesive organs allowing them to stick to grains and not be washed away. Diatoms and dinoflagellates are the main producers living in the sand and can migrate deeper and shallower in the sediment.

Oxygen availability is a main concern to the organisms living in the sediment and in this regard, coarse sediments are much better aerated than fine ones. Water flow through fine sediments is restricted therefore there is less oxygen circulation. Fine sediments also tend to be rich in detritus and decomposition of this further reduces the oxygen content, resulting in anoxic conditions.

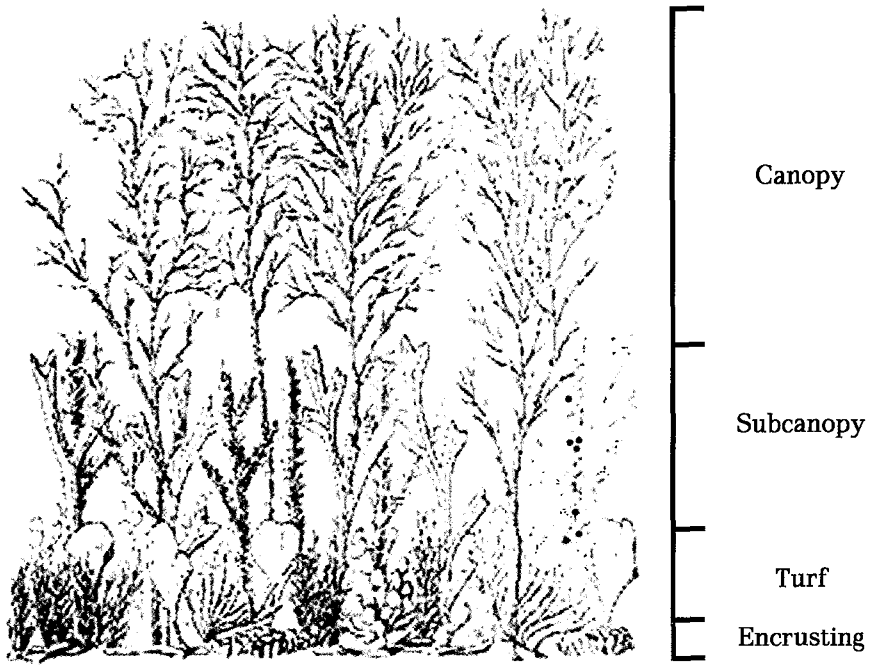
Anoxic conditions favour anaerobic bacteria that produce hydrogen sulphide (H_2S) as a by-product of their metabolism. Few animals can live in such conditions and those that do usually have special adaptations, for example, pumping oxygenated water from above the sediment.

On sandy shores, this zone is again dominated by burrowing animals, mainly amphipods and the polychaete worm *Ophelia bicornis*. In enclosed areas subject to little water movement and receiving an influx of freshwater, a characteristic brackish water community develops, dominated by hydrobiid gastropods living on the surface of the muddy sand, and the bivalve *Cerastoderma glaucum* burrowing in it.

2.5.6. *Infralittoral zone*

On hard bottoms attached algae dominate the infralittoral zone. The dominant algae on most Mediterranean coasts are species of *Cystoseira*. Different species of *Cystoseira* occur in different parts of the Mediterranean while in the same geographical locality, different species occur in different environmental conditions. For example, in the central Mediterranean, *Cystoseira stricta* is common on exposed, unpolluted shores, while *Cystoseira balearica* occurs in calmer waters, and *Cystoseira compressa* in moderately polluted conditions. Within these *Cystoseira* beds various other species of algae occur, arranged in a distinct layering pattern with tall forms (e.g. *Dictyopteris*) immediately beneath the *Cystoseira* fronds, shrubby forms (e.g. *Udotea* and *Halimeda*) in another layer beneath, and low-growing species (e.g. *Peyssonnelia*) encrusting the rock. A multitude of microhabitats occur within these algal beds, supporting a very rich flora and fauna.

Figure 2.5. Biota distribution patterns



Algal canopies can reduce the amount of light reaching the substratum, sometimes to less than 1 per cent of the surface irradiance. In exposed areas, water motion and sand abrasion associated with storms causes an overall decrease in algal cover in the winter, which then increases in the summer. This leads to a seasonal cycle in species diversity as compared to more protected sites.

Algal beds provide habitats for a large variety of invertebrates and fishes These biota are distributed among three different regions of the forests: the surface canopies, the subcanopy, and the substratum

Some organisms burrow into the rock supporting the plants (e.g. some sponges and bivalves). The holdfasts of the tall-growing algae and the mats of turf-like and encrusting algae provide microhabitats for an abundant and species-rich association, the most common members of which are polychaetes, amphipods, decapods, gastropods and ophiuroids (i.e. crevice-inhabiting forms).

On the rock between the holdfasts, sponges, tunicates, anemones, solitary corals and bryozoans are the most commonly occurring sessile animals within algal beds (i.e. encrusting forms). Other organisms live on the algal fronds, either permanently attached (e.g. epiphytes such as algae, bryozoans and hydroids) or freely mobile (e.g. isopods, opisthobranchs or sea-slugs, and shrimps). Many of these motile forms are grazers, the majority of which do not feed on the macroalgae themselves but graze upon their epiphytes. Additionally, some swimming animals feed, shelter or lay their eggs in the algal beds (e.g. many fish and some cephalopods).

Characteristics of soft-bottom assemblages

Soft-bottom assemblages differ from hard bottom ones in a number of ways:

- Organisms are mostly endobenthic (living in the substratum) as opposed to epibenthic (living on the substratum);
- Except for sea grass beds, there is little or no fixed vegetation;
- The environment is more structurally and spatially uniform;
- The granulometry (particle size) has a large effect on organisms;
- The greatest numbers and biomass of organisms are in two feeding groups: suspension feeders and deposit feeders.

Movement of bottom sediments by waves and currents is a dominant physical process influencing the structure of benthic communities in shallow water. Wave action produces a coarse, poorly consolidated, well-sorted (i.e. low variation in particle size), and therefore easily moved sediment. Large waves lift these surface sediments into a granular suspension tossed shoreward and then seaward by the passing waves.

The physical stability of the bottom increases with increasing water depth as wave-generated bottom currents decrease. As a result, bottom sediments grade from coarse to fine sand with increasing water depth and decreasing wave disturbance. However, sea grass cover stabilizes the bottom sediment by "insulating it" from the direct effect of waves and currents.

Sea grass meadows

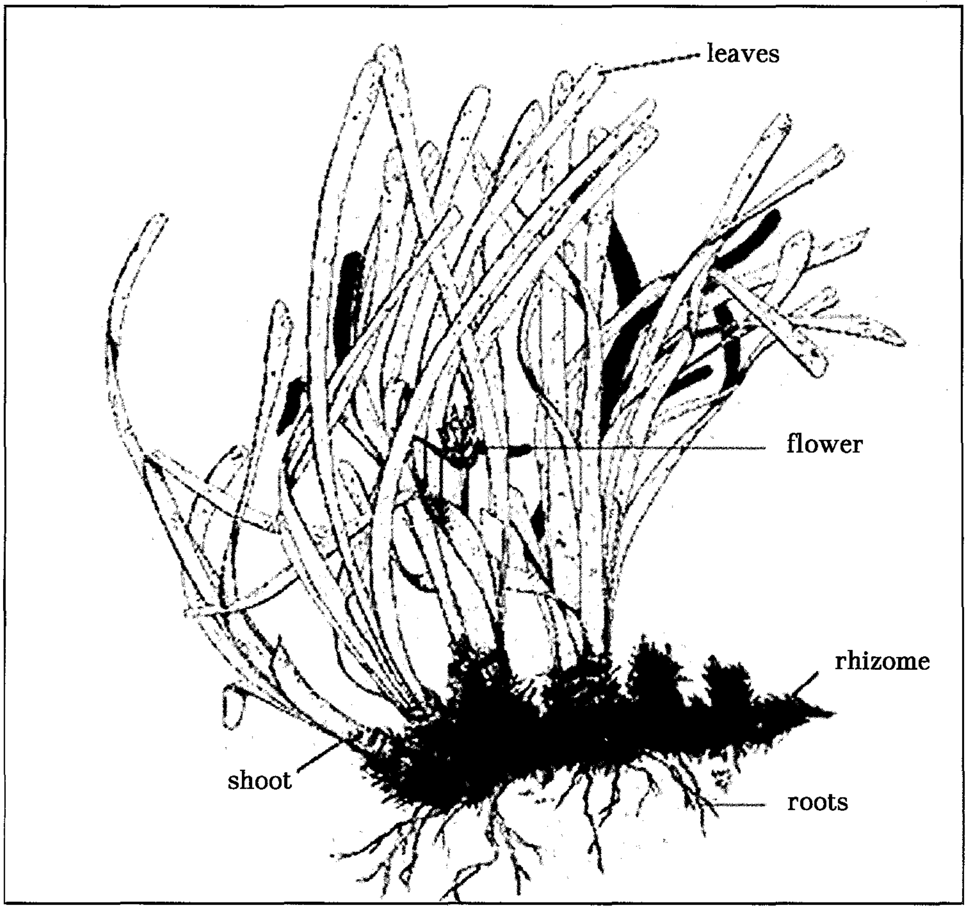
On soft bottoms, the most important infralittoral community is that of sea grass meadows. In shallow water the dominant species is *Cymodocea nodosa* while in deeper water it is the Neptune Grass *Posidonia oceanica*. *Cymodocea nodosa* is also found in deep water, at the lower limit of *Posidonia oceanica*. Both species form extensive meadows that are amongst the richest communities of the Mediterranean marine environment.

Sea grass meadows provide habitats for a wide variety of marine organisms, both plants and animals; these include meiobenthic, benthic, and epiphytic organisms, plankton and fish, as well as microbial communities. The relatively high rate of primary production of sea grasses drives detritus-based food chains, which help to support many of these organisms. Sea grasses are also directly consumed by a few invertebrates and by turtles. Although very few animals feed directly on sea grasses, in terms of production of detritus they contribute significantly to coastal productivity. In the nutrient poor waters of the Mediterranean, sea grasses act as a nutrient store, releasing their nutrients as they are decomposed, and as a result of detritus re-suspension during storms. Sea grasses act as a substratum for many epiphytic organisms. The added productivity of the epiphytic population is very important, since they provide a food source for many grazers.

Dense sea grass meadows may contribute to development of extensive sediment banks through a reduction in water flow. Neptune grass—*Posidonia oceanica*—forms a dense and complex tangle of rhizomes, roots and sediment known as "matte" that acts to stabilize the sediment, reducing potential sediment erosion in shallow waters.

Sea grass meadows provide shelter and food for a vast number of other species. Some of these burrow into the sediment supporting the plants (e.g. bivalves), others walk, creep or crawl on the substratum (sediment or matte) between the shoots (e.g. many gastropods, polychaetes and crabs), others live amongst the leaves, either permanently attached (e.g. algae, bryozoans and hydroids) or freely mobile (e.g. isopods, opisthobranchs or sea-slugs, and shrimps). Additionally, some swimming animals feed, shelter or lay their eggs in the sea grass beds (e.g. many fish and some cephalopods).

Figure 2.6. ***Posidonia oceanica***



2.5.7. *Circalittoral zone*

The circalittoral zone is a region of very dim light with much fewer organisms than found in shallower water. On hard substrata, the circalittoral is dominated by attached forms, such as encrusting algae, serpulid polychaetes or tube-worms, bryozoans or false-corals, sponges and corals. This same assemblage of species is also found in shallower water, where environmental conditions mimic those of the circalittoral zone, for example, in deep submarine caves.

Characteristic Mediterranean circalittoral communities are those formed by coralline algae and certain other calcified algae. These may either form massive reefs composed of accretions of encrusting calcareous algae, or maerl, composed of nodules of free-living calcareous algae.

Soft circalittoral substrata are characterized by burrowing animals (e.g. heart-urchins) or those that live on (e.g. brittle-stars and sea-cucumbers) or partly embedded in the sediment (e.g. pennatulaceans or sea-pens, and alcyonarians or soft-corals).

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3

Sustainability as applied to the coastal zone

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3 Sustainability as applied to the coastal zone

3.1. Introduction

Coastal environments are some of the most productive and diverse natural areas on earth, supporting a remarkable variety of habitats that have evolved over geological time as a result of changes in the sea level, and the influence of exposure to waves and currents, latitude, tidal range, and geology. The coast is a dynamic environment. And the way it is used also changes with new activities and pressures developing alongside more traditional uses of coastal land and inshore waters. Tourism is a recent and rapidly growing trend with an increasingly detrimental impact on the environment. Indeed, it is now the greatest growth industry on the Mediterranean coast where coastal locations are among the most popular destinations for tourists. As an example, in Greece 90 per cent of the tourist investment is directed to the coast, while in Portugal the population density on the coast increases by more than 300 per cent during the tourist season (CEC, 1994).

Historically, coasts have been of major economic importance, with cities developing where maritime trade routes made their landfall and where easy access to fisheries could provide food and create wealth for the nearby communities. Today coasts attract industry, tourism, trade and other activities, as well as housing for a large and growing population. Indeed, urbanization, population growth, industry and especially tourism today are at the root of many coastal problems. This is particularly noticeable in the Mediterranean where the population living in the coastal areas is predicted to reach more than 200 million by the year 2025 (Grenon and Batisse, 1989). This is far in excess of the carrying capacity of the Mediterranean coast, and its impact on both the coastal environment and ecosystems is not difficult to imagine.

Thus the problem of preserving the integrity of the Mediterranean coastal environments and ecosystems is one of growing concern, given the mounting detrimental impacts of diverse human activities and numbers. Notwithstanding some exceptions where remedial actions and policies are beginning to show signs of improvement, in general the situation continues to deteriorate. It is especially worrying to note that, despite numerous initiatives and expenditure of large amounts of money, not much of substance is happening to alleviate the relentless pressure of human numbers and activities on the coasts. On the contrary, the problems are becoming increasingly more serious, threatening the integrity of coastal environments and ecosystems; this, in turn, is diminishing and even destroying the natural resources (such as fish stocks, water quality, etc.) on which the coastal communities depend for their livelihood. Clearly, this state of affairs does not augur well for the future.

Starting with the concept of sustainability, attention is drawn in this paper to the various aspects of sustainability of the coastal zones. Even though such zones differ a good deal depending on location and can be site-specific, there are nevertheless aspects and problems that are common to all of them, especially with regard to sustainability. Particular attention is drawn in this paper to some of those common aspects and problems including the definition of coastal sustainability and development of sustainability indicators.

3.2. Relevant issues of sustainability of coastal zones

3.2.1. The concept of sustainability

A "coastal zone" is defined as a zone which includes maritime land as well as foreshore and inshore waters.

Following this definition, any effort at sustainability should involve elements of both marine and terrestrial systems. Also, the interactions that occur between the marine and terrestrial environments of a coast should be considered.

The complex and dynamic nature of marine, terrestrial and human ecosystems, and the interactions among them, create difficulties in planning and managing coastal zones.

Furthermore, ecologically vulnerable coastal zones face threats from competing interests such as urban development, tourism, industrial development and agriculture, all of which affect delicate and vulnerable coastal ecosystems, coastal aquifers, wetlands, and archaeological sites (World Bank, 1990).

Because of intense development pressures in coastal zones, it is usually very difficult to control land-use effectively and to enforce relevant plans and laws.

Therefore, it is important to recognize that a coastal zone is an integrated unit for planning purposes; that planning and management of coastal land and waters cannot be dealt with separately; and that the coastal zone is an area which requires special attention for planning and management (Gubbay, 1998; UNEP, 1995).

Coastal sustainability should aim to promote sustainable use of marine and terrestrial resources; achieve a balance between conflicting demands for coastal zone resources; resolve conflicts of use; and to promote environmentally sensitive strategic planning for coastal zones (Gubbay, 1998; UNEP, 1995).

Although the urgent need for sustainability in coastal zones has been widely accepted, and the principles of sustainability are considered in preparing plans and in setting management goals at all levels, its implementation in many countries at present falls far short of what is urgently needed.

This is due mainly to lack of both knowledge and political will. It is argued that both these deficiencies need to be addressed as a matter of priority in order to facilitate the effective implementation of sustainability. It is also argued that appropriate, simple and reliable indicators of sustainability need to be developed for measuring progress being made towards sustainability. Because, it is only with such measurements that we could tell whether the situation is improving (becoming sustainable) or deteriorating (becoming unsustainable) over time.

3.2.2. Measurement of sustainability— development and application of indicators of sustainability

What is a sustainability indicator?

A sustainability indicator gives an "indication" of whether or not a certain human activity, or a socio-economic aspect of life, is becoming "sustainable" over time (Nath, 1997).

Indicators are reliable signals which monitor the current state, the pressures effecting the state, and the changes. Such measurements can be used reliably as a signal to specify the current state, or to monitor the change of factors that have an impact on sustainable development (SD).

The United Kingdom Local Government Management Board (LGMB) defines sustainability indicators as those which "give a measurable indication of progress towards (or away from) sustainability".

Indicators are primarily intended to transform the concept of sustainability to measurable values for assessing the level of sustainability with quantitative data.

Indicators of sustainability are seen as tools. Therefore, their value and appropriateness depends not only upon their relevance to issues of sustainable development, but also on their intended use and audience.

A successful indicator of sustainability should have the following characteristics (Nath and Vivian, 1998):

- It should focus on the status of a significant and fundamental target problem or activity;
- It should be well understood and accepted by the community at large;
- It should enable the quantitative measurement of the target problem or activity for which it is designed;
- It should represent, or directly relate to, important quality of life issues and values of the community;
- It should be user-driven, policy-relevant and highly aggregated;
- It should be simple to understand and easy to use.

Indicators of sustainability have specific characteristics, described below, which compare with traditional economic, social and environmental indicators (Maclaren, 1996):

- Sustainability indicators are not just a collection of environmental, economic and social indicators. As sustainability requires greater integration, sustainability indicators should link all the three basic indicators (environmental, economic and social). The "integrating" indicators should also illustrate the linkages among the three sets of indicators.
- Development of sustainability indicators needs a holistic approach and a multidisciplinary effort.
- Sustainability indicators must be forward looking if they are to be used in measuring progress towards achieving inter-generational equity.
- Finally, a characteristic that distinguishes sustainability indicators from other types of indicators is the manner in which they are developed. It is useful either to assign full responsibility for making decisions about the selection of sustainability indicators to a broadly-based multi-stakeholder group, or to consult with multiple stakeholders in some other way.

The need for sustainability indicators

The primary purpose of developing indicators is to assess progress being made towards sustainability. Such an assessment requires quantifiable and measurable data.

Development of sustainable planning methods, and developing policies and assessing the success of both plans and policies in achieving sustainability, is only possible by using indicators and by expressing the impacts of human activities in terms of numerical values.

Besides, indicators are needed to identify the characteristics of both human and natural eco-systems, and to identify the interactions and linkages among the three aspects of sustainability, namely environment, society and economy.

Three main functions of indicators are: simplification, quantification and communication. Indicators are needed to make a complex phenomenon quantifiable in a way that enables or facilitates communication (LGMB, 1994).

In terms of their characteristics and function, indicators for coastal zones do not differ from the other types of sustainability indicators. They can be used for a wide variety of purposes, such as:

- Conceptualizing sustainability and defining goals for coastal areas;
- Monitoring existing conditions and trends in the coastal areas;
- Systematic monitoring of coastal environmental changes;
- Early warning of coastal environmental problems;
- Target setting;
- Measuring performance, and assessing the effectiveness of implemented policies;
- Public information and communication;
- Providing information for local and national policy-makers to improve their actions towards sustainability and in developing policies.

Methodology: frameworks for indicator development

Worldwide, there is now a growing effort in developing appropriate indicators and methodologies to measure sustainability at international, national and local levels.

As mentioned earlier, indicators of sustainability in a given area should cover all three aspects of sustainable development, namely economic, environmental and social. A framework for indicator development should integrate all three aspects as well as their interactions.

The overall aim of developing indicators is to simplify and quantify these extensive aspects of sustainability into a workable list of data and to enable their communication.

In this sense defining a framework is essential to identifying the context of the indicators which really measure sustainability and to check whether or not all the aspects are covered.

The national and international levels. The pressure-state-response (PSR) approach of the Organisation for Economic Cooperation and Development (OECD) is acknowledged as the pioneering work on the methodology for measuring sustainability.

The PSR framework builds on and develops a primary set of environmental indicators which the OECD developed to meet the immediate need for measuring environmental performance (WWF, 1994). This general framework, known as the PSR approach, has been designed to help integrate environmental considerations into national decision-making (Alberti, 1996).

The framework results in three types of indicators (Hens, 1996):

- "Pressure" or "driving force" indicators reflect the pressures arising from human activities. This reflection is considered to be on the environmental condition, as well as on the socio-economic condition. They are key to policy formulation;
- "State indicators" describe the actual condition/quality of the environment and quality of natural resources. They are especially informative when identifying problems and raising awareness;
- Response" indicators show how society responds to the changes in the state of the environment through environmental, economic and sectoral policies. They are useful for evaluating the effectiveness of policy targets.

Table 3.1 below gives two examples of how this framework can be applied to a coastal area:

Table 3.1. Pressure-state-response indicators for a coastal area

Issue	*Stress*	*Condition*	*Response*
Waste	Discharge of industrial waste into freshwater bodies (m^3) bodies (mg/l)	Concentration of toxic chemicals and heavy metals in freshwater treatment)	Waste water treatment (% of population served, total and by type of
Biological diversity and landscape	Land-use changes	Threatened or extinct species (% of known species)	Protected areas (% of total area)

Source: WWF, 1994.

The PSR framework was originally intended to measure environmental performance. But it can be easily be incorporated into a framework of sustainability indicators (WWF 1994). Most of the national and local initiatives, aimed at developing sustainability indicators, have followed OECD's PSR framework (Alberti, 1996).

The Commission on Sustainable Development, a functional commission of the Economic and Social Council (ECOSOC), is a United Nations body that is coordinating efforts to develop sustainability indicators for monitoring sustainable development as defined in Agenda 21.

Like the OECD indicators, the indicators of the Commission on Sustainable Development aim at monitoring national performance. But there is a difference in scope: while OECD indicators focus on measurement of environmental performance, Commission indicators aim at monitoring sustainability.

The local level. Apart from international and national agencies, many cities in Europe and North America have been developing indicators following the guidelines of local Agenda 21.

The United Kingdom LGMB has proposed an indicator framework consisting of four stages (LGMB, 1994), described below:

> *Stage 1: Define sustainable development.* LGMB draws four key components of the meaning of sustainable development: equity, futurity, quality of life, and environment. These aspects are incorporated into the definition of a sustainable community as proposed by the LGMB framework:
>
> > "A sustainable community lives in harmony with its local environment and does not cause damage to distant environments or other communities—now or in the future. Quality of life and the interest of future generations are valued above immediate material consumption and economic growth".
>
> *Stage 2: Identify broad categories of sustainability.* Two categories are chosen by LGMB: "carrying capacity" and "quality of life". The prime argument for this categorization was that, it makes it easier to handle the distinction between local and global issues. Quality of life was felt to be primarily affected by local issues, while carrying capacity was interpreted as a concept with implications that are broader than those of the local community.
>
> *Stage 3: Identify themes for a sustainable community within the broad categories.* At this stage themes drawn from carrying capacity and quality of life are set out. These themes attempt to define the goals of a sustainable community towards which the indicators can help it to move. In some cases there are sub-

themes. The resulting themes are then each converted into a key "sustainability factor".

Stage 4: Identify candidate indicators for each sustainability factor. A large number of indicators were explored, and candidate indicators were then collected for each theme. Having agreed an initial and long list of indicators (with reference to a set of criteria defined at early stages), a voting exercise was conducted by a steering group on a theme-by-theme basis.

The LGMB framework lists 101 potential indicators under 13 different themes. They bring together a wide range of aspects of sustainability which anyone can relate to.

This list contains of a broad set of indicators, but it should not be considered a blueprint of sustainability indicators. According to local circumstances, priorities and sustainability concerns, each community should set up its own indicators.

Table 3.2 below gives a typical example of how the LGMB framework could be applied to coastal zones.

Table 3.2. The LGMB sustainability indicator framework

Broad categories	*Theme*	*Sub-themes*	*Selected indicators*
Carrying capacity	Resource use	Land	Land lost to conflict uses (m^2)
		Marine	Fish/shellfish harvest (ton)
	Pollution	Land	Contaminated land (m^2)
		Marine	Bathing waters failing EU directive standards (% of total)
	Biodiversity		Protected natural habitats/landscapes (%)
	Basic needs		
	Information/ education		
	Leisure/culture		
	Freedom		
Quality of life	Access		
	Income		
	Work		
	Health		
	Beauty		

Source: LGMB, 1994.

Sustainable Seattle in the United States is a very interesting example of setting up a framework for indicator development at the local level.

This example follows the "bottom-up" and community-based approach. Right from the beginning, citizens of the local community were heavily involved in all phases of the process. The civic effort, called Sustainable Seattle, identifies itself as a "Volunteer Network and Civic Forum".

The Sustainable Seattle framework was developed in stages as described below (Atkisson, 1996):

Stage 1: Development of multisectoral relationships and definition of the tasks. Relationship building has a high priority at this stage. The intention is to involve representatives of the different sectors and different groups of the society. This is expected to lead to the development and definition of sustainability; to the identification of the concerns of the wide groups of citizens; and to finding a common ground on key issues facing the community.

However, this can be a time-taking process because sustainability is a new concept for most people in public life.

In the Seattle framework sustainability is defined as: "long-term cultural, economic and environmental health and vitality".

Stage 2: Identification of proposed indicators. Development of the proposed indicators is led by a "task team" which includes volunteers as well as diverse professionals.

Stage 3: Convening a community panel to review and legitimize the proposed indicators. A "civic panel" with wide participation of community members reviews the indicators in workshops by dividing up the 10 topical areas, namely resource consumption; education; economy; transportation; natural environment; health; social environment; culture and recreation; population; and community participation.
The goal is to recommend indicators for each topic that meet the overall criteria as set in the initial workshops.
After initial brainstorming, groups meet to develop, critically review, debate, form consensus and revise the proposed indicators.
Panelists use a simple voting scheme to register which indicators they thought most likely to capture public imagination.

Stage 4: Formation of a technical group to review the indicators. A technical group reviews the huge number of indicators and selects from them a manageable number. The group includes all members of the "task team" and several members of the "civic panel".
The technical group considers the preference voting results for eliminating indicators. This led to a final list of 40 indicators under 5 topics (environment; population and resources; economy; youth and education; and health and community).

Sustainable Seattle indicators are "trend indicators". For each indicator the "direction" of sustainability is determined. No benchmark or sustainability level is set for evaluation, as these levels are often impossible to determine. This framework can probably also be used for larger entities, even as large as nations (Goeteyn, 1996):

Synthesis of the frameworks and local-global approaches. The scale and specific mandates of different organizations lead them to concentrate on different aspects of sustainability, and, as a result, both indicators and methodologies differ. This arises mainly from the purpose of developing indicators, and from what to monitor by using them.

Efforts at international and national levels are more concentrated on monitoring progress with reference to international action plans and policies, and such efforts are mainly based on the "top-down" approach. At the local level, on the other hand, methodologies are based on the community-based and "bottom-up" approach.

Both OECD and Commission on Sustainable Development indicators aim at monitoring national performance. However, while the OECD indicators focus on environmental performance, Commission indicators are broader in scope and aim at monitoring sustainable development (Alberti, 1996). The PSR framework used by these two organizations can be called the "causal framework". It has two significant advantages: first, it can suggest why certain indicators are rising or falling; and second, it shows whether or not the implemented policies are having the desired impact. However, the main difficulty in using the PSR framework for developing sustainability indicators is that the distinction between economic/social pressures and economic/social conditions is not always apparent. In addition, the connection between these types of pressures and conditions may be considerably more complex than that between human activity pressures and environmental conditions (Maclaren, 1996).

Furthermore, measuring performance at global and national levels, and developing policies and management plans accordingly, does not always help us to reverse the negative trend; also, the expected results may not be realized. Moreover, policies may not be appropriate for most of the local areas within the same nation. Demographic, cultural, economic, social and environmental variations at the local level may also differ, and should therefore be considered.

The "top-down" approach is valuable for generalized policy-making. But it often lacks effective change at the local level; also, irrational changes can occur because the policy does not fit local conditions (Hatcher, 1996).

On the other hand, some of the most innovative experiences are emerging at the local level. The LGMB framework, which is "goal-based" and reflects the goals of a certain community to achieve a more sustainable life, is a typical example of this.

The strength of the goal-based framework is that it reduces the number of indicators that need to be considered for realizing specific sustainability goals. Use of the goal-based framework, and its explicit characterization of sustainability, also helps to evaluate whether the indicators are showing movement towards or away from sustainability (Maclaren, 1996).

Sustainable Seattle is a very good example of the "bottom-up" approach in which the community plays a vital role in all stages. The indicator development process does not refer to an explicit conceptual framework. But it is based on the themes that are defined by the community itself. As a result, three elements can be considered in comparing local and global frameworks (Alberti, 1996):

- The challenge is to integrate social, economic and environmental considerations into the same framework. However, different strategies have been adopted at different scales. While international programmes develop detailed and huge numbers of indicators, local programmes aim to achieve a very limited number of indicators that can detect critical trends;
- The second element is the different interpretations of sustainability. While international indicators focus on specific concerns (where a specific institutional framework exists), local indicators tend to place much more emphasis on locally relevant issues concerned with quality of life;
- The third element is the extent to which the public participates in the process. Public participation in international programmes is extremely limited, while in local programmes the public plays a critical role.

Criteria for choosing indicators

In developing effective sustainability indicators, following the definition of a suitable framework, a number of characteristics should be considered. The setting out of criteria for choosing indicators is necessary at this stage.

Selection criteria may differ depending on organizations and projects, but the following are common. The essential characteristics of a sustainability indicator are (Nath, 1997):

- It should be relevant to the stated goals of sustainability;
- It should be indicative of the issue of concern and capable of quantitative measurement;
- Sufficient reliable data, especially historical data, should be available for developing and monitoring it;
- It should be as precise as possible and simple to understand by the users;
- It should show trends over a reasonable timescale;
- Its monitoring costs should be as low as possible without diminishing its effectiveness or quality.

Steps in the development of sustainability indicators

The following six steps outline a process for developing sustainability indicators. They have been proposed by Maclaren (1996) for developing sustainability indicators:

Step 1: Define the nature of the problem, and the sustainability goals of coastal areas for which the indicators are needed. A multi-stakeholder and community-based approach can be adopted at this step.

Step 2: Identify the target audience, the purposes for which the indicators will be used, and the number of indicators needed. Indicators developed for policy-makers, scientists or general public, have different characteristics with regard to their complexity and number. While the indicators for policy-makers directly relate to policy objectives and target values, scientists are generally more interested in a highly detailed set of indicators.

Step 3: Choose an appropriate indicator framework. The framework should be selected in relation to the purpose of monitoring and the approach.

Step 4: Define criteria for the selection of indicators. A general selection criteria has been set out in the previous section. This can be modified in relation to the goal(s) and the target audience.

Step 5: Identify a set of potential indicators and evaluate them against the selection criteria. The set of potential indicators can be identified jointly by the scientists and the general public through brainstorming sessions and workshops. In evaluating this potential set, a simple two-point (present-absent) or three point (poor-medium-good) scale can be used.

Step 6: Choose a final set of indicators and test their effectiveness. The final set can be tested according to various aspects such as methodology and data availability.

3.2.3. United Nations Environment Programme indicators for sustainable development in the Mediterranean region

Since the first Mediterranean intergovernmental conference, organized by the United Nations Environment Programme (UNEP) and held in Barcelona in 1975, the countries that share the Mediterranean sea and its coastal ecology have adopted a series of legally binding agreements to sustain development while protecting the environment.

In the field of indicators of sustainability, the UNEP "Mediterranean Commission on Sustainable Development" (MCSD) carries out studies to establish a suitable regional strategy. In this context MCSD aims (UNEP, 1998):

- To link the indicator system for the region to the United Nations system;
- To identify those indicators that are of Mediterranean interest;
- To take steps to facilitate sustainable development being taken into account in the indicators and statistics for each bordering country.

In the last meeting of the "Indicators of Sustainable Development Working Group" of the MCSD in May 1999, a first group of indicators was selected as a common core set by all countries in the region. The indicators were chosen with reference to the list adopted by the United Nations Commission on Sustainable Development, and to the special features of the Mediterranean basin. This selection takes account of both relevance and availability of data for a significant number of countries. The list of indicators may be modified over the years in accordance with the focus and the requirements expressed by the MCSD (UNEP, 1999).

The indicators selected in the MCSD meeting in May 1999 are listed in Table 3.3.

Table 3.3. Table of selected indicators

	Pressure	*State*	*Response*
1. POPULATION AND SOCIETY			
1.1 Demography and population	Population growth rate		Total fertility rate (4.4)
1.2 Standard of life, social inequity, poverty, employment, unemployment		Women per hundred men in labour force	Employment rate
		Social disparity index	
1.3 Education, training, sensibilisation	School enrolment ratio (net)	Difference between male and female school enrolment ratios	Share of private and public finances allocated to professional training
		Production of culture (books, movies, records)	Public spending for the conservation and value for enhancing
		culture and patrimony	
(natural and landscape)			
1.4 Health, public health		Life expectancy at birth	Access to safe drinking water
		Infant mortality rate	
1.5 Culture			
1.6 Consumption and production patterns	Annual energy consumption	Main telephone lines per 100 inhabitants (3.4)	
	Number of passenger cars per 100 inhabitants	Distribution of food consumption per domicile	
1.7 Information, communication			
2. TERRITORY AND HUMAN SETTLEMENTS			
2.1 Habitat and urban systems	Rate of growth of urban population	Per cent of population in urban areas	
	Loss of arable land caused by the urbanization	Floor area per person	
2.2 Rural and dry areas, mountains and hinterland	Population change in mountain areas		Existence of programme concerning the less favoured rural zones
2.3 Littoral and "littoralization"	Artificialized coast line/total coast line	Population growth in coastal areas	Protected coastal area
	Number of tourists per km of coastline (4.4)	Population density on the littoral (4.4)	
	Number of moorings	Coastline erosion	
3. ECONOMIC ACTIVITIES AND SUSTAINABILITY			
3.1 Global economy	Distribution of GDP (Agriculture, Industry, Services, Tourism (4.4))	External debt/GDP	Environmental protection expenditures as a per cent GDP
	Direct investment from abroad	Saving/investment	Number of employment linked to the environment

	Pressure	State	Response
		Public deficit/GDP	
		Deficit of current payments/GDP	
		Employment distribution per sector	
3.2 Agriculture	Use of fertilizers per hectare of arable land (4.3)	Arable land per capita	
	Irrigation in percentage of arable land	Ratio of agricultural food dependence	
	Agricultural water demand per irrigated area	Average efficiency of wheat production	
3.3 Fisheries, aquaculture	Average prices of catches at constant prices per main species group	Fishing production per mode and per main species group	Spending allocated to stocks monitoring
	Production of aquaculture		
3.4 Mines industry	Industrial releases into water	Intensity of material use	Share of treated industrial waste
			Number of mines and
		quarries rehabilitated	
after exploitation			
3.5 Services and commerce		Turnover distribution of commerce according to the number of employees	Share of merchant services to the enterprises
3.6 Energy	Energy intensity		Share of consumption of renewable energy resources
	Energy balance		
3.7 Domestic and international transports	Average annual distance covered per passenger car	Structure of transport by mode	Share of collective transport
		Density of the road network	
3.8 Tourism	Number of nights per inhabitant (total and maximum)	Tourism receipts/ total exports	Share of tourism receipts in the export sector (net)
	Secondary homes (%)		Balance of currencies
	Number of bed places per accommodation mode and inhabitant		Public finances allocated to the conservation of tourism sites and diversification
	Public finances allocated to the tourism development		
4. ENVIRONMENT			
4.1 Freshwater and waste water	Annual withdrawal of ground and surface waters	Share of distributed water not conforming to quality standards	
	Non-sustainable water production index: share of total water withdrawals produced from fossil aquifers	Water quality indicator	Industrial wastewater treatment

Table 3.3. *(continued)*

	Pressure	State	Response
			Irrigation efficiency
			Drinking water demand efficiency
			Existence of economic tools to recover water costs in various sectors
4.2 Sea	Oil tanker traffic	Global quality of coastal water	Protection of specific ecosystems
		Density of solid waste disposed in the sea	Rate of monitoring
		Quality of the coastal area and main hot spots	Wastewater treatment rate before sea release for agglomerations with more than 100,000 inhabitants
4.3 Soil, vegetation and desertification	Ratio of land exploitation	Land-use change	
		Losses of arable land as percentage of the total	
4.4 Forests	Wood harvesting intensity	Forest area change	Protected forest area as percentage of total forest area
4.5 Biological diversity, ecosystems	Wetland area	Threatened species as a percentage of total native species	Protected area as a percentage of total area
	Number of marine turtles caught		
	% of fishing boats using barge		
4.6 Solid, industrial and hazardous wastes	Generation of municipal solid waste	Area of land contaminated by hazardous wastes	Destination of MSW including: waste recycling and reuse and proportion of MSW treated in sanitary field
	Generation of hazardous waste	Distribution of waste	Collection of MSW (by volume)
	Import and export of hazardous wastes		
	Generation of industrial solid waste		
4.7 Air quality	Emission of greenhouse gasses	Frequency of excess over air standard (ozone)	Proportion of clean fuels in total fuel consumption
	Emission of sulphur oxides		Share of agglomeration with more than 100,000 inhabitants with air pollution monitoring network
	Emission of nitrogen oxides		
	Consumption of ozone depleting substances		
4.8 Natural and technological risks	Number of enterprises with high risk	Economic impact	Existence of intervention plan
		Burnt forest area	

	Pressure	State	Response
5. THE SUSTAINABLE DEVELOPMENT: ACTORS AND POLICIES			
5.1 Actors of sustainable development		Potential scientists and engineers per million of population	
5.2 Policies and strategies for sustainable development			
6. EXCHANGES AND COOPERATION IN THE MEDITERRANEAN			
6.1 International trade, free trade zone and environment	Sum of exports and imports as a percentage of GDP		
6.2 Other Mediterranean exchanges	Net migration rate		
6.3 Mediterranean cooperation in the fields of environment and sustainable development			Financial transfers received from abroad (public aid and private transfers)

3.3. Relevant issues of environmental economics

3.3.1. What is conventional economics?

The subject of conventional (traditional) *economics* is concerned with the study of how to use available *factors of production* as efficiently as possible in order to attain the maximum fulfilment of society's unlimited demand for goods and services.

Here *factors of production* are natural resources, labour and capital that are used by firms to produce goods or services. These three categories—natural resources, labour and capital—are collectively also called *factor inputs.*

Factors of production can be combined together in different proportions to produce a given economic good or service. For example, while the production of a certain good may require a large investment of capital but a small work force (labour) and little natural resources, the production of another may require a smaller investment of capital but a large work force as well as a large amount of natural resources. Usually a firm will select that combination of factors of production which will minimize the production cost of the output (goods or services) in question.

Fundamentally conventional economics is concerned with the two sectors—"production" and "consumption". And exchanges (buying and selling) of goods, services and factors of production take place between these two sectors.

3.3.2. "Needs" and "wants"

In conventional economics, and to a lesser extent in environmental economics, it is necessary to distinguish between our "needs" and "wants". You *need* to eat a certain amount of nutritious food each day to live. However, if you can afford it, you may *want* (but you do not need) to eat caviar, *paté de fois gras* and other expensive foods each day.

Similarly, you *need* a decent accommodation in which to live, but you may *want* (but certainly you do not need) a palace to do so.

Thus our needs refer to the basic material resources (food, shelter, air, etc.) which we must have for maintaining our physical being. Need conveys the sense of a certain limit or a maximum. For example, a normal person could not possibly consume an unlimited amount of food each day. His or her "limit" would be within 1 to 2 kg per day depending on size and metabolism. "Want", on the other hand, is our desire for material possessions in excess of our "needs". Want is open-ended—without limit—and is often driven by greed. Just ask yourself why you want to replace your current Ford motor car, which is giving you perfectly good service, with a new BMW car; or why someone, who now has an old but fully functional BMW car, would like to replace it with a new Porsche car. Want is probably a feature of human nature itself. We all want a better future for ourselves and for our children; also most, if not all, of us want better and more material resources that make life more comfortable.

In general, it is difficult to fix the level of the need of a person or a family for material things. How could you tell a family (except in a national emergency such as war) that its monthly consumption must not exceed a certain specified level? The problem here is that such a level can only be stipulated on the basis of a value judgement on the aspirations of the person or the family in question, as well as a judgement on the amount they ought to consume based on some artificial criteria. But this is anathema to policy-makers in democratic societies, and to do so would be to intrude into sensitive ethical territory concerned with human rights.

It is for this reason that conventional economics is based on people's wants rather than needs. It is assumed that if people's consumption of food, clothes, entertainment, etc. falls short of what is required to give them complete satisfaction, they will demand greater consumption, and this in turn would generate greater economic activity to satisfy that demand. Indeed, continually growing consumption (and therefore production), as measured by the gross domestic product (GDP), is the key to the successful functioning of the economic growth model on which practically all the economies of the world are based. Continually growing consumption reflects the open-ended nature of our "want" referred to above.

3.3.3. What is environmental economics?

Conventional economics is concerned with the production and consumption of traditional economic goods like motor cars, television sets, cosmetics, etc. Such goods are called *market goods* because there is a well-defined market for them, characterized by supply and demand, where they could be bought and sold. Environmental economics, on the other hand, is concerned with *non-market* goods like clean air, scenic beauty, a noise-free environment, etc. for which there is no well-defined market where they could be bought or sold like motor cars or television sets.

Note that in conventional economics a *market* is defined as an arrangement which links buyers to the sellers. Historically markets have been physical places where buyers and sellers meet to buy or sell goods or services. But, because of developments in electronic communication, a market does not have to be a physical place any more. Today it can be the telephone or even the cyberspace or e-commerce.

It is pointed out that environmental economics uses the same microeconomic and macro-economic tools as in the other branches of economics. But in environmental economics these tools are applied in a unique context to address issues which do not arise in the other branches of economics. Take the case of air quality for example. In order to ensure increasingly greater production it is necessary to burn fossil fuels, and, as a result, the atmosphere is polluted. Therefore, there has to be a trade-off between air quality on one hand, and the need to burn fossil fuels for greater production on the other. An environmental economist will apply the tools of conventional economics to study this problem, but the context here is the atmosphere which is unique. This uniqueness does not occur in conventional economics. In the production of motor cars, for example, the context is not unique in the sense that it depends on technology, fashion, supply, demand, etc. that vary with time as well as place.

Here *microeconomics* means that branch of economics which is concerned with the study of the behaviour of individual firms and consumers. The purpose of microeconomic analysis is twofold: to investigate how to allocate scarce economic resources between alternatives; and to identify the strategic elements which determine the optimally efficient use of resources. For example, if as an economist you are studying the market for ladies: perfumes, then you would be performing a *microeconomic* activity. In this activity you will be involved in studying the purchasing behaviour of women who buy perfumes, the firms that produce and sell perfumes, and any other group (such as government) whose policies, activities or behaviour can affect the price and/or availability of perfumes.

Macroeconomics, on the other hand, is that branch of economics which is concerned with the study of aggregate economic activity—the overall economic activity of an entire country for example. The purpose of macroeconomic analysis is also twofold: to investigate how the economy *as a whole* works; and to identify the strategic elements which determine the levels of national income and output, employment and prices. The government of a country, which monitors the entire economy of that country to determine how it is performing with regard to unemployment, trade, government policy, etc., is actually performing a *macroeconomic* activity.

3.3.4. Major differences between conventional and environmental economics

Whereas both conventional and environmental economics are concerned with social welfare and quality of life in the widest sense, environmental economics is concerned primarily with the three environmental compartments—air, water and soil—and with the economic activities which affect them. The major differences between conventional and environmental economics are described below.

(a) *Market and non-market goods:* applied conventional economics is concerned with *market* goods such as motor cars, television sets, wheat, apples, etc. for which there is a well-defined market characterized by supply and demand which control their prices. For example, if you want to buy a motor car, then, depending on the amount of money you are prepared to pay and the type of car you want, you will normally have a choice of sellers from whom to buy.

Environmental economics, on the other hand, deals with *non-market* goods such as clean air, scenic beauty, etc. for which there is often no well-defined market like that for motor cars for example. You cannot buy a kilo of scenic beauty or clean air from a shop. Strictly speaking, there are no buyers or sellers. Most of the non-market environmental goods are nature's blessings vital to our survival.

(b) *Ownership:* after you have bought your motor car, you will look after it because you know it *belongs* to you. In other words, your car, and indeed all other market goods, are *private goods* that belong to their purchasers. This is a fundamental aspect of conventional economics.

On the other hand, an environmental good such as air for example, is vital to all of us and yet it belongs to no one in the sense of a private good like a motor car. It is actually a *public good* without which we cannot live. But, because a public good has no specific owner, we do not feel the same urge to look after it as a private good (motor car for example), even when our very survival may depend on its integrity. This is a very important aspect of environmental economics.

(c) *Economic externality:* what is called *economic externality* (or simply *externality*) is an important concept in both environmental and conventional economics. We will explain the concept here by means of the following examples:

Imagine that you buy a bar of chocolate and enjoy the pleasure (utility) of eating (consuming) it, and that I do the same. In this case my eating of the chocolate does not in any way interfere with the pleasure you get by eating your chocolate. In other words, your *utility* is not affected by my *consumption*, and *vice versa.*

Now imagine that I build a dirty and noisy factory next to your house which makes a certain product, and it is a very profitable business for me. It greatly improves my standard of living which I enjoy very much, and it enables me to live in a large new house in a clean area of the city. But the dirt and the noise of the factory make your life miserable. In this case, unlike in the case of the chocolate, my consumption has an effect on your utility (enjoyment). This environmental impact (in this case caused by noise and dirt) is called the *externality* of my consumption on your utility.

Practically all socio-economic activities, especially in the highly industrialized societies, have externalities which degrade the natural environment (air, water and soil) by creating environmental impacts. For example, the use of inputs (synthetic fertilizers and pesticides) in agriculture increases farm production, and the farmers benefit as a result. But the inputs also pollute both surface and ground waters. Thus, while the farmers make greater profit, the natural environment loses out by being degraded, and this diminishes the quality of life of many people including the farming communities themselves. In this case loss of water quality is the externality of input application.

(d) *The temporal dimension:* time often plays a crucial and even defining role in environmental economics in a way it does not in conventional economics.

Consider conventional economics first. Imagine that you make motor cars. You can make 100 motor cars today, just as you could make 100 similar or even better cars in 10 years' time. This is because existing or improved technology, as well as the *factors of production* (natural resources, labour and capital) for making motor cars would still be available in 10 years' time. Even if a certain natural resource (copper for example) became unavailable, you could still make motor cars with an alternative material.

Now consider a typical environmental good such as biodiversity for which there is no well-defined market. If we continue to destroy earth's biodiversity at the present rate, then some of the living plants and animals of today will become extinct in 10 years' time, and this could be disastrous both for the present generation and especially for future generations. There are two main reasons for this: first, biodiversity is linked to nature's life-support systems in ways that are not yet fully understood, but its importance to the integrity of the life-sustaining natural environment is not in dispute. Thus our very survival in the long-term may be put at risk if we continue to destroy biodiversity. And second, such a loss would be irreversible because it is not possible to recreate biodiversity in the way nature intended it.

3.3.5. Earth's life-support systems and our attitudes to the environment

Earth's natural environment, only within which life exists in an amazing multitude of forms, is actually a very thin "skin" of the earth. Above the earth's surface it extends to a height of 10-12 km containing the troposphere within which what we call the "weather" is made and all climatic activities take place. Below the earth's surface it extends less than 10 km. Thus the total thickness of the skin is not more than 22 km.

Clearly, the skin is very thin indeed compared to earth's diameter which is nearly 13,000 km. Yet this very thin skin contains all the life-support systems including forests, breathable air, oceans, biodiversity, rivers, fertile soil, etc. that make life on earth possible.

Our generation is the first to have seen the earth from outer space, and how fragile and vulnerable it looks. In the cosmic scale the earth is *less than insignificant* when we consider that it is only one of the planets of an insignificant star called the Sun which is situated in a minor galaxy called the Milky Way; that there are billions and billions of galaxies in the universe according to astronomers, each with billions and billions of stars; and that light from many of the distant stars and galaxies, travelling with a velocity of 300,000 km per second, has not reached us yet. And yet, we have been and are continuing to inflict serious and often irreversible damage to earth's thin and vulnerable "skin" in our headlong and often mindless drive for perceived economic development. In the process we are degrading and even destroying the very life-support systems and resources on which our long-term survival depends.

How we treat the natural environment is fundamentally a question of our attitude to it. Three points are worthy of note in the wider context of our attitude to the natural environment and how we relate to it. First, nearly all natural life-support systems are delicately balanced; therefore, any human activity which disturbs this balance may lead to unpredictable consequences. They are also inter-connected as an "organic whole" in the sense that impact on an individual aspect will in time affect the totality of which that aspect is a part.

Second, although the impact of human activities on the environment may begin and proceed imperceptibly, the final outcome is often irreversible and can be catastrophic. The ozone hole is a typical example of this. Before its discovery in 1985 by Professor Farman and his co-workers, little was known or noticed about stratospheric ozone depletion by chloroflurocarbons (CFCs). But when it was discovered, it was too late in the sense that nothing could be done to repair the damage already done. Indeed, such behaviour (imperceptible to sudden catastrophe) is characteristic of highly-connected and complex systems, as may be demonstrated mathematically by considering non-linear hydrodynamic or elastic systems for example.

The third point is concerned with the human condition itself, namely our inability to predict the future outcomes of present actions in any detail. What appears to be a good thing to do today turns out not to have been a good idea at some time in the future. Widespread application of DDT (dichlordiphenyltrichloroethane) to control malaria, harvesting of tropical rain forests for economic development, use of synthetic neurotoxins as pesticide and insecticide, and the use of CFCs as coolants and aerosols are among many, many examples that could be cited to support this argument. Indeed, to date a great deal of the environmental damage has been caused by our inability to predict the future outcomes of present actions. This inability, born of the human condition itself, is conveyed succinctly by Heisenberg's uncertainty principle in quantum mechanics: *"we cannot know the present in any detail"*. Given that tomorrow is today's future (today is the present), and that our prediction of future events is based largely on the extrapolation of present events into the future (that is, predicting tomorrow on the basis of today), how could we then know the future in any detail since we do not know the present (today) in any detail?

3.3.6. Sustainable development and environmental economics

Sustainable development

Ever since the industrial revolution and probably before it, all kinds of human activities have degraded, and are continuing to degrade, the natural environment at an increasing pace. Indeed, it is difficult to find a single human activity (including human reproduction) aiming at economic development which is, or has been, beneficial or even benign to the natural environment. Adverse impacts of human activities on the environment are increasing relentlessly, and projections indicate that if present trends continue, future generations would inherit a world of polluted air, water and soil, and of depleted natural resources, which may not be able to meet their needs or aspirations for an acceptable quality of life.

Alarmed by such a prospect, in December 1983 a special and independent commission was established by the Secretary-General of the United Nations to address this major challenge to the world community. Called the World Commission on Environment and Development and chaired by Dr. Gro Harlem Brundtland (former Prime Minister of Norway), in 1987 it produced its report entitled *Our Common Future* after extensive consultations with people in all walks of life, as well as experts, from many countries of the world.

The central message of *Our Common Future* is that sustainable development is the only means which has the potential for securing an acceptable quality of life for both present and future generations. And, therefore, effective policies for its realization should be implemented as a matter of priority worldwide. It defines sustainable development as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"* (*Our Common Future,* p. 8).

The United Nations Conference on Environment and Development (UNCED), held in Rio de Janeiro in 1992, acted as a catalyst to focus the attention of the international community on sustainable development as the only viable modality for long-term economic development. Agenda 21, which is a major agreement to emerge from UNCED, forms the general guiding document for pursuing sustainable development and initiates significant institutional changes. It is an immense document of 40 chapters outlining an *action plan* for sustainable development, covering a wide range of specific natural resources and the role of different groups, as well as issues of social and economic development and implementation. The importance of sustainable development can also be seen from the fact that it is enshrined in the Treaty of the European Union of 1992, popularly known as the Maastricht Treaty. In article 2 of the Treaty environmental protection is given the same importance as *all* economic concerns for promoting *"sustainable and non-inflationary growth in respect of the environment"*.

It is to be noted, however, that *Our Common Future* is essentially a political document, and that the above definition of sustainable development is a political definition, which is proving to be very difficult to translate into an operational definition. In fact, at present there is no unique operational definition of sustainable development. And this is making its implementation difficult in terms of uniformity of actions to be taken for achieving sustainability and especially in terms of measuring the progress (or otherwise) achieved by those actions with a common and internationally accepted "yardstick" (such as GDP in economics).

Progress towards sustainability is also thwarted by the apparent impossibility of satisfying some of the key conditions for achieving global sustainable development, conditions that are variously social, political and economic. Consider the following two conditions among several that must be satisfied. *First, people in the rich northern countries must accept a more modest and less polluting life-style.* Considering that people generally think of a "more modest life-style" in terms of a lower or reduced standard of living, and given that no election in democratic societies could possibly be won on a platform of reduced standard of living, it is difficult to see how this key condition could ever be satisfied. And second, *there should be a massive net transfer of funds from the rich North to the poor South.* Considering that in the decade ending in 1992 there was a net transfer of 1.3 trillion United States dollars from the poor south to the rich north through the World Bank alone, and given the current international financial architecture and aid and trade relations in particular that are skewed in favour of the rich north, one has to be a pathological optimist to believe that this condition could be satisfied even in the long-term.

Thus the problem at hand is clear. We know that the end result to be achieved is sustainable development, and that progress towards it must be made as rapidly as possible in order at least to arrest the accelerating degradation of the natural environment before it is too late. But we only have a limited idea of the means to be adopted for its achievement (at present we do not even have a unique operational definition of sustainable development). Also, some of the key conditions for its achievement are practically impossible to satisfy, and, perhaps more importantly, at present there appears to be little political will for even attempting to satisfy those conditions.

Role of economics in sustainable development

The international consensus on sustainable development, which emerged especially after the UNCED conference in Rio de Janeiro, firmly established sustainable development as a legitimate *genre* in environmental economics. And this resulted in a flood of books and papers which still continues unabated. It appears, however, that we have reached a kind of *impasse* with regard to sustainable development in the context of conventional economics, as will be gathered from the following.

As pointed out above, practically all the macroeconomies of the world today are based on the economic growth model, which works *only* if the macroeconomy continues to grow. In other words, there must be increasingly greater production and consumption of goods and services over time. This means that each year the GDP of a macroeconomy must be greater than in the preceding year. To put the implication of this in perspective, consider the fact that the world's industrial production has grown by a factor of more than 50 over the past century, and that 80 per cent of this growth has taken place since 1950 (page 4, *Our Common Future*).

But increasingly greater production and consumption—in line with the open-ended nature of conventional economics to satisfy our "wants" rather than our "needs"—means increasingly greater consumption of natural resources and energy, as well as generating increasingly greater amounts of wastes to be disposed of. But sustainable development demands reduced or reducing consumption of natural resources and energy in line with a more modest and less polluting life-style. Also, note that the definition of sustainable development, as given in *Our Common Future*, refers to human "needs" and not our "wants" (see section 3.3.2 above).

Thus, clearly the requirements of sustainable development are diametrically opposed to those of conventional economics. They are also opposed to the requirements of environmental economics, because environmental economics operates within the general framework of conventional economics and not outside it.

It follows therefore that, in order for sustainable development to succeed as intended by the authors of *Our Common Future*, the conventional economic framework must be replaced by a new framework whose requirements accord with, or are at least in sympathy with, those of sustainable development. But this is not possible for several reasons, notably the following: first, the origins of conventional economics can be traced back to the ancient times, certainly to the time of Alexander the Great and probably earlier. The Phoenician, Venetian, Chinese, Indian and other traders of the old world operated within a rudimentary economic system, often based on barter, which was akin to what is now called conventional economics. Its modalities resonate with man's innate desire to make profit from his endeavours for a better living for himself and his family, as well as for improved social status. In doing so, or wanting to do so, one is only following human nature itself so to speak. And second, although several attempts have already been made to develop new economic models which, it is claimed, accord with the core requirements of sustainable development, in general they are fraught with questions and problems that are difficult to resolve. In any case, even if a perfectly sustainable economic framework could be developed tomorrow by magic or otherwise, it is difficult to see how it could be field-tested or substituted internationally for the existing and pervasive conventional economic framework—with the rapidly inter-locking and inter-dependent macroeconomies of today—which is driven by the profit motive as well as greed, the latter said to be a Darwinian condition for survival that goes back to our primeval roots.

Thus we are stuck, as it would appear, with an economic framework whose requirements are diametrically opposed to those of sustainable development and which cannot be replaced at least in the foreseeable future. It is for these reasons that attempts are now being made to change some of the modalities of conventional economics, and/or to innovate new modalities, so that they would accord however modestly with the requirements of sustainable development as intended in *Our Common Future.* And environmental economics is largely concerned with those changes and innovations. The *tradable emissions permit* in the United States, which is a market instrument intended for controlling industrial emissions to the atmosphere, is a typical example of such an innovation. These are permits which legally allow the polluters to pollute for a price, and there is now a well-defined market in which such permits can be bought and sold. But critics argue that they are really permits to pollute the atmosphere which compound the problem and contribute little or nothing to sustainable development.

Notwithstanding these changes and innovations, the basic operating modalities of the prevailing conventional economic framework still remain the same, namely increasingly greater production and consumption without which the economic growth model cannot work. Therefore, the best that could be hoped for under these circumstances is improvements at the margins that could bring about a limited degree of sustainability.

Weak and strong sustainability

With regard to the definition of sustainable development given in *Our Common Future,* which we have quoted earlier, the central and fundamental question is this: *how do we compensate the future for the damage caused by our present activities?* According to economists the answer to this question is through the transfer of "capital bequests". What this means is that the present generation makes sure that it leaves for the next generation a stock of capital which is not less than what is available at present. In this context "capital" is the resource base that provides the capacity to generate well-being by creating the necessary goods and services.

In the definition of "capital" here the environmental stock is not considered separately or in a special way. Instead, it is considered simply as another form of capital. Therefore, this interpretation of sustainable development, called *weak sustainability,* requires that an aggregate of all capital stocks (including environmental stock) be transferred to the next generation, subject to the condition that the total stock transferred is not less than that which is available to the present generation. This means that, for example, we may pass on less of the environmental capital (biodiversity, rainforest, etc.) and more of man-made capital (roads, buildings, etc.), and *vice versa,* as long as the total (aggregate) capital transferred to the next generation is not less than that of the present generation.

Clearly, this interpretation assumes that there is *perfect substitutability* between environmental capital and man-made capital. For example, it assumes that loss of biodiversity can be substituted for by building more roads, bridges, etc. But the deficiency of the argument is that, while man-made stocks can be built now just as they could be built by the next generation, lost biodiversity cannot be re-created in the way nature intended it. This lies at the heart of what is called *strong sustainability.* It acknowledges that there cannot be perfect substitutionability between environmental and man-made capitals except in a very limited sense. Strong sustainability thus makes a fundamental distinction between environmental capital which provides our life-support systems and are essential to our survival on the one hand, and man-made capital on the other.

Test for sustainability

As we have already pointed out above, as yet there is no unique operational definition of sustainable development or of sustainability for that matter. Recognizing this, chapter 28 or Agenda 21, called *local Agenda 21*, urges municipalities and local authorities everywhere to identify their local unsustainable activities and patterns of development and to develop and implement policies that would make them sustainable. The logic is that, if all the local authorities of a given country do so, then in time that country may be said to have achieved (at least a degree of) sustainability. And, if all the local authorities of all the countries of the world do so, then in time the whole world may be said to have achieved (at least a degree of) sustainability. This is what is meant by the Rio slogan, "act locally and think globally".

Thus, the strategy for implementing local sustainable development in accordance with local Agenda 21 is as follows: the local authority in question carries out an extensive study, with public consultation and/or participation, of all its activities and practices in order to identify those activities and practices that are not sustainable over time. A priority list of its unsustainable activities and practices to be dealt with is then drawn up based on affordability, feasibility, cost-benefit analysis as well as social and political acceptability. Targeted policies are then developed and implemented in order to make the identified priority activities and practices sustainable.

It is then necessary to monitor the implemented policy (or policies) in order to determine whether, or the extent to which, it is bringing about sustainability in the activities and practices that have so far been unsustainable. The task here is to test whether the implemented policies are working or not as intended. The test is carried out by using a "yardstick" which measures whether a given target problem (unsustainable activity or practice) is improving or deteriorating over time under the implemented policy or policies.

The "yardstick" used in practice is called the "indicator of sustainability". Depending on the nature and complexity of a given target problem to be addressed, it may be necessary to develop and use one or more indicators of sustainability for it. The example given below is instructive:

> Suppose that in a given local authority there are at present too many households without piped drinking water supply and that the situation is becoming worse (unsustainable) over time. The authority intends to improve the situation as a matter of priority. In this case the target problem is the supply of piped drinking water to households. In order to make this problem sustainable, suppose that the authority implements a policy whereby greater resources are made available for connecting households to piped drinking water supply. Clearly, the local authority would like to know whether or not the implemented policy is making the target problem sustainable over time as intended. But how?

In order to answer the above question, the local authority must develop one or more "indicators of sustainability" with which progress (or otherwise) towards sustainability could be measured objectively.

For example, it could define an "indicator of sustainability", I, for this specific target problem as follows:

$$I = N_1/N_2$$

in which N_1 is the number of households within the jurisdiction of the local authority connected to piped drinking water supply; and N_2 is the total number of households within the jurisdiction of the local authority.

Now, suppose that after the implementation of the policy in 1995 the situation changes as shown below in table 3.4.

Table 3.4. Changes in the value of the indicator of sustainability (I)

Year	*Value of I*
1991	0.66
1992	0.63
1993	0.61
1994	0.56
1995	0.51
1996	0.52
1997	0.57
1998	0.62

Clearly, the proportion of households under the jurisdiction of the local authority connected to piped drinking water supply has increased following the implementation of the policy in 1995 (although the rate of progress may not be considered rapid enough). In this situation the target problem would be said to be becoming "sustainable" because the intensity of the target problem is reducing over time. The ideal value of I is 1.00, which indicates that all the households under the jurisdiction of the local authority are connected to piped drinking water supply; this situation would represent perfect sustainability.

If, on the other hand, the value of I continued to decrease over time from 1995, then this would indicate that the target problem is becoming unsustainable (deteriorating) over time, and this would call for a review and revision of the implemented policy.

It is clear that I, which is the indicator of sustainability for this particular target problem, is really a measuring device (yardstick) which is used to determine whether or not progress is being made towards sustainability following the implementation of a policy (or policies) intended to address the target problem.

3.3.7. Environmental economics in the context of ICZM

As we have already pointed out in section 3.3.3 above, environmental economics operates within the general framework of conventional free-market economics and not outside it. Consequently, all the issues and problems of integrated coastal zone management (ICZM) also lie within the confines of the conventional free-market economic system. The implications of this are twofold: first, the concepts, definitions, instruments etc. of free-market economics also apply to ICZM; and secondly, valuation of non-market goods in ICZM, such as the natural beauty of a coast line, water quality, beach quality etc. relies on the methods of CVM, HPA, TCM etc. (described in section 3.5.8) that belong to both conventional and environmental economics.

In a *market economy* (also called *capitalist economy, free enterprise economy* or *laissez-faire economy)* a society attempts to deal with its economic problems by allowing a free play of what are called *market forces* (for example, the "forces" of supply and demand). In theory the State plays little or no part in the activities of such an economy, but it does so in practice by imposing taxes to control prices for example. To this extent such an economy is not really "free". However, the primary role of the State in a market economy is twofold: to create an economic environment that is conducive to the free play of the market forces; and to ensure that effective measures and structures are in place to curb the worst excesses of these forces so that they do not harm society and/or the natural environment.

3.4. Some basic concepts of conventional economics

In this section some basic concepts that are common to both conventional and environmental economics are discussed.

3.4.1. "Utility" and "marginal utility"

In economics, *utility* is defined as the *satisfaction obtained from the consumption of a good or a service in a particular time period.* You buy a good (such as a motor car or a suit), or a service (a foreign holiday for example), because its consumption (or use) gives you satisfaction (pleasure). In theory the more you buy and consume, the greater is your satisfaction. But for most goods and services there is a cut-off point beyond which additional consumption ceases to give additional satisfaction. These concepts are explained by means of the following example.

Imagine that you like eating (consuming) chocolate very much. So you buy a bar of chocolate and eat it, and, by doing so, you get satisfaction (utility). But this utility of consumption is difficult to measure quantitatively because satisfaction or pleasure is subjective and there is no scale or unit with which to measure it (as 100 g of satisfaction for example). Nevertheless and for the sake of argument, let us say that the utility of your consumption of the bar of chocolate is equal to 100 units. Soon after eating it, you buy a second identical bar of chocolate and eat it. It is almost certain that the *additional* utility you derive from the second bar will be less than that of the first bar. Let us assume that the additional utility of this bar is 85 units. Then you buy a third identical bar and eat it. The additional utility of this bar will be even smaller. If you go on eating like this in a given time period, there will be a cut-off point beyond which the consumption of an additional bar of chocolate will not give you any additional utility at all. In fact, it may give you *negative* additional utility in the sense that any further consumption could make you uncomfortable or even sick.

The additional utility you derive from the consumption of an additional unit of a good or a service (in this case bar of chocolate) in a particular time period is called *marginal utility* of consumption (in economics "marginal" means additional or extra).

The second column of table 3.5 gives the marginal utility of your consumption of chocolate bars. As you will see, the marginal utility of the fifth bar is negative. The third column gives the total (cumulative) utility of consumption. Typically, the total utility of consumption of four bars of chocolate is 275 units.

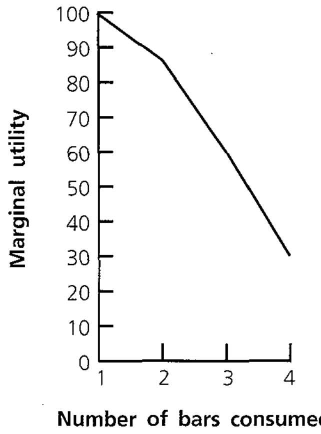
Figure 3.1 shows the marginal utility curve based on the data of table 3.5. Since it is not logical to consume any further when the marginal utility falls below zero, the sub-zero segment of the marginal utility curve is not shown. The marginal utility curve has a negative slope. Because for most goods and services consumers would be willing to pay less for successive units of a good or service as they give decreasing levels of satisfaction. Therefore, consumers would be willing to buy more of a given good or service only if its price is reduced. This phenomenon is called *diminishing marginal utility.*

Table 3.5. Utility of consumption of chocolate bars

Number of bars consumed	*Marginal utility*	*Total utility*
1	100	100
2	85	185
3	60	245
4	30	275
5	−15	260

The marginal utility curve for a good or a service forms the basis of its demand curve. This is because the demand for a good or a service is determined by its marginal utility to the consumer. As a consumer you will demand a good or a service only if in your judgement it has sufficient marginal utility to you so that you would be willing to pay for it.

Figure 3.1. Marginal utility of consumption of chocolate bars (see table 3.5)



As we have already pointed out, utility (satisfaction) is subjective and difficult to measure quantitatively. But in economics it is necessary to express utility quantitatively in terms of money, and in this case it could be done as follows: suppose that you are "dying" to eat chocolate, but the shopkeeper is asking an unreasonably high price for it, say 1,000 units of a certain money for a bar. It now depends on how badly you want the bar—in other words, your willingness to pay for it. If you want it so badly that you are willing to pay the high price of 1,000 units of money for one bar, its *estimated* utility will be 1,000 units of money. But, if the shopkeeper is reasonable, he will sell it to you at its proper price of 100 units, as in table 3.5. In this case your willingness to pay will be 100 units of money, and this would also be the estimated utility of the bar. After you have eaten the first bar, your urge to eat a second bar would be less, and you would be willing to pay less for it, say, 85 units of money. Thus the estimated utility of the second bar would be 85 units of money, and so on.

3.4.2. Demand

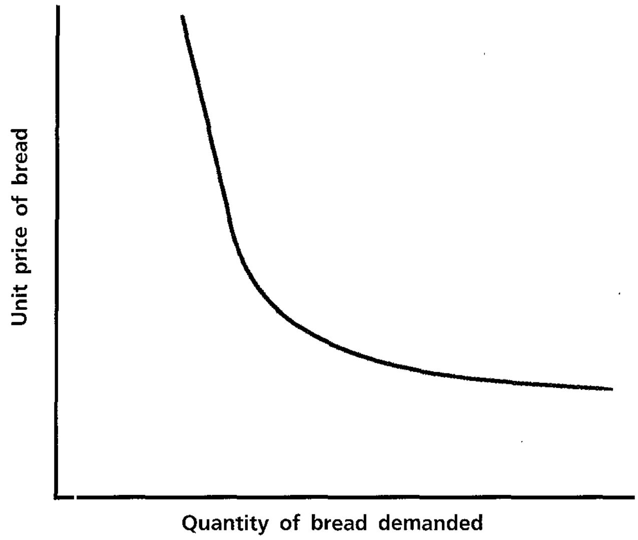
Concept of demand and the demand curve

In economics *demand* is defined as the *quantity of a good or service that will be demanded at any price and in a given time period.*

It is the consumers' demand for a good or a service that determines its price in the market. Note that consumers' mere *want* or *desire* for a good or service will not influence its price, unless their want or desire is backed up by their ability and willingness to pay. Thus, your mere desire to possess a brand new motor car will have no effect on its price if you do not have the money to buy it. If, on the other hand, you are able and willing to pay not more than $9,500 for a car whose price is $10,000, for example, the seller might be persuaded to reduce the selling price to $9,500. In this case you have a *demand,* because your desire for the car is backed up by your ability and willingness to pay. And it is the influence of your demand that could bring down the price to $9,500.

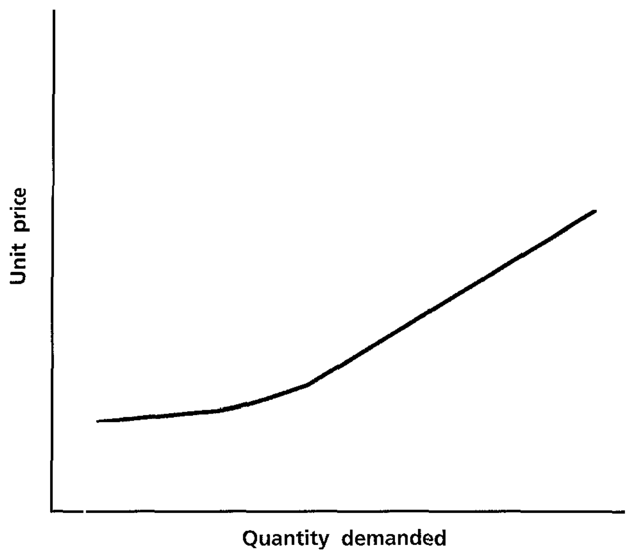
For most goods and services price is inversely related to demand—higher the price smaller the quantity demanded and *vice versa.* Figure 3.2 shows a typical demand curve which is for bread. It shows how the quantity of bread demanded changes with price, assuming that the other relevant factors remain unchanged. Figure 3.2 also shows that when the price of bread is very high, there is little demand for it. On the other hand, if the price is very low, demand is high but limited (because you cannot consume an unlimited quantity of bread).

Figure 3.2. A typical demand curve (for bread)



There are, however, exceptional goods and services whose demand is *directly* related to price, not inversely. This means that the quantity demanded increases with rising price, as in figure 3.3. High fashion and luxury goods belong to this category.

Figure 3.3. A typical exceptional demand curve



Consider, for example, designer fashion clothes. You can easily find and buy a perfectly satisfactory suit for $200 or less. But, if you are willing and able to pay, and if you are highly fashion conscious, you would probably buy a similar suit for $500 or more simply because it is made by a well-known fashion house such as that of *Armani* or *Gucci* and bears its "designer" label. Consumers who are able to pay would be willing to buy such goods (and services) simply because they are expensive, have a well-recognized designer label as well as "snob" appeal. The extra satisfaction consumers get from such goods or services, for which they are willing to pay a good deal more than necessary, derives from the perception that the consumption of such goods or services would enhance their personal status and/or social standing among their friends, colleagues and others.

Buying a very expensive motor car, a *Rolls Royce* for example, also serves the same purpose. For the sake of argument, if the price of a Rolls Royce motor car falls to the level of an ordinary Ford car for example—and this is extremely unlikely to happen—then owning a Rolls Royce car will become rather mundane and lose its snob appeal. The buyers of Rolls Royce would then switch to other expensive and luxurious cars to display their wealth in pursuit of greater social status.

Consumer surplus

What is called "consumer surplus" occurs when the consumer actually pays less than the amount he or she is willing to pay for a good or a service. The example given below is illustrative:

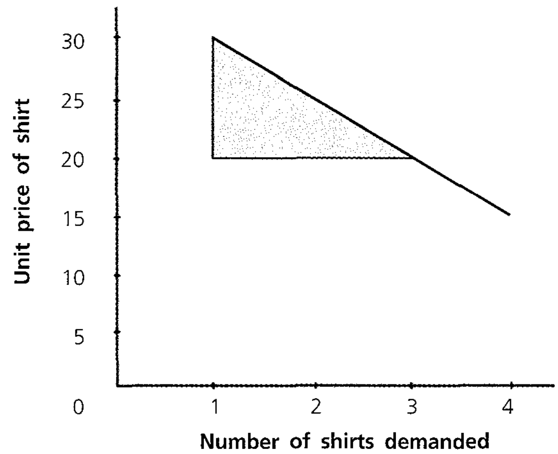
Imagine that you want to buy four shirts and that you are willing to pay $30 for the first shirt, $25 for the second, $20 for the third and $15 for the fourth. Now imagine that the actual price you paid for each shirt was $20. Then your consumer surplus would be as shown in table 3.6. below.

Table 3.6. Calculation of consumer surplus

Shirt number	*Consumer surplus ($)*
1	10
2	5
3	0
4	–5

The consumer surplus for the first shirt is $10 because you actually paid $20 for it instead of $30 that you were willing to pay; and so on. You will probably decide not to buy the fourth shirt because its consumer surplus is negative. Therefore, the total consumer surplus for the three shirts is $15. Your demand curve, based on the above data, is shown in figure 3.4. The shaded part under the demand curve represents consumer surplus.

Figure 3.4. Illustration of consumer surplus



Major factors affecting demand

The major factors which affect the demand for a good or a service are described below.

(a) Real disposable income (RDI). RDI is defined as the amount of current income available to households after paying personal income taxes and national insurance contribution (if any). What is called *purchasing power* is directly related to RDI—higher the RDI, greater the purchasing power. The RDI of the members of a community is the primary factor determining that community's ability and willingness to pay for goods and services. Consequently, RDI is also the primary determinant of the community's demand for goods and services. For example, if the community's RDI is high, it would have a correspondingly high demand for all manner of goods and services. On the other hand, in the case of an impoverished community with a low RDI (and therefore low purchasing power), the level of demand would be correspondingly low due to the unwillingness or inability of its members to pay for goods and services.

(b) Income distribution. Imagine a hypothetical community in which only 5 per cent of the members are very rich while 95 per cent find it hard even to buy bread for their families. In such a community there will be a disproportionately high demand for luxury goods together with a disproportionately low demand for basic necessities like bread, heating, etc. Clearly, demands for luxury goods and basic necessities would change as income distribution becomes more equitable.

(c) Price changes. Imagine that for some reason the price of rice rises steeply. Then the demand for rice would fall and consumers will buy cheaper substitutes such as pasta instead of rice; as a result demand for pasta would increase. This is a typical example of how price changes affect demand.

Demand for a good is also affected when there is a change in the price of another good that is *jointly demanded* with it. Motor cars and petrol provide a typical example of two different goods that are jointly demanded; you will not demand petrol if you do not have a motor car. If the price of motor cars rises steeply for some reason, demand for cars would fall correspondingly. Consequently, demand for petrol would also fall, as well as its price.

(d) Changes in taste and fashion. Demand for certain goods such as clothes, furniture, etc. and even food changes as both taste and fashion change over time. As an example, currently the demand for denim jeans is said to be declining because increasingly consumers now consider them as being less fashionable than before.

(e) Advances in technology. The market for personal computers provides a very good example of how demand is affected by advances in technology. For example, the demand today for a new 486 machine is small (perhaps negligibly small) compared to that for one with the Pentium chip. This is due entirely to rapid advances now taking place in computer technology.

(f) Advertising. Advertising is a major tool for increasing the demand for goods and services. And so producers and suppliers spend large sums of money on advertising. The purpose of advertising is to entice the consumer to buy the good or service being advertised, and it is done by making a clever presentation of its virtues, why it is important for the consumer to buy it, how its possession could enhance the social status of the consumers or make them more healthy, etc. Indeed, advertising is an indispensable tool especially in highly competitive markets for both positioning a good or a service in the market place as well as for raising its demand.

(g) Availability of credit. In many countries of the world goods and services are often bought on credit—under a "hire-purchase" or "leasing" agreement for example. As a result, demand for a good or a service in those countries is directly related to the availability of credit. A high rate of interest reduces the availability of credit, and thus it discourages consumers from buying goods or services on credit; this is because the

interest to be paid on the borrowed money becomes unacceptably high. As a result there is a fall in demand for goods and services. On the other hand, a low rate of interest increases the availability of credit and stimulates demand.

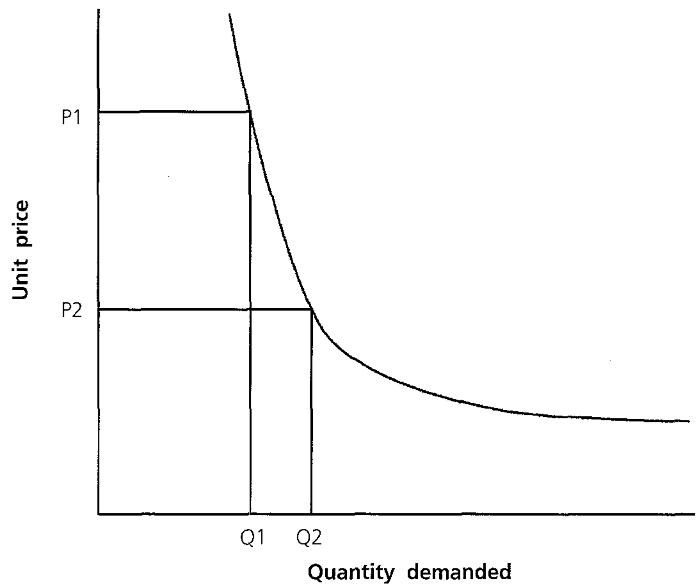
Price-elasticity of demand

The *price-elasticity of demand* for a good or service is defined as the *responsiveness of demand to a change in price.* It shows how, and the extent to which, the demand for the product changes when its price is changed (increased or reduced).

Consider the demand curve of figure 3.5. When the price is P1, the quantity demanded is Q1. But, when the price is reduced to P2, the quantity demanded increases to Q2. The ratio, Q1Q2/P1P2, which is a measure of the responsiveness of demand to a price change, is called the *price-elasticity* of demand. It can also be expressed as:

Price-elasticity of demand =
(percentage change in quantity demanded)/(percentage change in price)

Figure 3.5. Definition of price-elasticity of demand (= Q1Q2/P1P2)



If a price change causes a more than proportionate change in the quantity demanded (that is, if the above ratio is large), the demand is said to be *price-elastic.* And demand is said to be *price-inelastic* if a price change causes a less than proportionate change in the quantity demanded (that is, if the above ratio is small). At the extremes, when the demand curve is a horizontal straight line, demand is said to be *perfectly price-elastic* because the quantity demanded is not affected by price. In this case the above ratio would be infinite. But when the demand curve is a vertical straight line, demand is said to be *perfectly price-inelastic,* meaning that a price change will not cause any change in the quantity demanded. In this case the above ratio would be zero.

Cross-elasticity of demand

Cross-elasticity of demand occurs when a change in the price of good A changes the quantity demanded of good B, where goods A and B are either close *substitutes* of each other or are closely *complementary* to each other. There is no cross-elasticity of demand when A and B are neither close substitutes nor complementary to each other. For example, a change in the price of video cassettes will not affect the demand for eggs because these goods are unrelated to each other.

The concept of cross-elasticity of demand is useful because its enables the assessment of whether two different goods are close substitutes of each other, or are closely complementary to each other. Cross-elasticity of demand (CED) is expressed as:

CED =
(percentage change in quantity demanded of good B)/(percentage price change of good A)

As a typical illustration, consider again the example of rice and pasta (subsection *(c)* above) which are close substitutes of each other. Suppose that the price of rice rises by 10 per cent and that, as a result, the demand for pasta increases by 15 per cent. Then, according to the above equation, CED is 1.5. In this case the CED is positive, as it would be in all cases in which goods A and B are close *substitutes* of each other.

Consider again the example of motor cars and petrol (subsection *(c)* above) which are closely *complementary* to each other and not close substitutes of each other (you cannot use petrol as a substitute for your car). Suppose that the price of motor cars increases by 20 per cent and that, as a result, demand for petrol falls by 10 per cent. Then, according to the above equation, CED = $-10/20 = -0.5$. Note that here, as in all cases of closely complementary goods, CED is negative.

Demand management

Under the free-market system an unregulated economy behaves in a cyclic manner. And what is called the "economic cycle" of a macroeconomy is characterized by a "boom" followed by a "depression" or the opposite. A "boom", which may cause inflation to harm the economy, occurs when the actual GDP is greater than the potential GDP; a boom can also cause what is called the "overheating" of an economy. And a "depression", which can cause loss of output and employment, occurs when the opposite is true. In general, governments intervene to "smooth" the economic cycle as far as possible—so that the adverse impacts of boom and depression are lessened or avoided—by controlling the level of aggregate demand in the economy. And they do so by using monetary and/or fiscal policies.[1] Management of a macroeconomy in this way is called "demand management"; the policies implemented for smoothing the economic cycle are called "stabilization" policies.

In order to lessen the impacts of a boom, or to avoid it, monetary policies are implemented to reduce the level of spending. This is done by raising the rates of interest so that availability of credit is reduced; by increasing the level of tax so that disposable income is reduced; and so on. The remedy for a depression, on the other hand, calls for an increase in money supply to stimulate the economy. This is done by lowering the rate of interest so that availability of credit is increased; reducing tax so that consumers have more disposable income to spend; etc. The aim is to increase the level of economic activity by increasing the level of consumption and therefore of production.

3.4.3. Supply

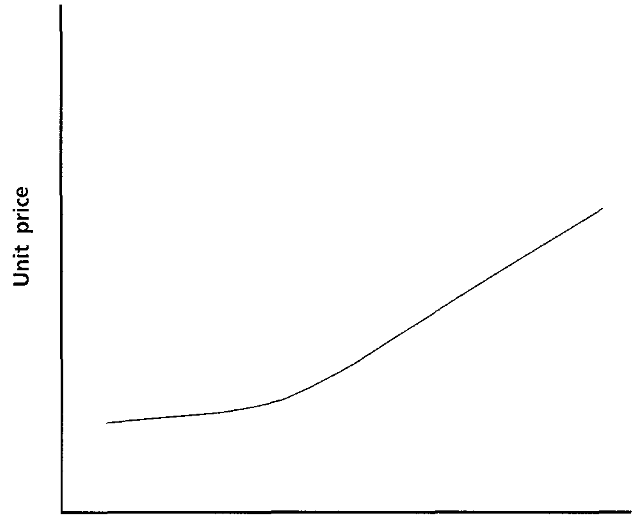
Concept of supply and the supply curve

The concept of supply is probably best understood by looking at it from the viewpoint of the producer or seller. If you are the seller of a certain good, you would be interested

[1]*Monetary* policies are concerned with the regulation of money supply, credit and interest rates in order to control the level of spending in the economy. *Fiscal* policies are concerned with the control of taxation and government expenditure in order to influence the level of economic activity in the economy.

in selling a large quantity of it when the price is high, because by doing so you would make a good profit. Conversely, you would be less interested in selling when the price is low. In fact, you would probably stop selling altogether if the price is too low for you to make any profit. It is because of this reason that generally the supply curve, shown typically in figure 3.6., has a positive slope. The supply curve shows how the quantity of a good or service supplied varies with its price.

Figure 3.6. A typical supply curve



Note that supply is not the same as the stock or quantity of the good available. For example, you may have a stock of 100 television sets to sell. But the actual number of sets you may wish to sell during a given period of time—in other words the quantity you are willing to supply, or the "supply"—will be determined by the market price of the good at the time.

Producer surplus

Producer surplus is the extra earning which the producer receives by supplying a good when its equilibrium market price is higher than the price at which he would be willing to supply.

Consider figure 3.7 in which Pe is the *equilibrium market price*, defined as that price at which the quantity supplied is equal to the quantity demanded. Typically, a producer would be willing to supply quantity OQ at price P1, but the price he actually receives is Pe. And so the producer surplus is P1Pe. The shaded area represents total producer surplus.

Major factors affecting supply

The following are some major factors affecting the supply of a good or a service:

(a) Weather. The supply of agricultural products is seriously affected by adverse weather conditions. Productivity can vary from year to year depending on weather. Poor harvest would shift the supply curve to the left indicating reduced supply (that is, a smaller quantity would be available for supply for the same price);

Tourism and touristic activities are also affected by weather. People go for their summer holiday to destinations where the weather is warm and there is little or no rain, and so on;

(b) Changes in factors prices. The prices of the factors of production (natural resources, labour and capital) are called "factor prices". Supply is sensitive to changes in factor prices. When the factor prices rise, the supply curve shifts to the left, and to the right when they fall. Sometimes it is possible to compensate for factor price rises by increasing productivity. For example, a wage rise of 15 per cent would be completely compensated for by a 15 per cent increase in productivity, if it could be achieved;

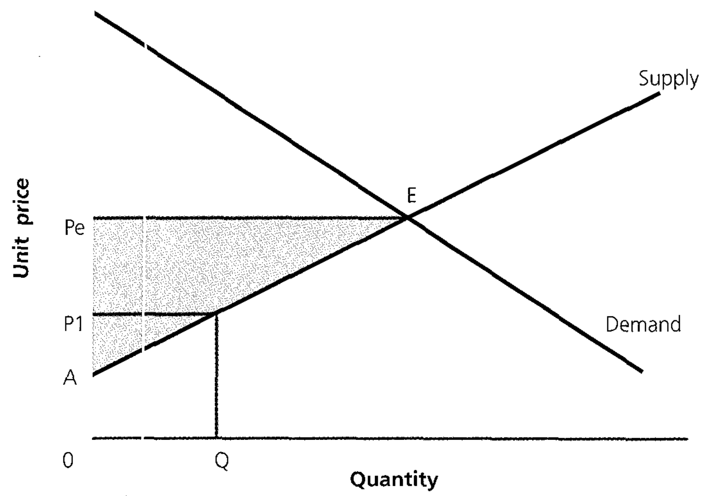
(c) Prices of other goods. If you are producing good A, but find that producing good B would be more profitable to you because of its greater demand and higher price (and profit margin), you may wish to change over to the production of good B. This process would divert factors of production from A to B, and, as a result, the supply curve of A would shift to the left indicating its reduced supply;

(d) Taxes and subsidies. A rise in tax would shift the supply curve to the left, indicating reduced supply, while a subsidy (or a tax incentive) would shift it to the right indicating increased supply;

(e) Advances in technology. Over the last 25 years or so rapid advances in technology—industrial robots, computers, computer controlled machinery, desktop publishing, etc.—have greatly increased the supply of all manner of goods and services;

(f) Natural and man-made disasters. Natural disasters (such as floods and earthquakes) as well as man-made disasters (such as war, riot and terrorism) can shift the supply curve to the left indicating reduced supply.

Figure 3.7. Illustration of producer surplus and market equilibrium price



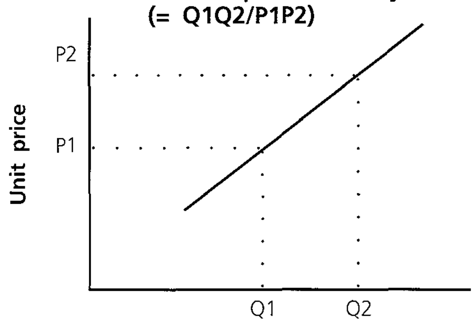
Price-elasticity of supply

Price-elasticity of supply is a measure of the responsiveness of supply to a change in price. Consider the supply curve of figure 3.8. The quantity supplied at price P1 is Q1. But, as the price rises to P2, the quantity supplied increases to Q2. The ratio, Q1Q2/ P1P2, which measures the change (increase or decrease) in the quantity supplied caused by a given price change (rise or fall), is called price-elasticity of supply. It can also be expressed as:

Price-elasticity of supply =
(percentage change in quantity supplied)/ (percentage change in price)

If a price change causes a more than proportionate change in the quantity supplied (that is, if the above ratio is large), supply is said to be *price-elastic.* And supply is said to be *price-inelastic* if a price change causes a less than proportionate change in the quantity supplied (that is, if the above ratio is small). At the extremes, when the supply curve is a horizontal straight line, supply is said to be *perfectly price-elastic* because the quantity supplied is not affected by price. In this case the above ratio would be infinite. But when the supply curve is a vertical straight line, supply is said to be *perfectly price-inelastic,* meaning that a price change will not cause any change in the quantity supplied.

Figure 3.8. Definition of price-elasticity of supply (= Q1Q2/P1P2)



3.4.4. GDP and GNP

The gross domestic product (GDP) of a macroeconomy is defined as the total money value of *all* final goods and services produced in that macroeconomy over a one-year period. For example, if the total money value of all goods and services produced in country X in 1998 was £328 billion, then the GDP of X in 1998 would be said to have been £328 billion.

Now suppose that country X has investments (property, business, etc.) in other countries from which it receives an annual *net* income as interest, rent, dividends and profits (net means after paying local taxes and charges). Then the gross national product (GNP) of country X in a given year will be defined as:

GNP of X = GDP of X + net income generated from X's foreign investments

Example: If in 1998 country X received a *net* income of £100 billion from its foreign investments, then the GNP of X in 1998 would be £428 billion.

GNP is an important indicator of a country's general economic prosperity—when the GNP continues to rise, its economy is said to be doing well and *vice versa.* The *per capita* GNP of a country (defined as GNP/population) indicates the average monetary standard of living of the population of the country.

By expressing it in a common currency such as the United States dollar, GNP is used as an internationally agreed measure to compare the economic performance of different countries in a given year, as well as the economic performance of the same country in different years. For example, if the GNP of country X in 1999 was £380 billion, then clearly the economy of X would have performed less well in 1999 than in 1998, and so on. Sometimes GDP, rather than GNP, is used for measuring macroeconomic performance and for making comparisons.

It is to be noted that GNP and GDP are only concerned with the total national income produced, and not with *how* it is produced. It does not take into account whether or not the economic activities performed to produce national income degraded or protected the natural environment. Thus, a country can achieve an excellent economic performance (that is, a high GNP or GDP) by performing economic activities that seriously degrade the environment. Strictly speaking, in this sense the use of conventional GDP or GNP in environmental economics is not acceptable.

3.5. Some basic concepts of environmental economics

3.5.1. Economic externality and its internalization

We have already discussed some of the aspects of economic externality in section 3.3.4 *(c)*. It is to be noted that externality can occur from the behaviour of consumers as well as of producers. The examples given in subsection 4. are those of externalities caused by the behaviour of producers (the owner of the dirty factory and farmers using inputs). A person becoming drunk and misbehaving in a bar, thus spoiling the enjoyment of the other drinkers, is a typical example of externality caused by the consumer.

An externality can be either *positive* or *negative.* All the above examples are of negative externality, because in all cases the behaviour of the producer or consumer diminishes the enjoyment of others, or harms the environment. A positive externality, on the other hand, is one that brings benefits to others. Consider, as a typical example of positive externality, the building of a large car production plant in an economically depressed region of your country. No doubt the cars produced would add to environmental pollution, especially air pollution. But it would also create a large number of jobs and support a variety of small and medium-size local businesses, thus contributing in good measure to the economic regeneration of the region. The community at large would benefit as a result.

What is called "internalization of externality" usually refers to a negative externality. The idea is to deal with the problem of negative externality in a way that minimizes or, if possible, eliminates it. Consider again your dirty and noisy factory (see section 3.3.4 *(c)*.) which produces negative externality to the neighbours. You could use appropriate equipment (like dust-elimination devices, mufflers etc.) to reduce or eliminate both noise and dirt. But the purchase and installation of such equipment would cost you money, and this would reduce your profit margin.

However, if there are municipal or government regulations which require you not to create noise or dirt above a certain stipulated level and if such regulations are strictly enforced, then you would be obliged to spend money on such equipment in order not to fall foul of the regulations. The *true* unit cost of production includes the costs of pollution prevention or reduction in compliance with the existing regulations. Thus,

True unit cost of production =
unit cost of production + cost of pollution prevention or reduction per item produced

A negative externality is said to have been internalized when the cost of production is expressed in terms of the true unit cost of production as above.

In general, producers will do the minimum necessary for pollution prevention or reduction in order to comply with existing regulations. This is because the technology and sometimes processes needed for pollution prevention or reduction cost money; as a result, profit margins are reduced and/or the product becomes less competitive in the market place. Also, producers will try not to do anything to comply with the regulations if they are not forced to do so, or if the penalty for non-compliance is less than the cost of purchasing and installing pollution reduction technology.

While the free market works very efficiently in using market goods (such as cars, cameras, etc.) that are priced, it fails to guide firms and industry in general in the correct use of non-market environmental goods such as air, scenic beauty, etc. that are not priced. This "market failure" *vis-à-vis* environmental goods and resources occurs because, since they are not priced, the quantity to be used in production or servicing is usually not an issue. For instance, if you are in the business of producing a gas for medical application using air, you will not be concerned with the amount of air you use because it is not priced and its supply is unlimited. If your production causes air pollution, this would be a social cost, and not a cost to you, because society as a whole would be subject to the negative externality of your behaviour. But of course it would be a cost to you, in terms of a financial penalty, if you violate existing regulations that are strictly enforced.

3.5.2. *Willingness to pay*

The concept of willingness to pay (WTP) is very important in both conventional and environmental economics. We will explain this concept by means of the following examples:

> *Example 1.* Consider a plot of land, which is one hectare in area. What is the price of this piece of land? Certainly nature did not put a price tag on it saying that its market price is, say, $1,000. If it happens to be in a very desirable location, in the business district of New York for example, then there would be many purchasers who would be willing to pay a high price for it, probably millions of United States dollars. If, on the other hand, it is located in a remote desert where no one goes and there are no natural resources (such as oil), it would be hard to find anyone who would be willing to pay even $1 for it.
> Clearly therefore, this piece of land, like many goods and services, has no intrinsic price. Its market price depends entirely on how much the consumers are willing to pay for it—in other words, on consumers' willingness to pay (WTP). And, clearly, their WTP is determined by its demand due to its potential or manifest usefulness to them.
>
> Now consider the following example in the context of environmental economics:
>
> *Example 2.* Suppose that there are 500 households in your neighbourhood, and that in the middle of it there is a polluted lake which produces an unpleasant smell and is a potential health hazard. Your municipality wishes to clean up the lake and to transform it into a recreational facility suitable for picnics, boating, swimming, fishing, etc. What is the price of the cleaned-up lake and the amenities it would provide to you and to your community, and how do you calculate it?
> Suppose that your municipality has no money for the project, and that it would like to raise the money needed as a special tax to be imposed on the 500 households. As a householder near the lake, would you be willing to pay this tax, and, if so, what is the maximum you would be willing to pay? In other words, what is your WTP?
> In this case your WTP would depend on your RDI (section 3.4.2 *(a)*) and other financial commitments, as well as on the value you put on the amenities that the cleaned-up lake would provide. If you are able to pay, and if you put a high value on the amenities, then your WTP would be high. For the sake of argument, imagine that you are willing to pay $1,000 for it; that is, your WTP is $1,000. Then, the amenities of the cleaned-up lake are worth $1,000 to you. If each of the 500 households has the same WTP, then, clearly, the value of the cleaned-up lake with all the amenities would be $500,000 to your community.
> If, on the other hand, none of the 500 households is willing to pay even $1 for the clean-up (because of their very low RDI for example), then the value of the cleaned-up lake to your community would be zero.

It's clear therefore that an environmental good such as a cleaned-up lake with amenities has no intrinsic value or price to the consumers; its value or price depends on their WTP which, in turn, depends on their ability to pay as well as on the value they attach to it.

The money value, inferred through WTP in this way, is called the "shadow price" of the environmental good. Thus, for example, the shadow price of the cleaned-up lake is \$500,000 corresponding to a WTP of \$1,000 dollars per household. Shadow price is not the good's market price, because there is no conventional economic market for such environmental goods or services that bring pleasure or satisfaction to people and/or improve their quality of life.

3.5.3. Willingness to accept

Willingness to accept (WTA) means the willingness to accept a financial compensation for an adverse environmental change. We will explain the concept of WTA by means of the following:

> *Example 1.* Consider again the lake of section 3.5.2 above. Imagine that there is a proposal from a factory to make the lake even more polluted by discharging greater amounts of industrial wastewater into it. Clearly, this would further diminish the quality of life of the 500 households in the neighbourhood. But the owners of the factory are willing to pay a compensation of, say, \$1,000 to every household. If the householders agree to accept this compensation for the marginal (extra) pollution of the lake, then the WTA in this case would be \$1,000 per household.
>
> Once again the price of the marginal pollution caused by the factory, which causes marginal loss of quality of life of the households, can only be inferred in terms of shadow price. Thus, the agreed compensation of \$1,000 per household is a shadow price and not a market price, because quality of life is not an economic good in the sense that it is not traded in the market.

WTP and WTA are essentially measures of economic value which can be used as restrictions to guide environmental policy-making. They can also be used in cost-benefit analysis, on the basis of which environmental policies are generally made.

3.5.4. Marginal abatement cost

Marginal abatement cost (MAC) is defined as the marginal (extra) costs a polluter has to pay in order to reduce his emissions into the environment from the current level to a specified *lower* level.

Consider the MAC function of figure 3.9, which is typical. It is for a factory emitting smoke containing air pollutants. In order to maximize his profits, the owner of the factory is likely to do as little pollution abatement (reduction) as necessary to comply with existing regulations, because pollution abatement generally increases production costs and reduces profit.

Suppose that in compliance with existing regulation, pollutant concentration is currently at point A, for which the abatement cost is equal to OC (abatement cost is mainly the cost of additional equipment and/or cleaner processes needed to reduce pollution).

Now suppose that the regulations become more strict, so that the factory's pollution concentration must be further reduced to A* for which the abatement cost will now be OC*. Then,

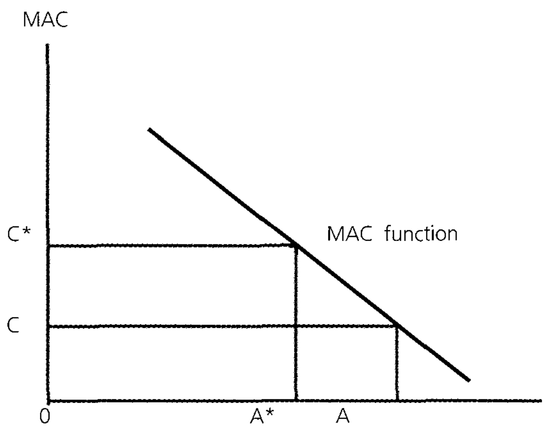
$$\text{Marginal (extra) abatement cost (MAC)} = CC^*$$

$$\text{Marginal (extra) pollution abatement} = AA^*$$

The curve of figure 3.9 is called the "MAC function" of the factory. Different factories will have different MAC functions depending on their size, raw materials used, abatement technology and processes used, type of energy source (coal, gas, electricity, etc.) and so on.

The importance of the MAC function from the point of view of pollution abatement is obvious. It shows the marginal costs of reducing the pollution emissions of a source, usually a factory or production facility, to a specified lower level.

Figure 3.9. Typical marginal abatement costs (MAC) of a factory



Concentration of pollutants in smoke

However, the construction of the MAC function of a factory or production facility can be difficult, because this would need comprehensive information on all its production and distribution activities along with data on latest pollution abatement technologies and processes.

3.5.5. *The polluter pays principle*

According to this principle, developed by the OECD in the 1970s, the polluter should bear the costs of preventing and controlling pollution. The intent is to force polluters to add the environmental costs of the pollution they cause to the production costs of their goods and services (also see "internalization of externalities", section 3.5.1 above).

A problem with this principle is that it adds to production costs by an amount equal to the cost of pollution abatement. And often polluters (producers of goods and services) are inclined to pass on the extra cost of pollution abatement to the consumers. However, if an inefficient and/or highly polluting producer does so in a free market, the prices of his goods or services will be higher than those of a rival producer who is more efficient and less polluting. As a result inefficient and/or highly polluting producers are likely to go out of business, leaving the market to efficient producers who employ clean or cleaner technologies and/or processes to produce their goods and services.

Pollution abatement costs of a good or service are said to be "internalized" when they are added to the production cost of that good or service.

The polluter-pays principle is enshrined in the Maastricht Treaty of the European Union and also in the Rio Declaration on Environment and Development.

3.5.6. *The precautionary principle*

If we implement a certain policy to achieve a certain objective in the short, medium or long term, we hope that the policy would realize that objective. But, it is possible that even if the policy does achieve its objective, it may create other equally or more serious environmental problems that could not be predicted.

The development and use of chlorofluorocarbons (CFCs) is a typical example of this. When the policy to use CFCs in industrial applications was implemented, no one could predict that one day they will create the ozone hole to degrade the global environment affecting us all.

The problem here is the inability of humans to predict the impact of a certain policy on the environment, especially in the long-term, with any degree of certainty (also see the last two paragraphs of section 3.3.5, above).

It is for this reason that policy-makers are urged to follow the precautionary principle which states that *when there is doubt about the impact of a policy, it should be managed according to the worst-case scenario of its impact on the environment.*

In other words, if we cannot predict reliably the environmental impacts of a policy but suspect that they might be adverse, due caution should be exercised in implementing it. If we have reason to believe that the impacts could be severe, it may be wise to abandon the policy altogether.

The precautionary principle is also enshrined in the Maastricht Treaty of the European Union and also in the Rio Declaration.

3.5.7. Cost-benefit analysis

Cost-benefit analysis (CBA) is an important element of both conventional and environmental economics. It is used for determining the costs and benefits of a proposed project, plan, policy or an economic activity in order to assess whether it should be implemented. CBA is undertaken *before* the project, plan, policy or economic activity in question is implemented.

Clearly, the implementation of a project, plan, policy or economic activity aiming at socio-economic development or social welfare costs money. It is necessary, therefore, to determine both its costs and benefits *in advance* so that a decision could be made on whether or not it should be implemented. CBA, which is the tool usually employed for this, thus plays a very important role in both decision-making and policy-making.

Environmental policy-making as well as decision-making is generally based on CBA. Any environmental good (benefit or improvement) or service entails costs. Therefore, we must know both costs and benefits of the good or service in question *in terms of money*, because it is only then that we can find out whether its benefits would be greater than its costs. Usually an environmental good or service is said to be economically viable if the benefits it brings are greater than its costs.

Consider again the lake (example 2, section 3.5.2, above). The restoration of the lake would involve removing the items discarded into it, purification of water, landscaping, establishing a fish population, etc. Let us say that the cost of all this is estimated at $700,000.

The benefits of this project will be the pleasure and satisfaction deriving from an improved quality of life, fishing, swimming, relaxation, scenic beauty, etc. However, as we have pointed out earlier, there is no defined market for such environmental goods, and, therefore, the *money value* of such non-market goods can only be inferred using WTP (section 3.5.2). For the sake of argument, if the community's WTP for the restored lake is $800,000, which is also the money value of the benefits, then clearly the restoration of the lake would be an economically viable project.

In environmental economics there are several methods in which WTP is used to infer the benefits of a non-market environmental good or service in terms of money. Three of these are discussed in section 3.5.8 below.

3.5.8. *Some of the methods of valuing environmental goods*

The contingent valuation method

The contingent valuation method (CVM) is based on the simple premise that, if you wish to find the WTP of an environmental good (benefit or improvement), the sensible thing to do would be to ask the consumers of that good how much money they would be willing to pay for it.

CVM relies on survey data of a statistically valid sample of the *relevant population* of the consumers. Each consumer in the sample is asked how much money he or she would be willing to pay for the environmental good in question. A CVM survey is said to be "open-ended" when the respondents are asked to name the amount they would be willing to pay; and it is said to be "close-ended" when they are asked whether they would be willing to pay a given amount. An analysis of the survey data produces the WTP value of the consumers as a whole.

Here *relevant population* means a population, all the members of which have a common interest in the environmental good in question. For example, if the CVM survey is about the WTP prices of houses in a certain town, it would not be proper to include in the sample people who have no interest in buying a house in that town.

Experience shows that face-to-face interviews are the most reliable CVM survey method; but it is also most costly. Also, a sufficiently large sample size is needed to guarantee results with the desired degree of precision.

The CVM is widely used. When CVM surveys are conducted rigorously and with a well-designed questionnaire, reliable WTP (or WTA) estimates are obtained. Some international agencies, such as the International Development Agency (IDA) at the World Bank, require CVM studies on water, sewage and tourism projects for assessing the merits of such projects for funding.

The hedonic pricing approach

The hedonic pricing approach (HPA) is based on the straightforward premise that the economic value of a good is determined by the sum total of all the benefits that derive from it.

Consider two identical houses, house X and house Y. The price of X, located in an environmentally unpleasant part of the city, is $30,000. The price of Y is $40,000 because it is located in a beautiful and clean area of the city.

If you have the financial resources and if you value living in pleasant surroundings, then you would be inclined to pay the extra $10,000 for house Y. In this case this extra $10,000 would be called the "hedonic price" of the house. You would be inclined to pay this extra amount because, in your way of thinking the hedonic[2] pleasure, which the environmental amenities of house Y will give you, is worth $10,000 or perhaps more.

This $10,000 is also your marginal (extra) WTP for the marginal (extra) environmental benefits of house Y compared to those of house X.

Depending on consumers' marginal WTP for marginal environmental benefits or utility, the market will decide the difference between the prices of X and Y. However, there are analytical methods of calculating the HPA of goods, based on WTP and current and historical price data, using standard methods of mathematical programming such as log-linear models.

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[2]In the Oxford English Dictionary, the meaning of "hedonic" is given as "characterized by pleasure" or "pleasant or unpleasant sensations". The meaning of hedonism is given as "belief in pleasure as the highest good and humankind's proper aim".

The travel cost method

The travel cost method (TCM) is used to estimate the value of environmental amenities. In Europe, north America and Australia it is widely used to estimate the value of public recreation sites such as beaches, parks, historical sites, etc. Increasingly it is also being used in developing countries to assess the economic value of such amenities.

The TCM is based on three observations:

(a) The cost of using a recreation site is more than the admission price, because it includes: (i) cost of travel to the site and parking charges if any; and (ii) the opportunity cost of your time; that is, the price of any productive or pleasant activity or paid work that you could do in the time spent on visiting (time spent at the site plus travel time) if you did not go to the site.

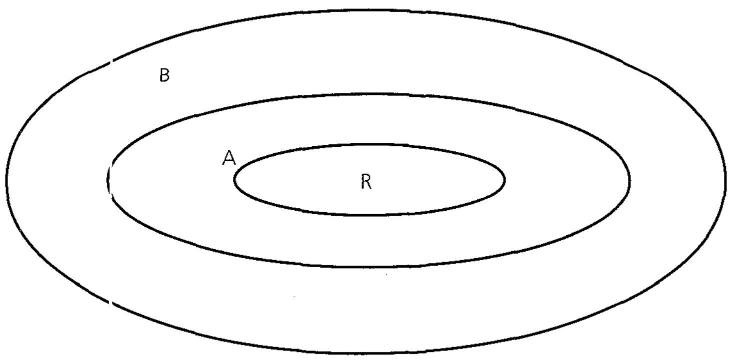
(b) Visitors from different distances incur different costs depending on travel time and distance travelled.

(c) If the value the consumers place on the site is independent of the distance travelled, then travel costs can be used as proxy for price in deriving the demand curve for the recreation site in question.

The TCM is used to calculate the money value of a site as follows: first the demand curve is prepared by considering visit frequency and price per visit. Information given by the demand curve is then used to find the WTP.

Imagine that in figure 3.10 people from zones A and B go to visit the recreation site at R, and that R is only one of its kind in that area. Let x_a and x_b denote the number of visits per period to R from zones A and B respectively. Now let P_a denote the average travel costs per trip per visitor from zone A to R, and P_b denote the same from zone B to R. Here "travel costs" include all relevant costs such as costs of transport, car parking, entrance fee (if any), costs of hiring equipment (if any), etc., as well as the opportunity costs of time spent (see (ii) in *(a)* above).

Figure 3.10. Recreation site R attracting visitors from zones A and B



A demand curve is now prepared on the basis of the above, shown in figure 3.11. In this figure the visit frequency from zone B is less than from zone A, as we might have expected, because $P_b > P_a$. In fact, for zone O (not shown in figure 3.10.), which is just too remote from R to attract any visitors, $x_o = 0$, corresponding to the costs per trip of P_o.

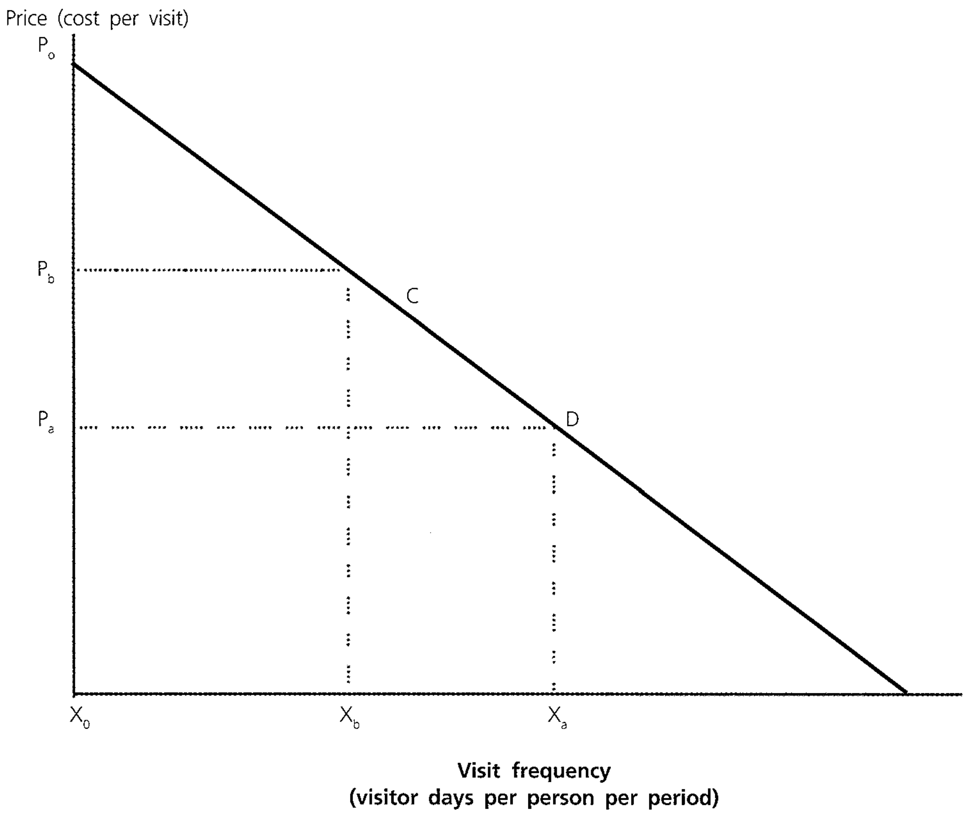
For the average visitor from zone A, his or her WTP is the area enclosed within $P_o x_o x_a D P_o$. In other words, he or she is willing to pay an amount of money represented by this area. This is the *gross* WTP because it includes travel costs, P_a. The *net* WTP is obtained by subtracting travel costs (area enclosed within $P_a x_o x_a D$) from the aforementioned area. Thus the *net* WTP of the average visitor from zone A is represented by the area enclosed within $P_o P_a D P_o$. Similarly the net WTP of average visitor from zone B is represented by the area enclosed within $P_o P_b C P_o$. Note that the net WTP is also the consumers' surplus.

Therefore, the total WTP (or consumers' surplus), Z, of site R is:

$$Z = N_a \text{ X net WTP of average visitor from A} + N_b \text{ X net WTP of average visitor from B}$$

in which N_a and N_b denote the total number of visitors from A and B, respectively, over a given period. Z is also the economic value the visitors attach to R. The same approach is used when visitors from several zones visit R.

Figure 3.11. Hypothetical demand curve for site R



Note: For simplicity the demand curve is shown as a straight line. It may not be so in practice.

3.6. Concluding remarks

Given the continuing environmental deterioration of the coastal areas and its ecosystems, there is now urgent need for the effective implementation of sustainable policies. At the same time, there is need for developing indicators of sustainability with which to determine whether, or the extent to which, sustainability in at least the key areas of human activities in the coastal areas is being realized.

Given that the jurisdiction of many environmental problems is also regional and even global, development of indicators of sustainability sometimes involves extensive coordination and consultation at the regional and/or international levels. At present there is no unique operational definition of sustainability which is universally accepted. Consequently, it is difficult to develop a common yardstick (indicator of sustainability) which could be used in different countries or in different geo-political regions. This aspect alone highlights the urgent need for cooperation and consultation at both regional and international levels.

However, it should be considered that, despite the geographic scale, changes and conditions in one community can be quite different from those in others. In this case it may be possible to identify groups of communities with similar social, economic and environmental characteristics for which common indicators would be appropriate. A possible compromise solution to this problem would be to supplement a small core set of indicators with other sets if or as appropriate (Maclaren, 1996).

The indicator development process should be seen as a dynamic process which will need to respond to changing conditions and priorities. The types of issues, for which indicators are needed, are likely to change over time as perceptions and attitudes change. Developing indicators of sustainability, and using them for monitoring, is a long-term commitment and there are major problems facing most of the countries in this regard—especially developing countries. Large amounts of data are needed for indicator development and monitoring. Availability and reliability of data is thus a basic requirement for both developing indicators of sustainability and using them for monitoring.

Clearly, development of efficient procedures for gathering reliable data is essential for project development, management, and monitoring in order to achieve sustainability targets. In the national context, this means that all national government departments should coordinate their efforts efficiently to support data collection, to disseminate information, and to be involved in the development of indicators of sustainability. The role of effective coordination and consultation at this stage cannot be over-stated.

The development of Indicators of sustainability can be an important catalyst in the debate on major issues of sustainable development, thus creating an effective forum for the debate and discussion of relevant issues and problems in which non-governmental organizations and other interested parties could participate, share information and interact. A useful spin-off of this would be wide dissemination of information and raised awareness of the pertinent issues and problems. It is pointed out, however, that developing indicators and making impressive publications on them is certainly not enough, neither is it the objective. What is urgently needed is the practical application of the indicators to address the serious and growing quality of life problems especially in the developing countries. Both municipalities and local governments have an important role to play in this.

Environmental economics plays a very important role in the development of both sustainable ICZM policies and indicators of sustainability. Unfortunately, at present there is a considerable lack of knowledge and appreciation of the rudiments of environmental economics among the practitioners of environmental managers including those charged with the responsibility of managing coastal zones. With a view to addressing this serious deficiency, relevant aspects of environmental economics have been included in this text in a way that is easy to understand.

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4

Environmental planning for conservation on the coastal zone

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4 Environmental planning for conservation on the coastal zone

4.1. Introduction

4.1.1. Rationale

The Mediterranean coast has, since early times, provided human populations inhabiting the basin with a multitude of benefits. As a result, the coastal zone experienced significant resource conflict, suffering a systematic and severe degradation. Over the millennia, demographic growth throughout much of the region exerted terrific pressures on coastal and marine ecosystems. However, it was essentially during the last four decades, or so, that the Mediterranean region underwent notable change in land-use patterns, primarily through industrialization and tourism development. Population expansion and accompanying anthropogenic activities have led to unsustainable demands on the natural resources of the region which, as a consequence, may eventually outpace the system's ability to recuperate. Such an eventuality, seen in a socio-economic context, may have far-reaching consequences on the future economic growth in the region.

It is estimated that as much as 38 per cent of the region's inhabitants occupy coastal areas; while projections indicate that, by the year 2025, coastal populations are likely to more than double (from 84 million at present to between 150 and 170 million). Furthermore, tourist numbers are projected to reach 260 million per annum.

The tourist industry manifests a major socio-cultural force with the potential to reconfigure not only national economies but, often, the way of life. From a sociological point of view, tourism involves the interaction of three components, that is, the tourists, locals, and brokers at tourist destinations. Each of these has different, at best parallel, but rarely converging interests. In situations involving ethnic groups, for example, visitor impact may have significant social implications—*the loss of cultural diversity can be deemed, in certain cases, as serious as species extinction.*

Compared with other industries, tourism may be described as a relatively "clean" trade; however, visitor-oriented development and the construction of amenities relating to tourism services all contribute towards altering the coastal environment. In a sense, tourism is a paradox: it can bring considerable benefits, primarily to the economy of an area, but can also cause immense damage if not properly managed. The time is perhaps ripe to evaluate the priorities of financial means for "economic development" of natural resources and ecosystems within a given area or country, in order to determine what percentages are utilized for *conservation (debit)* and *exploitation of the resource (credit).*

In addition to encroachment through human disturbance and unplanned development, the coastal zone sustains significant damages from other sources, namely, environmentally hazardous industries sited on the littoral. Such enterprises are largely responsible for adversely affecting coastal habitats and biota, as well as leading to increased land-use conflict.

During recent times, environmentally conscious elements of society have, for a variety of reasons (namely scientific, economic, aesthetic, and/or ethical), attempted to protect nature from the negative consequences of the human agency. The field of coastal and marine areas' conservation is relatively new. As one may well appreciate, methods developed for managing terrestrial sites cannot easily be applied to coastal and marine conservation areas, since their ecosystems are so open and difficult to demarcate.

4.1.2. Mediterranean coastal ecosystems

The Mediterranean basin supports a variety of ecosystems, unique in diversity and richness. Biodiversity is generally much richer in the Mediterranean (including southern Europe, north Africa and the Levant) than in the rest of Europe (Synge, 1993). The region also supports an abundance of endemism that is absent further north. Mediterranean coastal ecosystems are of special interest both biologically and economically. Some notable biological reasons include:

- The Mediterranean basin features many unique ecosystems, supporting some 25,000 species, half of which are endemic (Leon *et al.*, 1985);
- Mediterranean coastal ecosystems are considered to be transitional between tropical ecosystems and boreal ecosystems (Batisse, 1990); and,
- Components, which constitute these ecosystems, have long been associated with the human agency, and can thus provide baseline data to determine the impact on biodiversity. Such information is important in understanding and managing biodiversity (Mooney, 1988).

Notwithstanding, conservation areas in the Mediterranean, with few exceptions, have less overall coverage than their counterparts in the rest of Europe, and, in addition, are afforded meagre protection. This is generally due to: lack of financial resources allocated for conservation, weak institutional backing and the lack of public support for the protection of nature.

Consequently, many important sites have still not been provided with adequate protection and a number are consequently under threat. Traditionally, the approach to planning and managing the coastal zone, including both the terrestrial and marine environmental components, has been to identify resources and subsequently target resource-specific activities. Predominantly, this has applied to activities, of an economic nature, such as fisheries, mineral and petroleum extraction, shipping, etc., with the result that conservation planning was not being appropriately addressed. In recent years, however, conflicts arising as a consequence of resource exploitation, coupled with a greater awareness towards environmental concern and a marked increase in international cooperation, appeared to have instigated a shift towards integrated environmental planning and management. This innovative approach complemented, rather than substituted, the traditional focus of regulating individual activities, hence affording better protection to ecologically important coastal areas.

4.2. Planning and management applications

4.2.1. Managing coastal areas

The planning and management of various elements of the coastal zone, so as to ensure that anthropogenic activities do not in any way compromise the "state-of-health" of existing resources, is referred to as *integrated coastal area management* (ICAM) or *coastal zone management* (CZM)—the former often referring to a broader geographical area, incorporating interconnected elements further inland such as watersheds, etc.;

the latter refers to the coastal sector *per se*. This interdisciplinary approach to planning and management of coastal regions may be applied at both the national and regional level. It is a dynamic process in which a coordinated strategy is developed and implemented in support of the conservation of natural resources and the general sustainable use of the coastal zone.

Primarily, ICAM aims to *(a)* provide strategic planning for the coastal region and interconnected areas distant from the coast; *(b)* promote the responsible use of coastal resources using environmentally sound technologies; and, *(c)* balance demand for coastal resources and resolve conflicts of use.

The concept of integrated coastal area management defines the coastal zone as the unit for planning purposes; where management is concerned, ICAM considers both the terrestrial and marine components of the coastal zone as one entity. It is likewise important for ICAM to be seen as a proactive mechanism, which in the long-term provides a multidisciplinary approach to planning and management, encouraging *communication, collaboration and coordination* between the planning team, the reserve managers, and all other stakeholders. The "public's right to know" is a concept which is very often neglected, particularly in countries on the southern shores of the Mediterranean.

Four major sources of potential threats to coastal conservation areas include: development; encroachment; natural and man-induced disasters; and inadequate liaison—management failure

4.2.2. Ecosystem management

One of the important functions of conservation areas is to provide a relatively undisturbed environment that can be observed over time in its natural state. Therefore, before any attempt to protect, conserve or manage a natural area, it is important that the managing entity—be it a steering committee, a group of wardens, or, simply, a reserve manager—becomes acquainted with, and understands, the site in question. To achieve this, *baseline data* must be gathered, analysed and utilized wisely, in order to be in a position to apply sound management techniques.

By inventorying and monitoring both natural and man-induced changes in the environment, *conservation area managers* can establish a baseline for describing the patterns of change in plant and animal communities of as well as in the ecosystem itself. Such information can then be incorporated into management plans, where decisions, based on concrete facts and findings—rather than just educated guesses—can be made concerning the effects of different uses and levels of use.

A monitoring programme may consist of any number of appropriate information gathering techniques such as cursory assessments, large-scale surveys, or intensive inventories. Whichever method is used, it is important that a conservation area is managed with adequate backing data. The contrary will result in the inability to determine carrying capacities[1] of the ecosystems under protection, as well as lead to haphazard management decisions.

> *Example.* Tropical logging in Latin America and the Caribbean is often carried out despite the lack of sufficient information on forest growth and yields, resulting in unsustainable exploitation. The same may be said of specific fishing activities in the Mediterranean Sea.

Monitoring of biological conditions within a conservation area will shed information about land-use patterns and changes that surround the particular site. Typical

[1]Carrying capacities should merely be utilized as indicators; at no time should ecosystems or any of their components be pressured to the threshold of their tolerance level.

activities that have an impact on conservation areas (through alteration of habitats, elimination of species, etc.) include deforestation, agricultural expansion, grazing, road construction etc.[2]

Before any attempt is made to manage an area however, it is exceedingly important to develop conservation plans, on a regional *or* national scale (rather than protect areas piecemeal and have a fractured conservation policy), into a comprehensive area management programme. This can only be achieved through *system planning*.

4.2.3. Planning a system of conservation areas

The prospect of planning a regional or national system of coastal conservation areas (terrestrial reserves/marine parks) may appear daunting, particularly in countries with extensive shorelines. However, on small islands, albeit small and appearing to be manageable, the task may prove just as difficult if not more complicated given the socio-cultural state of affairs usually prevalent on island states and, because of their smallness, the high degree of land-use conflict.

The system planning process should be able to provide an overview of prevailing problems, issues and conflicts encountered by ecosystems (*or* some of the supporting habitats and biota), and people.

It is a good point of convergence for conservation and development and every effort should be made to integrate the two.

> "For development, system planning indicates areas needing special management to sustain both human development and environmental stability, and it indicates how, where, and when certain development activities will have negative and positive effects on the environment";
>
> "For conservation, it indicates the present and future vulnerabilities of renewable resources and identifies habitat areas most urgently in need of protection. The result of system planning is selecting specific sites for protection and defining their purposes and objectives" (Salm, 1984).

Essentially, *system planning* consists of three primary components. Broadly speaking these components follow the basic sequential order, to plan-making, of *survey/analysis/plan*: habitat-type classification; identification of candidate areas; and site selection for conservation.

Each of these may have several applications ranging from *regional planning* for sustainable development; *national planning* as a process to integrate conservation into coastal zone management, to *analysis of critical coastal habitats* of particular species within their ecological range (Ray *et al.*, 1978, as quoted in Salm, 1984).

4.2.4. Conservation areas programme

Assuming that the legislative structures and preliminary objectives exist, *system planning* can come into play, fitting into the evolution of a conservation area programme. The following is a typical sequence of programme development (adapted from Salm, 1984):

(a) *Policy/legislation:* formalizes an administrative decision to commence a conservation programme, and, as a result, sets the goals for its implementation;

(b) *Preliminary planning:* interprets the legal framework; sets the planning agenda; identifies the multidisciplinary planning team; and, defines objectives;

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[2]These in turn may alter patterns of, for example, water flow as well as sediment loads, thereby increasing *flood risk*. Apart from the potential risk to human life and property, such changes may have serious repercussions on various levels of the ecosystem's food chain. In this respect, planners cannot afford to ignore the wide range of impacts that may occur consequent to activities further afield.

(c) *System planning:* identifies issues and conflicts; classifies habitat-types; and, provides criteria for site identification;

(d) *Site planning:* provides a comprehensive implementation schedule, including a design proposal with appropriate delineation, and a management plan for each sector of the protected area. Site planning also makes provision for future revisions;

(e) *Implementation and management:* is the phase responsible for the operational management and development components, and, where necessary, makes recommendations for future improvement.

It is generally encouraged to follow the progression recommended above, bearing in mind the specific exigencies of the country concerned; however, in real-life situations such a seemingly logical sequence does not always occur. On certain occasions conservation area programmes are set into motion without the appropriate legal frameworks, supported only by *ad hoc* regulation. In addition, it often happens that certain phases of conservation area development are bypassed completely.

The conservation area: site planning and management

Conservation area development requires specific planning prior to undertaking the management-related phase. The charting out of management plans takes place during *site planning* which follows the initial phases of the planning process, namely: *the administrative decision which, when formalized, establishes the mandate; the defining of objectives;* and, *completion of the system planning process.*

It is exceedingly relevant to differentiate between the *planning* and *management* phases. The *planning* phase provides the mechanism for decision-making on resource-allocation, e.g., through the analysis and selection processes, and through the design (*or* zoning = widely accepted method to control access in sensitive coastal areas, and to limit impact) and management criteria. *Management* addresses the day-to-day operational element required to satisfy the defined objectives of the management plan.

Plan-making for conservation areas

The process commences with scientific surveys being undertaken by a multidisciplinary team of specialists, carrying out studies of each sector within the conservation area. The purpose is to determine and/or identify:

(a) The type and exact location of localized and/or threatened habitats; the habitat-type's vulnerability and status; and, existence of any specific characteristics such as species diversity, population size, and degree of species' dependence.

(b) The type and extent of land-uses, conflicts, and other anthropogenic activities; the potential effects these may have on the habitats and biota occurring on site; the level of dependence of *resource users* and *affected locals* on current uses; and, all those activities which may potentially result in the degradation of existing habitats, subsequently leading to a depletion of species' numbers.

(c) Existing and potential threats to the zone's *or* conservation area's resources from anthropogenic activities taking place immediately beyond the area's delimitation.

With the above data in hand, the subsequent development of the conservation area may progress according to specific guidelines.

Management objectives

The basic as well as prime objective of any conservation area is to afford protection to the supporting elements, which maintain the natural processes within the said area. Given adequate protection, accomplished through a proactive and integrated management programme, conservation areas may help enhance the social, aesthetic and cultural fabric of a particular area and its surroundings, in addition to conserving the habitats and biota present and providing a suitable venue for education and research. Where large conservation areas are concerned, it may be deemed worthwhile to encourage an element of economic activity such as tourism and fisheries.

Zone delineation approach

Zoning for management purposes should be carried out during the early stages of the process, so that any activities within the different sectors can be planned and, if necessary, controlled according to defined objectives.

Intensive management practices may be required in some sectors of the conservation area, while other sectors will require limited attention. Zoning allows a better understanding and protection of core areas and buffer zones, while necessitating the monitoring of human impact, and efficient allocation of personnel, equipment, and funds.

The management plan

It may be argued that effective management practice may not require a schedule or plan to commence operations, but it does need a defined agenda to develop. The value of a formalized document lies in its explicit mandate to follow a particular course of action. A management plan also serves as a blueprint for routine operational tasks.

Such a document will be instrumental in establishing a philosophy of management, serving as a reference point for planners and managers throughout the life span of the *plan*.

It is exceedingly important that the plan does not set unattainable goals for the management of resources. Encouraging false expectations will almost certainly damage the success of the project.

- A management plan should feature some sort of mechanism for measuring its effectiveness. Therefore, plans should be structured such that adequate manoeuvrability for subsequent modification and revision is possible, as new data is gathered and evaluated during the implementation phase.
- It is essential that management plans should, from the onset, make known their intended life spans. A recommended length would be 3 to 5 years.

4.2.5. Need for cost-effective intervention

Although conservation can be costly, in today's world authorities feel the need to allocate financial and human resources among many competing sectoral needs. Setting of priorities for action includes defining cost-effective interventions.

As with the identification of priority environmental problems within a conservation area, deciding on the urgent action required to solve them, is in the end, also a political matter. It depends on such factors as the availability of funds, political visibility, balance of regional and sectoral interests, and the willingness and capability of local government agencies to undertake the task to implement a *management plan*.

4.3. A broad approach

4.3.1. *Approaches to environmental strategies*

A basic approach to plan-making is the "Survey-Analysis-Plan" method. Its focus may be broadened to integrate socio-developmental concerns. Successful strategies involve three elements: identifying priority problems; defining priority actions; and ensuring effective implementation.

For environmental strategies to be implemented with success, apart from sound technical and economic analysis, the planner must have a sound understanding of the nature of the area on which change is being proposed.

To achieve this, a multi-faceted plan must come into play, bringing together: nature conservation; the management of natural resources, through existing legislation; and the socio-economic requirements of the stakeholders.

As much as possible, every effort should be made to seek common ground (although often difficult) among opposing interest groups, since neither nature conservation nor economic activity can be efficiently managed without a certain amount of interaction between the two.

4.3.2. *Broad objectives for an action framework*

Lack of streamlining among national environmental agencies, inadequate legal instruments coupled by ineffective enforcement, weak public information systems and failure to incorporate environmental education in school curricula and within in-service training courses for both the public and private sectors are key elements responsible for the prevailing situation in most developing countries, characterized by: inadequate flow of information to the public; lack of grassroots involvement including weak consultations with non-governmental organizations; and too low a priority given to environmental education.

Additionally, there are clear linkages between these fundamental issues, ecosystem conservation, and sustainable land-use practices. Nature conservation and natural resource management need to feature more prominently in a country's development strategies and should be adequately represented in national policy frameworks.

Techniques for quantifying the value of environmental services and the long-term costs of resource degradation need to be developed in line with local requirements. Also required are improvements in the current analysis of natural resource and development issues, so that their relevance to the economic, social and cultural impacts can be clearly demonstrated. Furthermore, the creation of incentives, the decentralization of management systems and, where appropriate, increased involvement by industry and non-governmental organizations all need to be included in improved national policies (Cassar, 1994). National planning systems will need to be enhanced in order to function within a varied, multi-sectoral set of priorities, and be responsive to environmental needs.

A strategy for the conservation of specialized coastal habitats goes hand-in-hand with sustainable economic development. Both components need to build on and provide the mechanism for other forms of strategy processes operating at national level. Once the concept of the strategy as an adaptive and cyclical process has been embraced, then whether it is a biodiversity action plan, an international agency-supported national environmental action plan, a national Agenda 21 strategy, or any other multi-sectoral process, it is likely to have similar management needs.

The strategic planning process should include: information assembly and analysis; policy formulation; action planning; implementation; and monitoring and evaluation.

Each of these components is driven and facilitated by *participation* and *communication.*

A basic management mechanism for most strategies is a *steering committee*, made up of specialists and a secretariat based within an established national environmental agency. Although the composition, size, terms of reference and functions of such bodies varies according to specific tasks, experience suggests some general rules since the initiation phase of any strategy can be a time of frustration. *Well-targeted, decisive* but *diplomatic management* at this early stage can determine the level of success of the plan in its later phases.

Once the political decision has been taken to pursue a conservation strategy, the main actors need to have a common understanding of the way forward. Although government environmental agencies, experienced specialists, and possibly non-governmental organizations will probably be taking the primary responsibility for managing the process, it is very important that *all* of the key stakeholders, including the *affected locals* and *resource users*, become involved at a very early stage if not from the start.

4.3.3. Political support

Decisions of when and where to declare protected areas, or how much money should be allocated to protected areas, fall within the domain of politicians. In many countries where public opinion is deemed important, many politicians have joined, *or* appear to have joined, the ever-growing ranks of the conservation conscious—their political life depends on public support. In cases where the political decision-maker may have to take an unpopular stance on a controversial issue related to environmentally sensitive areas, an informed public could influence decisions on conservation issues and thus rally the political support necessary to declare and maintain protected areas (Barzetti, 1993).

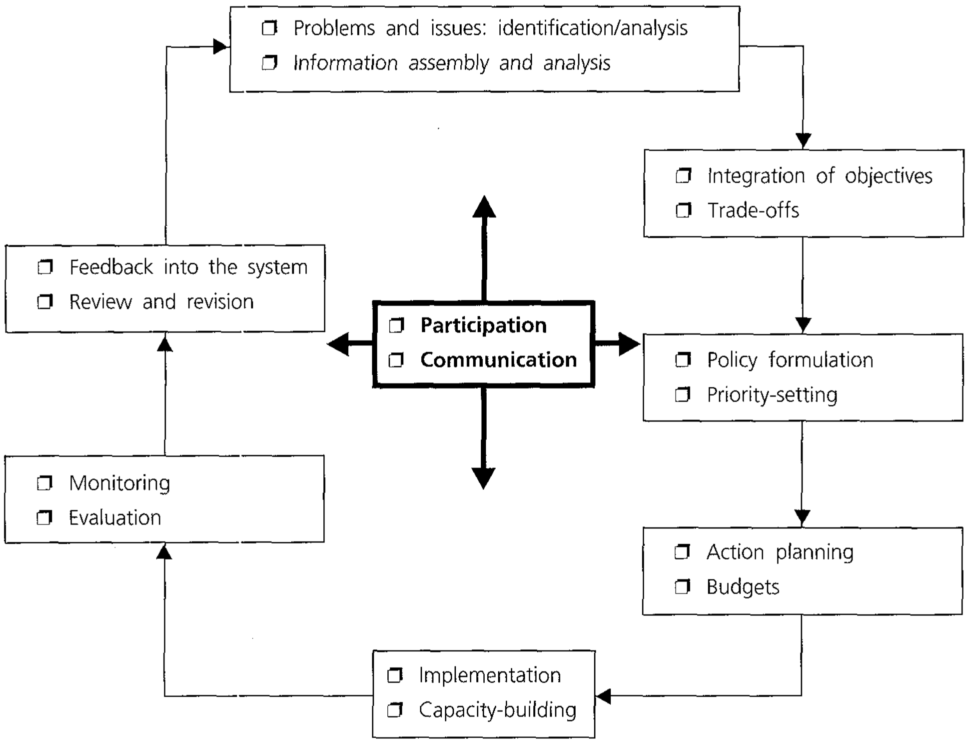
Public support for conservation areas can take the form of direct or indirect pressure on political decision-makers:

- Direct pressure may involve the provision of information to politicians that will enable them to convince their peers of the importance of establishing protected areas. Until recently, economic reasons tended to be the common justification. However, social arguments are rapidly becoming more valid—while hard-core sciences provide the baseline data on the scientific importance of a particular site, the data from the social sciences (anthropology, sociology, geography, political science and psychology) can provide political decision-makers with a clearer picture of the integral role protected areas play in the social and economic life of the nation;
- Indirect pressure often takes the form of public opinion that influences political decisions. In this arena non-governmental organizations can play a crucial role, in particular since they tend to be independent of official political and economic interests. Additionally, non-governmental organizations represent a sector of the population (Barzetti, 1993).

Support could also be derived from among the stakeholders in and around protected areas, mostly from "affected locals". Resource users can likewise provide additional public support. Those benefiting from a protected area will "defend" it against incompatible uses, and often support management structures designed to maintain the resources from which their benefits derive. Therefore, incorporating local people into the management and maintenance of a protected area can result in their being among the staunchest supporters of the project.

It is at the point following the establishment of the initial steps of the strategy cycle—that is, the *information assembly and analysis, policy formulation,* and *action planning*—that the *affected locals* and *resource users* are involved in the management mechanism. This does not imply however, that *some* stakeholder groups are disregarded and simply brought in so as to comply with some political agenda. It is important to remember that *communication and participation* are key driving forces of all the elements that make up the strategic planning process. Although these stakeholders are not brought on board at the management level initially, they should nonetheless be kept informed of, and consulted on, every level of development in order not to create any antagonism which may prejudice the project at a later stage.

Figure 4.1. The different components that make up the strategy cycle



Source: Carew-Reid, *et al.*, 1994.

Figure 4.1. illustrates the elements of the strategy as a series of consecutive steps. In a real life situation many of the elements will occur concurrently. For instance, policy formulation and action planning may take place, at the same time as implementation and capacity building.

There is, of course, no single correct way of implementing a strategy, and many approaches exist. The objective is to be pragmatic and incremental—aiming not for perfection but for constant improvement. The accent on *participation* cannot be overstressed. This needs to involve as many people as possible from all sectors of society. However, "If a strategy were to start off by attempting to involve everybody, it would quickly become bogged down and exhausted of its resources. Participation in the first cycle of the strategy may involve *only* a few key sectors of society but can be widened as the strategy develops" (Carew-Reid, *et al.*, 1994).

Inevitably, strategies are processes that require optimization and opportunism, and often require getting involved in somewhat difficult administrative and political situations. In view of their complexity, strategies must cater for varying interests, and offer mechanisms for trade-offs. An important aspect when negotiating with *affected locals* and *resource-users*, is the consideration of the will of a minority.

On occasions a sector of a community (e.g. fishermen, farmers etc.) or simply private individuals may have a different point of view from the majority of stakeholders. In such cases allowances should be made for minority desires; that is, every effort should be made, where agreement by consensus is unattainable, to understand and integrate fundamental requests by these groups.

4.3.4. Conflict resolution

Invariably, in planning conservation areas and in proposing legislative measures, that is, controls and restrictions, some stakeholders may offer resistance (either in the way of protest or, even, physical) to conservation schemes. This may be due to lack of information, egoism, political instigation or, quite simply, genuine concern. This usually leads to conflict between the affected stakeholders and the government agencies, and sometimes even with environmental non-governmental organizations.

Human nature has it that once an individual or group takes a position and defends it strongly, it may then prove exceedingly difficult for the planner/mediator to convince the opposing party to back down from it. Good conflict resolution needs to first distinguish between peoples' *interest* and their *positions*—an interest is a fundamental need or concern; while a position is an idea put forth to further one's interests (Lewis, 1993).

> *Example.* A farmer who may be growing crops on agricultural land adjacent to a sand dune system finds that sand blowing inland is constantly affecting his yield:
>
> *(a)* His first position would be to plant fast growing alien tree species such as Eucalyptus or Acacia on the dune ridges to prevent sand blowing over his land. In doing so, the newly planted trees would effectively be competing with the dune vegetation and also affect the area's hydrological balance, in view of the large amounts of water these particular species are reputed to utilize;
>
> *(b)* Alternative positions would be to fence in his crops or to request, from government, compensation for damages. Thus, the farmer's interest is the same, that is, of protecting his crops, but his position may change.

In addition to focusing on each party's interests rather than positions, policymakers need to address the issue of *power* in the conflict. This can come in many forms—personal, political or economic power or influence, or it can be the power of information, legal or "strong-arm" backing. It is important to be conscious of the *real* and *perceived* power of the stakeholders involved in the conflict, as they will act according to their own perceptions of the power balance (Lewis, 1993). The planner, therefore, should ensure that all significantly affected stakeholders are included in resolution discussions. In addition, understanding their interests and power positions will go a long way toward helping resolve existing disputes.

Ideally and whenever possible, it is best to avoid conflict in the first instance. This can be achieved by preparing adequately, during the initial planning phases, for potential areas of conflict:

(a) First, by consulting with potentially affected stakeholders and including their active participation in the conservation area's management issues;

(b) Secondly, by being somewhat flexible and adaptable to local circumstances.

Like all processes that determine how resources are to be utilized and by whom, strategies are constantly influenced by political forces. These can be seen as necessary and useful influences, as long as the strategy secretariat adheres to an open process while being flexible; seeking to capitalize on opportunities as they arise to promote agreed strategy objectives.

4.3.5. *Involvement of non-governmental organizations*

Although conservation areas fall within central government jurisdiction, it is often well worth considering vesting environmental non-governmental organizations with management and upkeep responsibilities. Two constraints, which readily come to mind, if central government should attempt to manage protected areas alone, are:

(a) Funding for management of such areas often falls victim to short-term national development goals, as a result of which conservation areas end up without management plans or adequately trained, personnel; and,

(b) Being multidisciplinary by nature, conservation areas require inputs from different disciplines for their effective management.

Conservation non-government organizations are becoming increasingly more active in collaborating with government environmental agencies with regard to protection efforts. Non-governmental organizations tend to have advantages that can compliment governmental management efforts. These include:

- Non-governmental organizations are less bureaucratic than official agencies and therefore more flexible in their management;
- Non-governmental organizations may have more hands-on and scientific expertise than government departments;
- Non-governmental organizations have access to funding sources not usually offered to governments;
- Non-governmental organizations can raise funds for direct use in conservation areas as opposed to government, who must direct all revenue to the national treasury;
- Non-governmental organizations are usually less politically influenced than government departments.

There are several situations where non-governmental organizations can actively become involved in the management of conservation areas, the more effective management models being: *intervention-oriented* or *interactive*, where the assistance of international non-governmental organizations or donor agencies is sought:

(a) The first involves the seeking of international aid by a national non-governmental organization in order to proceed with its conservation agenda;

(b) The second option involves mutual sharing of tasks in executing a management plan. A model that may be applied, is one in which government is the landowner but where it cedes the management functions, under appropriate supervision, to a competent non-governmental organization or body of non-governmental organizations.

4.4. Conclusion

In places of extreme land-use conflict, as is the case of small islands, habitat and species conservation is vastly difficult. The Mediterranean island state of Malta is a case in point, where a high population density makes huge demands on natural resources, particularly the coastal zone, resulting in complex environmental management problems.

In such a situation, the larger the conservation area the more diluted is its management effectiveness. The challenge to effective *site management* is to establish zoning schemes that identify priority sites for specific uses and enhanced protection levels. The introduction of international delineation criteria for conservation areas (such as those applied by the Man and the Biosphere Programme (MAB) of the United Nations Educational, Scientific and Cultural Organization (UNESCO) can be used on the macro-scale. On the micro level, existing national scheduling ratings within a particular country, such as, *areas of ecological importance* and *sites of scientific importance,* can be used to further highlight small but important ecological areas for management purposes.

> *Example.* Such a system can effectively be put into action in a number of localities, which are important, both socio-economically and conservation-wise.
>
> Such sites may include land-cover comprising agricultural land surrounding sandy beaches with adjoining sand dune systems and/or saline marshes. Together, the adjacent habitats, beach zone, agricultural land, and the nearby valleys so important in supplying the dune system with terrigenous sediment from inland locations, will present an excellent example for conservation area zoning, given that local support and involvement is sought.

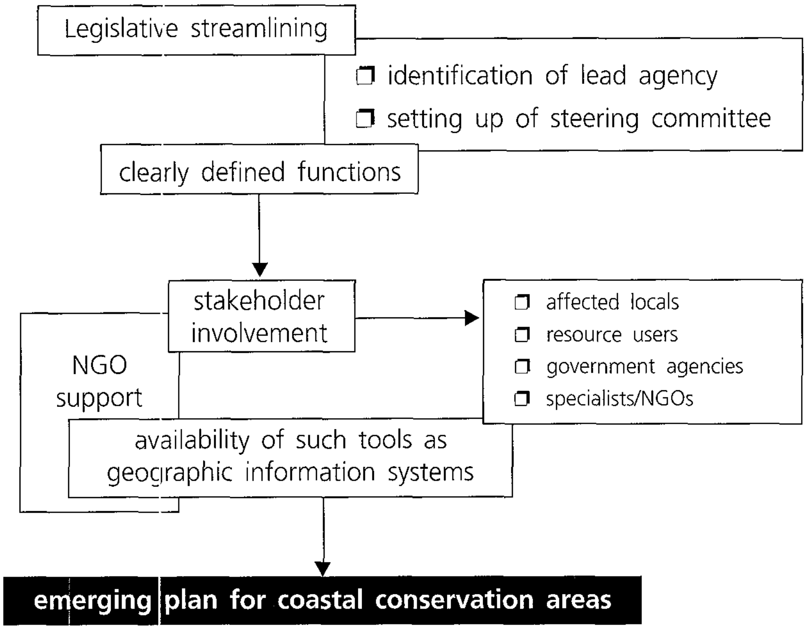
In locations where rare or endangered coastal habitat-types are scattered throughout the area and subjected to anthropogenic pressures through unsustainable activities, the planning team must ensure some form of "contact" between the different ecological communities.

In the case of protected animal and plant communities, it is widely acknowledged that species preserved in isolation in scattered conservation areas may eventually die out from lack of genetic diversity needed to maintain strong populations. In an effort to allow ecosystems to adapt to changes, the planner, in planning conservation area programmes, should seek to design *biodiversity corridors* to connect the various habitats so as to preserve natural genetic dispersal.

> *Example.* Suitable models include those places where land-use is intense and conflicts prevalent. This tends to occur, especially, in coastal areas supporting important habitats and biota, and, where the presence of recreational activities (including those relating to the tourism industry) is high, coupled by other competing land-use elements.
>
> A case in point is a region known as Marfa peninsula, located on the northernmost point of the main island of Malta, where a number of sand dunes, all fairly limited in size, can still be found to the rear of some beaches on the peninsula. Apart from the direct threat through human disturbance and encroachment, these already restricted coastal habitats occur within an area where numerous immobile caravans (so called boat-houses), have been constructed, some illegally. This ever-spreading menace to the environment has, in some cases, surrounded dune systems entirely, *or,* by their very siting in certain locations, these constructions have "cut off" the valuable terrigenous supply which would otherwise nourish the beach zones and dunal areas through natural processes. As a result, the dynamic equilibrium of a good number of the dune systems has been disrupted. In this case, the setting-up of biodiversity corridors between the various dunes would serve to maintain a physical link between these ecologically important sites.

To ensure that biodiversity corridors are respected, it is not enough to delineate their boundaries and embark on a buffer zone management programme, it is imperative that the cooperation of local resource users is sought. In the end, conservation area system plans should be the product of informed consensus among all interested parties. Concurrently, the plan should seek to balance the requirements of society within levels well away from the carrying capacity of the environment.

Figure 4.2. Some of the main elements required for planning and management of conservation areas



4.4.1. The future of environmental strategies: lessons from implementation

As environmental planning and management is consolidated at the national level, attention will need to shift to the local (provincial) level, where the natural environment is concerned. Sub-national environmental strategy formulation—those often referred to as *local plans*—also plays an important role, where smaller areas are singled out for rehabilitation and improvement. While encouraging such initiatives, care ought to be exercised in planning such a delicate strategy. In coastal areas, where the small percentage of natural environment which remains cannot afford further degradation through insensitive planning and uncalculated risks, proposed landscape changes should undergo thorough analysis and assessment, involving all the key players from day one.

The use of cost-benefit analysis, where possible, and cost-effectiveness analysis when benefit estimates are not available, strengthen the analytical process. This is where monitoring and evaluation play an important role. By monitoring a plan's progress, the relevant agency (*planning agency* or *environmental planning agency*) can begin to understand the plan's constraints and, as a result, learn how to implement it more effectively and revise existing strategies and/or policies as necessary. In this regard, it is important for the relevant agency to ensure that its environmental strategies as well as its decision-making are consistent; because external support (general public, non-governmental organizations, scientific community, etc.) can be regarded as a crucial component in the planning process, and in determining a plan's success rate. Credibility is a lifeline element, which once lost, especially in a small country, is exceedingly difficult to regain.

The present study suggests that the conservation of endangered coastal habitats and the ecosystems they support, can only be attained if criteria for the selection and, planning and management of conservation areas are based on the systems approach. Thereby, strongly adhering to principles of interdisciplinarity, combining the natural sciences with the humanities, and applied in practical ways by the professionals in the field. Far from the historical passive role of protection and control, environmental planning and management emerges as a professional activity that demands integrative skills from the various disciplines involved. Well planned and meaningfully managed, conservation areas have an important role to play, for society at large, in raising an awareness of the interconnectedness between our natural and cultural heritage, and our future welfare.

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5

Environmental appraisal: planning and management tools and processes—environmental impact assessment and strategic environmental assessment

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5 Environmental appraisal: planning and management tools and processes—environmental impact assessment and strategic environmental assessment

5.1. Introduction

5.1.1. Rationale

Since the 1960s growing environmental awareness has focused attention on the interactions between development actions and their environmental consequences. This has been particularly important in estuaries and coastal areas. In developed countries this concern has led to the public demanding that environmental factors be explicitly considered in the decision-making process. A similar situation is now occurring in developing countries where it is either decision-makers in government environmental and health departments, or increasingly articulate environmental objectors, who are taking the lead.

Early attempts at project assessment were often crude and limited to technical feasibility studies and cost-benefit analysis (CBA). CBA was developed as a means of expressing all impacts in terms of resource costs valued in monetary terms. A number of major developments such as the proposed third London airport and the Aswan high dam, which were assessed using CBA techniques, caused considerable public disquiet. Flaws in CBA, such as its claimed ability to place realistic monetary values on "environmental intangibles", became apparent. One consequence was the development of a new evaluation approach which came to be known as environmental impact assessment (EIA). It is important to note, however, that real attempts are now being made to link EIA, CBA and risk assessment to overcome these earlier deficiencies and to achieve new objectives in the context of sustainable development. The concept of EIA was seen by the environment lobby as a potentially useful tool to assist their cause whereas in the early 1990s, EIA is now seen by many major developers as an important management tool. It has evolved as a comprehensive approach to evaluation, in which environmental considerations, as well as economic and technical considerations, are given their proper weight in the decision-making process.

When EIA was first conceived, it was regarded as an "add on" component to CBA, designed to incorporate all those potential impacts that had proved troublesome in CBA. Table 5.1. illustrates the trends in the development of project assessment and indicates how EIA has evolved in recent years, including in the 1990s the development of strategic environmental assessment (SEA).

Originally EIA was conceived as a mechanism to fulfil a legal requirement. In the United States, the first formal EIA system was enacted under the National Environmental Policy Act (NEPA) 1970. Increasingly in both developed and developing countries, environmental assessment is seen as an ongoing iterative process, which can contribute to the formulation of sound environmental management and planning strategies to help achieve sustainable development.

Table 5.1. Development of environmental assessment

Approximate date	*Innovations in techniques and procedures*
Pre-1970	Analytical techniques: largely confined to economic and engineering feasibility studies; narrow emphasis on efficiency criteria and safety of life and property; no real opportunity for public review.
ca. 1970	Multiple objective benefit-cost analysis; emphasis on systematic accounting of gains and losses and their distribution; reinforced through planning, programming and budgeting review; environmental and social consequences not incorporated.
1970-1975	EIA primarily focused on description and "prediction" of ecological/land-use change; formal opportunities for public scrutiny and review established; emphasis on accountability and control of project design and mitigation.
1975-1980	Multi-dimensional EIA, incorporating social impact assessment (SIA) of changes in community infrastructure, services and life-style; public participation becomes integral part of project planning; increasing emphasis on project justification in review process; risk analysis of hazardous facilities and unproven technology in frontier areas.
1980-1992	Attention given to establishing better linkages between impact assessment and policy-planning and implementation-management phases; research focus on effects monitoring, post-project audit and process evaluation; search begins for more disciplined scoping and focusing procedures and less protected forms of consultation based on negotiation and mediator.
1992-onwards	Role of EIA in achieving objectives of sustainable development. Applying EIA to policies, land-use and coastal management plans. SEA. Role in company environmental strategies and policies.

This module does not attempt to duplicate the description and analysis of the key features of the coastal zone and its management, which is covered in other modules. It should be noted however that it has been estimated that over 50 per cent of major projects (both existing and planned) are located either on the coastline or on estuaries.

The focus therefore of this module is on: a consideration of the concept of EIA and the main stages in the process; and the principles and application of SEA.

5.1.2. Environmental impact assessment at the project level

Definitions of environmental impact assessment

The objective of EIA is to determine the potential environmental, social and health effects of a proposed development. It attempts to assess the physical, biological and socio-economic effects in a form that permits a logical and rational decision to be made. Attempts can be made to reduce or mitigate any potential adverse impacts through the identification of possible alternative sites and/or processes. There is, however, no general and universally accepted definition of EIA and there never can be. The following examples illustrate the great diversity of definitions:

- "... an activity designed to identify and predict the impact on the biogeophysical environment and on man's health and well-being of legislative proposals, policies, programmes, projects and operational procedures, and to interpret and communicate information about the impacts";

- "... to identify, predict and to describe in appropriate terms the pros and cons (penalties and benefits) of a proposed development. To be useful, the assessment needs to be communicated in terms understandable by the community and decision-makers and the pros and cons should be identified on the basis of criteria relevant to the countries affected";
- "... an assessment of all relevant environmental and resulting social effects which would result from a project";
- "... an assessment consists in establishing quantitative values for selected parameters which indicated the quality of the environment before, during and after the action";
- "... the systematic examination of the environmental consequences of projects, policies, plans and programmes. Its main aim is to provide decision-makers with an account of the implications of alternative courses of action before a decision is made".

Such definitions provide a broad indication of the objectives of EIAs, but illustrate differing concepts of EIA. The scope of an EIA is clearly defined in only the first definition. Three definitions include socio-economic impacts, but only in the last definition is the environment mentioned. One definition implies that decision-making of the relative importance of beneficial and adverse impacts, should be part of EIA. The other definitions merely indicate that EIA is an "objective", technical and predictive exercise, with no decision-making component.

For the purposes of this module, it is assumed that the main objective of EIA is to provide decision-makers with an account of the implications of proposed courses of action before a decision is made. The results of the assessment are assembled into a document called an environmental impact statement (EIS) which contains a discussion of beneficial and adverse impacts considered to be relevant to the project, plan or policy. The completed report, or EIA, is one component of the information upon which the decision-maker ultimately makes a choice.

At this stage, others factors such as unemployment, energy requirements, urban land-use planning or national policies may influence the outcome of the decision.

A final decision can be made with due regard being paid to the likely consequences of adopting a particular course of action, and where necessary introducing appropriate mitigation and monitoring programmes.

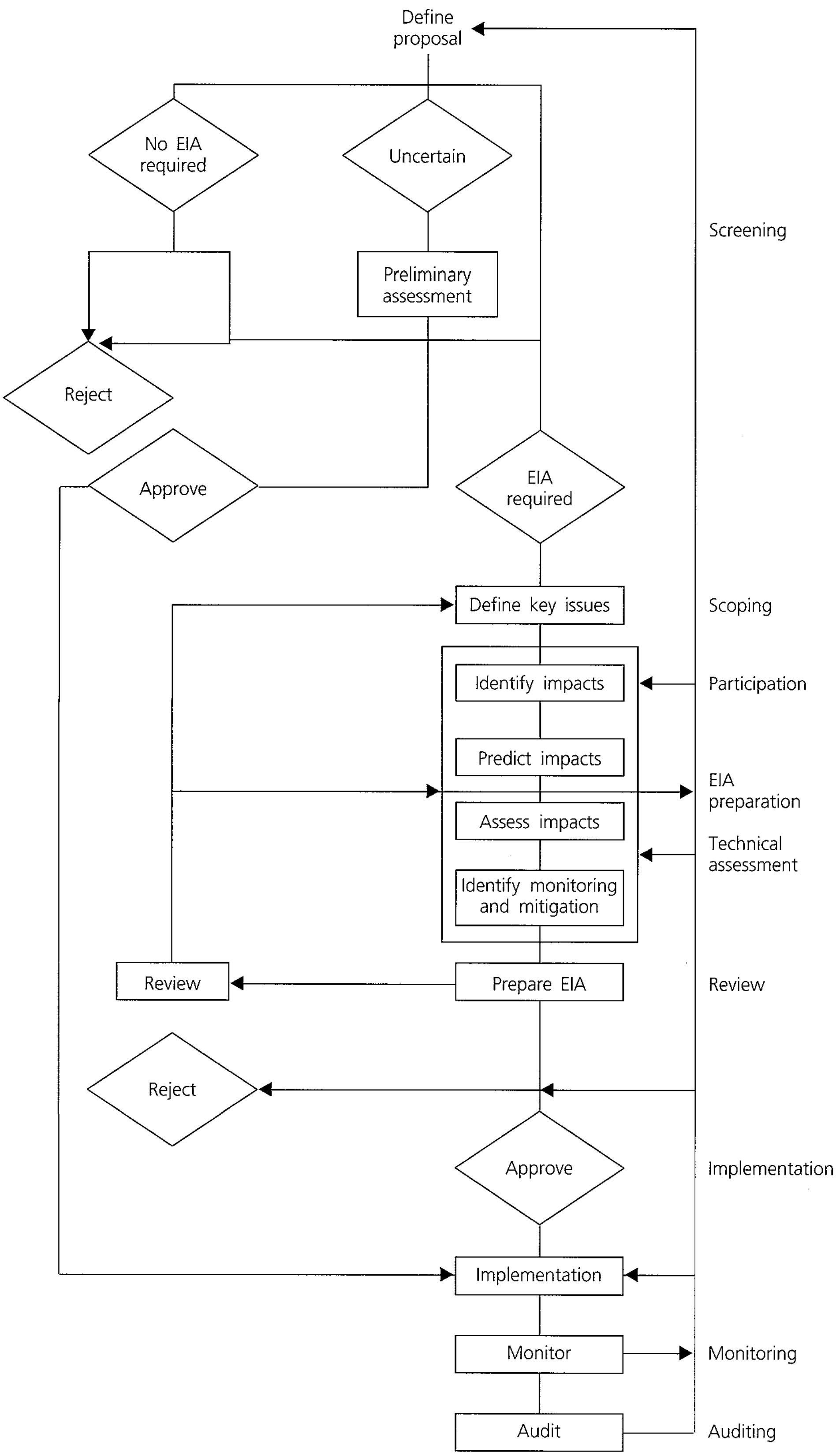
It is probably more useful, therefore, to consider EIA as a process which combines not only a procedure to ensure that appropriate urban projects are subjected to an EIA and that the results influence the planning and execution of a project, but also a method to analyse and assess the effects of a proposal on environmental systems and the quality of the environment.

5.2. Planning and management applications

5.2.1. Main stages in the environmental impact assessment process

Figure 5.1 below generalizes the main stages in the environmental assessment process as adopted in many countries. Key stages are highlighted in later sections of this module.

Figure 5.2. Main stages in the environmental assessment



In some countries an EIA is a direct legal requirement whilst in others it is enforced indirectly under general planning, health or pollution control powers. The stages include:

- *Screening* is undertaken to decide which projects should be subject to environmental assessment. Criteria used include threshold, size of project and sensitivity of the environment;
- *Scoping* is the process which defines the key issues which should be included in the environmental assessment. Many early EIAs were criticized because they were encyclopaedic and included irrelevant information;
- *EIA preparation* is the scientific and objective analysis of the scale, significance and importance of impacts identified. Various methods have been developed to execute this task;
- *Review:* as environmental assessments are normally produced by the project proponent, it is usual for a review to be undertaken by a government agency or an independent review panel. The review panel guides the study and then advises the decision-makers;
- *Monitoring* is normally adopted as a mechanism to check that any conditions imposed on the project are being enforced or to check the quality of the affected environment;
- *Auditing* is now being developed to test the scientific accuracy of impact predictions and as a check on environmental management practices.

These broadly defined stages reflect what is now considered to be good practice within environmental assessment. However, it should be noted that there are other key elements which should be included, among which the participation by the public, other government departments and agencies are integral parts of the process.

5.2.2. Selection of projects for environmental impact assessment—screening

Literature on EIA has focused on the effectiveness of EIA procedures, methods and predictive techniques in achieving desired objectives. The success of EIA, however, is only as effective as the coverage of projects to which it is applied. Little attention has been paid to the topic of selecting those projects, which should be subject to EIA. This has often led to the development of case law, which indicates to the agencies, developments for which an EIA will be required. In countries without such a procedure, guidelines rarely exist, the decision being dependent upon the scale of the proposal, its environmental setting, uniqueness of the project and the likely degree of public opposition. Because countries have adopted different approaches large disparities exist as to the number of EIAs prepared.

There are a number of means by which project selection for EIA can be undertaken. Specified development types accompanied, in some instances, by thresholds of size, cost or power requirements, may automatically require EIA. In some countries, EIAs are mandatory for certain classes of development which exceed a specific financial threshold. This approach unfortunately neglects the importance of the environmental setting of a project. The extent and significance of a particular impact depends not only on the causative agent, for example, the amount of a pollutant, but also on the sensitivity of the receiving environment. Alternatively, environmentally sensitive areas can be designated in which an EIA is required for specific developments. This approach contains the implicit assumptions that only specific development types are detrimental to certain environmental features.

5.2.3. *Scoping—defining the key issues*

It is difficult to over-emphasise the importance of scoping since the success of an EIA will depend largely upon how well the scoping exercise is conducted. Scoping refers to the process of identifying, from a broad range of potential problems, those key issues that should be addressed by an EIA. It attempts to focus the assessment on a manageable number of important questions. The importance attached to scoping arises from the fact that environmental assessments are usually conducted under serious limitations of time, cost and resources. Any priority-setting activity, therefore, should improve efficiency and provide a more focused product for decision-makers.

Many methods have been developed to assist scoping, which was given a legal status in the United States in the 1979 regulations to the NEPA. Depending upon the nature of the priority issued identified, the baseline study programme undertaken as part of the EIS can be structured around the results on the scoping exercise. The scoping programme may have a major influence on the entire EIA and upon the advice given to decision-makers and in many instances will prevent time and resources from being wasted.

5.2.4. *Preparation of the environmental impact assessment*

Description of the environmental baseline

Baseline studies consist of a description of those aspects of the physical, biological and social environments which could be affected by proposed development. They need to be conducted early on in the EA process usually following scoping, since they provide information on the "before-project" conditions which need to be established before the identification and prediction of impacts can be made. However, baseline studies may not occur exclusively at this early stage. Additional baseline data may be required later on, for example, to help refine impact predictions.

Baseline studies can account for a large part of the overall costs of an environmental assessment, particularly where they require extensive field studies. Although new data may need to be acquired, existing information from appropriate sources should be regarded as a valuable and vital resource to be used whenever possible.

Identification of key impacts

An environmental impact is an event or effect which results from a prior event. Impacts can be characterized as follows:-

> "An impact has both spatial and temporal components and can be described as the change in an environmental parameter, over a specific period and within a defined area, resulting from a particular activity compared with the situation which would have occurred had the activity not been initiated".

Impact identification brings together project characteristics with the aim of ensuring that all potentially significant environmental impacts (adverse or favourable) are identified and taken into account in the EIA process. A wide range of methods have been developed including: checklists; matrices; quantitative methods; networks; and overlay maps.

A distinction must be drawn between methods for environmental assessment, and EIA techniques for predicting specific impacts. The former normally describes a method for impact identification and may include guidance on impact evaluation; EIA techniques are concerned with predicting future states of environmental parameters, such as air and water quality and may involve mathematical modelling.

Prediction of impacts

Having established the range of impacts associated with a coastal development it is necessary to predict their magnitude. In general terms, this relies upon baseline studies to establish environmental conditions/levels prior to the project, forecasting methods to predict future conditions with and without the project, and comparison with environmental standards and guidelines where appropriate.

Predicting physio-chemical impacts such as noise, air and water quality, using quantitative modelling procedures is well established. In some cases, it is possible to follow published standard guidelines (e.g. World Health Organization (WHO standards). The assessment of other impacts are more subjective, e.g. social impacts.

Evaluation and assessment of significance

Evaluation follows from prediction and involves an assessment of the relative significance of the impacts. This may be done by reference to statutory and other guidelines such as those produced by the WHO and by consultations with appropriate organizations and the public.

Evaluation methods range from the intuitive to the analytical, from qualitative to quantitative, from formal to informal. The prediction and evaluation of impacts associated with many biological and socio-economic environmental components have tended to be more reliant on subjective value judgement in the past. This is understandable given the complexity of ecological systems and the nature of many aesthetic, social and cultural issues, but the aim should be to base environmental assessments on objective measurement and analysis where at all possible.

Several evaluation methods have been developed in order to deal with the body of complex information produced from a variety of impact predictions. All seek to reduce disparate data to a common unified base expressed either in real or arbitrary units. Aggregation methods, such as "weighting-scaling approaches", have been developed for use specifically within EIAs, while others have been adapted for use from other disciplines (e.g. extended cost-benefit analysis).

Mitigation

Mitigation is defined in European Council directive 85/337 as "measures envisaged in order to avoid, reduce and, if possible remedy significant adverse effects". Examples of methods to avoid impacts include:

- The control of solid and liquid wastes by recycling on site;
- Minimal use of toxic substances to avoid impacts on local ecosystems;
- Sensitive design of structures.

Although mitigation may follow logically from prediction and assessment of relative significance of impacts, it is in fact inherent in all aspects of the process. Mitigation measures may be highlighted during scoping activities, baseline studies, consultations etc. Mitigation measures are normally discussed and documented in each topic section of the EIA (e.g. air quality, water quality, socio-economics etc.).

Presentation of the environmental impact statement

The principal objective of an EIA is to provide decision-makers with an account of the implications of proposed courses of action before a decision is made. The results of the assessment are assembled in a document called an EIS which contains a discussion of beneficial and adverse impacts considered to be relevant to the project. A non-technical summary is an important component of an EIS, it improves communication with the various parties.

The completed EIS is one component of the information upon which the decision-maker ultimately makes a choice. At this stage other factors such as unemployment, energy requirements or national policies may influence the outcome of the decision. A final decision can be made with due regard being paid to the likely consequences of adopting a particular course of action, and where necessary by introducing appropriate monitoring programmes.

5.2.5. *Review of environmental impact assessments*

Because most EIA systems state that an assessment must be produced by the project proponent there is usually a need for an impartial, scientific and independent review. This is not to imply that all EIAs are biased and play down adverse impacts and emphasis positive ones, although there is some evidence to suggest that this occurs. The public needs to be confident of impartiality and for this reason there is a need for some form of independent review.

The review authority is often likely to be the authority from which authorization for the development is requested. Questions relating to impartiality may arise when the authorizing agency has been responsible for the EIA. An independent review agency may remove any suspicion of bias in those cases where the authorizing agency is an advocate for the development or holds unreasonable views against the development. The functions of the review authority may include:

- The "scope" of the assessment, i.e. which projects should be subjected to a full or partial EIA;
- General or specific guidelines and advice on methods of EIA;
- Formulating the terms of reference and initiating a detailed EIA;
- Ensuring that the EIA has been adequately completed within the terms of reference;
- Submitting the EIS together with any separate contributions from other organizsations, with recommendations to the appropriate authorizing agency;
- Acting as a focus for the exchange of information and opinions concerning environmental affairs.

It is essential that the EIA is not regarded as a procedure which is only to be utilized at the decision-making stages. EIAs ought to be regarded as an adaptive process which continues after the decision. It can ensure that the project conforms to the standards detailed in the relevant permissions, provide a database for any subsequent impact study as well as allowing the monitoring and control programme to adapt to changing circumstances or increased knowledge.

Decision-making

The determination of applications with an EIS is made by the competent authority (local planning authority, Secretary of State, Inspector). The competent authority reviews the EIS and may suggest further mitigation measures following consultations, and will seek to negotiate these with the developer.

5.2.6. *Post-decision monitoring and auditing*

Perhaps the area of greatest current interest relates to the concept of auditing. To many people monitoring and audits are one of the best means of converting an EIA from a static to an interactive process, characterized by feedback and adjustment. They provide information which is useful at a number of points following project approval. Ongoing monitoring, for example, provides the basis for fine tuning of mitigation measures and other management interventions to facilitate project implementation. At the post-project stages, monitoring data provides the basis for audits which can identify the record of change and verify the accuracy of predictions and the utility of mitigation. The transfer of knowledge on the nature of impacts and appropriate methods of analysis is designed not only to improve future project design and EIAs but also to assist better management of the existing project.

5.2.7. *Public information and participation in environmental impact assessments*

Public involvement should be an integral part of any EIA system. Efforts should be made to obtain the views of, and to inform, the public and other interest groups who may be directly or indirectly affected by the project. The authorizing agencies may not always identify the environmental issues which the public perceives to be important and they may also lack the detailed local knowledge that the public possesses. Advantages of participating may lead to the provision of information about local environmental, economic and social systems; the possible identification of alternative actions; an increase in the acceptability of the project as the public will better understand the reasons for the project; and a minimization of conflict and delay. Problems may nevertheless arise. Public participation may, in the short-term be time-consuming and increase costs, and participants may be unrepresentative of the community. In spite of these potential problems, many countries are actively encouraging public involvement in EIAs and the World Bank have now made it a legal requirement before any loan can be made.

5.2.8. *Financial aspects of environmental impact assessments*

Initially, EIAs may be expensive to implement, particularly in areas where little is known about existing environmental and social conditions. Design changes produced as a result of EIA findings may also increase capital costs, but it can be argued that the avoidance of deleterious impacts and the maximization of beneficial impacts will outweigh costs of an EIA system in the long-term. The cost of an EIA system will decline once procedures and techniques have been established and assessment personnel have become accustomed to their tasks. Indeed, it can be further argued that a thorough investigation of impacts at an early stage of project planning may save money by speeding up the process of implementing a proposal. The costs of EIAs are commensurate with the complexity and significance of the problem and the level of detail required.

In many countries, the cost is borne by the authorizing authority. In those countries with considerable experience in EIA, the costs vary between 0.01 and 1 per cent of the project value. It is misleading, however, to regard the "actual costs" of EIAs as being saved if an EIA is not undertaken, for if the information is required it will have to be collected by some means.

The benefits represented by EIAs have usually not been determined, because it is difficult to assign monetary values to such benefits. Many of the environmental amenities that would otherwise have been degraded or destroyed have a unique value, which over time will far outweigh EIA costs.

Many cases show that the use of EIA has allowed the choice of an option, which is both environmentally and economically superior to the original choice—for example the deposition of contaminated dredge sludge from the Rotterdam port area.

5.3. Broader concepts of environmental assessment

5.3.1. Strategic environmental assessment

At face value, SEA may be perceived of as a relatively simple concept. It is applying the principles of EIA to existing and proposed policies (environmental and non-environmental), plans, (sectoral, coastal and spatial) and action programmes. In reality, the concept, as it is now being formulated and applied, encompasses a wide range of conceptual and definitional terms, at times resulting in confusion and ambiguity. Much of this confusion arises because different countries, and organizations, have created their own jargon and definitions as to how they now assess actions which are not at the project level. Terms, therefore, such as policy appraisal, area wide assessments, regional environmental assessment, sectoral environmental assessments, now abound in the literature. For the purposes of this module the broad terms SEA will be used to consider the wide range of types and approaches which are becoming prevalent. It should also be noted that the concept of SEA is also being linked to the evolving, but nevertheless murky waters, of developing "Local Agenda 21", national sustainability, development plans, sustainability indicators and other approaches being adopted to implement the post Rio Agenda.

5.3.2. The evolution of strategic environmental assessment

EIA has now been in existence for many years in both developed, and an increasing number of developing countries. SEA has had a less rapid growth, but increasing pressure is developing for its introduction. Reasons for this are many. First, it is now recognized that the EIA of projects alone is not sufficient. Alternatives whether of site or process are often not considered, the dynamic nature of interactions between environment and development is not addressed, and cumulative impacts are neglected. Second, many people now accept that land-use plans and sectoral plans are weak as they do not consider environmental dimensions. Third, there is pressure from international agencies, and in particular the World Bank, to introduce mechanisms to ensure more sustainable practices and SEA is believed to be one potentially powerful tool.

The history of SEA dates back to the United States National Environmental Policy Act (NEA), 1969, which required reports on the environmental consequences of Federal actions. Whilst the United States included policies, plans and programmes within the procedures, the majority of assessments concentrated only on projects. SEAs have, however, been produced for legislative bills including the Fuel Use Act, 1978, and management programmes, such as a weed control programme for national parks. One reason for the success of SEA in the United States has been common procedures for strategic and project level assessments.

In the European Union, development of EIA has occurred over an extended period through the development of a European Council directive (85/337/EEC). The initial proposal planned to incorporate environmental assessments at all levels of decision-making, but because of opposition from several Member States, it was decided that implementation should be a two-stage process, initially being restricted to projects with the possibility of extension to strategic levels at a later date. Since the implementation of directive 85/337, the European Commission has published a number of draft directives on the implementation of SEA. Some Member States have already introduced their own legislation. The Netherlands and Germany, for example, require assessments for certain development and sectoral plans, such as drinking water, or waste disposal plans, and the United Kingdom of Great Britain and Northern Ireland is carrying out assessment of land-use plans and appraisal of policies.

5.3.3. The Principles of strategic environmental assessment

A general framework SEA has been defined as the formalised, systematic and comprehensive process of evaluating the environmental impacts of a policy, plan or programme and its alternatives, including the preparation of a written report on the findings of that evaluation and use of the findings in publicly accountable decision-making. The processes of SEA and of EIA are essentially similar. However, the political problems and practical difficulties of undertaking assessments at a strategic level are many and varied and it is this which has led to a lack of commitment to the implementation of SEA. The SEA process can be related to the following stages.

Screening is the process as to whether or not an SEA is required. A number of methods are available, and it is possible to list the plans and programmes which require this type of assessment,. A decision may be based on the extent or type of areas affected. As policy development is usually incremental, it is often difficult to define when a new policy or a change to an existing policy may have significant environmental effects. The overriding objective, however, of both SEA and EIA is that appraisals should only be conducted if significant impacts are likely to occur.

Scoping identifies the key issues and alternatives which should be addressed in the appraisal. While consideration of alternatives is often a small component of EIA, in SEA much of the work focuses on the viability of alternatives.

Baseline information is collected to describe the existing environment to allow predictions to be made concerning changes which will arise if the proposal is implemented. The data collected usually has to cover an extensive geographical area and will be general in nature. It should indicate trends in environmental components through space and time and highlight sensitive areas and important sites.

Impact prediction should be quantitative where possible, but in most cases qualitative predictions are utilized. Magnitude of impacts should always be included but cumulative impacts are of particular importance in SEA.

Impact evaluation is more difficult that in SEA as the predictions of impacts are often imprecise and general. Often there are no agreed standards against which to judge the acceptability of the impact so attempts to evaluate impacts usually involve assigning outcomes to qualitative categories such as high, medium or low significance, although some attempts are now being made to incorporate international environmental standards.

The EIS report is for the benefit of decision-makers and the public. Conclusions of an SEA may be less important than in a project EIA since the benefits may arise as the policy or plan is altered and adapted as environmental information is interpreted. Thus, the reporting may not be a critical part of the policy or plan making itself as the decision is likely to be concerned with the acceptability of the final proposal, rather than a comparison of the alternatives which were included at the start of the process.

An independent review of the EIS has to be undertaken both to give it credibility to the public and to consider if the EIS is technically acceptable. This stage, however, often leads to problems as it is often the proponents of a policy or plan who believe they are the only appropriate authority to review it! When a policy or plan is being implemented, monitoring should be carried out to identify the nature, extent and acceptability of environmental impacts.

5.3.4. *Procedural and methodological differences between strategic environmental assessment and environmental impact assessment*

Procedural differences arise from timing at which SEA and EIA are triggered in the planning and decision-making process.

Five key issues can be identified, as described below:

- *Confidentiality.* The draft contents of certain policies (such as details of central government budget proposals), plans and programmes, may be considered too sensitive to be released for public consultation prior to their approval. As in the case of EIA, this may be handled by exemptions from certain consultation arrangements in cases where confidentiality may justify such a strategy.
- *Constitutional issues.* Certain actions (such as high-level policy decisions) are approved by national cabinets acting under conditions of collective ministerial responsibility. If these were subject to legal SEA procedures, cabinet decisions may be subject to legal challenges in the courts. In Canada, this has been addressed by incorporating an environmental assessment procedure within Federal cabinet decision-making procedures.
- *Procedural deficiencies.* In order to be fully effective, SEA should be integrated into existing procedures at key decision-making points for policies, plans and programmes. These procedures need to meet SEA requirements concerning the provision of documentation provided by the proponent and the form of the consultation and the use of this information in the decision-making.

Within a tiered system of environmental assessment, there is considerable flexibility in selecting the stages in the planning process at which to carry out assessments. The existence of suitable planning procedures into which these may be integrated is one of the factors in making that selection.

Proponent-competent authority relationship. In many instances, the proponent may be the same organization as the competent authority, i.e. authorizing authority. One means of safe-guarding the objectivity and quality of the EIA process, in this type of situation, may be to submit the EIS to review by an independent environmental authority or commission as occurs in the Netherlands.

Curtailment of competencies. SEA may be resisted by some government departments as an intrusion into their areas of competence. Whilst SEA (like EIA) is not intended to change the decision-making responsibilities of competent authorities, there is little doubt that the introduction of SEA, particularly at a national policy-making level, is a highly sensitive issue. It provides a real challenge to governments and, more particularly, Departments with developmental responsibilities, to demonstrate that environmental factors have been given proper consideration.

It is clear that whilst assessment methods for SEA and EIA are broadly similar, there are differences in the scale and timing of the study as well as the degree of detail required. EIA methods for impact scoping, identification, and prediction can be adapted for use in SEA and methods of policy analysis and planning studies can also be used.

These differences are summarized below.

Differences in scale

The scale of an SEA tends to be much greater than that of an EIA because:

- The proposed action contains a number of different activities rather than a single project, i.e. coastal tourism plan;

- The range of alternatives that may be considered is greater (for instance, alternative locations, technologies, and land-use patterns);
- The area over which the assessment is conducted is larger because impacts are likely to be more geographically diffuse;
- The range of environmental impacts to be assessed may be greater (for instance, certain resource use impacts—water and fuel use—may be significant at the strategic planning level but not at the project assessment level).

Differences in timing

The time interval between planning and approving an action and the implementation of the specific activities which give rise to environmental impacts is greater in SEA than in EIA. This can result in more uncertainty in impact predictions for SEA since less may be known about the eventual action which may also change as it passes through the planning process.

Differences in degree of detail and level of accuracy of information

The degree of detail and the level of accuracy of information needed for decision-making is generally less than that required for project evaluation and decision-making.

Differences in available time

The time available for gathering and analysing information for an SEA is, with the important exception of some policy decisions, greater than for an EIA. Currently a number of distinctive types of SEA are evolving. Many it can be argued have a potentially important role in the future rational planning of coastal zones and estuaries.

5.3.5. Regional environmental assessment

Regional EA (REA) is the process of determining the regional, cumulative, environmental and social implications of multi-sectoral developments within a defined geographic area, such as an estuary, over a certain period. If a number of infrastructure components are planned for a discrete region, then a regional EA is undertaken, even if only one of the components in that region is planned to start in the near future. Often, REAs are undertaken when a "new" or greenfield site is planned for a different type of development, such as the first industry, or the first highway in an "unspoiled" coastal area. REAs are also commonly undertaken by provincial planning authorities when the province over which they exert control begins to "fill up" with development, so that it becomes a concern where the next development will be constructed.

5.3.6. Cumulative environmental assessment

Cumulative EA (CEA) is the process of assessing the cumulative impacts of a proposed project added to existing developments in an area, and to the impacts of foreseeable projects in the same area, whether made more likely by the current project or not. CEA and REA often overlap. The distinction is not sharp and is one of focus: an REA focuses on a specific geographic region, while including past, present and future developments with an emphasis on resource allocation between competing uses. CEA focuses on the synergistic relationships between impacts from current, past and future developments in a coastal area. CEAs are used to assess the cumulative impacts of today's project added to existing projects in the same area, taking account of foreseeable projects. Some countries (e.g. Canada) restrict CEA to future projects which are already approved and whose impacts are likely to interact with existing or proposed projects.

When a region is slated to have several major developments over a relatively short time, an agency different from the proponent of the individual projects (e.g. Port Authority) may require a special cumulative EA to assess the synergies between the proposed project at a level rarely envisaged by a specific project-level EA. Cumulative EAs may be important because the cumulative impact of all proposed projects may exceed the simple sum of the impact of individual projects. Several piecemeal EAs might identify the problems, but would not prevent or correct them.

5.3.7. Sectoral environmental assessment

Sectoral EA, the commonest form of strategic EA, is the process of examining potential environmental and social implications of all or most of the potential projects proposed for the same sector. Sectoral EA can influence project selection, which project-level EA cannot achieve. Sectoral EAs provide an environmental ranking of all proposed projects in one sector before pre-feasibility, and helps decide in project selection (e.g. on a coast a major hotel, small rent apartments, open space etc.).

Sectoral EA begins with a development objective or goal and then evaluates the numerous possibilities of meeting agreed or desired results. Instead of beginning with a pre-conceived proposal for a 200 MW coal-fired power plant at spot "x" on the map, a sectoral EA would begin with the premise of meeting projected power needs by optimal methods, including energy conservation and development of renewable energy. Sectoral EAs reduce the costs of subsequent project-level EAs, but do not obviate the need for them.

In an ideal world, sectoral EAs would routinely become part of sectoral studies. When sectoral needs and priorities are established, sectoral EAs could provide planners with the most environmentally and economically sound strategy for meeting agreed development objectives. This would introduce non-traditional options into development planning at an early stage and also increase the transparency of the decision-making process.

The value of sectoral EAs is to gather existing data and examine it to detect gaps in time to start collecting data required to make informed decisions about the selection of the next project in the sector. Sectoral EAs makes project-specific EAs much faster, cheaper and more robust because data are already assembled into information management systems and data gaps are already identified. The great power of sectoral EAs is that it helps rank potential projects in an environmental sequence, so that sound environmental projects are selected before environmentally weaker ones. Environmental ranking of all potential projects exposes society to trade-offs.

5.4. Benefits of environmental appraisal

5.4.1. Effectiveness of environmental assessment in decision-making

EIA is a mechanism which aids the efficient use of natural, human and man-made resources, and has proved valuable both to those promoting developments and those responsible for their authorization. EIA may reduce costs and the time taken to reach a decision by ensuring that subjectivity and duplication of effort are minimized. In addition it can identify and attempt to quantify primary and secondary consequences which might necessitate the introduction of expensive pollution control equipment, compensation payments or other costs at a later date.

There are a number of ways in which EIA can improve the efficiency of decision-making, but to be effective EIA should be implemented at an early stage of project planning and design. It must be an integral component in the design of projects, rather than something utilized after the design phase is completed. Preferably, EIAs should be part of an incremental decision-making process which has a number of decision-points in the project planning procedure. This means that there can be a continuous feedback between EIA findings, project design and locations. EIAs can be implemented to test alternative project designs at an early stage and to help choose the project design which emphasizes benefits and minimizes harmful effects. EIA therefore can be used not only to investigate and avoid harmful impacts, but also to increase likely benefits.

The emergence of an optimum alternative in terms of the objectives or goals relevant to a proposed coastal project means that EIAs may have significant long-term financial advantages. If a potential problem is identified early in project planning it may allow considerable financial savings to be achieved. At the crudest level the abandonment of a project may be required in terms of likely detrimental effects. This type of action is, however, very rare and normally design modifications can produce an environmentally acceptable project which at the same time will often reduce the need for expensive ameliorating action once a project becomes operational. If a development is not assessed for its likely impacts, it may cause serious social and health problems.

The incorporation of EIA into decision-making may create a number of benefits. If a forecast of the likely impacts of developments is available, allowances can be made and the coastal infrastructure can be provided in a manner whereby impacts are minimized. Where uncertainty exists as to future development, EIA can identify those areas most susceptible to adverse impacts and so guide site selection. To be effective, EIA can only be used when the alternative sites are few in number, otherwise the process can be time-consuming and expensive. EIA can, nevertheless, aid the identification of the most suitable site in terms of benefit maximization and reduction of harmful effects. Should no site be considered suitable, then the results of an EIA can aid the determination of broad environmental, social or health criteria to be used when a large number of sites are screened for their suitability.

For many reasons therefore, EIA would appear to have a key role to play in the way that proposed new developments, both in developed and developing countries, should be assessed. EIA does not provide a solution, but if conceived as a tool to assist rational coastal development it has great potential to those planning, authorizing and operating projects.

If the concept of sustainable development is to be achieved, as so eloquently promulgated by Gro Bruntland, in the World Commission on Environment and Development report, *Our Common Future,* and Agenda 21 is to be implemented, environmental assessment will be a key element in the process. As a tool EIA can attempt to balance the legitimate desire to achieve economic growth whilst at the same time protect the environment.

Regional and strategic environmental assessment can make a significant contribution towards a comprehensive and coherent system of environmental management and planning. By addressing the policies adopted for environmental protection and economic development of a coastal region or estuary and assessing them in a clearly structured fashion, potential conflicts can be identified, avoided or mitigated.

Regional, cumulative, environmental and social implications of development in a defined area can therefore be assessed, planning strategies developed, and priorities set to maximize socio-economic benefits within the carrying and assimilative capacity of productive coastal ecosystems. Regional and strategic environmental assessment also provides consistency across the planning system, allowing individual projects to be effectively assessed in the context of an overall development strategy.

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6

Institutional arrangements for implementing integrated coastal area management

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6 Institutional arrangements for implementing integrated coastal area management

6.1. Introduction

6.1.1. Rationale

Human activities and natural processes may have a harmful impact on coastal resources. Coastal areas are highly populated throughout much of the planet. It is estimated that 50 per cent of the world's population lives within 1 km of the coastal zone. Overexploitation and/or inadequate exploitation of coastal resources often brings about land degradation, loss of marine habitats, pollution of air, sea and water, and, destruction of cultural and historic sites. The environment may be, and often was, sacrificed in exchange for fast-track, albeit temporary, economic growth. In recent decades, it became apparent that overexploitation of natural systems is not viable in the long term. The need for the creation of such a development policy, which would integrate economical, social and environmental concerns, was thus realized.

6.1.2. Some basic definitions

Coastal zone

The term "coastal" usually refers, generally, to the sea-land interface. The "coastal zone" may be, therefore, defined as the area of land and sea interaction. Limits of a coastal zone are usually arbitrarily defined and have varying width, depending on the nature of the environment and management needs. Consequently, a coastal zone may represent an administratively designated area, an ecosystem area, and/or a resource base area.

Coastal area

The "coastal area" is geographically broader than the coastal zone, with less strictly defined boundaries. Specific to the term "coastal area" is a notion that national or subnational recognition exists, with a distinct transitional environment between the ocean and terrestrial domains. The coastal area comprises distinctive systems, natural and socio-economic, which aggregately constitute the "coastal area".

Coastal resources

"Coastal resources" are commodities in the production of goods and services, dependent on the coast. They include natural, human and man-made components or systems. Natural systems contain physical or biophysical units, ecosystems, flora and fauna. Human resources include such activities as tourism and recreation, exploitation of natural resources, preservation and protection of the environment. "Constructed resources" are man-made structures designed to facilitate use of natural resources (examples of constructed resources are dams, highways, treatment plants, etc.). Moreover, added cultural value may be derived from existent sites of significant cultural, historical, archaeological or aesthetic quality, which thus contribute to a specific image of a particular coastal zone.

Another important division of coastal natural resources is between renewable and non-renewable resources. Renewable resources are dominant, and they comprise resources which can be naturally regenerated to provide new supply units. Non-renewable resources (minerals and land) cannot reproduce themselves at a rate meaningful to human use.

Sustainable development

The term "sustainable development" was coined, in the early 1980s, to denote "state and process" of achieving economic and social development without compromising environmental resources and ecosystems.

6.1.3. Sustainable development perspectives

In this context, sustainable development of coastal areas may put the emphasis on the following perspectives:

- *Environmental conservation* places strict emphasis on environmental quality in general, including social and economic aspects, and, in particular, on the use of specific natural resources and waste management;
- *Economic development* stresses the viability of economic activity in general, with particular interest in balancing various economic activities, or in specific sectors of importance for coastal areas, such as tourism;
- *Social equity perspective* gives emphasis on the right to employment, accessibility to decision-making by various social groups on the basis of democratic progress, and, on the availability of opportunities and access to amenities, services and facilities.

Box 6.1. Some coastal impacts in the Mediterranean

Sea pollution:	Untreated urban waste, industrial activities agriculture run-offs, marine transport and other factors brought to severe sea pollution in some parts of the Mediterranean. Waste volumes are expected to increase from 0.4 billion to 1.5 billion cu m by the year 2025.
Beach erosion:	This widespread phenomenon is especially emphasized in southern and eastern shores of the Mediterranean. Coastal protection and defences follow conventional hard engineering solutions which often adversely affect the problem, bringing negative implications for human property and life.
Water shortages, land pollution:	Southern and eastern shores of Mediterranean suffer particularly from water shortages. Pollution and salinization further aggravate the lack of water. The annual per capita consumption increased from 90 cu m in 1980 to approximately 120 cu m by the year 2000.
Habitat loss:	In the last 50 years the Mediterranean has lost 1 million hectares of wetlands. Dune losses are also a severe problem—it is estimated that 75 per cent of dunes in southern regions have been lost since 1960.
Forest loss:	The Mediterranean forests today are mostly endangered by human activities such as massive logging, overexploitation for firewood or degradation by grazing. Fire is an important problem due to the hot and dry climate, but also due to deliberate or accidental forest fires near urban, tourist and recreational areas. Forest losses contribute to flooding, erosion, desertification, dam siltation, microclimatic changes, etc. Almost 5 per cent of the Mediterranean region is still covered by forests, although the trend is constantly decreasing.

Although the *concept* of sustainable development is widely accepted among governments and decision-makers, there is no consensus on how to *implement* and *operationalize* it. Some observers suggest that genuine sustainable development is unachievable, given current trends of resource-use in most countries, the "political" strength of some interest groups to pursue their own agenda and the many (resource-use) conflicts that prevail and which decision-makers seek to resolve.

Evidence suggests that the philosophy of sustainable development may be actually understood and/or incorporated into policy-making in very different ways. In fact, due to the lack of a universally understood definition of "sustainable development', it was not difficult for a number of governments and agencies to claim that they are practising the concept of sustainable development. Notwithstanding, the retention of old practices based on short-term oriented decision-making. Therefore, the sustainable development policy should, besides comprising certain universal principles, contain precise objectives in operational terms which are fine-tuned at the local level for each area concerned.

Sustainable development of coastal areas should be viewed as a dynamic process, by which a number of common rules for environmental behaviour are introduced, concurrently taking into account prevailing social and economic factors. A strategy for sustainable development of coastal areas should be:

- ❐ Multi-dimensional and long-term oriented;
- ❐ Targeted to critical factors (defining, for example, the critical stock of coastal resources to deliver sustainable outputs, or the critical level of quality of coastal resources compatible with the critical stock);
- ❐ Adapted to the type of problem or area it is addressed to (e.g. what species and ecosystems need to be preserved, how to control urbanization, how to provide the necessary infrastructure to ameliorate services, etc.); and,
- ❐ Instructive and realistic, in a sense that a set of precise policies must be defined in order to make implementation of sustainable development measures as efficient as possible.

Achieving complex goals set forth by a sustainable development strategy calls for an integrated approach, multisectoral coordination and the integration of such tools as decision-support systems, and those relating to environmental appraisal, e.g. EIA and SEA.

6.2. Integrated coastal area management

6.2.1. *The need for introducing the concept of integrated coastal area management*

Any single coastal resource may be used for economic and social objectives, e.g. industry, tourism, fisheries, agriculture, urbanization, transportation, and energy production. These sectoral activities produce combined environmental impacts resulting in marine and fresh water pollution, air pollution, loss of marine resources, land degradation, destruction of historic and cultural heritage, noise and congestion, etc. Governmental policies based on the sectoral approach and aimed at reducing the coastal degradation have failed to take into account the overall impact of coastal development on resources. Sectoral policies proved to be inadequate for managing complex systems, such as coastal areas.

The need to interrelate and guide the activities of two or more sectors during planning and development phases, brought about a new approach in the management of coastal areas—integrated coastal area management. ICAM can be shortly defined as a dynamic planning and coordinating process intended to achieve sustainable development of a coastal area.

The need for ICAM is obvious: tourism, for example, will not flourish in the area where industry and energy facilities have degraded the landscape and the environment in general. Sectoral solutions tend to "transfer" the problem between resources, products and services. However, ICAM should not be viewed as a substitute for sectoral planning, but rather as a link between sectoral plans to achieve more comprehensive goals.

An ICAM programme should have the following attributes:

- A dynamic process, with in-built mechanisms to allow continual updating and review (it should not be seen as a one-time project).
- A governance arrangement, which ensures that policies for making allocation decisions are established.
- A governance arrangement that uses one or more management strategies to rationalize the allocation decisions in a systematic manner.
- Management strategies based on a systems perspective, requiring a multisectoral approach for the design and implementation of the management strategy.
- A geographic boundary that is spatially defined within the sea-land interface and with an inland limit.

Box 6.2. Some principles for ICAM

1. The coastal area is a unique resource system which requires special management and planning approaches.
2. Water is the major integrating force in coastal resource systems.
3. Essential that land and sea uses be planned and managed in combination.
4. The edge of the sea is the focal point of coastal management programmes.
5. Coastal management boundaries should be issue-based and adaptive.
6. A major emphasis of coastal resources management is to conserve common property resources.
7. Prevention of damage from natural hazards, and, conservation of natural resources should be incorporated within ICAM programmes.
8. All levels of government within a country must be involved in coastal management and planning.
9. The nature-synchronous approach to development is especially appropriate for the coast.
10. Special forms of socio-economic benefit evaluation and public participation are to be used in coastal management programmes.
11. Conservation for sustainable use is a major goal of coastal resources management.
12. Multiple-use management is appropriate for most coastal resource systems.
13. Multiple-sector involvement is essential to sustainable use of coastal resources.
14. Important that traditional resource management is respected.
15. The environmental impact assessment approach is essential to effective coastal management.

Source: Clark, J. R., 1992: Integrated Management of Coastal Zones, FAO Fisheries Technical Paper No. 327, FAO, Rome

Fundamental to ICAM is the attempt to strike a balance between the various stakeholders involved and the actual management of coastal resources. Stakeholders may be relatively well organized, like ministries, sub-ministries, political parties, State- or privately-owned enterprises, non-governmental institutions, conservation organizations, etc. Less organized stakeholders also exist, for example, some sectors of the public, like coastal landowners, ethnic groups, communities within sub-standard housing areas. ICAM should strive to facilitate horizontal and vertical dialogue between all the stakeholders mentioned. Participation of the majority of stakeholders would enable discussion and consideration of local values, traditions, needs and priorities to be included during the programme's implementation.

Although the principles and methodological approaches adopted in ICAM may generally be applied across the board, each individual country will need to interpret and apply some of the guiding principles within its own national and local context.

6.2.2. The development and implementation of ICAM programmes

The ICAM process can be divided in three main separate stages: *initiation, planning* and *implementation.*

6.2.3 Initiation

Initiation includes the analysis of triggering factors which could strengthen public awareness of coastal issues and the need to take actions in coastal areas. There seems to be a similar pattern in the evolution of ICAMs at national and subnational levels. Firstly, significant coastal resource damage and/or intense conflicts among coastal activities often trigger political recognition by a national or sub-national unit for the need of an ICAM programme. This is usually followed by an awareness of ICAM programmes, which spreads via public debate, conferences and workshops. The outcome of such awareness is often succeeded by the preparation of national studies, which analyse coastal resources, suggest possible institutional arrangements and propose management strategies. National studies may then either launch a new ICAM programme or revise the existing one. This approach, whereby government bodies initiate ICAM programmes, is usually referred to as "top-down" approach. Alternative approaches, whereby local groups initiate the preparation of ICAM programmes, is referred to as the "bottom-up" approach.

In practice, the majority of ICAM programmes are initiated by a "top-down" approach. The degree of government involvement in initiating ICAM depends on the extent to which resources being managed are viewed as public goods. For example, farmers and city dwellers often view access to fresh water as a personal right, alike, but access to fisheries tends to be seen as a collective right, more naturally involving government leadership. The geographic setting also seems to have a relationship as to whether initiation is "top-down" or "bottom-up". The majority of island States seem to exert a "top-down" approach. This may be partially attributed to the pressure from international agencies to initiate ICAM efforts, since these pressures are usually applied to central governments.

A proposal to start ICAM should be prepared by the concerned parties (authorities, scientific communities, non-governmental organizations, individuals etc.). This proposal should contain all the elements necessary. Some of these elements include:

- ❐ Analysis of the prerequisites of ICAM;
- ❐ General goals of ICAM;

- Tentative boundaries of the geographic area to be considered;
- Modalities of horizontal and vertical links between institutions and organisations expected to participate in the preparatory phase;
- Financial means available for the completion of the preparatory phase;
- Work plan and timetables (activities, responsible institutions, time required).

Of particular importance is the definition of the role of the coordinating mechanism which will be responsible for guiding the ICAM process during the preparatory phase. This mechanism has the task of bringing together various governmental and non-governmental institutions involved in ICAM, in order to prevent conflicts among them, and to enable a rational use of financial and human resources needed for the implementation of ICAM.

Final decision on launching the ICAM process lies within an authorized political body. However, that body may also decide that the conditions for launching the ICAM process have not yet matured. In such case, it is advisable to reconsider the decision after a period of time.

6.2.4. Planning

Planning refers to the development of policies and goals, and selection of concrete sets of actions (strategies) to produce the desired mix of goods and services from the coastal area over time.

Preparation

This phase of the planning stage usually starts with the preparation of a coastal profile. The coastal profile helps identify the coastal resources, activities, uses, habitats and protected areas, as well as major resource management issues, such as open access to coastal resources, multi-purpose use, development patterns, user conflicts and specific priorities for management in a coastal area. The second task is to prepare the ICAM programme, using the previously prepared coastal profile and inputs from various sectors and interest groups. The ICAM programme should consist of the following:

- Precise definition of the coastal area, i.e. the area boundaries;
- Identification of the main problems of the area and their causes (sector by sector with emphasis on problems requiring cross-sectoral solutions);
- Proposal of the general goals and objectives of development and environmental protection;
- Identification of information gaps;
- Analysis of other planning programmes and project activities, with an assessment of their impact on the coastal area and in relation to their relevance for ICAM activities;
- Proposal for the preparation of the integrated coastal master plan;
- Analysis of legal requirements posed by the proposal (e.g. a need for new legislation or for changes in existing legislation);
- Proposal of institutional arrangements needed to support the coordination and implementation of ICAM.

Table 6.1. Stages, phases, activities and outputs of the ICAM process

Sectoral inputs	*Stages*	*Phases*	*Activities*	*Outputs*	*Political decisions*
Triggers: past decisions, new decisions, external influences	**INITIATION**	*INITIATION OF ICAM*	Analysis of prerequisites for ICAM Tentative boundaries of the area Preparation of the proposal for initiation of ICAM	Proposal for the preparatory phase of ICAM	To start ICAM
Sectoral problem identification	**PLANNING**	*PREPARATORY ACTIVITIES*	Definition of coastal area Identification of sectoral and cross-sectoral problems Proposal for general goals and objectives Preparation of development environment, outlooks and tentative strategy Identification of information gaps Definition of legal, financial and institutional requirements for ICAM Proposal for integrated Coastal Master Plan preparation procedure	Coastal profile ICAM programme	To establish ICAM as a continuous and long-term process
Sectoral analysis and forecasting		*ANALYSIS AND FORECASTING*	Issue-oriented new surveys (generation of missing primary data) Analysis of natural and socio-economic systems Forecasting of future demand Generation of cross-sectoral scenaria and selection of preferred scenario	Alternative scenaria	
Definition of sectoral goals and strategies		*DEFINITION OF GOALS AND STRATEGIES*	Proposal for sectoral and cross-sectoral goals and objectives Preparation of alternative strategies, including legal requirements, financial implications and institutional arrangements Evaluation and selection of strategy	Management strategy	Approval of goals, objectives and strategies
Sectoral plans		*INTEGRATION OF DETAILED PLANS*	Allocation of land and sea uses Proposal for implementation procedures (legal, institutional, financial) and relevant instruments Definition of implementation stages Draft integrated Coastal Master Plan presented to relevant body for approval	Integrated Coastal Master Plan	Adoption of Integrated Coastal Master Plan and relevant policies
Sectoral plans and policies	**IMPLEMENTATION**	*IMPLEMENTATION OF PLANS*	Phasing of ICAM proposals and policies Application of economic, regulatory, and environmental evaluation instruments in development control Adaptation of institutions to ICAM	EIA CBA	Approval of implementing instruments used in the development control process
Sectoral monitoring		*MONITORING AND EVALUATION*	Redefinition of cross-sectoral problems Identification of inadequacy of instruments	Evaluation study	Update of ICAM process

Source: UNEP, 1995: *Guidelines for Integrated Management of Coastal and Marine Areas—With Special Reference to the Mediterranean Basin,* Split, PAP/RAC (MAP-UNEP).

Analysis and forecasting

This follows the preparatory stage, and once the decision to establish ICAM has been made, a far more detailed stage of analysis is to be carried out. The purpose of this phase is to provide an analytical basis for the establishment of precise goals and objectives and definition of management strategies for sustainable development in the coastal area. In this phase, it is necessary:

- To carry out new surveys in order to identify selected issues within sectors of human and economic activities, natural system processes and institutional arrangements;
- To analyse the natural systems in the coastal and marine area;
- To analyse the system of human and economic activities in the coastal and marine area;
- To estimate (forecast) future demand for goods and services from coastal resources, and their capacity to fulfil these requirements;
- To prepare alternative cross-sectoral scenarios, and to select the most effective one.

Definition of goals and strategies is one of the most important phases of the whole ICAM process. Before proceeding further, decision-making bodies at the highest level have to approve the goals and strategies of environmentally sustainable development in the coastal area concerned. Within this phase ICAM goals and objectives should be refined and adopted, alternative strategies for ICAM prepared, and, the most suitable strategy for ICAM implementation decided upon. On the basis of goals and objectives defined by relevant government levels, coastal area management policies should be developed.

One of the objectives of ICAM is to avoid policy conflicts which often cause environmental problems in coastal areas. In other words, during this phase it is necessary to coordinate various aspects of individual sectoral policies (for example, among fisheries, tourism, land-use, industry, etc.). The most important element of coastal area management policies is political commitment to see that policies are translated into action.

Policies should be carried out throughout the implementation of various management strategies. Strategies are a succession of logical steps aimed at the realization of the goals and objectives which were set in the initial policy statement. The objective of this ICAM phase is to integrate the sectoral and cross-sectoral management strategies. A typical integrated strategy should pay attention to the pattern of future activities in the area, and indicate the intended changes in the physical, economic, social and environmental life of the coastal area as a result of implementation of desired policies.

In most cases alternative strategies could be generated. The final output of this phase is a document that may be called "management strategy" or "strategic plan". It should not be too detailed, but consist of the major dimensions such as: future population growth, economic structure, social patterns, basic land and sea use, major infrastructure systems, environmentally sensitive areas, conservation requirements, priorities, institutional structure, legal and financial requirements, etc. This document is intended for use by decision-makers with the aim of final acceptance of the *coastal area management strategy* which will serve as the basis for the preparation of a coastal management plan in the next phase of the ICAM process.

Integration of detailed plans

This is the ICAM planning phase in which the document called "integrated coastal master plan" (ICMP) should be completed. ICMP is a complex document, which requires substantial institutional and financial resources. The objective of the ICMP is to create conditions for making operational decisions in the implementation phase of ICAM by means of a detailed elaboration of the selected cross-sectoral management strategy prepared in the previous stage. ICMP includes detailed site-specific proposals for land and sea use, based on detailed plans for prioritized areas. In addition, the ICMP should outline the basic administrative framework which the plan requires for its implementation, and which is already broadly defined within the ICAM framework.

6.2.5. *Implementation*

Implementation is the final stage of ICAM, which consists of two phases: *implementation of plans* and *monitoring and evaluation.*

Implementation of plans

This is the stage in which the proposals defined in the integrated coastal master plan should be formally adopted at an appropriate government level. An adopted plan should have legal status. Solutions and policies should be implemented in a coordinated way. Plan implementation is most efficient if implementation phases are defined. This phasing is essentially a breakdown of the ICMP proposals which usually cover periods of up to 20 years, divided into short, medium and long-term achievement targets. To implement the process, it should be broken into smaller, manageable tasks or investment projects; this should ensure adaptability by the administrative system, the budgeting process and the public at large. An important advantage of phasing is the minimization of risk and of uncertainty in the planning process. Phasing reduces the element of uncertainty in the implementation process by bringing long-range goals into closer perspective and limiting the range of time over which specific planning objectives are expected to be reached. Of great importance in this phase is the application of instruments to determine the environmental effects of the plans and projects defined by ICMP. It is specially recommended that EIA and CBA be included in the process of ICMP implementation.

Monitoring and evaluation

Monitoring and evaluation of ICAM implementation are both broadly concerned with the assessment of the performance of the ICAM policies and the results achieved by ICAM over the years, relative to the goals and objectives of the ICAM process. The monitoring part of the ICAM process must establish a regular flow of information on the decisions, actions and investments involved in the implementation of the ICAM. Monitoring and evaluation allow for continuous revision and updating of goals and objectives in the light of actual performance, effectively securing continuity and integration of the ICAM process.

Evaluation is a process that attempts to determine, as systematically and objectively as possible, the relevance, effectiveness and impacts of programme, plan, or project activities in the light of their objectives. In order to undertake an evaluation procedure as rigorously as possible, one will have to determine an evaluation framework. The evaluation framework contains a number of key dimensions within which an evaluation procedure is carried out. These dimensions are:

- Performance dimension, which distinguishes between the successes and weaknesses within a programme, plan or a project. It concerns, first, the perception of the extent to which the intervention has fulfilled its objectives. The extent of success or failure could be measured in multiple terms: in measurable outcomes (e.g. the number of water connections, kilometres of roads, etc.), and in less quantifiable terms (in changes such as attitudes, awareness, strengthening of institutions, etc.). Secondly, in the analysis of the performance it is important to distinguish between factors which are the result of the intervention itself (which might depend, for example, on the internal consistency of the goals and objectives of the ICAM initiative) and those factors that originate in the wider context where the programme, plan or project operates, i.e., externalities (which might affect the performance of the initiative, for example, inadequate interministerial coordination, lack of plan implementation mechanisms, etc.).

- Integration dimension, which refers to the level of horizontal or vertical interlinkages or interdependencies achieved among sectors, planning interventions or administrative levels in the area concerned. Distinction is being made between *sectoral* integration (level of coordination among the sector-specific concerns), the integration of *environmental components in the socio-economic context* (adequate concern for the interaction of human activity and natural ecosystem, and their mutual impacts), the *governance* integration (ensuring that all the actors involved are coordinated among the various administrative levels concerned), and the level of *participation* (among government institutions, private sector, non-governmental organizations, general public, etc.);

- Sustainability dimension, which deals with the follow-up prospects of the initiative. It shows whether these prospects have been taken into consideration, either in the form of a mechanism directly built into the initiative, or in the form of a context created to allow the long-term implementation of the initiative's proposals. A distinction can be made between the *financial* aspects (whether an adequate financial system has been put in place), the *institutional* aspects (whether adequate institutional arrangement exist. to implement the initiative's proposals), and *political* aspects (whether there is enough political commitment for implementation).

To conclude, ICAM is in many cases a government-sponsored process. It should, however, always include other major stakeholders in ICAM. To avoid or resolve conflicts among ICAM stakeholders, proper institutional arrangements for ICAM should be established and conflict resolution techniques devised.

Box 6.3. Assessment of ICAM initiatives in the Mediterranean: experience from METAP and MAP (1988-1996)

Mediterranean Environmental Technical Assistance Programme (METAP) of the World Bank and Mediterranean Action Plan (MAP) conducted a comprehensive analysis and evaluation of ICAM initiatives in the Mediterranean, at three levels:

- Classification (typology) of 30 interventions, which were identified as coastal area management initiatives in the region. The analysis was limited, because of the amount of data available.
- Further analysis of 14 of these initiatives, for which the relevant questionnaire was received.
- In depth analysis and evaluation of nine case studies.

Several important lessons could be learned from this evaluation:

Performance

- an evaluation mechanism has to be built in right from the beginning, while programme monitoring must be linked to evaluation throughout project implementation;
- fulfilment of project level objectives in the planning phase does not automatically lead to implementation of recommendation or of the plan;
- fulfilment of project level objectives does not ensure impacts beyond the immediate project area, unless results are widely disseminated and replicated elsewhere.

Integration

- environmental concerns must be integrated into the design and implementation of an initiative from the very beginning;
- a programme could be issue-oriented at the outset, taking primarily into account most of the factors contributing to these problem issues, but will have to become more comprehensive at later stages in order to deal with all complex linkages and provide integrated solutions;
- the interested national institutions, demanding and initiating the project should be better identified at an early stage;
- policy interventions must be closely linked to the objectives of the ICAM initiative;
- without undermining the importance of technical capacities, it is advisable to ensure that the solutions to technical problems relevant to coastal environments be adapted to the local customs and cultural context.

Sustainability

- strong political commitment at all levels to the preparation and implementation of initiatives is the most important determinant of sustainability of an initiative;
- participation of stakeholders and end-users from the design phase through project implementation is of utmost importance;
- a longer-term sustainability of the project should be secured, while greater importance should be accorded to an easier utilization of project results by the institutions and those who benefit from these results.

Source: MAP—METAP. 1996: *Assessment of Integrated coastal area management Initiatives in the Mediterranean—Experiences from METAP and MAP (1988-1996).* Washington, D.C.: World Bank.

6.3. Institutional arrangements for integrated coastal area management

6.3.1. Rationale for institutional arrangments within integrated coastal area management

Creation of institutional arrangements in any society is needed in order to use scarce resources efficiently and to resolve conflicts among competing stakeholders. Institutional arrangement may be defined as the composite of laws, customs, and organizations established with the goal of efficient resource allocation and conflict resolution.

Institutions for ICAM have three roles:

- An executive role, for decision-making;
- A judicial role, for enacting regulations and directives, standards and procedure, enforcement and arbitration;
- A market role, allocating funds, offering incentives or subsidies.

Various institutions are present in each of the stages of ICAM. Practical evaluation of ICAM initiatives throughout the world confirmed the notion that the earlier an institutional arrangement for planning and implementation of ICAM is selected and established, the more likely will an ICAM initiative be successful. Selection of adequate institutional arrangements is dependent on various sources of complexity: sectoral, geographical and hierarchical.

Sectoral differentiation

This is a result of specialization of governments in various sectoral policy areas. Sectors which are most often coastal specific are fisheries, mariculture, shipping and navigation, port and harbour development, tourism and recreation, marine and coastal research, shoreline erosion control, certain national defence operations (coastguard, customs). Often a single government agency exists with responsibility for only one of these sectors.

There are also sectors which are usually not coastal area specific, but have direct impact on coastal area management. Some of them are: transportation, water pollution control, water supply, oil and gas exploitation, energy, agriculture, forestry, housing, etc. Each of these sectors may also be under the responsibility of a separate government agency. Specialization is further increased with the functional divisions of agencies due to their regulatory and/or intervention power.

Examples of governmental intervention are:

- Regulation of private development;
- Long-term planning;
- Coastal area property management;
- Funds allocation;
- Taxing and levying charges;
- Education and scientific research.

Geographic differentiation

This relates to the scale of the geographic area on which ICAM decisions should be taken. The geographic division of governmental responsibilities occurs both lengthwise along and perpendicular to the shoreline axis. Responsibility of government agencies may change for the same sectoral function at the shoreline boundary, or different government agencies may be responsible for different activities within the same sectoral function.

Functional differentiation

This stems from the significance of ICAM decisions in the national context (national, regional and local level). National level administration should be concerned with development and implementation of broad coastal management policy. This would include preparation of a *coastal area management act*, a *coastal area management strategy*, and designation of a *lead agency* for coastal management at the national level.

More detailed, but integrated planning and management are needed at the regional level. Regional authorities should have responsibility to ensure the consistency between the activities of local governments to reduce current trends of overburdening the coast. Detailed planning, development and implementation takes place at the local level.

ICAM should be incorporated into national development plans, to ensure appropriate institutional and budget support. Basically, institutional framework for ICAM may be established either by integrating the institutional structure or by coordinating the various agencies responsible for coastal management on the basis of common policy.

Integration

This is an important mechanism in ICAM planning and implementation. Institutional arrangement may be considered integrated when it is under an entirely new, integrated institutional structure (systematic integration) or when various agencies and other stakeholders are being coordinated in order to achieve common goals by following mutually agreed strategies (multisectoral integration). Integration of the ICAM planning and implementation requires:

- *Systems integration*, which attempts to ensure that all relevant sectoral interactions are taken into account;
- *Functional integration*, which represents harmonization of envisaged programmes with stated objectives in coastal area management;
- *Policy integration*, which focuses on integration of management plans and policies with development plans and policies.

Integrated ICAM processes and relevant institutional arrangements are not easy to achieve. They are typically the result of the long history and experience in ICAM planning and implementation. In reality, few countries have shown a proven capability of efficient integrated nation-wide management of coastal areas.

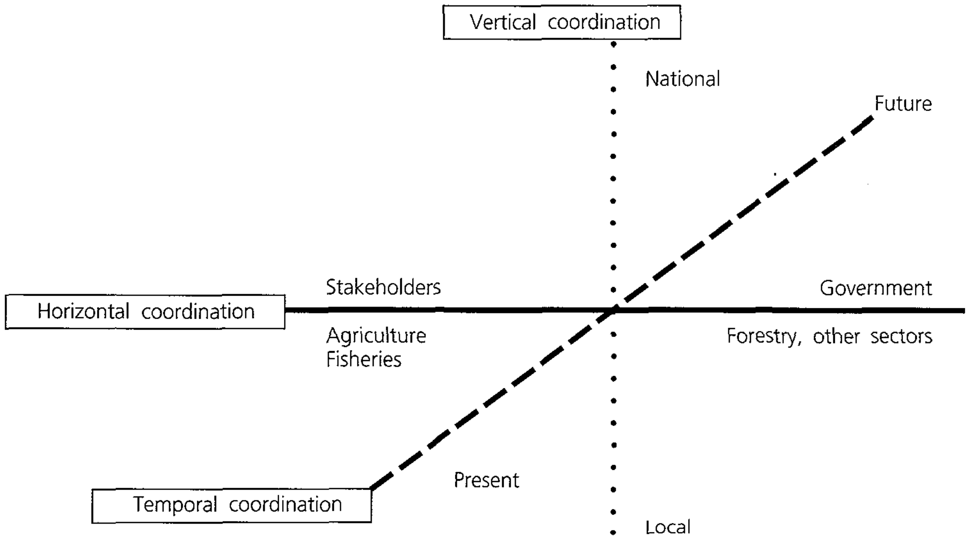
Coordination

In ICAM implementation, *coordination* refers to a system in which independent components of the system work towards a common objective. Coordinated ICAM institutional arrangement aims at bringing together various interested stakeholders (government agencies, scientific community, non-governmental organizations, minorities, resource users) towards the common goal of sustainable development of coastal areas. Coordination is needed to promote stakeholders' communication, enable conflict resolution and minimize overlaps and gaps in responsibilities for use of coastal resources.

At least three levels of coordination in ICAM exist:

- *Horizontal coordination* is aimed at cooperation within a specific level of government hierarchy;
- *Vertical coordination* represents cooperation between various levels of government hierarchy, national, regional and local;
- *Temporal coordination* refers to optimal management at any stage of the ICAM process.

Figure 6.1. Various levels of coordination needed for ICAM



Source: Guidelines: Integrated Coastal Area Management and Agriculture, Forestry and Fisheries (Rome, FAO, 1998).

Coordination is a method, typical of ICAM implementation where coastal management powers are already decentralized. Also, coordination is most often preferred to integration because estblished ministries and accompanying departments have a tendency to want to retain their power and responsibilities, and are reluctant to transfer their responsibilities to newly established institutions. The selection of the most appropriate institutional arrangement is, therefore, a critical part of the ICAM management process. Among the criteria for selection of such an arrangement are:

- Compatibility of the institution's mandate with its proposed functions as the coordinating agency;
- Capacity to lever funding for ICAM from concerned ministries or a combination of national sources and donor funding;
- Institutional experience in multisectoral or integrated planning;
- Long life expectancy and ability to survive changes in government;
- Strong constituency base and ability to perform well in negotiations with line ministries in the ICAM process;
- A strong institutional capacity for ICAM driven by the culture, morale and technical competence within the organization;
- A holistic approach to policy issues;
- Adaptability to new procedures and policy instruments;
- Willingness to involve local communities.

Obviously, the range of possible institutional arrangements for ICAM is simply enormous. Different types of institutional arrangements for ICAM implementation are discussed in the next section.

6.3.2. *Stakeholders in integrated coastal area management*

ICAM is a complex process with many stakeholders (actors, parties, interest groups) involved. The "stake" is the value, use or interest which some stakeholder has in the resources base. Views of the stakeholders on the value of a resource may be both subjective and objective. These views affect the level of success in planning and implementing ICAM progress. On the other hand, proper ICAM implementation may affect the subjective and objective position of stakeholders and their appraisal of coastal resources' values.

Effective institutional arrangements for ICAM should have embedded mechanisms which prevent or provide smooth resolution of disputes between stakeholders. Institutional arrangements should, therefore, enable negotiations within same interest groups, as well as between various interest groups of ICAM stakeholders.

Major stakeholders in ICAM can be divided as follows:

(a) State or parastatal organizations. Coastal areas, adjacent sea and some of the relevant resources are usually under public ownership. Therefore, governments prepare programmes for use of coastal resources and operate coastal areas for the benefit of all stakeholders. Typically, particular government ministries, departments, and/or agencies are responsible for particular resources, at various governmental levels.

- *National (central) government.* The active support of the central government is critical for the eventual success of an ICAM programme. Central government is typically the provider of funds for major ICAM programmes. It also provides the expertise and databases for coastal area information. Regulative mechanism usually rests with individual departments of the central government.

- *Regional (State) government.* In federally organized countries (for example, United States, Australia, India), regional governments may have the responsibility for the management of the particular coastal area. In these countries, therefore, regional governments can give the impetus for launching ICAM programmes and provide the relevant funding.

- *Local government.* In countries with multi-layer governmental management, local government is that entity mostly concerned and affected by the economic, social and environmental state of particular coastal area. Furthermore, many of the stakeholders in the coastal area are constituents of the local government. This is the reason why local governments need to be fully involved in ICAM programmes.

- *Line agencies and ministries.* The sectoral planning is the responsibility of line agencies and ministries. Ministries and agencies specifically entrusted with some type of coastal resources management possess the best expertise in their particular fields (for example, fisheries and aquaculture management, tourism, control of coastal erosion, etc.) and are therefore very important participants in ICAM.

- *State-owned enterprises.* In some nations a part or whole coastal dependent sector (e.g. oil and gas exploration) may be nationalized.

(b) Stakeholders with dominant commercial interest. Parallel with government, there exists an equally powerful sector, and this comprises the stakeholders with commercial interest in coastal resources. The most important are privately owned enterprises, multinational corporations and coastal landowners.

- *Privately owned enterprises.* Private industries ceased to treat coastal resources as self-renewable. Instead of unsustainable use of coastal resources, their own private interest and general public awareness forces them to use careful and nature-sensitive techniques of exploitation in coastal areas.
- *Multinational corporations.* A single multinational company may have greater political power and greater financial resources than a national economic sector. Due to that, multinational corporations may be dominant stakeholders in any new ICAM initiative. Their role in development of national economies is still being discussed.
- *Coastal landowners.* An important group of coastal landowners with speculative interests often exists. Individual landowners may come into dispute with national governments if restrictions are imposed on coastal development, in order to preserve cultural heritage of the country or to enable all people equal right of access to the coast.

(c) *Other coastal stakeholders.* There are many other individuals or interest groups which are involved in activities that take place in a coastal area. Especially fast growing are those interest groups which place a high value on aesthetic, touristic, health, and environmental values of the coastal area. These stakeholders often influence public opinion and generate the political will to initiate specific ICAM programmes.

- *United Nations agencies and international assistance organizations.* The United Nations, through its individual agencies (UNEP, UNESCO, UNIDO; etc.) offers theoretical and practical assistance, primarily to developing nations, on many various ICAM issues.
- *National and international non-governmental organizations.* Many national and international non-governmental organizations exist today, with a particular interest in nature conservation. These organizations are neither governmental agencies nor private for-profit firms. They are especially important in raising public interest on specific environmental issues. Non-governmental organizations tend to form coalitions with social classes, consumer and ethnic groups, and other local stakeholders in order to gain influence and bargaining power in negotiations with governmental institutions.
- *Social classes and consumer groups.* Strong separation between social classes and/or consumer groups may in some countries prevent broad participation in ICAM programmes. Moreover, different ICAM programmes, policies or tools and techniques may affect different social classes and consumer groups in distinct ways. Therefore, coastal management must deal with competing aspirations of classes. Often, as a result, a specific social class is simply excluded from negotiations about particular coastal issues.
- *Ethnic groups.* Existence of different ethnic groups with different interests within the same coastal area may pose extreme obstacles to the implementation of ICAM programmes. This problem is even deepened when an ethnic group reflects a certain social class background at the same time. Regulatory mechanisms can not be the only solution to conflicts of this type.
- *Political parties.* Although coastal issues are rarely a major concern of political parties, some interest groups could articulate their requests by means of political discussions.

The above list of coastal stakeholders is by no means complete. However, the number of various coastal actors highlighted, illustrates just how sensitive coastal managers should be when preparing and implementing ICAM programmes in order not to create new conflicts, or aggravate existing ones.

6.3.3. *Types of institutional arrangements*

Continuing from the previous discussion, a country could choose one of the following *main institutional arrangements* for ICAM implementation:

New centralized government agency

This agency is usually entrusted with jurisdiction over the coastal zone and power to enact, amend and complete an ICAM plan and to prepare the necessary legislation. Sri Lanka, the British Virgin Islands and the State of California chose to establish such an agency.

In 1981, Sri Lanka created the Coastal Conservation Department (CDD), charged with responsibility for coastal protection and coastal area management. Policy integration is achieved through the mechanism of the 1990 Coastal Zone Management Plan. This plan addresses well-defined coastal management issues, sets out the regulatory framework for coastal permits, proposes changes to the legislative, administrative and financial framework for the coast, and stresses the need for more research, public awareness and education.

Centralized government agencies may be very effective in resolving conflicts between various stakeholders and harmonizing development of various coastal-dependent sectors. However, establishing a new agency requires the highest level of efforts and commitment of a substantial amount of human and financial capital. A significant obstacle to create such an agency, as highlighted earlier, is the reluctance of existing line ministries and agencies to transfer their duties and responsibilities to a new agency.

Lead agency

This institutional arrangement is characterized by expanding the duties and responsibilities of an existing agency responsible with some aspects of coastal area management. This approach is appropriate only when sufficient laws and authorities to properly manage coastal resources exist; the main requirement would be the better coordination and enforcement of existing legislation. A *lead agency* usually has the mandate to prepare a coastal management plan, and the power to direct actions of other government agencies. Examples of appointing a lead agency exist in the United States, China and Costa Rica.

Costa Rica, for example, decided to entrust the Costa Rican Institute for Tourism with the mandate to implement the 1977 Coastal Zone Law. The Institute is intended to be the primary vehicle for achieving vertical policy integration and institutional coordination. In addition to preparing tourism development plans, the Institute is responsible for drafting a general plan on land-use in the coastal area.

There are some inevitable problems which may arise when the implementation of ICAM is envisaged by a lead agency. These problems could be overcome, firstly, by giving the lead agency a clear mandate, and, secondly, enough power to ensure greater cooperation between agencies and legislative streamlining once the new ICAM legislation is enacted.

Permanent interministerial or intersectoral council

These councils usually have the authority to devise a coastal management plan, issue guidelines for the integration and coordination of existing policies and to develop appropriate laws. Setting up interministerial councils is motivated by the notion that no single agency has sufficient power, information, capacity and authority to fully implement ICAM plans.

Box 6.4. Example of government organizations structure for coastal management—Indonesia

Line agencies	*Responsibilities relevant to coastal management*
Department of Agriculture/ Directorate General of Fisheries	Fish and aquaculture management
Department of Forestry/Directorate General of Forest Protection and Nature Conservation	Marine conservation and protected areas, mangrove management
Department of Communications/ Directorate General of Sea Communication	Ports, shipping, navigation, safety, including emergency responses
Department of Mining and Energy/ Directorate General for Oil and Gas	Gas and oil exploration and production
Department of Education and Culture/Universities	Education and research
Department of Security and Defence/Hydrographic and Oceanographic Service	Territorial water security, hydrography
Department of Industry	Development and waste management
Department of Public Works	Engineering and erosion control
Department of Tourism, Post and Telecommunication	Tourism
Coordinating agencies	
Ministry of State for Environment	National coordination
Environmental Impact Management	Environmental impact assessment
National Development Planning Board	National Development Plans
Department of Home Affairs/ Directorate General of Regional Development	Regional development
Ministry of State for Science and Technology/Technology Assessment and Application	Natural resource inventory
National Coordinating Agency for Surveys and Maps	Coastal mapping
Indonesian Institute of Science/ Research and Development Centre for Oceanology	Marine science and research
Coordinating Committee for National Sea Bed Jurisdiction	National boundaries and Law of the Sea
Coordinating Board for Marine Security	Security in national waters
Non-governmental organizations	
Indonesian Forum for Environment	National coordination of non-governmental organizations
World Wide Fund for Nature	Marine conservation, public education
Asian Wetland Bureau	Coastal wetland management, aquaculture development, environmental impact assessment
United Nations, Educational, Scientific and Cultural Organization	Marine pollution, education
International Union for the Conservation of Natural Resources	Marine protected areas
United Nations Development Programme	Marine pollution
Clean Coastlines and Beaches	Public awareness, coastal litter and pollution
Mangrove Foundation	Mangrove conservation and sustainable use
Indonesia Green Club	Sea turtle conservation; public awareness

Source: Kay, R., and Adler, J. 1999: *Coastal Planning and Management*. London: E&FN Spon.

Ecuador, Indonesia, Thailand and the Philippines have constituted various types of interministerial councils, with the task of coordination sectoral planning and implementing ICAM policies. Often a top government executive or his/her delegate serves as a chairman of such councils. Permanent interministerial or intersectoral councils proved to be more efficient in gathering data and writing ICAM guidelines than in implementation of ICAM policies on-site. If not properly run, councils may represent merely another layer of bureaucracy in the governmental institutional framework.

In addition to the main institutional arrangements for ICAM implementation, several *supplemental institutional arrangements* exist.

Non-executive advisory committee

Such a committee should consist of members from several government agencies and interest groups. An advisory committee should study coastal area management issues in detail in order to advise an executive government agency on how best to address them. One advantage of advisory committees is that they bring valuable insights to coastal problems and make proposals for conflict resolution. A further advantage of non-executive advisory committees is that they do not require additional staff and that they usually include coastal stakeholders other than State and parastatal institutions.

Regular interdepartmental or intersectoral consultations

This type of institutional arrangement may supplement a permanent interministerial or intersectoral council. However, it will usually be less powerful and more informative rather than problem-oriented.

Ad hoc panels

This may be a more or less formal type of institutional arrangement for ICAM. An ad hoc panel could serve to supplement lead agencies or interministerial councils. The role of ad hoc panels is to produce greater understanding on some scientific or management issue. Opposed viewpoints of scientific experts may be represented at ad hoc panels. In this way, through joint fact-finding and discussion exercises, any disagreements may be overcome and clear recommendations will thus be proposed on the specific ICAM management policies.[1]

There can be no uniform prescription to any national, regional or local government as to what type of institutional arrangement is the most appropriate. A new, centralized government agency may be good choice for countries with a long history of ICAM management and implementation, proper enacted coastal laws and good integration of sectoral planning.

Many countries, however, use some kind of coordinated institutional arrangements. Nations with strong traditional sectoral planning might start with a permanent interministerial council. When stronger integration of sectoral policies in the ICAM process is achieved, these countries may seek lead agency or, even, new centralized government agency approaches. Most developing countries will encounter difficulty with comprehensive institutional arrangements. They often lack national coastal legislation or have weak law enforcement mechanisms. The best approach here is the gradual amendment of existing laws and coordination of ICAM policies by means of interagency guidelines. Developing countries may start with supplemental institutional arrangements, establishing more formal arrangements parallel with development of coastal legislation, tools and techniques for ICAM and public awareness.

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[1]Ad hoc panels have been created in many countries for specific coastal research agendas. Some observers even believe that the most significant progress in international environmental cooperation was made through multinational scientific investigations.

6.3.4. *Conflict resolution techniques in integrated coastal area management*

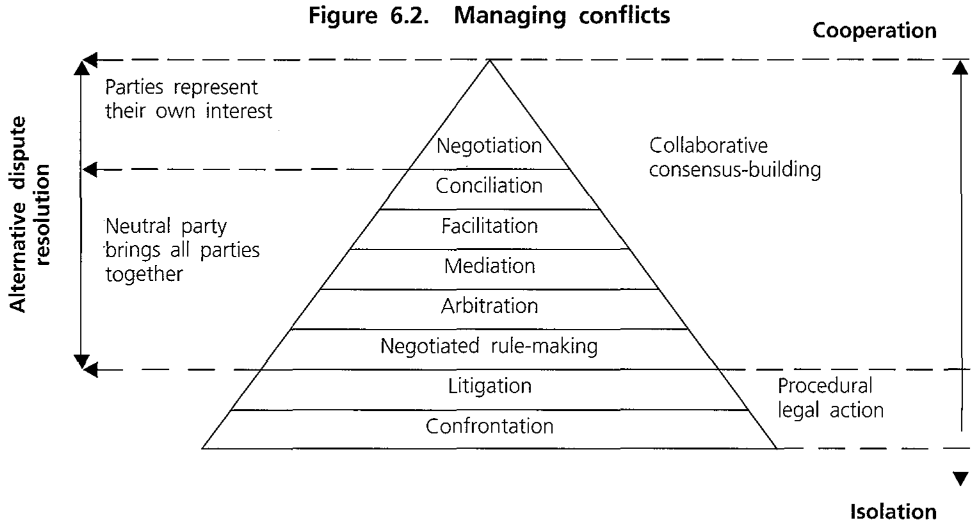
Limited availability of coastal resources provokes various types of conflicts between competing resource users. Conflicts may arise between governmental institutions and private landowners, between various sectors (e.g. industry and tourism), between residents and non-residents of the coastal area, etc. Disputes very often evolve due to exploitation of resources, taking into account only their current market values. Some disputes can be avoided if all parties are aware of the intrinsic value of resources in dispute, taking into account also their social and/or environmental costs and benefits (so called "externalities").

Adequate planning and implementation of ICAM processes, as well as appropriate legal and institutional arrangements for ICAM, may prevent conflicts or facilitate dispute resolution. On occasion, conflicts produce significant positive effects—they can stimulate public discussion on coastal issues and bring about institutional changes, which in turn may result in a more equitable and sustainable use of resources.

Parties in dispute may have an option to settle their conflict to their mutual interest. This is the case when a conflict situation is not a "zero-sum game", in which gains of one party means loss for the other party, but a "plus-sum game", in which all parties in dispute gain overall through collaborative effort. Plus-sum game includes so called "win-win solutions" with outcomes, which, as a result, all parties concerned in the dispute will, in the end, be better off. Collaborative resolution of disputes, however, is not always the best option for all conflicting parties.

Conflict resolution techniques range from resolving disputes through procedural legal action to building a collaborative consensus.

Figure 6.2. Managing conflicts



Source: Guidelines: Integrated Coastal Area Management and Agriculture, Forestry and Fisheries (Rome, FAO, 1998).

Figure 6.2 illustrates the main conflict resolution techniques, described below.

- *Litigation* represents a technique of resolving conflicts by means of a judicial system. Solving disputes in courts is typically a zero-sum game, which produces a "win-lose outcome". Judicial mechanism is an appropriate mechanism for conflict resolution in cases when conflict is governed by clear legal rights. The decision of an arbitrator is legally binding for all parties involved. The litigation, however, rests on an adversarial approach to conflict resolution, and court decisions are being made on the basis of narrow points of law.

Wider issues, regularly present in disputes that arise in the context of ICAM, are often not taken into account and the real differences between contending parties remain unresolved. Furthermore, in many jurisdictions legal rules prevent lawsuits unless some particular right has been directly infringed. In these jurisdictions, individuals or organizations can not, for example, represent the interests of the damaged environment which, itself, has no legal rights.

Alternative to litigation and judicial decision-making are *collaborative conflict resolution techniques.* Fundamental to these techniques is that they encourage parties in dispute to reach solutions that they can all support. The final result should not be a compromise at any cost, but a synergy gained through creative cooperation.

- *Negotiation* is a collaborative conflict resolution technique in which parties in dispute meet each other to reach a mutually acceptable solution.
- *Conciliation* is a process in which discussion between parties in dispute is initiated by an outside party. The outside party, conciliator, does not engage actively in settling the dispute.
- *Facilitation* is a technique in which an outside party, the facilitator, agrees to moderate discussions about an existing conflict. Role of the facilitator, similar to the role of conciliator, is not an active one. S/he should simply enable everyone to express his/her own opinion on the dispute.
- *Mediation* is a conflict resolution technique in which parties in dispute call upon a neutral outside party, the mediator, to oversee the negotiations. The mediator, unlike the conciliator and the facilitator, takes an active role in conflict resolution, expressing his/her own ideas and finally deciding how the conflict is to be resolved. The main quality of mediation is that it induces parties to achieve a mutually beneficial agreement, without imposing any rules on them.
- *Arbitration* is a technique similar to solving conflicts through the judicial system, but less formal. An outside party, the arbitrator, makes a decision on the basis of presentations of the conflicting parties. This decision may or may not be binding, pending on the previous decision of parties in dispute. The arbitrator is usually an expert in the subject-matter of the conflict.
- *Negotiated rule-making* is a combination of mediation and negotiation. Regulations which govern application of laws are as a rule being prepared by governmental agencies. The process involves the drafting of regulations by a few experts, then circulating the drafts for comments and, subsequently, publishing both drafts and comments. This process often neglects opinions of the parties affected by new regulations. The negotiated rule-making technique offers affected parties a possibility to express their views on the subject and influence the final contents of new regulations. In this way, acceptable solutions are reached by regulators and affected parties, thereby reducing possible litigation costs and delays in implementation of new laws. This technique is still not in broad use due to prevailing reluctance of decision-makers to delegate their decision-making power to other parties.

In sum, every effort should be made to resolve environmental conflicts worldwide, through the use of collaborative techniques rather than resorting to the use of litigation processes.

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7

Decision support systems as a tool in coastal zone management

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7 Decision support systems as a tool in coastal zone management

7.1. Introduction

7.1.1. Rationale

The multitude of environmental problems in dynamic and unpredictable natural systems calls for new methods that make use of recent development in data and dynamic decision support models. A decision support system (DSS) is a computer-based interactive system that helps managers in solving semi-structured problems (Sprague, 1980; Turban, 1986; Murphy and Stohr, 1986).

"The concept of decision support has evolved from two main areas of research: the theoretical studies of organizational decision-making done at the Carnegie Institute of Technology during the late 1950s and early '60s and the technical work on interactive computer systems, mainly carried out at the Massachusetts Institute of Technology in the 1960s." (from Addison Wesley series on decision support, foreword by Peter G. W. Keen and Charles B. Stabell, May 1978).

Decision support systems are playing an important role in assisting today's organizational decision-making. The implementation of the sustainable development idea has repercussions on both coastal management and the demand for DSS to aid the policy and decision-making processes in connection with coastal problems. As a result of the widespread recognition of coastal zone related problems, policy changes and actions for improving the planning and management of coastal areas have been coming forth.

An effective DSS will create new possibilities to attack vexing problems of poverty, inequality and environmental degradation with the potential to achieve unprecedented gains in economic and human development.

The main objectives of the module are to illustrate the concepts of decision support systems as a whole, with emphasis on coastal management; to demonstrate the methodology used to assess the main policy failures as a result of improper coastal resource use; and, to simulate the discussion on public participation in decision-making.

The training module is divided into two sections. The first section consists of theoretical background of decision support systems and information systems. This section will include definitions of DSS and will make emphasis on the decision-making process, different decision support systems types and decision analysis. Topics such as group decision support systems (GDSS) and public participation in decision-making will also be discussed.

In the first section, trainees familiarize themselves with the historical background of decision support systems and how the concept of information systems evolved during the last decades. This section will illustrate different subjects related to DSS, ranging from basic definitions of DSS to the analysis of the decision process. The case-study will be applied as an example throughout section 1. A list of discussion topics is presented at the end of each topic.

The second section of the module consists of a simulation game concerning a fictitious coastal problem case-study. This section will expose trainees to hands-on opportunities in relation to the decision-making process.

7.1.2. Evolution of information systems[1]

"The first computers were used to process numerical data for solving calculations and to automate repetitive calculations. Electronic computers found commercial uses in the 1950s. Their first large-scale use to process business-like data was a Univac I at the United States Bureau of the Census in 1951.

Automated data processing was later used by a number of corporation for their operations such as payroll etc. Such operations were previously done by a punched card tromechanical process and called electronic data processing. These terms were shortened to "data processing".

Decision-makers realized then the importance of transforming the huge amount of data existing in their computers into valuable information. The decision-makers then asked for reports that contained every possible data, which led to the development of the information reporting system.

By the 1960s the information technology began to evolve and instant access to the data was possible, which led to the evolving of the management information system (MIS).

Decision-makers realized that in fact they did not need all these data in their reports and there is no need for a global MIS to have useful information. As a result, a new system was evolved in the 1970s to assist decision-makers to interact directly with computers to create information useful in making unanticipated semi-structured and unstructured decisions (Hicks, 1993) these systems were called decision support systems."

Discussion topics

- What are the different information systems? Give examples.
- How useful are these systems?

7.2. Decision support systems

7.2.1. Definitions of decision support systems

Decision support systems, by definition, are to help people make decisions, however, there are several definitions of DSS, including the following:

- "... a set of tool, data, models, and other resources that managers and analysts use to understand, evaluate and solve problems";
- "... an integrated set of computer tools that allow a decision-maker to interact directly with computers to create information useful in making unanticipated semi-structured and unstructured decisions" (Hicks, 1993);
- "... a computer-based information system that affects or is intended to affect how people make decisions";

[1]Mallach, 1994.

- "... a computer based system that is used on an on-going basis by managers themselves, or their immediate staffs, in direct support of managerial decision-making" (Keen and Morton, 1978)
- "... decision support systems are used for less structured problems where the art of management is blended with science" (Kanter, 1992)

7.2.2. *What is a decision?*

A decision is a choice among alternatives. A decision statement, a set of alternatives and decision-making criteria characterizes each decision.

- Decision statement: states what we are trying to decide;
- Alternatives: the possible decisions we can make;
- Decision-making criteria: what we want to optimize in a decision.

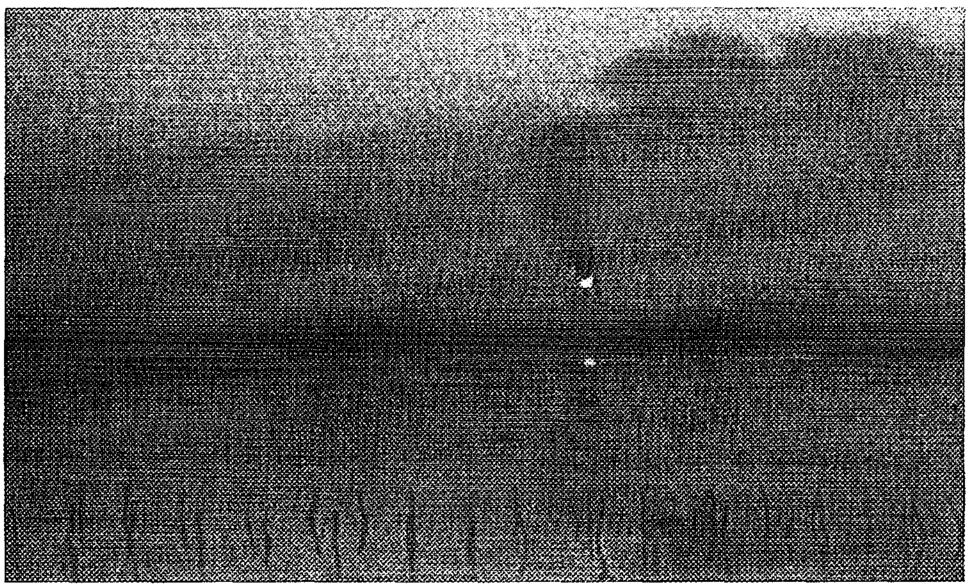
7.2.3. *Why take a decision?*

- There is a problem;
- The problem is important and needs to be solved;
- There are obstacles preventing solving the problem;
- There are several ways to solve this problem.

7.2.4. *Case study*

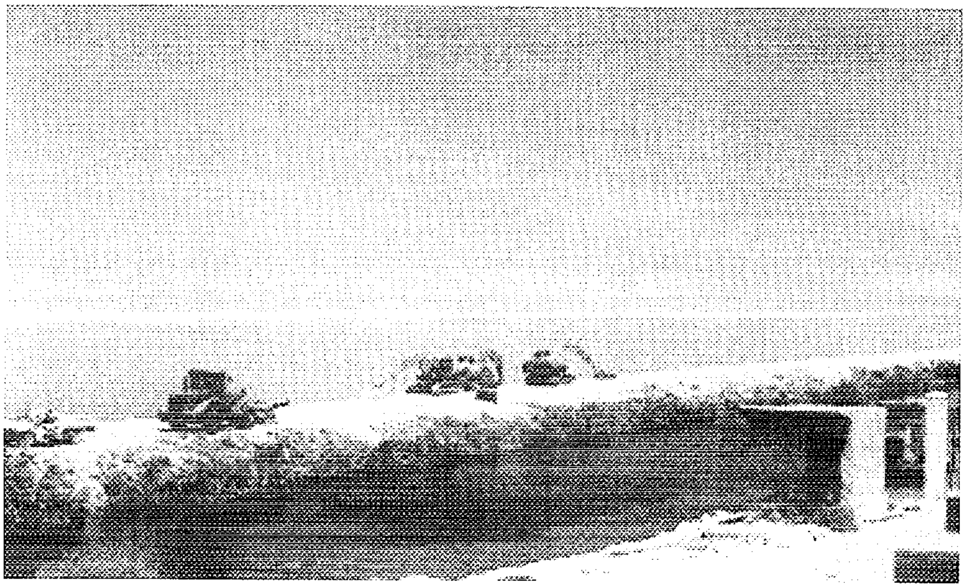
A large brackish water lake is subjected to chemical, biological and agricultural pollution. Industrial pollution is a result of a vast number of factories around the lake (figure 7.1) The factories contribute to the economy of the area and employ a large number of locals. Parts of the lake were filled out for urban expansion (urban expansion is contributing to the economy of the area by providing more jobs and providing more touristic villages which could be built as a result of this expansion.

Figure 7.1. Factory development



The majority of the people living around the lake are fishermen. The fish production of this lake is dramatically affected by the pollution and by the dewatering of the lake (water level is another function of the fish catch). The tourism industry has also been affected. The land value around the lake has decreased. There are direct health impacts on the people living around the lake and the surrounding areas. There are some major construction activities (figure 7.2) (roads, bridges etc.) which led to dividing the lake into individual basins (figure 7.3).

Figure 7.2. Construction activities



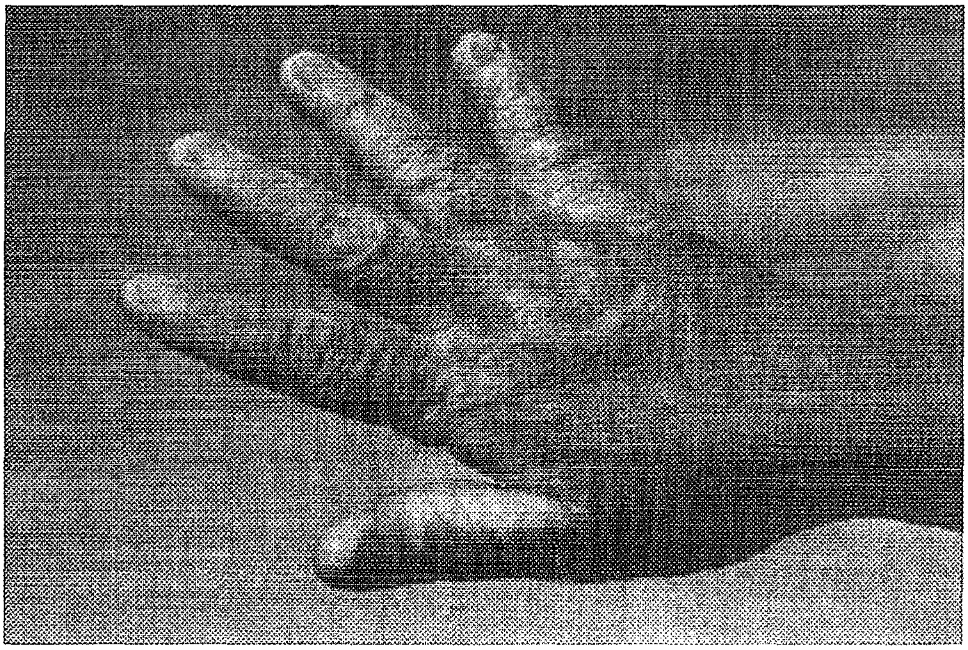
The lake receives drainage water, domestic and industrial wastes from five major drains, as well as from 40 industrial plants. Industrial wastes are discharged through pumping stations. The lake water is extremely saline and has appreciable organic loading, significant concentrations of oil and grease and a very high fecal coliform level. As a result of this pollution fish and wild life inside and around the lake have been severely damaged.

Figure 7.3. Lake basins

The current phase of the lake's decline could be traced back to the late fifties of the last century when thousands of acres of its southern parts were dried and reclaimed to be used as agricultural land. Despite the fact that the fishermen were offered plots of the agricultural areas, a house and livestock each, as compensation for the areas taken from the lake, very few of them accepted the offer. They simply refused to become farmers instead of being fishermen. Even though it reduced the size of the lake considerably, it did not affect the productivity of the remaining parts.

The lake's environmental degradation, and depletion as a natural source of fishing that provided a living for thousands of fishermen and their families entered a very critical stage when the lake was made into *the* "sewage dump", receiving most of the near city's sewage, which formerly used to go into the sea, without any form of treatment. The city's sewage, which contained a considerable percentage of chemical pollution, added to the growing toxic pollution caused by the numerous factories located around the lake, many of which used to dispose of their waste in it. Figure 7.4 illustrates the impact of repeated exposure to the toxic brew in the lake that may have caused a fisherman's hand to become blotchy and swollen.

Figure 7.4. Pollution exposure



Currently, industrial waste presents the most dangerous component of the lake's pollution. Industrial pollution, comes through agricultural drainage canals and through the city's sewage system. Agricultural drainage canals, which bring water that is heavily polluted with pesticides, come second in significance. Least harmful is the biological component of the sewage water.

The decrease in production automatically decreased the fishermen's income, the lake's produce was declining while they (i.e. the fishermen) had at the same number of mouths to feed. Naturally, many fishermen had to search for other sources of income in view of the fact that very few of the lake's species of fish, survived the pollution and remained available in near city's markets, the lake's production was full of dangerous chemical pollution that fish were unable to survive. The environmental degradation of the lake made what used to be a beautiful natural resort, and an extremely productive fishery, into an unbearable place to live or work in.

Discussion

In the above-mentioned case study-area, the decision statement is clear: "What should be done to stop the pollution and increase the fish production?" Trainees have to discuss what is the possible decision we can make (possible alternatives) and what are the decision-making criteria.

7.2.5. The decision process

As defined by Herbert Simon, every decision has three phases; intelligence, design, and choice.

The intelligence phase

This phase involves finding, identifying and formulating the problem or situation that calls for a decision (deciding what to decide).

The design phase

The design phase is where we develop alternatives. Two important points should be considered:

- What are the available options?;
- Objectives for the decision should be stated.

For example, in deciding what to do about the lake, we have several choices:

- Stop the industrial pollution (negative impact on the local economy);
- Increase the water level and dredging the lake (discuss the impact on other stakeholders);
- Stop all urban expansion and major construction projects (other stakeholders are against this strategy including some governmental planners);
- Build a water treatment plant for primary treatment of sanitary wastes (additional cost to government).

The above mentioned are only a few of many choices that we could think of in such a situation. These choices can also be broken down further and will be discussed in the next sections.

The choice phase

In the choice phase, we evaluate the alternatives that we developed in the design phase and choose one of them. The end product is a decision that we can carry out.

Example

For the lake problem, we might decide a choice based on budget practicality and current legislation. If we have a limited budget, we could stop filling out the lake and apply legislation, which limits chemical pollution in the lake. If we have a more flexible budget, we could start dredging the lake and try to get the lake back to its original size. If we decide a choice based on a different priority the final decision will come out differently. (Try to get a decision based on the fish production.)

The choice could be a combination of several solutions depending upon factors that have been mentioned previously.

7.2.6. *Types of decisions*

Following Keen and Scott Morton (Keen, 1978), decisions can be categorized by the nature and the scope of the decision.

- A structured decision is one in which a well-defined decision-making procedure exists;
- A unstructured decision is one in which all three decision phases are unstructured;
- A semi-structured decision has some structured aspects but cannot be completely structured;

The three levels of decision reflected in table 7.1 (Anthony, 1965) are as follows:

(a) Strategic decision: a decision that affects the entire organization, or a major part of it, for a long period of time. The effects usually encompass:

- Organizational objectives and policies;
- Generally made at the upper levels of organizational management;

(b) Tactical decision: a decision that affects how a part of the organization does business for a limited time into the future:

- Takes place within the context of previous strategic decisions;
- Made by middle managers;

(c) Operational decision: a decision that affects activities taking place in the organization right now but either has little or no impact on the future or—if it does—is made within the confines of a controlling policy:

- Relates to activities whose tasks, goals, and resources have already been defined via prior strategic and tactical decisions;
- Made by lower-level managers or by non-managerial personnel.

Figure 7.6. Decision grid

Decision	*Operational*	*Tactical*	*Strategic*
Structured	1	2	3
Semi structured	4	5	6
Unstructured	7	8	9

7.2.7. *The anatomy of a decision*

The following are the main steps that should occur when applying a decision-making process:

- Problem definition;
- Identify the criteria;
- Identify strategy variables;
- Assign weight to each criterion;
- Assign weight to each variable on each criterion;
- Formulate the strategy;
- Compute the optimal strategy.

7.2.8. *Group decision support systems*

"One of the first ministers for environment in Western Europe used to say that environmental protection is a school for democracy. His prophecy is justified by the growing importance of public participation in decisions related to the environment".[2]

Due to the increase of environmental degradation in the last decades, the issues of environmental protection have been raised in the last years. Human rights and environmental protection went hand in hand. This includes the right for all humans to participate in planning projects which may deteriorate their natural environment, however the public participation role in the decision-making process in the third world is still missing.

Definition of group decision support systems

A group decision support system (GDSS) is a decision support system whose design, structure, and usage reflect the way in which people cooperate to make a particular decision or type of decision (Mallach, 1994).

Reasons for group decision support systems

Organizational reasons are:

- The decision-making environment has become more complex;
- The increased complexity of many aspects of decisions;
- The growth of rapid or instant communications media.

Technical reasons are:

- Wide area and fast telecommunications links, a necessity for many group GDSS, are becoming less expensive;
- Gateway to local networks with high-speed links to decision-makers, desktops is now available.

Group activities

This is by definition anything we do in groups that we could not do equally well as individuals.

Group think

This may be defined or dealt with as follows:

(a) "The tendency of some groups who work together over a period of time to produce poorly reasoned decisions" (Janis, 1972);

(b) "The tendency of group members to fall into similar thought patterns and to disapprove, implicitly or explicitly, of opinions that do not conform to these patterns";

[2]Quoted in Nagy and Bowman, 1994.

(c) "When social pressures and conflict avoidance overtake the desire to rigorously question alternatives, contradicting opinions are suppressed in favour of occurrence seeking. Eventually, the growing cohesiveness within the group leads to shared illusion of invulnerability (Bazerman, 1998);

(d) "Group decision support systems can help overcome group think where it is an obstacle to reaching good decisions. They do this by making it less threatening for group members to violate group norms by stating new opinions or by agreeing with them. In some cases they do this by providing anonymity to opinions. Even where they do identify the person associated with an opinion, both research and experience have shown that people are more willing to state their views candidly when typing at a computer terminal than across a conference room table. Group DSS can also help by enabling junior members of a group to state their opinions before they know what senior members think, which is difficult in a face to face meeting."

Discussion topics

- ❐ Group versus individual activities;
- ❐ Difference between DSS and GDSS;
- ❐ Impact of group thinking on GDSS;
- ❐ Examples of the growth of GDSS.

7.3. Public participation in decision-making[3]

7.3.1. Background

The "right of environment" was mentioned for the first time at the United Nations Conference on the Human Environment, held in Stockholm in 1972, which linked human rights and the environment. Later several national and international declarations, conventions, legislation and treaties were developed.

Public participation in environmental decision-making is not only advocated by the Rio Declaration of 1992 and Agenda 21 adopted by the same conference; it is also included in the most recent international treaties concerning the protection of the sea and rivers, related to transfrontier pollution (Nagy and Bowman, 1994).

7.3.2. Historical context

The term public participation in environmental decision-making is not exactly a new term, there are a lot of examples of such practices throughout the history of mankind. In the Middle Ages, around 1000 A.D., the lives of people living in the low countries bordering the sea (Netherlands, Germany and Denmark) have continually faced the eternal struggle against the threats of the sea. For that reason, land reclamation and water level control out of sheer necessity preoccupied them. Dike building requires management and regulations, which date back to 110 A.D. These are the Rustringer rules of law, which directly involved the people living in these areas. In the Netherlands this system and this structure of direct public involvement still exist.

[3]Quoted in Nagy and Bowman, 1994.

7.3.3. Legal framework

This involves: public awareness; logical consequences; and structuring public participation in a legal framework.

Major ecological disasters causing heavy losses, such as the follwing, had a great impact on the development of public participation: Seveso in Italy, 1976; Chernobyl in Ukraine, 1986; and Bophal in India 1987.

7.3.4. Basic rights

This involves: a right to information; a right to lodge comments; a right to initiate legal proceedings; and a right to participate.

7.3.5. Participation instruments

This involves: notice and comment procedures; public hearings; advisory committees; international treaties; environmental impact assessments; and other instruments.

7.4. Case study simulation game

Participants will be divided into smaller groups (teams consist of 3 persons). The fictitious case study that was presented throughout section A will be simulated. The trainer will discuss the problem and issues related to the case study in brief. The handouts with detailed information about the location and the problem will be given to each group. Each group (team) will choose to represent one of the stakeholders of the lake. The group usually consists of members representing a group of people with the same opinion and may include one expert to assist in addressing special issues (water quality, chemical pollution, economic constraints etc.). The facilitator/trainer will try to form teams with diverse opinions. Another handout will be given to each group with more detailed information about what the team should be presenting. The teams should start by defining the main problem of the case study (each team may present its own problems). The second step is to identify the criteria that will be used in the decision model (water quality, fish production etc.). Teams have to get to a common understanding of the main variables affecting the case study (water level, fishing season etc.). Teams must present their inputs and fully understand the decision process behind the model. Through individual and group discussion each team will present its strategy by assigning weights to the proposed variables. The assigned weights could be expressed in terms of shares (0-100). The groups must divide the 100 shares for all the proposed variables. These shares express the degree of importance of the variable to each stakeholder. The trainer/facilitator will collect the team strategies and present all strategies and compare different weights assigned to each variable by different groups. The average of each weight assigned to each variable will be calculated and compared with the collected individual group weights. Another round of discussion will be conducted and each group could modify its weights. The facilitator will present the result as in the first round etc. until reaching stability or until no change in group weights is taking place. At the end, all strategies will be evaluated and further discussion should be conducted on the impact of each strategy on the different criteria.

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8

Integrated coastal zone management as a toolbox for environmentally sustainable industrial development in coastal areas

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8 Integrated coastal zone management as a toolbox for environmentally sustainable industrial development in coastal areas

8.1. Introduction

8.1.1. Rationale

Coasts and estuaries are the areas where there can often be conflicting pressures between economic and social activity and the maintaining of improvement of environmental quality. By definition, coastal zones include the ecosystems of coastal plains, deltas, estuaries, coral reefs and the shelf seas.

Continuing protection and enhancement to the environment must be ensured. Precaution must be encouraged and risks anticipated. A long-term view must be taken where the predicted impacts on the environment are perceived as being irreversible. If the effects are perceived as being reversible then appropriate assessment measures and monitoring must be planned in order to effect remediation.

Furthermore, a broad view must be taken which is precautionary and assumes, for instance, potential transport of chemical contaminants to the deeper ocean where our knowledge of toxic impacts is singularly lacking.

8.1.2. What causes coastal and estuarine stress?

Stresses are caused by:

- Natural forces such as sea level rise and coastal erosion;
- Coastal zone development—industry, transportation and ports, urban development, recreation and tourism;
- Mining and resource removal—industrial extraction of metals and other minerals (e.g., oil and gas, metals, gravel and coral for construction), overfishing and the cutting of mangrove forests (can lead to erosion);
- Discharges—municipal and industrial outfalls, release of water used as ballast (i.e., for balance) from ships (can contain exotic species of plants and animals from other parts of the world, which can then spread out of control as in the Black Sea), atmospheric deposits and land run-off;
- Illegal practices—dumping of waste and chemicals from ships and oil spills.

The concept of "integrated coastal zone management" (ICZM) supports regional transboundary level programmes (e.g., the Global Environmental Facility (GEF) Gulf of Guinea Large Marine Ecosystem Programme) for inter-governmental bodies. A significant proportion of the human population (up to 70 per cent, depending on the definition of "coastal zone") lives in close proximity to the coastal zone, often in the vicinity of large estuaries and river deltas, and is frequently dependent on the fishing industry for food, employment and wealth generation.

Consequently, the coastal and shelf areas are the most vulnerable zones of the ocean, since they are the most heavily used regions of the planet, with immense industrialization.

Coastal zones receive a multitude of waste inputs originating from industrial land-based sources (approximately 60 per cent of all pollution inputs). A complex mix of other toxic chemical pollutants is also introduced through shipping activities, offshore petrochemical industries and atmospheric inputs of airborne particles of industrial origin. To further complicate this already complex situation, coastal zones include the most diverse and productive ecosystems in our oceans.

8.1.3. Need for impact reduction

Recent economic studies have placed a higher value on coastal zones ($12.6 trillion/year for coastal zones out of a global total of $33.3 trillion/year) than any other compartment of our environment (Costanza *et al.*, 1997).

The world's coastal regions (e.g., estuaries and deltas) are often characterized by a very rich diversity of plants and animals; particularly those situated in the tropics. In spite of their abundant natural resources, these areas are often environmentally sensitive and fragile regions owing to their particular natural physical setting and their distinctive ecological features and functions. Considerable changes are already occurring in the ecology of many coastal regions as a result of both natural and man-made changes largely linked to industry. These include upstream dam construction, coastal zone modification and erosion, urbanization, forest clearance, agriculture, fisheries, industrial development, oil and gas production and human population pressure.

In the future, changes are also likely to be brought about by sea level rise and increased harmful UV-radiation. Such, often conflicting pressures have resulted in the environmental degradation of many estuarine and delta regions; unless this trend is reversed it will undoubtedly lead to increased conflicts over resource rights and deprive the indigenous population of their main source of protein (i.e., fish). To further exacerbate the situation, continuing problems of water supply and sanitation (associated with pollution and water-related diseases) are likely to result in considerable human deprivation and death.

Example

The Niger Delta, one of the world's largest deltas, is a vast coastal plain covering some estimated 70,000 square kilometres in the central part of southern Nigeria. It is an area endowed with immense natural resources, including forests, mangroves and especially hydrocarbon deposits. Crude oil production and exports from the region dominates the Nigerian economy, accounting for over 90 per cent of the nation's total export earnings. This delta is already subjected to many of the problems described above.

8.2. Dealing with risk

8.2.1. An integrated approach

A way forward in dealing with the complexity of problems found in delta areas is through the implementation of effective ICZM. ICZM holistically assesses the changing states of deltic and coastal ecosystems based on information obtained from five operational modules: ecosystem productivity; fish and fisheries; pollution and health; socioeconomic conditions; and governance protocols.

These modules link science-based information to socioeconomic benefits for countries sharing or bordering on large estuaries and deltas. The methods are used in an integrated interdisciplinary way in order to address the consequences of ecosystem change and the ensuing implications for sustainable exploitation and development of food resources, as well as the needs of industry and the impact on human health. It is essential in the use of these methods to always strive to address the needs and welfare issues of regional populations, as well as the requirements of industry for sustainable economic development.

The methodology of ICZM brings together, by necessity, elements for dealing with the complex interactions of the many and varied demands placed on the coastal zone. Examples of these include habitat destruction (harbour construction and fish farms), industrial and municipal discharges and the often poorly regulated use of resources by the fishing industry. The methods are implemented through training (sharing of expert knowledge and technology transfers) and capacity building. These are firmly grounded on strategic science-based assessments and monitoring (Bayne and Moore, 1998; Livingstone *et al.*, 2000; Lowe *et al.*, 1992, 1995; Minier and Moore, 1995; Moore *et al.*, 1994, 1997), linked to standard internationally agreed quality assurance protocols.

The interfacial character of the questions being addressed requires an holistic approach. Hence, any proposed integrated management strategy must be truly interdisciplinary if an effective capability for risk assessment and prediction is to be developed in relation to resource sustainability. The process of estimating risk associated with the possibility of future events in the coastal zone has two principal elements:

- A capacity to predict environmental impacts which when related to dynamic processes typically involves the use of simulation models in environmental forecasting of natural and man-induced events;
- The calculation of risk itself, which requires a probabilistic analysis of predicted events, typically using Monte Carlo simulations, Markov Monte Carlo methods, dependency bounds analysis and "fuzzy logic" theory.

Judgement of the acceptability of risk is not an issue for scientific research alone, as it involves economic, social and other issues. These elements all need to be integrated in order to develop prognostic risk models, which are suitable for operational application.

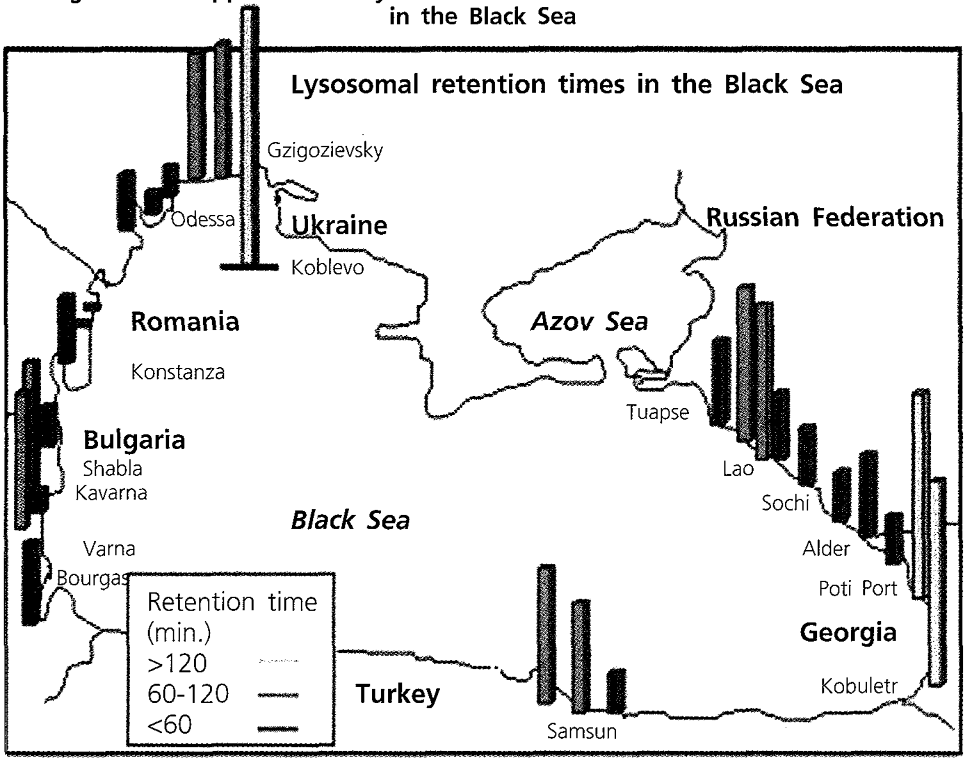
Precaution, or the reduction of risk, has important economic components related to the value of the resources to be protected and the costs of increasing safety margins. Thus, risk assessment is intrinsically a cross-disciplinary issue.

8.2.2. *What's at risk?*

Risk involves the following areas:

- Land use and environmental resources (e.g., salt marshes, coral reefs and deltas are under pressure from sea level rise and coastal erosion);
- Coastal biodiversity (e.g., loss of species from coastal rainforests, mangrove forests, fish and plankton populations are declining in some areas);
- Environmental quality (e.g., shellfish growth studies and rapid biomarker tests can show where there are areas of contamination and harmful effects; see figure 8.1);
- Environmental health (e.g., contaminants with endocrine-disrupting properties leading to sex changes in some animals and reproductive pathologies, carcinogenic and mutagenic compounds impacting on plants, animals including humans);
- Aesthetic considerations (e.g., oil and litter on beaches).

Figure 8.1. Application of lysosomal biomarker test to mussel blood cells in the Black Sea



Source: Moore, M. N., *et al.*, "UNESCO-IOC Black Sea Mussel Watch: biological effects and contaminant residues" (1998).

Note: Koblevo is located in the Ukraine, it has been moved to be kept within the map confines.

8.2.3. How to forecast and reduce risks

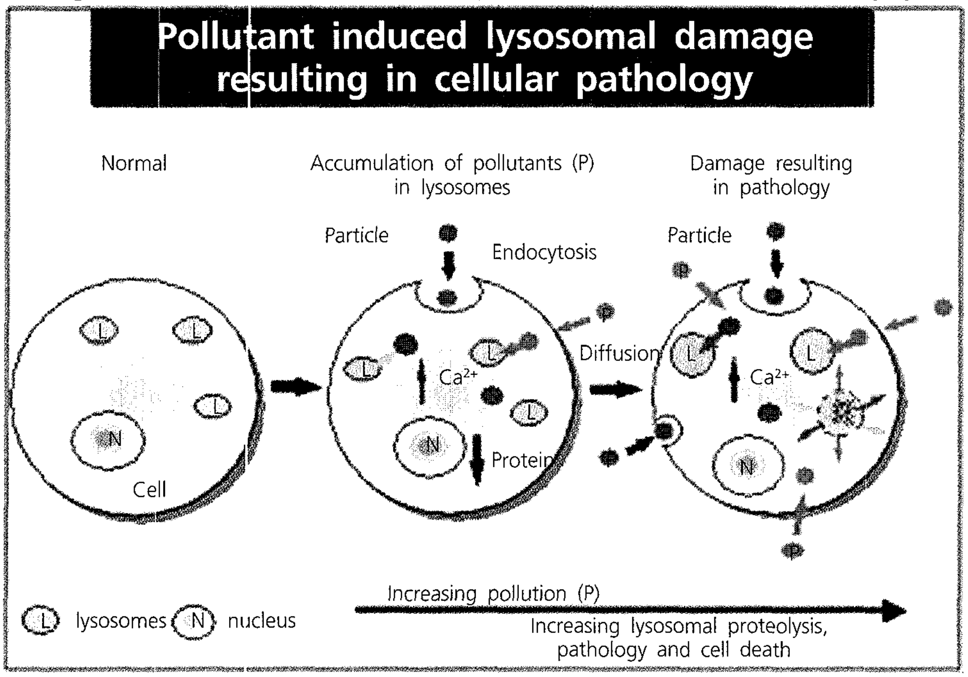
Research is needed into specific problems to find the most cost-effective solutions. In particular the following is required:

- Innovative monitoring and surveillance techniques to understand the extent of the problems (e.g., earth observation systems);
- Research into understanding processes (e.g., physical, chemical and biological; see figure 8.2);
- To develop models to determine appropriate control areas (e.g., the extent of high natural dispersion areas around discharge points);
- To develop expert systems to link existing models with our experience and knowledge of the environment;
- To develop and use indicators to show effectiveness in moving towards sustainable development where there is a need to link environmental, social and economic measures.

Programmes for environmentally sustainable management of coastal areas must engender a move away from the traditional sector by sector management practice to a holistic integrated (cross-sectional) approach. This practical and philosophical transformation is essential, in order to deliver the capacity to anticipate and minimize risks by improving the definition in space and time of master variables that determine change in environmental quality.

Risk is sometimes greater than has been estimated (i.e., hyper-conservative) because of the incompleteness of data (e.g., point samples compared with airborne or satellite remote-sensed data), or marked heterogeneities in key variables (e.g., accumulation of toxic contaminants at an interface), or non-linear processes (e.g., toxicity thresholds), where small changes in concentrations may have marked harmful effects. What is needed is an effective conservative methodology, such as "dependency bounds analysis", that makes no assumptions unwarranted by empirical evidence (Ferson and Long,1995).

Figure 8.2. Uptake of xenobiotics, lysosomal accumulation and cell injury



Source: Moore, M. N. and Willows, R. I., Mar. Environ. Res., 46 (1998), pp. 509-514.

Effective coastal and estuarine management has the prerequisite of a sound foundation of scientific research and understanding of environmental processes. This, in turn, requires collaboration between environmental managers (i.e., in national and international environmental protection agencies) and research centres with the strategic capability to understand processes of change and the impact of human activities upon them.

In addition, it is important, particularly in the context of the GEF International Waters Programme, that the various United Nations organizations the United Nations Development Programme, UNEP, the Intergovernmental Oceanographic Commission, UNESCO, WHO, the World Meteorological Organization, the International Maritime Organization and UNIDO), which have interests in ICZM, harmonize their activities in order to effect synergies in this global activity.

Areas of collaboration need to include, among others, environmental monitoring and remote/satellite surveillance, risk assessment, interpretation of complex information and predictive modelling.

8.3. Conclusion

8.3.1. Making Industry aware of environmental issues and constraints—the role of UNIDO

Finally, a United Nations specialized agency like UNIDO is uniquely placed to bring together the necessary skills and expertise on industrial development and environmental protection essential for the development and application of integrated coastal zone management. In particular the effective engagement of the private sector is essential if integrated management strategy systems for resource sustainability are to be successfully implemented. Here, UNIDO can act as the crucial catalyst in bringing together industry and governments in a shared approach to what is in essence a common problem. In this context, the Shell Oil Company has carried out the Niger Delta Environmental Survey ($5 million) and it is hoped that there will be a continuation of this project in collaboration with the Gulf of Guinea Large Marine Ecosystem Programme.

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9

Process simulation and its environmental application

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9 Process simulation and its environmental application

9.1. Introduction

9.1.1. Rationale

Throughout the last two decades of the second millennium, sustainability was increasingly looked upon as a key social, political, scientific and engineering issue. During the initial years of the third millennium, it will be necessary to work hard at converting words into deeds; therefore, putting policies into practice. Indeed, there are increasing signs that sustainability will become a major new paradigm influencing the Society of tomorrow, and, the accompanying infrastructure it requires. In this respect, therefore, engineering and design are envisaged to play a major role, together with other disciplines involved, in bringing about important changes in current trends of resource use.

With knowledge of chemistry and physics, particularly mass and energy flows, and process technology, chemical engineers are in an apt position, in the broad sense, to influence major decisions concerning design and operation of chemical processing plants. Moreover, the implementation of sustainable development polices involving the use of science and technology will have a bearing on ethical and rational public policy decisions.

It has been cited that sustainable development, that can be simplistically defined as a process in which one tries not to take more from nature than nature can replenish, can be attained without sacrificing the many benefits that modern technology has brought about (Lemmes *et al.*).

In order to achieve acceptable levels of sustainability, through the reconciliation of dynamic industrial growth and low environmental impact, it is imperative that accessibility of highly advanced and sophisticated technologies to developing countries is guaranteed. This not only implies the transfer of advanced and new technologies, but also indicates the necessity to stimulate innovation and sound research applicable to industrial development. Sustainable development depends on a broad harmonization of economic growth and environmental conservation and protection. In recent years, engineers have endeavoured to design new processes and/or modify existing processes with the aim of using renewable resources and producing by-products that can be returned into the system and, subsequently, become biologically degraded (White *et al.*, 1995).

Aspects of safety, health and environment have been on the agenda for some years. By extending the concept of scale, sustainability can easily be related to issues of safety, health and environment, which already receive a great deal of attention by government authorities and industry alike. In a sense. sustainable development has clear linkages with traditionally well-developed areas in chemical engineering, like those relating to environment, safety and loss prevention. Existing techniques, such as those used for hazard and risk analysis (e.g. QRA) and environmental impact assessment, can be combined with innovative techniques, like life cycle analysis, to create powerful new tools for the design of chemical processes and products (Cabezas and Bare, 1997).

Moreover, sustainability effectiveness can be viewed quantitatively, by analysing data over a long period of time. Extrapolating data from the past and correlating trends with more recent data, e.g., numerical indicator data concerning social sustainability, may reveal the extent to which sustainability measures are successful (Lemkowitz *et al.*, 1998).

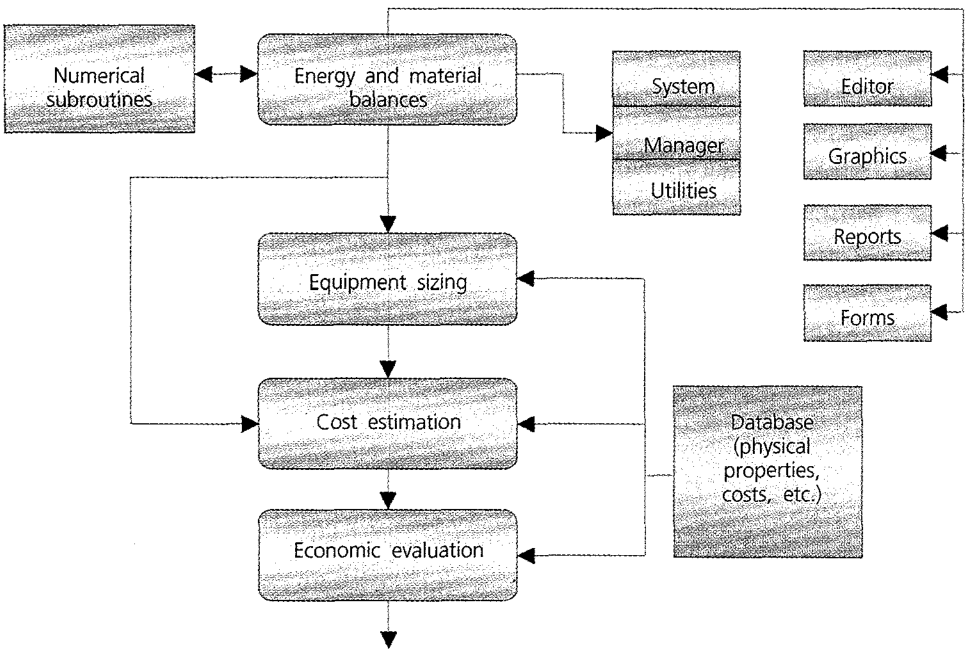
There is no doubt that sustainable industrial development requires a balance between economic and environmental aspects. Thus, the introduction of cleaner technologies is becoming an imperative goal, mainly because the efficiency of the processes (especially those using new efficient catalytic systems) leads to the reduction of environmental impact and, at the same time, they should imply economic advantages. This is particularly important for developing countries and countries in transition, where "turnkey" solutions are not feasible due to prohibitive economic requirements. In this context, modern tools like modelling and process simulation are becoming increasingly important, because they are able to evaluate possible technological solutions with much lower costs and time involved. On the other hand, one must be aware, at all times, of the limitations of this approach.

9.1.2. *Process simulation goals and definitions*

A process simulator solves material and energy balances by means of a computer code. A description of a typical process simulation code is shown in figure 9.1 below, where the most important elements of a simulator and their connections are illustrated. Figure 9.1 clearly indicates that a process simulator includes cost estimation routines as well as economic evaluation. Importance of the database is shown in the figure as a necessary source of information for different objects in the structure (Thome, 1993).

Mathematically speaking, this points towards solving a set of n non linear material balances equations and 1 energy balance non linear equation. As a result, this gives a set of differential—algebraic equations, if the dynamic simulation is considered, in presence of very many components; complex thermo-physical models for phase equilibrium calculations; a high number of subsystems (equipment); rather complex equipment (distillation column); recycle streams; and control loops.

Figure 9.1. General scheme representing a steady state process simulator



The following different approaches are available in the process simulation:

- Steady state simulation, which considers a snapshot at the time of the process;
- Dynamic simulation, which considers the evolution at the time domain of the equations describing the process;
- Integrated steady state—dynamic simulation, which combines the two above.

The approaches listed above may be used in three different scenarios when dealing with process simulation. One possibility is to perform *process analysis*, in which an existing process is studied and alternative conditions, as well as dynamic behaviour, are investigated for the appraisal of "effectiveness of design'. The second approach is *process synthesis*, in which different process configurations are compared, aiming to identify the optimal choice of units and the connections between them. The third possible scenario is *process design and simulation*, aiming to establish the optimal operating conditions of a given process.

In all possible application scenarios, the impact of process simulation on industry is pervasive rather than restricted to a single moment in the development of the process. Process simulation has had a fairly strong positive impact on the way engineering knowledge is used in industry. The traditional way of applying process simulation was mainly focused on "flow sheet design" and on "equipment critical parameters definition", such as distillation column stages, column diameter, and so forth.

Nowadays, process simulation is oriented towards a more comprehensive utilization throughout the entire "life" of the plant. Situations include control strategies design; process parameters optimization; time evolution processes to understand start-up and shut-down procedures and to conduct risk analysis; operator training; and, the definition of procedure to reduce unsteady state operations.

The main benefits of such comprehensive use of process simulation include the partial or total replacement of pilot plant operations (reduction of the number of "runs" and "runs planning"); the reduction of time to market for development of new processes; and, the fast screening of process alternatives to select the best solution in terms of economic and environmental aspects, energy consumption and flexibility of the proposed process.

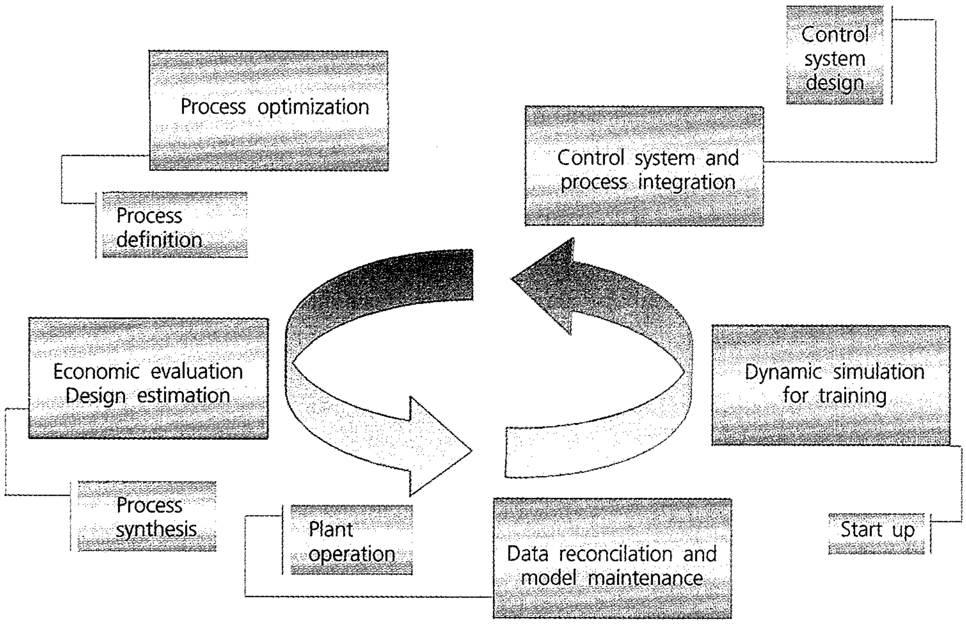
9.2. Applications

Due to the complexity of the chemical process, to achieve any amount of benefit, one must simplify the process and endeavour to apply process simulation techniques throughout the entire life cycle of the chemical process. Figure 9.2 illustrates how process simulation methods can be of benefit to engineers in different periods of the life cycle of a process, from process synthesis to control strategies design.

The solutions of the material and energy balance equations can be performed by an equation-oriented strategy, namely the simultaneous solution of all the model equations or the sequential modular approach. In the first case, one must write down the entire set of equations, identify the constraints and solve the non-linear system. In the sequential modular approach each sub-system is solved independently, commencing with the first sub-system: the output streams for the resolved sub-systems are input streams for the next sub-system. In the sequential modular approach the main problem is to deal with recycle streams (recycle of material, energy and information).

There is another possible approach, which involves the amalgamation of the two fundamental approaches in which equations can be lumped into modules that can be represented by polynomials that fit input-output information.

Figure 9.2. Process simulation and the life cycle of a process



The main advantages of the sequential modular approach are the following:

- The flow-sheet architecture is easily understood because it follows the process closely;
- Individual modules can easily be added and removed;
- Modules of different levels of accuracy can be substituted.

The drawbacks of this approach are:

- The input of a module is the output of a module: you cannot arbitrarily introduce an output or input;
- The modules need extra time to generate derivatives (perturbation of the input);
- The modules may require a fixed procedure for the order of solution: slow convergence;
- Parameter specification is done with control loops: possibility of introducing nested loops;
- Phase equilibrium instability during the convergence of the process.

Steady state simulators are considered the core products of process simulation and they are used for process design, evaluating process changes and analysing what-if scenarios.

All the other kinds of simulation are normally performed after a steady state simulation: dynamic simulation, process synthesis with "Pinch technology', detailed equipment design, off-line and on-line equation-based optimization, application technologies for vertical markets, e.g. polymers.

9.2.1. Procedures

The procedure to be followed in process simulation may be briefly outlined as follows:

- Identification of the problem;

- Obtain all relevant information:

  Get process data: flow rates operative conditions;

  Get thermodynamic data from in-house data, data banks (such as Dechema), literature or through test-runs in laboratories and/or pilot plants;

  Get kinetic data: directly from pilot plant, from excess Gibbs energy calculations (if possible) or directly from real plant data. At this stage one needs to avoid a rigorous definition of kinetic model and use concept of yield and conversion wherever possible and reasonable;

- Select the software:

  Steady state simulation: AspenPlus, ChemCad III, Design 2000, Hysim, Pro II;

  Dynamic simulation: Speedup, Aspen Custom Model, Hysis, gPRON, ABACUS;

  Integrated solution: Aspen Dynamic, Hysis;

- Select the hardware;

- Organize training on the following topics:

  Basics on process simulation;

  Thermodynamic model selection;

  Specific topics (heat exchangers, batch, heat integration, cost analysis, etc.);

  economic factors;

  Energy consumption and its implications;

  Environmental impact analysis;

  Operational procedures.

The procedure for performing a simulation is outlined as follows: First, all the components to be used in the simulation should be defined, including the conventional and non-conventional components. An important step in defining the simulation is the selection of the physico-chemical (Prausnitz *et al.*, 1998) properties set to be used in the calculations. Having done this, one may proceed in the flow sheet connectivity and in the definition of the feed conditions.

The next sequential step will be unit operation internal definitions. At this stage it should be possible to run a base case and check that the system is converging. Process specification, control parameters, equipment hold-up will be added at a subsequent stage in order to refine the simulation.

The results obtainable from a simulation run are different. The most important are the validation of phase equilibrium models for the real system to be used in similar conditions, the verification of process operating conditions, information on intermediate streams, enthalpy balances information, verification of the plant specifications, and influence of the operative parameters on the process specifications.

All this information may be exceedingly useful for de-bottlenecking the entire process or part of it and for the *a priori* identification of process control strategies and tuning of instrumentation. This is very important since it gives the possibility to verify security systems behaviour for variation of process condition.

As far as the dynamic simulation is concerned, applications can be found in continuous processes, concurrent processes and control design, evaluation of alternative control strategies, trouble-shooting process operability and verification of process safety.

The most important benefits of dynamic modelling is the capital avoidance and lower operating costs through better engineering decisions, the throughput, product quality, safety and environmental improvements through improved process understanding, and, the increased productivity through enhanced integration of engineering work processes.

An important feature of modern process simulators is related to its usability and inter-operability with other applications. A user-friendly graphical interface and easy and standard inter-process communication techniques are key elements to obtain workflow integration in the process design.

To obtain the engineering workflow integration, it is necessary that the software can exchange information with other applications. This is done through the basic Windows interoperability by using the Microsoft COM/OLE automation technology.

A two-way data transfer between the software and other Windows applications should be performed. A Windows environment will give access to all inputs and results and enable access to plots and flow sheet graphics. It should be possible to copy data tables and spreadsheets into the simulator for data regression, datafit etc.

Another important point in the workflow integration is the support to interfaces to specific third-party engineering applications such as equipment design (B-JAC, HTRI, HTFS), engineering databases (Aspen Zyqad, PASCE), costing packages (ICARUS) and in-house technologies.

9.2.2. *Workflow integration benefits*

In sum, the benefits of the workflow integration are the following:

- Support for engineering infrastructures that integrate engineering work processes;
- Error-free data transfer into third-party Windows engineering programmes;
- Quick and consistent use of simulation results throughout the engineering lifecycle;
- Improved engineering quality;
- Work-flow integration.

Process simulation plays an important role in decision support systems (DSS), with the latter being based on fast and reliable communication among all the activities in the manufacturing system. Three layers of activities are normally present in a manufacturing system: *(a)* management control; *(b)* process simulation off-line and on-line; and *(c)* control system. The information distribution is made through inter-operability of the software by using component-based software (such as Active X or Java components).

9.2.3. *Pollution prevention in the chemical process industry*

One of the great economic and environmental challenges today is that of reducing the mounting quantities of hazardous and toxic wastes that are the by-products of industrial operations. The key drivers to pollution prevention are the increasing costs of waste disposal as well as the growing number of environmental regulations (Berglund and Lawson, 1991; Borup *et al.*, 1987). Many companies in the chemical process industry now view their environmental policy as an integral component of their corporate strategy (Dorfman *et al.*, 1992).

Waste minimization is at the heart of the waste management strategies employed by the chemical process industry to confront the mounting global environmental crises. Reducing wastes at their source leads to advantages in cost savings, improved product yield and quality, reduced pollution, safer workplace conditions, fewer waste management needs, and conservation of natural resources. However, waste treatment is often needed to clean-up the wastes that have been created. Although end-of-pipe methods are generally more expensive, these approaches are still necessary to control the release of pollutants into the air, water and land.

To promote good waste management practices, companies have incorporated the following features into their environmental policies:

Leadership

In order to ensure effective pollution prevention, many companies have sought the experience of a technical plant manager-cum-environmental/safety and health officer. Practice has shown that these multidisciplinary professionals are, indeed, capable of setting goals for reduction in generation of specific wastes, while understanding the particular needs of industry.

Material balance

This is a quantitative assessment of the chemical inputs and outputs of an individual process. It is useful in determining whether all sources of wastes have been identified. A material balance aims to account for every quantity of a chemical that is: used in the process; created or destroyed in the process; delivered as a product from the process; or released as gaseous, liquid or solid waste.

Cost accounting

This assigns the pollution costs to individual processes, rather than to general plant overheads. Pollution costs include components such as the costs of pollution control, waste disposal, regulatory compliance, lost materials, insurance, future liabilities, and public and customer relations dealing with waste issues.

Employee involvement at all levels

Programme success depends highly on worker output. In this regard, it is vital that all employees, from top management to production and maintenance workers, are involved to ensure success. Workers need constant training and an avenue for contributing suggestions. Pollution prevention initiatives by middle and upper-level management is often a good motivator.

9.2.4. Techniques are available for preventing pollution

Several techniques are available for preventing pollution (Farag *et al.*, 1992; McInnes *et al.*, 1990). The different techniques used to minimize and treat wastes can be divided into five key categories:

Process changes

Involve refinements or alterations in the chemical process itself. They can range from simple changes of process conditions, such as temperature or pressure, to the use of new chemical pathways or production techniques that can advance the state-of-the-art in manufacturing as they help achieve pollution prevention.

Operations changes

Involve improving plant operations, including material handling and equipment maintenance, in order to create less waste. They can include better control of material use and employee practices in order to minimize spills, process problems, excessive use of chemicals, or other problems that can generate wastes. Operations changes can occur in every stage of the manufacturing process, including storing, moving, mixing, and reacting chemicals.

Equipment changes

Modifications and additions can also occur at every stage of the manufacturing process. Because equipment is used in all aspects of a plant's operation, there are numerous possibilities for waste generation and as many opportunities to implement source reduction through equipment changes.

Chemical substitutions

Involve using raw materials that create fewer toxic and hazardous wastes during the production process without necessarily changing the product itself. Furthermore, chemical manufacturing facilities use many materials for essential operations outside the manufacturing process itself, such as cleaning and maintenance, pollution control, and corrosion inhibition. Substituting non-hazardous or non-toxic chemicals for these purposes can also reduce the generation of hazardous and toxic wastes.

Product changes

Involve designing the end-product so its manufacture creates less toxic and hazardous waste; this can often be achieved without changing the fundamental manufacturing process. For example, creating a chemical product in the form of pellets rather than as a powder can reduce the generation of waste dusts (particulate contamination) as the material is packaged.

9.2.5. Computer process simulation

This has been in use for some decades in other chemical engineering endeavours and is a valuable tool for tackling environmental problems. The modelling of a chemical process enables the process engineer or environmental engineer to efficiently analyse the many process requirements and trade-offs that need to be considered.

Many of the simulation requirements for environmental applications are similar to those for chemical or biochemical manufacturing processes. These include the ability to:

- Compute the operating conditions to meet the discharge requirement;
- Compute the performance, capital and operating costs for each equipment item;
- Compute the properties of materials in a waste treatment process;
- Prepare an integrated flowsheet that considers design constraints;
- Perform sensitivity calculations;
- Automatically maximize performance, within process constraints;
- Fit the parameters of the waste treatment models to experimental data.

9.2.6. *Incorporation into corporate policy*

In many ways, process simulation can play an integral role in a company's environmental policy for the following reasons:

- *(a)* A model provides a complete material balance, which quantifies the source of each waste stream;
- *(b)* It is also useful in identifying the costs and savings potential of pollution prevention options;
- *(c)* It provides an effective vehicle of communication among managers, engineers, and production workers to describe the impact of making process, operations, or equipment changes;
- *(d)* "What if" scenarios of alternative waste management strategies can be evaluated for their feasibility of implementation;
- *(e)* The model allows accurate support of pilot plant tests, determination of the key process variables, and the prediction of their effect on the process objectives.

Waste minimization often requires fundamental changes to the process, such as changes in raw material or catalyst, or reformulation of the product. Process simulation aids the engineer in understanding the underlying process design which has a bearing upon achievement of environmental objectives. An engineer may want to evaluate several process alternatives for a new or existing facility to determine the optimal process design, equipment configuration, and operating conditions. Process simulation enables the engineer to address these important design issues before a final design is selected.

Waste treatment, on the other hand, deals with the wastes that have been generated by a chemical process. Process simulation is a useful tool for quantifying the impact of process changes, operations changes, and equipment changes on the treatment of the wastes. The waste treatment process can be optimized to identify the operating conditions that achieve the most effective and economic treatment within regulatory constraints.

9.3. Broader concepts of environmental assessment

9.3.1. *Examples of application of process simulation for mitigating environmental problems*

This section reviews a number of examples on the use of a process simulator for environmental applications and for modelling pollution prevention processes.

A process simulator is well suited to address the waste minimization and waste treatment considerations of a wide range of chemical processes. Gas scrubbing, flue gas desulphurization, NOx absorption, solvent recovery, sour-water stripping, air stripping, steam stripping, neutralization, waste water treatment, and incineration are just a few examples (McInnes *et al.*, 1990).

Meeting government regulations for coke oven gas desulphurization

Stringent government regulations for air pollution mandate the need to lower the hydrogen sulphide content of purified coke oven gas (McInnes *et al.*, 1990). To achieve this objective, a desulphurization model was used to identify ways to optimize process parameters in order to lower the total sulphur content (hydrogen sulphide and organically bound sulphur) of the purified gas. Simulations were able to identify the new process conditions that lowered the sulphur content. To date, this has resulted in a decrease of sulphur dioxide emissions of 360 tonnes per year, which corresponds to 30 per cent of the sulphur dioxide emissions caused by the coke oven gas.

Optimizing steam consumption for solvent recovery

The solvent recovery system from a chemical plant was used to recover methylene chloride from waste water before it was discharged into the sewer (McLaughlin *et al.*, 1992). The plant had been under pressure to reduce operating costs while, concurrently, pressed to meet government emission standards. It was also unclear whether current operations were at optimal conditions. A simulation model was developed to optimize steam consumption, which constitutes the biggest operating cost within the existing process configuration. As a consequence, unexpected savings in steam usage resulted without any major process or equipment changes.

Improving the operations of a waste water treatment plant

A process simulator was used to model the waste-water treatment plant adjacent to a production facility (Metcalf and Eddy, 1991). The plant had a history of not conforming to effluent discharge standards. The goal of the simulation work was to de-bottleneck the plant, and to determine how operating variables can be manipulated to improve effluent quality. Simulations identified the clarifier as the bottleneck unit. Sensitivity analyses showed how additional capacity plus operating changes in the clarifier would improve the hydraulic capacity of the waste-water treatment plant. The impact of the plant loading on the effluent quality was evaluated. The model was also used to study the ability of alternative operating techniques, such as changing the residence time, recycle, and level of biomass, to lessen toxicity.

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10

Geographical information systems, remote sensing and decision support systems for coastal zone management

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10 Geographical information systems, remote sensing and decision support systems for coastal zone management

10.1. Introduction

For years it was felt that the Tunisian coastline was infinitely capable of supporting human pressures, hosting a variety of activities including habitation, recreation, industrialization, tourism and shipping, among others. This concentration of resource-use, however, stemming from activities of a socio-economic nature, gave rise to a series of environmental problems intricately linked to the fragility of coastal ecosystems and non-rational resource use; all of these being the main causes of the environmental degradation.

In Tunisia, the land-cover is characterized by a dynamic system, which is the result of inter-annual variability of climate and land-use conversion (urban expansion and desert reclamation). This is mainly a result of the considerable spatial and temporal variations of rainfall repartition, coupled with population increase, particularly in coastal areas. According to UNESCO Environment and Development Briefs (1993), some 60 per cent of the world's population now live within the coastal belt. This number is rising rapidly owing to a combination of population growth, migration and urbanization. In fact, close to 67 per cent of the Tunisian population lives within the coastal strip, which represents barely one third of the national territory. The major urban areas are located within this strip—Greater Tunis with a population of 1,600,000 inhabitants, Greater Sfax (510,000), Greater Sousse (186,000), Gabés (140,000) and Bizerte (130,000). In coastal areas, there are 1,257 ha of industrial zone, either in operation or under construction, out of a total of 1,410 ha for the whole of Tunisia. The coastal zone also hosts, 93 per cent of the Tunisian tourism infrastructure (Meat, 1995).

As a result, decision-makers using an intersectoral approach to coastal zone management are confronted with the task of developing a planning system that aims to accommodate multiple and often conflicting activities on the coast. High expectations are now required of geographical information systems (GIS) and remote sensing for their role in planning. As a contribution to more effective coastal decision-making, the present work provides a case-study demonstration concerning the coastal areas of the region Tunis-Bizerte.

10.2. Concepts

10.2.1. Environmental planning and coastal zone management

"Planning and management are based on a generic problem solving process which begins with problem definition and description. It involves various forms of analysis including simulation and modelling and moves to prediction and therefore to prescription or design which often involves the evaluation of alternative solutions to the problem" (Batty and Howes, 1996). According to Forman (1997), "Management and planning for sustainability at an intermediate scale, the landscape or region, appears optimum". Based on these concepts, some generic requirements are necessary for environmental management (Hindle *et al.*, 1996):

- Human and environmental safety;
- Efficient use of resources and waste management;
- Addressing societal expectations and concerns;
- Regulatory compliance;
- Respect towards habitats, biota and physical environment on which ecosystems depend.

10.2.2. Coastal zone and integrated coastal zone management

The coastal zone that is, where land meets sea and where fresh and salt waters mix (UNESCO, 1993), contains many of earth's most complex, diverse and productive ecological systems. Nowadays, managers and decision-makers have access to a number of management tools for applying integrated coastal zone management (ICZM). Foremost among these are: GIS applications and related technologies of *remote sensing* and *cartography* as well as Internet facilities.

Coast and human society

A coastal zone can be defined as "extending from the coastal plains to the outer edge of the continental shelves, approximately matching the region that has been alternatively flooded and exposed during the sea level fluctuations of the late Quaternary period" (Pernetta and Milliman, 1995). The actual delineation of the coastal zone depends upon the management purposes at hand. Its physical extent will tend to vary according to the nature of the problem, the extent of the resource and the boundaries of government with jurisdiction and responsibility for management in the coastal zone. In short, the boundaries of the coastal zone should extend as far inland and as far seaward as appropriate to achieve the objectives of the management programme (WCC, 1993).

Carter (1988) defines the coastal zone as "that space in which terrestrial environments influence marine environments and vice versa". Barlett defines the coastal zone as a region of the earth's surface with extreme significance for human affairs: many social, cultural, economic and political activities depend on the characteristics of the coast (Bartlett *et al.*, 1993). The coast does not only facilitate the workings of society. Sometimes it can impede or restrict the range of available options by acting as a barrier to trade and communications, or by being highly vulnerable to natural catastrophe (Bartlett *et al.*, 1993). Indeed, as Bartlett and Carter (1991) point out "many of the most popular coastal regions are also the most dynamic, and frequently, the most hazardous locations to live in".

Such considerations are particularly important for the populations of low-lying developing countries such as Bangladesh. But are also of growing concern to the more affluent parts of the world such as the Atlantic margins of Europe (Carter, 1990; Bartlett and Devoy, 1991; Bartlett *et al.*, 1993). The management of coastal zones should be based on the ecosystem approach (OECD, 1993) which considers the physical, chemical and biological interaction among various components of the system in relation to anthropogenic exploitation of and outflows from the system.

Integrated coastal zone management

ICZM has been formally defined as a "dynamic process in which a coordinated strategy is developed and implemented for the allocation of environmental, socio-cultural, and institutional resources to achieve the conservation and sustainable multiple use of the coastal zone" (CAMPN, 1989). ICZM deals with the management of the coastal zone as a whole in relation to local, regional, national and international goals. It implies interactions between various activities, sectors, and resource demands (WCC, 1993).

The need for institutional collaboration is implicit in this definition; successful management planning relies, to a great extent, on cooperation among government institutions, non-governmental organizations, and local interests (Ricketts, 1992). Although institutional cooperation is undoubtedly the way to the success of an integrated approach to coastal zone management, it is clear that the emergence of rational policy relies on accessibility to data drawn from a wide range of sectors and based on a variety of collection techniques. Given the spatial nature of these planning data and the (often understated) importance of assembling them into coherent and accessible map products (Tortell, 1992), the adoption of GIS technology is not only appropriate but perhaps essential.

A GIS is a computer-based system for storing, querying, analysing, and displaying geographically referenced information (Smith, 1991). The technology is well established as a management tool for terrestrial systems and its popularity is rising among marine managers, especially given the increase of digital data sources (Ricketts, 1992) and improvements to the software. GIS provides an ideal environment in which to manipulate classified satellite imagery (Ricketts, 1992). Transferring the image to a GIS also allows easy modification of the original classification. This may be necessary because some geomorphological zones may be over-classified, under-classified, or simply misclassified during image analysis. Providing that supportive data are available, these geomorphologic zones, present as polygons in a GIS, can be modified or reclassified.

According to L. Jordão *et al.*, (1996), the spatial dimension associated with the biophysical and socio-economic processes and pressures occurring in the coastal zone is often underestimated. In order to achieve sustainable use of coastal zones, namely through an adequate allocation of existing ecological, socio-economic and institutional resources, space should not be neglected in ICZM policies and decision-making. So, there is a need and opportunity for the development of adequate methodologies that can handle and integrate such spatial data, assembling it in valuable information, directed to support the decision-making process, namely in the design of instruments and frameworks. A GIS-based methodology is proposed for ICZM, taking into account the spatial dimension associated with the management process. The framework integrates several components, each designed to address a specific purpose, including:

- Delimitation and classification of the coastal zone into homogeneous management units, according to previously defined management objectives;
- Identification of pressures/impacts in the coastal area;
- Prediction of the environmental and socio-economic impacts from alternative development actions/plans;
- Definition of policies with the support of economic valuation and multi-criteria decision-making methods.

Information technology in integrated coastal zone management

The following paragraph presents the utility of information technology for aiding decision-making in ICZM. Given the complexities of coastal systems and the multidisciplinarity required for sound ICZM, the integration of technologies (including geographic information systems, decision support systems, Internet etc.) is especially useful for integration and distribution of vast amounts of data and specialist knowledge, and for performing analyses to aid decision-makers in their difficult task of proving optimal coastal management solutions (Fabbri, 1996).

A geographic information system (GIS) consists of a "powerful set of tools for collecting, storing, retrieving, transforming, and visualizing spatial data from the real world for a particular set of purposes" (Burrough, 1991). Due to the complex dynamic and spatial nature of coastal zone systems, GIS are particularly suited for handling and analysing voluminous coastal zone data sets (Fabbri, 1996). A decision support system (DSS) may be defined as an integrated, interactive and flexible computer system that supports all phases of decision-making with a user-friendly interface, data and expert knowledge (Radwan and Bishr, 1995). DSS have the capability of performing multicriteria analysis (MCA) which deals with the evaluation of alternatives according to set of varying criteria (Fabbri, 1996).

The integration of these two technologies towards the development of a spatial information and decision support system (SIDSS) would be ideal to promote consistent decision-making and to evaluate coastal development alternatives to ensure ecological sustainability of the coastal zone (Fabbri, 1996). Nyegers (1993) distinguishes two approaches for integrating GIS and DSS capabilities. These are the loose-coupling approach and the tight-coupling approach. The former links GIS and DSS by a common file exchange module, in other words, the GIS and DSS are separate systems linked by a data transfer bridge. The latter attempts to incorporate a shared database, a common user interface and MCA techniques within the GIS tool box, such that the GIS can evaluate the effects of decisions through (spatial and temporal) simulation (Fabbri, 1996).

10.2.3. Decision support systems for environmental coastal management

Definitions

Definitions of decision support systems range from: "interactive computer based systems that decision-makers utilize data and models to solve unstructured problems" (Gorry and Morton, 1971) to "Any system that makes some contribution to decision-making" (Sprague and Watson, 1986). Other definitions, according to Voogd (1983), Rosenthal (1985) and Feiering (1986) include:

- A decision is a choice between alternatives. The alternatives may represent different courses of action or different hypotheses and rational human behaviour involves the evaluation of choice alternatives based on some criteria;
- A criterion is some basis for a decision that can be measured and evaluated. It is the evidence upon which a decision is based. Criteria can be of two kinds:
    - Constraints which serve to limit the alternatives under consideration;
    - Factors which are criteria that enhance or detract from the suitability of a specific alternative for the activity under consideration.

A criterion is therefore a measure on a continuous scale of the effect on the activity on a given indicator commonly named impact (Patrono, 1997).

- A decision rule is the procedure by which criteria are combined to arrive at a particular decision and by which evaluated data can be compared and acted upon. Decision rules are structured in the context of a specific objective, for example, to determine which area is suitable for a given activity. To meet a specific objective it is frequently the case that several criteria will need to be evaluated (multicriteria evaluation).

The decision support field is the "development of approaches for applying information systems technology to increase the effectiveness of decision-makers in situations where the computer can support and enhance human judgement in the performance of tasks that have elements which cannot be specified in advance" (Sol, 1983).

DSS must provide integration of information and feedback loops to support the exploratory nature of the process of scientific discovery (Terfai and Schrimpf, 1997). Issues of data integration include the ability to scale information without distorting the technical content, to handle temporal information and to support spatial information throughout the analysis and decision-making process (Van Voris *et al.*, 1993). According to Eastman *et al.* (1995):

- A decision is a choice between alternatives. The alternatives may represent different courses of action, different hypotheses about the character of a feature, and, different sets of features;
- A criterion is some basis for a decision that can be measured and evaluated. It is the evidence upon which a decision is based. Criteria can be of two kinds: factors and constraints;
- Factor is a criterion that enhances or detracts from the suitability of a specific alternative for the activity under consideration. It is therefore measured on a continuous scale;
- Constraint serves to limit the alternatives under consideration. In many cases constraints will be expressed in the form of a Boolean (logical) map: areas excluded from consideration being coded with a 0 and those open for consideration being coded with a 1;
- Decision rule is the procedure by which criteria are combined to arrive at a particular evaluation and by which evaluations are compared and acted upon.

Multicriteria evaluation

To meet a specific objective, it is frequently the case that several criteria will need to be evaluated. Such procedures are called multicriteria evaluations (MCE) (Eastman *et al.*, 1995). Two of the most common procedures for multicriteria evaluation are weighted linear combination and concordance-discordance analysis (Carver, 1991). Weighted linear combination is very straightforward in GIS. Indeed, it is the derivation of the weights, within the context of the decision objective, that provides the major challenge. The weights are developed by providing a series of pairwise comparisons of the relative importance of factors to the suitability of pixels for the activity being evaluated (Eastman, 1997).

In MCE, an attempt is made to combine a set of criteria to achieve a single composite basis for a decision according to a specific objective (Eastman *et al.*, 1995). A decision is a choice between alternatives (such as alternative actions, land allocations, etc.). During the last two decades, further support has emerged for the view that a decision is a multidimensional concept (Nijkamp *et al.*, 1990; Paruccini, 1994). Decisions about the allocation of land typically involve the evaluation of multiple criteria according to several, often conflicting objectives (Eastman *et al.*, 1995). With the development of GIS, we now have the opportunity for a more explicitly reasoned process of land use evaluation. However, despite the wide range of analytical tools these systems provide, they are typically weak in the provision of decision support procedures (Honea *et al*, 1991).

The advantage of MCE is that it provides a flexible way of dealing with qualitative multidimensional environmental effects of decisions (Munda, 1995). Even in the absence of monetary information, the point of departure of any multicriteria analysis is the generation of a discrete set of alternatives, the formulation of a set of criteria, and the evaluation of an impact of each criterion for every alternative.

Pairwise comparison method

Although a variety of techniques exist for the development of weights, one of the most promising would appear to be that of pairwise comparisons developed by Saaty (1977) in the context of a decision-making process known as the analytical hierarchy process. In the pairwise comparison method, the decision-maker needs to select the most important of each possible pair of effects (Janssen and Van Herwijen, 1991). Subsequently, comparison must be established, in qualitative terms, as to what extent one effect is more important than the other one (Saaty, 1980) to express the differences of importance.

Decision process

According to Sol (1983), the decision support field is a development of approaches for applying information systems technology to increase the effectiveness of decision-making, in particular, in situations where PC-aided support can enhance human judgement in the performance of tasks that have elements which cannot be specified in advance.

Decision support systems must provide integration of information and feedback loops to support investigation in the quest for scientific discovery. The intangible factors in the decision-making process may be accounted for through information supplied and choices made by a decision-maker who operates the SDSS interactively or through an analyst. The above suggest that spatial decision support systems may be developed as general purpose tools for decision-making (Goodchild and Densham, 1990).

Spatial decision support systems

The spatial DSS have been extensively and adequately covered in the literature (Craig and David, 1991; Densham, 1991; Goodchild and Densham, 1990; Moon, 1992; NCGIA, 1992). According to Densham (1991) and Geoffrion (1983), DSS have six characteristics:

- Explicit design to solve problems;
- Powerful and easy-to-handle user interface;
- Ability to flexibly combine analytical models with data;
- Ability to explore the space analysis solution by building alternatives;
- Capability of supporting a variety of decision-making styles;
- Interactive and recursive problem-solving.

The distinguishing capabilities and functions of spatial DSS are to:

- Provide mechanisms for the input of spatial data;
- Allow representation of the spatial relations and structures;
- Include the analytical techniques of spatial and geographical analysis;
- Provide output in a variety of spatial forms, including maps.

Users of spatial decision support systems

As an extension of DSS, spatial DSS is a computer-based information system used to support decision-making where it is not possible for an automated system to perform the entire decision process. According to Goodchild and Densham (1990), "A decision-maker's job is to make decisions, not deal with the technical minutia surrounding geographic databases...".

For decision support systems to have profound impacts on managers activities, they should be integrated into an organization's decision-making culture and process. Who are the potential spatial DSS users, the decision-makers, the intermediaries, and other actors and players?

To enhance organizational efficiency and effectiveness, support must be developed for working groups, since peer discussions and negotiations are considered an important dimension for decision-making. Spatial DSS users may include individual decision-makers, technical advisers, planners, interest groups and the "public" at large; in sum, many consider spatial DSS the "litmus test" for measuring the ability of addressing the immediate needs of decision-making.

10.3. A case study

10.3.1. Multicriteria evaluation for industrial siting

Decisions about the siting of industries on certain land areas typically involve the application of multicriteria algorithms based on logical pairwise comparison. With the advent of GIS, we now have the opportunity to apply decision-making processes (Eastman *et al.*, 1995), in a more enhanced and integrated context.

The work aims at designing a suitability map depicting the industrial sensitivity of the coastal zone of the region Tunis-Bizerte. It consists of landscape evaluation for industrial siting and includes a GIS tool developed for the IDRISI geographic information system software.

Objective and methodology

Among the IDRISI software (1997), MCE module is a decision support tool for MCE. A decision is taken as a choice between alternatives such as alternative actions, land allocations, etc. In MCE, an attempt is made to combine a set of criteria to achieve a single composite basis for a decision according to a specific objective.

In the present study a decision needs to be made about what areas are the most suitable for industrial development. A GIS-based methodology will be integrated thanks to the "Weight" IDRISI module to quantify criteria contributing most or least to industrial allocation. The concept consists of inserting interactive effects of several contributing factors (table 10.1) and constraints that may contribute to enhancing or decreasing industrial susceptibility. The factors are raster images containing the target features from which distance is measured thanks to the "Distance" IDRISI module. The target features are vector files such as roads, rivers, coast, etc. The constraint, on the other hand, is a raster image that excluded certain areas from consideration (sea, lakes, rivers, urbanized settlements and industrialized zones) (figure 10.1).

Table 10.1. Factors contributing to the change of industrial susceptibility

Factor	*Description*
1	Proximity to main industrial sites
2	Proximity to main residential sites (figure 10.2)
3	Proximity to main roads
4	Proximity to coast and inland water (sea, lakes and rivers) (figure 10.3)
5	Proximity to protected forest and national parks
6	Proximity to bare soils

Through MCE, these criteria images were combined to form a single suitability map from which the final choice will be made. The output will consist of a certain number of categories, each reflecting its susceptibility to the installation of new industries.

Figure 10.1. Landsat TM classified image of September 1997

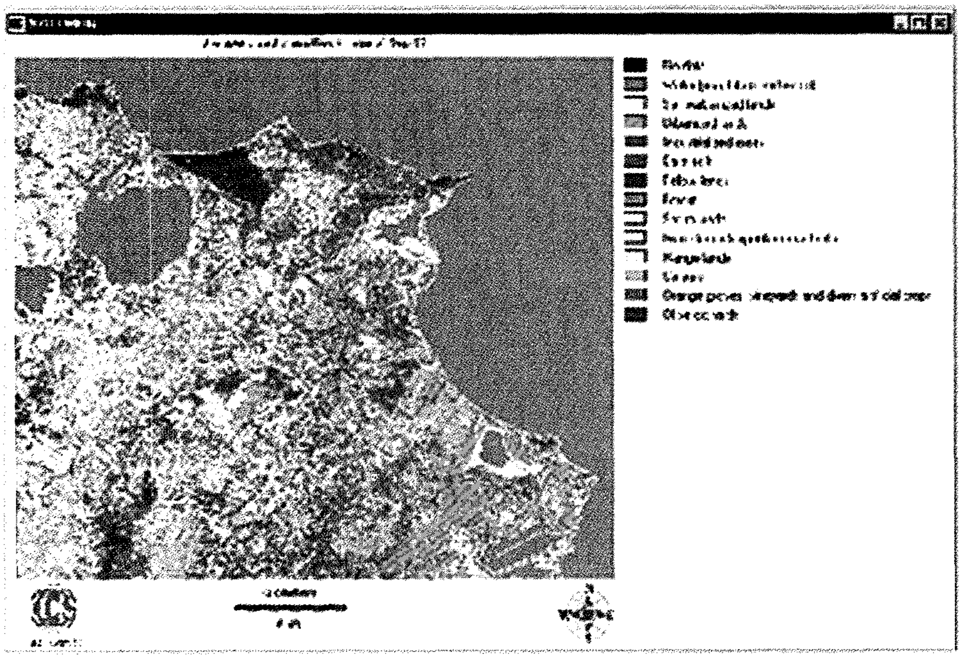


Figure 10.2. Proximity to main residential sites

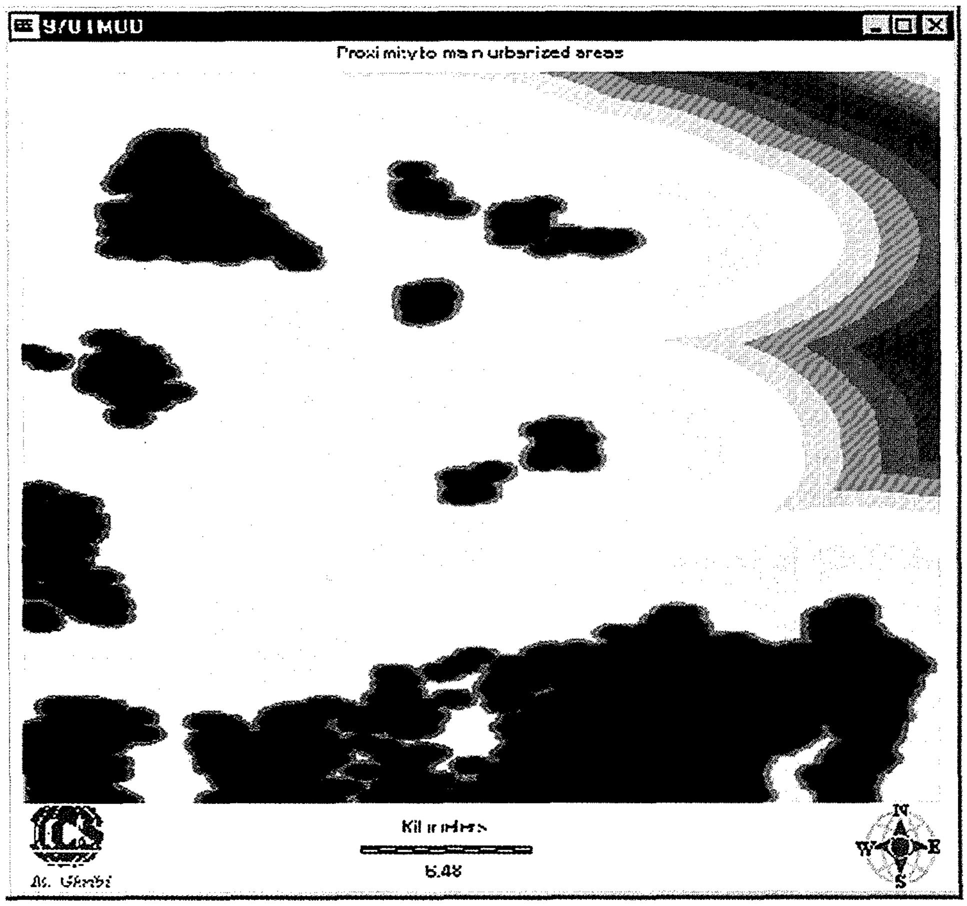
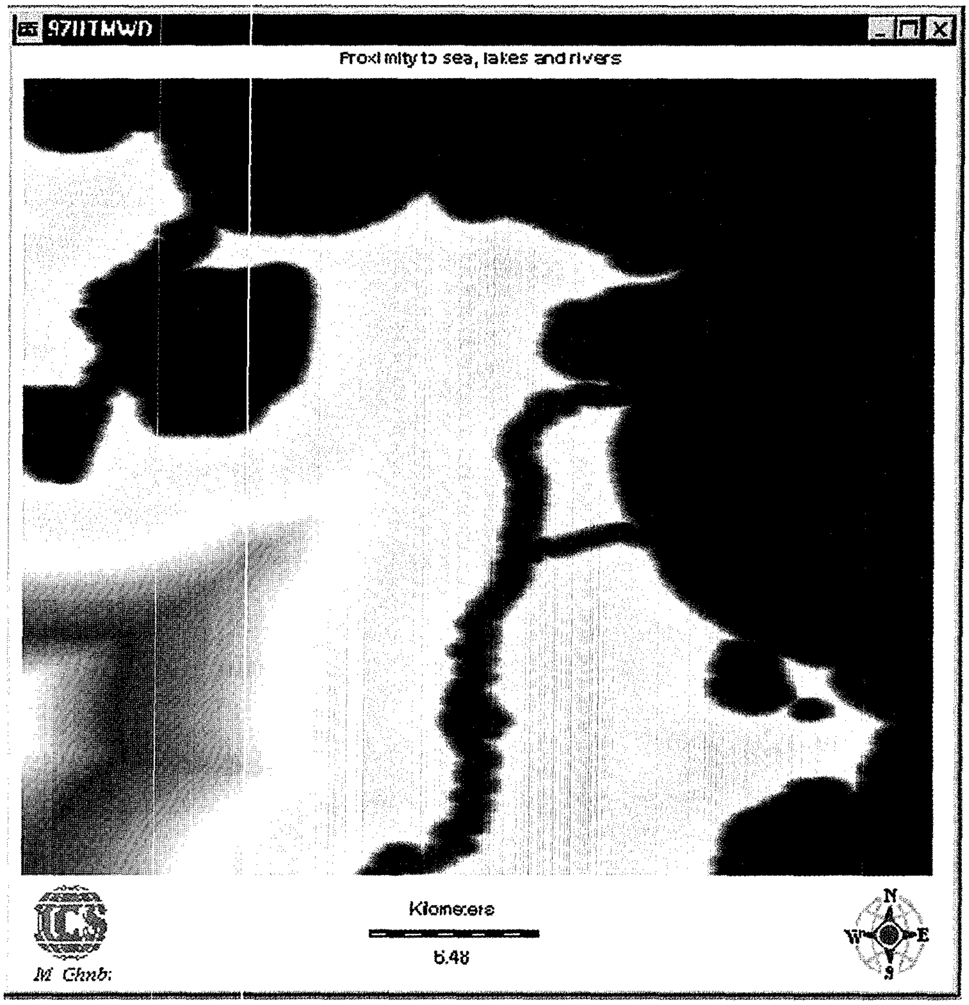


Figure 10.3. Proximity to coast and inland waters (sea, lakes and rivers)



Pairwise comparison

Although a variety of techniques exist for the development of weights, one of the most promising would appear to be that of pairwise comparison developed by Saaty in the context of a decision-making process known as the analytical hierarchy process (Eastman *et al.*, 1995).

In the procedure of MCE using a weighted-linear combination, weights are derived from the principal eigenvector (figure 10.4) of a square reciprocal matrix of pairwise comparison between factors. The comparisons concern the relative importance of the two criteria involved in determining suitability for installation of new industries. Ratings are provided on a nine-point continuous scale (figure 10.5). The weights are developed by providing a series of pairwise comparisons of the relative importance of factors to the suitability of pixels for the activity being evaluated (Idrisi, 1997).

Industrial suitability map

The suitability map (figure 10.6), resulting from MCE, shows different classes for which the degree of susceptibility to accept new industrial plants vary from extremely prone areas to less prone. The extremely prone areas are concentrated around the main existing industrial sites ("Echarguia", "Ariana", "Ettadhamen", "Mannouba", "Menzel Bourguiba", "Mateur" and "Bizerte"), encompassing the urbanized areas along the coast.

Figure 10.4. The principal eigenvector of weights resulting from pairwise comparison between factors

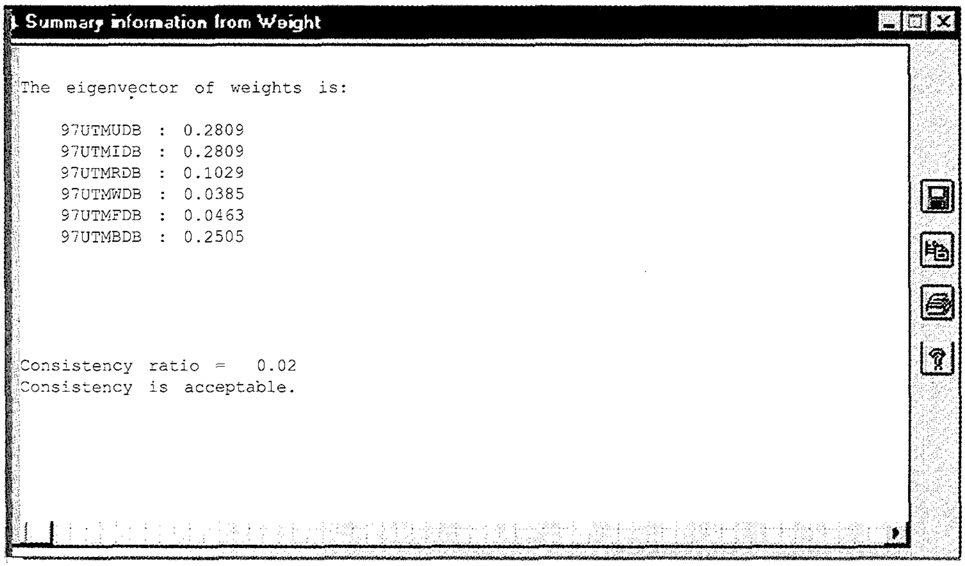
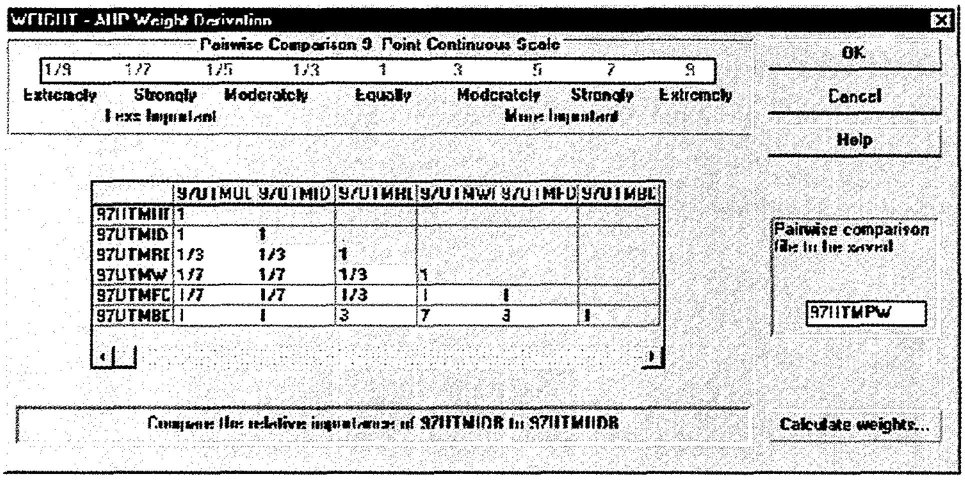


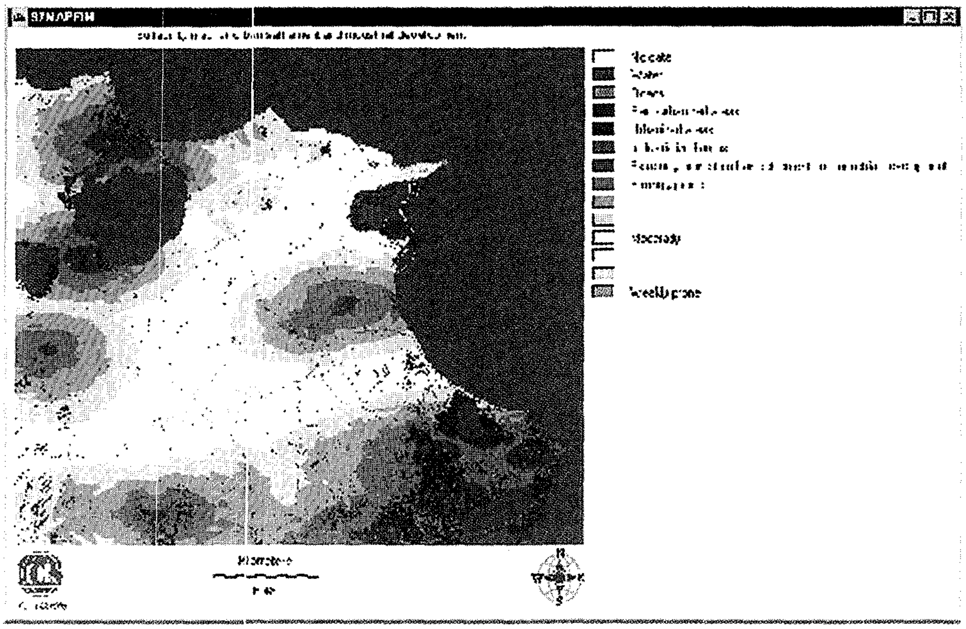
Figure 10.5. The continuous rating scale used for the pairwise comparison between factors



In order to define the extremely prone areas with precision, tracts of land are highlighted based on:

- Its proximity to the existing industrial zone in which the probability of finding existing infrastructure and organized industrial system is high;
- Its proximity to residential and commercial sites that represent a first necessity for any social activity and, in particular, industrial activities according to the high number of workers in this domain;
- Its proximity to main roads and its good connection with the market. Access to transportation is, thus, an important consideration (Eastman *et al.*, 1995);
- Its natural allocation (coast, rivers, lakes, slope, etc.) which can represent an environmental delimitation.

Figure 10.6. Industrial suitability map



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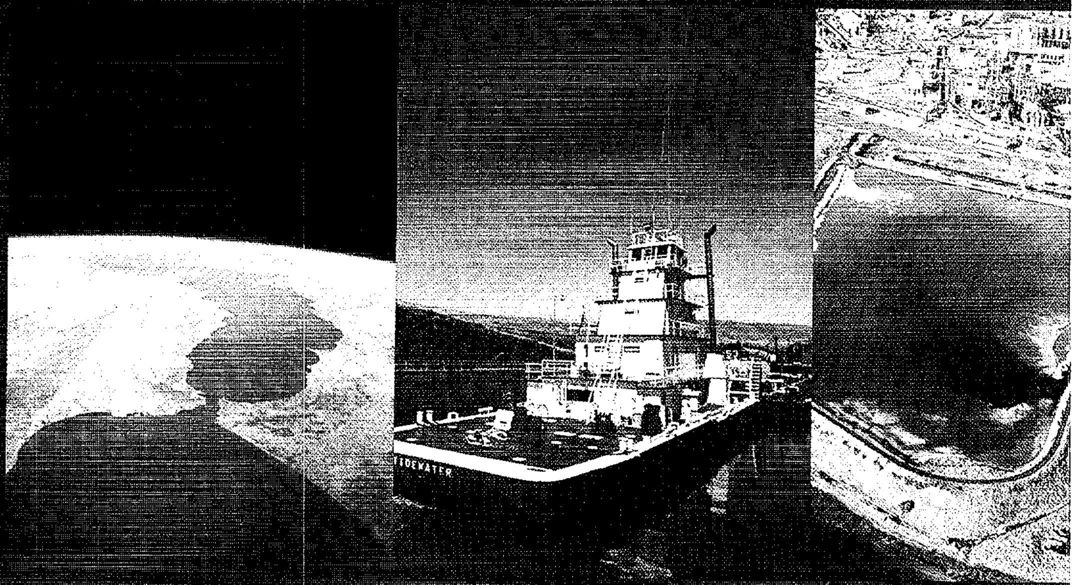
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Geopolitics: linkages between the physical setting and use of resources on the Mediterranean coast

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RESOURCES OF THE COASTAL AREA

Resources common to other areas:

- ❑ residential occupation and attendant services
- ❑ agriculture
- ❑ forestry
- ❑ military installation
- ❑ tourism and recreation
- ❑ quarrying
- ❑ dumping and waste disposal
- ❑ conservation and research

Resources specific to the coastal area:

- ❑ fishing
- ❑ ports and port industries
- ❑ desalination and salt production

COASTAL ZONE DELIMITATION

Landward delimitation:

- ❑ geomorphological features
- ❑ land-use
- ❑ vegetation change
- ❑ climatic effects
- ❑ legal constraints
- ❑ convention

Seaward delimitation:

- ❑ territorial sea
- ❑ Exclusive Economic Zone (EEZ)

COASTLINE FACTORS

Classification:

- ❑ advancing: retreating
- ❑ erosional: depositional
- ❑ submerged: emerged

Maritime forces:

- ❑ waves: corrosion
- ❑ water pressure: attrition
- ❑ currents: transport of material
- ❑ tides: control zone of erosion
- ❑ weathering: especially wetting and drying
- ❑ flora and fauna
- ❑ wind: deflation of unconsolidated material

Landward forces:

- ❑ fluvial action
- ❑ mass movement
- ❑ wind: deflation of unconsolidated material

Landforms:

- ❑ highland: lowland

COASTLINE FACTORS CONTINUED

Coastlines:

- ❑ depositional: erosional
- ❑ compound: neutral

Features of erosion:

- ❑ cliff
- ❑ wave-cut and shoreline platforms
- ❑ cave
- ❑ stack
- ❑ stump
- ❑ arch
- ❑ bay (variously classified)

Features of deposition:

- ❑ beach (classified a ccording to size, position, material)

Features of long lowland coastline - beach shaped into:

- ❑ spit
- ❑ offshore bar
- ❑ bay bar
- ❑ tombolo

SCALE CONSIDERATIONS

Macro-political: events on a global scale

- ❑ globalization
- ❑ dominance of the United States
- ❑ future of the Russian Federation
- ❑ criminality
- ❑ refugees
- ❑ drugs
- ❑ terrorism
- ❑ Israeli-Arab conflict
- ❑ collapse of the former Yugoslavia
- ❑ religious extremism

National: events on an interstate level or relating to specific areas

- ❑ Greece and Turkey
- ❑ Israel
- ❑ Palestine
- ❑ Spain
- ❑ Gibraltar

SCALE CONSIDERATIONS CONTINUED

Regional: events on a substate level

- ❑ Turkey: eastern Turkey
- ❑ Algeria: religious extremism
- ❑ Egypt: terrorism
- ❑ Cyprus: partition

Subregional: events on a local scale

- ❑ Libyan Arab Jamahiriya: Gulf of Sirte
- ❑ Yugoslavia: Kosovo
- ❑ Libyan Arab Jamahiriya: Greco Bank

LAND-USE COMPETITION

Land-use	Requirements	Possible competitors
Agriculture	F L a	industry: pollution: quarrying
Fishing	I/F L/H A	water pollution: sewage
Ports	I H A	security (eg Zuwara)
		hinterland (eg Trieste)
Desalination	F L/H a	water pollution: terrorism
Military	I H A/a	security
Tourism	F H A	pollution: military: industry
Quarrying	F/I L a	tourism: agriculture
Dumping	F L a	every other form of land-use
Conservation	F L a	every other form of land-use

Key

F	=	flexible
I	=	inflexible
L	=	low investment returns
H	=	high investment returns
A	=	accessibility (requires good access)
a	=	access of minor importance

2

Mediterranean coastal habitats and biota

Patrick J. Schembri and Sandro Lanfranco

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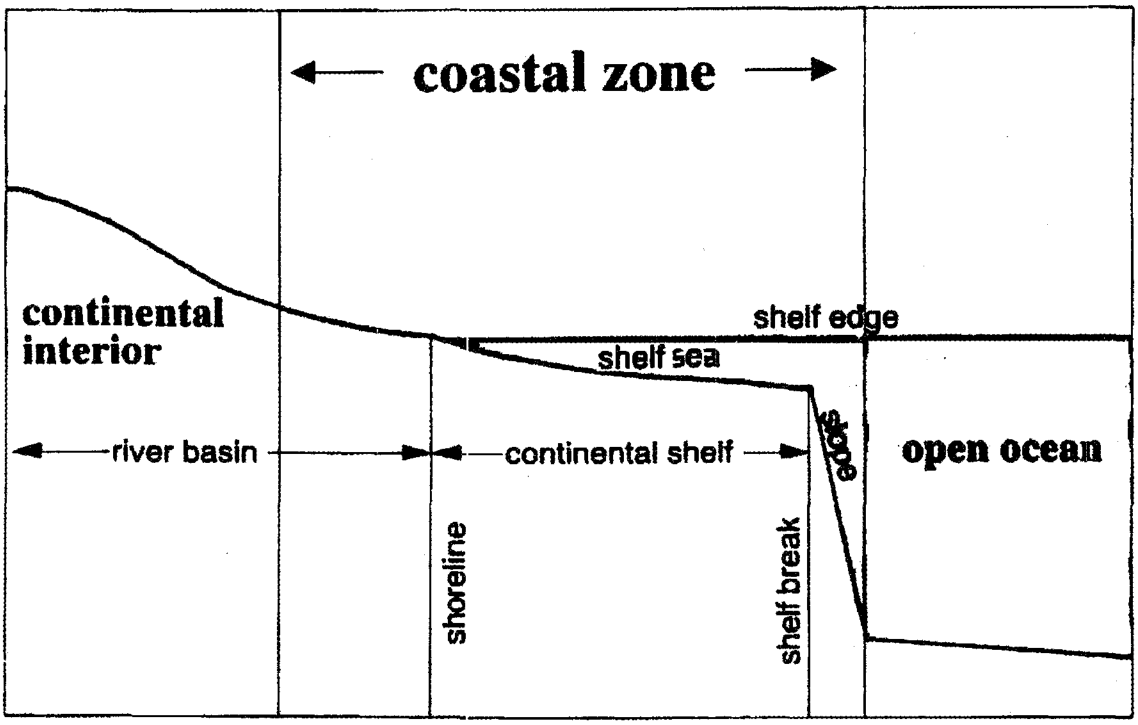
The Coastal Zone

Subdivisions of the coastal zone



Coastal Communities of the Mediterranean

- **Adlittoral**

  terrestrial environment under maritime influence
- **Supralittoral**

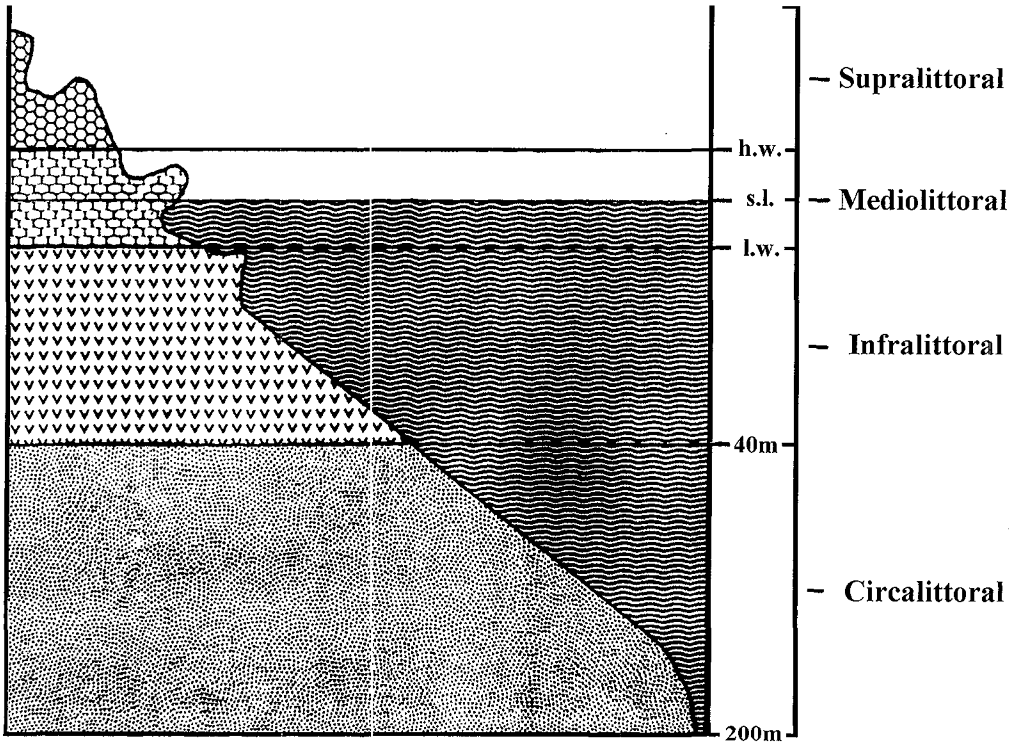
  occasional wetting by sea-spray and wave action
- **Mediolittoral**

  regularly exposed and submerged
- **Infralittoral**

  from lower mediolittoral to lowest limit of sea-grasses and photophilic algae
- **Circalittoral**

  from lower infralittoral to maximum depth at which vegetation can survive (ca. 200 m)

Mediterranean Phytal System



Mediterranean phytal system

h.w. = high water
s.l. = mean sea-level
l.w. = low water

Supralittoral Zone

- Colonized by organisms that require some **wetting** with seawater but not **constant immersion**

- Supralittoral zones may be **rocky** or **sandy**. Each is colonized by a different faunal assemblage

Supralittoral Zone (Sandy Shores)

- Dominated by **burrowing animals**, mainly amphipods (e.g. *Talitrus saltator*). Also beetles and woodlice

- Generally characterized by a **strandline** colonized by terrestrial and marine invertebrates. Gulls and other shore birds scavenge here

- *Posidonia* banquettes deposited by winter storms support a varied biota

Supralittoral Zone (Rocky Shores)

- Maritime **lichens** (*Verrucaria*)
- Microscopic **algae** living in or on the rock
- Two species of **periwinkle**. More common is *Melarhaphe* (= *Littorina*) *neritoides*
- **Isopods**, including *Ligia italica*

Mediolittoral Zone

- Vertical **zonation** of biota
- Highly **stressful** environment due to continual habitat alternation, wave shock and shallow water depth
- Biological activity **synchronized** with fluctuation in water-level
- Seasonal influx of **predators**
- Species composition generally determined by physical and biological **disturbance**

Mediolittoral Zone (Rocky Shores)

- Upper reaches dominated by **barnacles**
- **Limpets** at lower limit of barnacle zone
- **Chitons** within limpet zone
- Attached **snails** close to sea level. Most shores characterized by **trottoirs** (vermetid rims)
- **Top-shells** *Monodonta turbinata* and *M. articulata* occur throughout this zone in calm conditions

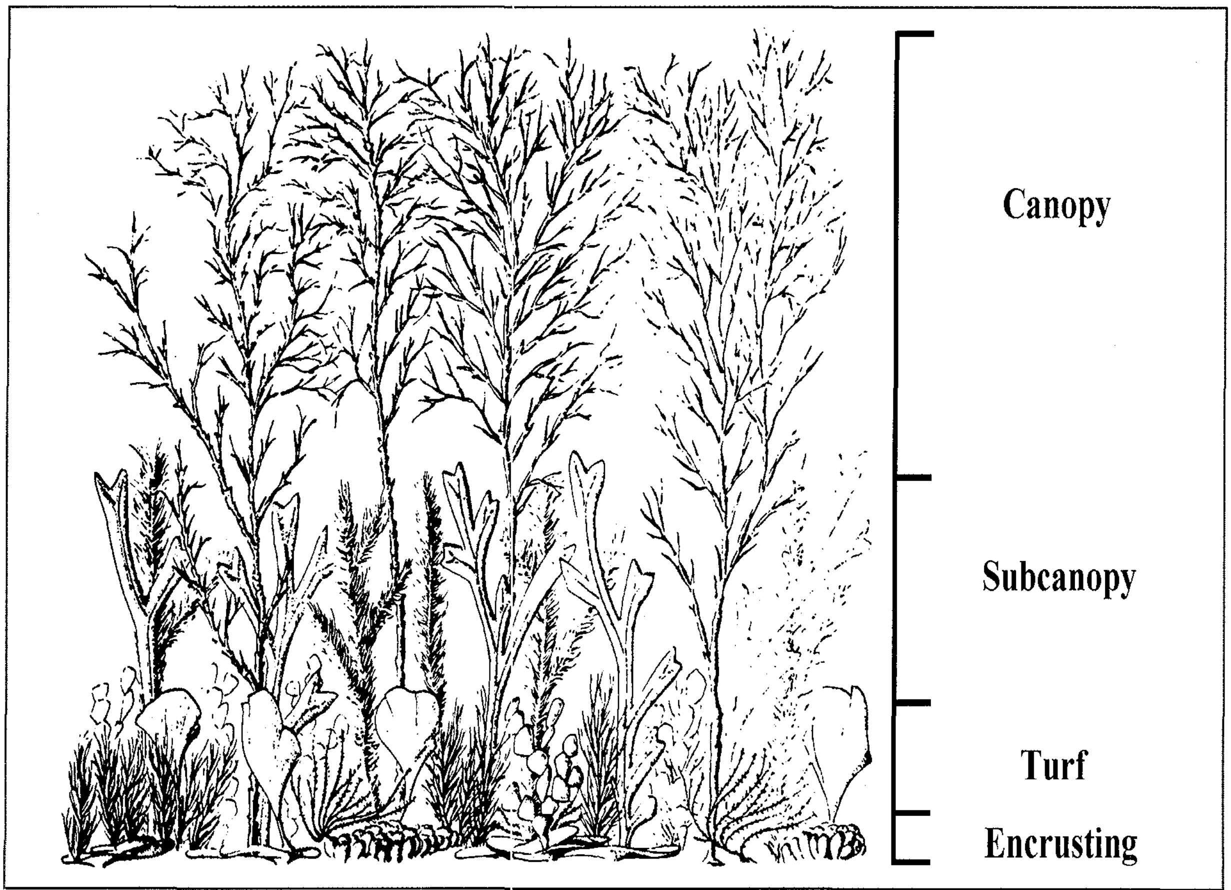
Mediolittoral Zone (Sandy Shores)

- Extremely **stressful** environment
- Colonized by **interstitial** organisms
- Fine-grained sediments promote **anoxic** conditions
- Dominated by burrowing animals (amphipods and the polychaete *Ophelia bicornis*)
- Brackish water community, dominated by hydrobiid gastropods develops in **enclosed areas**

Infralittoral Zone (Hard Substrata)

- Dominated by **attached algae** (e.g. *Cystoseira* spp.)
- Algal communities are **stratified**
- Algal beds provide **habitats** for a wide variety of fish and invertebrates
- Various organisms **burrow** into the rock (e.g. some sponges and bivalves)
- Various fish and cephalopods **feed**, **shelter** and **lay eggs** in the algal beds

Stratified algal bed in the Infralittoral Zone



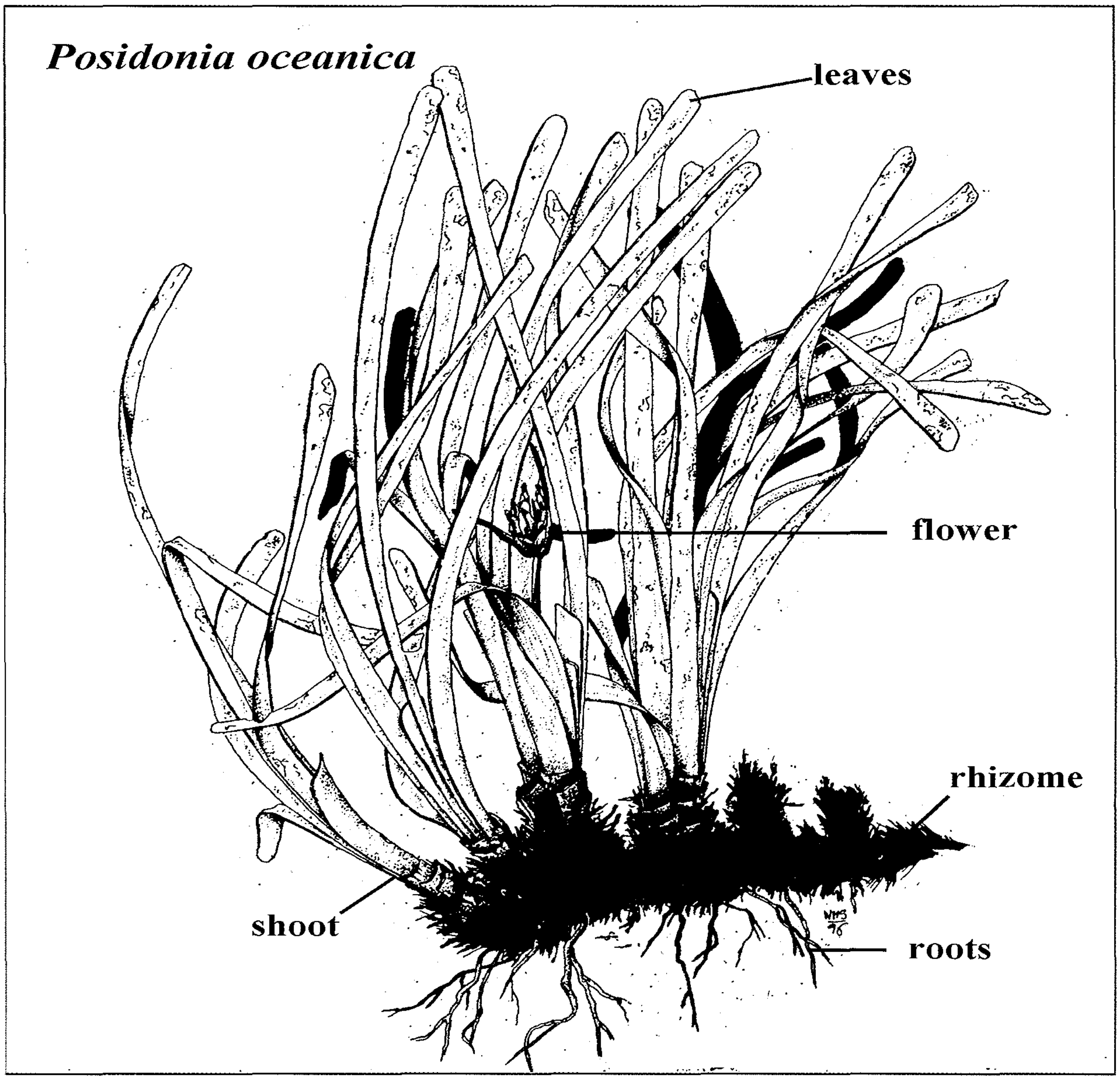
Infralittoral Zone (Soft Substrata)

- Organisms are mostly **endobenthic**
- **Little or no fixed vegetation** apart from seagrass beds
- Considerable structural and spatial **habitat uniformity**
- Much secondary production is composed of **suspension feeders** and **deposit feeders**
- **Agitation of bottom sediment** by wave action is a dominant physical process influencing communities

Sea-Grass Meadows

- Dominant species are *Cymodocea nodosa* (shallow water) and *Posidonia oceanica* (deeper water)
- Provide habitats for a very wide variety of organisms
- High primary productivity drives heterotrophic detritus-based food chains
- Promote establishment of dense sediment banks reducing erosion of sediment in shallow water

Posidonia oceanica (Neptune Grass)



Circalittoral Zone

- **Very low** light intensity
- **Low abundance** of organisms
- Dominated by **attached forms** (encrusting algae, serpulid polychaetes, bryozoans, sponges and corals)
- Characteristic Mediterranean communities may form either **massive reefs** or **maerl** (nodules of free-living calcareous algae)
- Soft substrata characterized by burrowing animals (e.g. heart-urchin)

Characteristics of Adlittoral Habitats

- Inland habitats under **maritime influence**
- Soil (*or* substratum) is generally **saline** leading to increased stress for biota
- Sources of water in aquatic adlittoral habitats may be **seasonal** or **unpredictable**, leading to **drought stress**
- Profoundly affected by human activity

Habitats of the Mediterranean Adlittoral

- River deltas
- Coastal lagoons
- Saline marshlands
- Inter-tidal wetlands
- Sand dunes
- Rocky coastlines
- Salinas

River Deltas

- Form at the mouths of **major rivers**
- Typical deltas contain a **range of habitats** (sand banks, shingle banks, marshes, pools)
- Deltaic habitats characterized by **increasing salinity** with decreasing landward distance from the shore
- Most are **ancient** but some may result from recent **deforestation** (e.g. Ebro Delta, Spain)

Coastal Lagoons

- Form in **low coastal plains**, often in association with river deltas
- River-borne **sediments** settle offshore when mechanical equilibrium between marine and freshwater currents is attained
- Generally surrounded by **salt marshes**
- **Reduced connection** with the sea

Saline Marshlands

- Occur along the **interface** of aquatic and terrestrial habitats
- Generally on coastal and deltaic **plains**
- Many Mediterranean marshes are **flooded seasonally** (by runoff, precipitation, flooding of rivers, wave action)
- Many marshes are **desiccated** by a **summer drought**

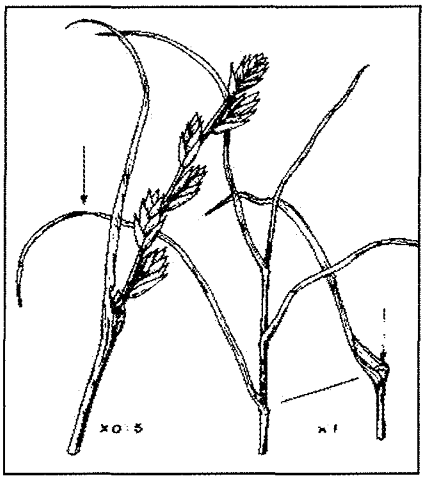
Inter-tidal Wetlands

- Few large areas of **mudflats**, since most of the Mediterranean is tideless
- Main areas occur on the southern coast of **Tunisia** and the Kneiss Islands, (tidal range of up to 2 m creates intertidal mudflats covering some 200 square km); on the upper **Adriatic** with a tidal range of 1 m - 1.5 m

Sand Dunes

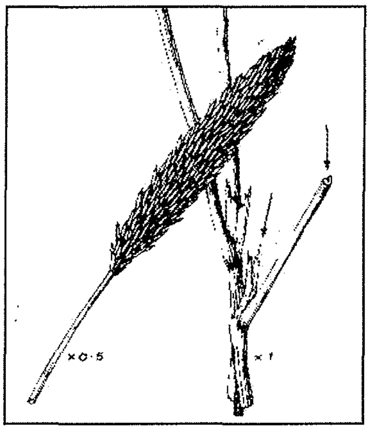
- Coastal dunes are valuable in **protection** of coastlines
- Built and maintained by **vegetation** (dune-building grasses)
- Sand derived from **land** (through rivers), from **coasts** (through wave action and wind erosion), from the **sea bed** through currents, storms and dredging

Dune-building Grasses



Elymus farctus

(*Agropyron junceiforme*)



Ammophila arenaria

Rocky Coastlines

- May be **karstified**
- Ephemeral brackish-water or freshwater **pools** develop in **kamenitzas**
- Generally characterized by **discontinuous** vegetation cover
- Perennial vegetation is **halophilic**
- Annual species generally colonize **disturbed fringes** during winter and spring

Salinas

- Highly **engineered** but extremely **valuable** as wetland habitats
- Most have been established on the sites of **natural salt lagoons**
- Salinas offer relative **shelter to waterfowl**. They are considered as a change of wetland rather than as a loss of wetland
- Current and former salinas are almost the only regular habitat for **flamingos** in the Mediterranean

Fauna of Adlittoral Habitats

- **Birds**
  (herons, egrets, ducks, cormorants, flamingos etc)
- **Mammals**
  (wild boar, wolves, lynx, souslik, fox, rabbits, coypu)
- **Reptiles**
  (snakes, skinks, terrapins, turtles)
- **Amphibians**
  (frogs)
- **Fish**
- **Invertebrates**
  (mainly crustaceans, molluscs and insects)

Vegetation of Adlittoral Habitats

- **Halophytes**

  (*Ruppia*, *Salicornia*, *Arthrocnemum*, *Limonium*, *Juncus*, *Tamarix*, *Aeluropus*)

- **Reed beds**

  (*Phragmites*, *Arundo*)

- **Remnants of riverine forests**

  (*Alnus*, *Populus*, *Salix*)

- **Hydrophytes**

  (*Potamogeton*, *Chara*, *Callitriche*, *Damasonium*, *Ranunculus*)

Threats to adlittoral Wetlands

- Drainage and “reclamation”
- Population pressure
- Eutrophication
- Overfishing
- Exploitation

  (hunting, aquaculture, agriculture: esp. cultivation of rice, recreation)
- Hydrological management

Drainage and Reclamation

- Past drainage mainly concerned with providing **arable land** and **eradication** of malarial vector
- Present drainage concerns **housing**, **industry** and **tourism** development
- **Example:** The Fos Port and Industrial complex (near Marseille) have taken over 46 square kilometres of coastal wetlands

Population Pressure

- **Rapidly increasing** resident and transient populations
- 50 coastal cities with populations of more than **100,000**
- The Mediterranean accounts for approximately **30% of world tourism** annually. Most pressure is generally on coastal areas (e.g. beaches)

Eutrophication

- Principal pollution threat
- Caused by **inflows of sewage** into coastal wetlands and other habitats
- **Warm, calm, stratified waters** of Mediterranean lagoons promote eutrophication
- Causes **high mortality rates** in fish, shellfish and aquatic vegetation

Overfishing

- Arises due to **improvement** in capture technologies
- **Migratory lagoon fish** would be affected by degradation of habitats along their route
- **Eutrophication** in the Adriatic and in many bays damages fisheries
- **Trawling** in coastal areas damages coastal vegetation including **sea-grass meadows**

Exploitation

- **Hunting** annually destroys millions of waterfowl in coastal wetlands
- **Spent lead shot** is a source of toxicity in coastal wetlands
- **Aquaculture** may introduce new fish which disturb pre-existing ecological equilibria
- **Excreta from fish farms** add to the nutrient load of coastal wetlands

Effects of Hydrological Management

- **Waterworks on the wetlands**
  e.g. abstraction for agriculture
- **Salinity balance upset**
  discharge of fresh irrigation water disrupts salinity of wetland habitats
- **Upstream dams**
  leads to reduced flow
- **Sea-levels, river flow and sediment**
  due to possible climatic instability

3

Sustainability as applied to the coastal zone

Bhashar Nath and Ilkden Talay

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Coastal Zone Management

It is important to recognize that:

- coastal zone is an integrated unit for planning purposes
- planning and management of coastal land and waters cannot be dealt with separately

(Gubbay 1998, UNEP 1995)

Coastal sustainability

Coastal sustainability should aim:

- ❑ to promote sustainable use of marine and terrestrial resources
- ❑ to achieve a balance between conflicting demands for coastal zone resources
- ❑ to promote environmentally sensitive strategic planning for coastal zones

(Gubbay 1998, UNEP 1995)

What is a sustainability indicator?

A sustainability indicator:

gives an "**indication**" of whether or not a certain human activity, or a socio-economic aspect, is becoming "**sustainable**" over time

Characteristics of a sustainability indicator

- it should focus on the status of a significant and fundamental problem or activity
- it should be well understood and accepted by the community at large
- it should enable the quantative measurement of the problem or activity for which it is designed
- it should represent or directly relate to important quality of life issues and values of the community
- it should be user-driven, policy relevant and highly aggregated
- it should be simple to understand and easy to use

(Nath and Vivian, 1998)

Specific characteristics of sustainability indicators

- environmental, social and economic indicators need to be **integrated**
- their development needs a **holistic approach** and a **multildisciplinary effort**
- they must be **forward-looking**

(Maclaren, 1996)

Why do we need sustainability indicators?

- to **conceptualize** sustainability and **define** specific goals
- to **monitor** existing conditions and trends
- to obtain **early warnings** on key issues
- to **identify progress** with reference to set targets and benchmarks
- to **measure the performance** and **assess effectiveness** of implemented policies
- for public **information** and **awareness**
- to **compare trends** between different localities and countries
- to **establish a database**

Some examples: LGMB indicator framework of the United Kingdom of Great Britain and Northern Ireland

Stage 1: Define sustainable development

Stage 2: Identify broad categories of sustainability

Stage 3: Identify themes for sustainable practices within broad categories

Stage 4: Identify candidate indicators for each activity

(LGMB, 1994)

Sustainable Seattle framework

Stage 1: Develop multisectoral relationships and define task

Stage 2: Identify proposed indicators

Stage 3: Convene a community panel to review and legitimize the proposed indicators

Stage 4: Form a technical group to review the indicators

(Atkisson, 1996)

Criteria for choosing an indicator

- it should be **relevant to the stated goals** of sustainability
- it should be **indicative of the issue of concern** and **capable of quantitative measurement**
- **sufficient reliable data, especially historical data, should be available** for monitoring
- it should be as **precise** as possible and **simple** to understand by the users
- it should **show trends** over a reasonable time scale
- its **monitoring costs should be as low as possible** without diminishing its effectiveness or quality (Nath, 1997)

Procedural steps for the development of sustainability indicators

Step 1: Define the nature of the problem and the sustainability goals of coastal areas for which the indicators are needed

Step 2: Identify the target audience, the purposes for which indicators will be used and the approximate number of indicators needed

Step 3: Choose an appropriate indicator framework

Step 4: Define criteria for the selection of indicators

Step 5: Identify a set of potential indicators and evaluate them against the selection criteria

Step 6: Choose a final set of indicators and test their effectiveness

"Needs" and "wants" in conventional economics

"Needs" conveys sense of a certain limit or a maximum:

- it refers to basic material resources (food, shelter, air, *etc.*) for maintaining our physical well-being

"Wants" is open-ended, and without limit:

- refers to one's desire for material possession in excess of one's needs

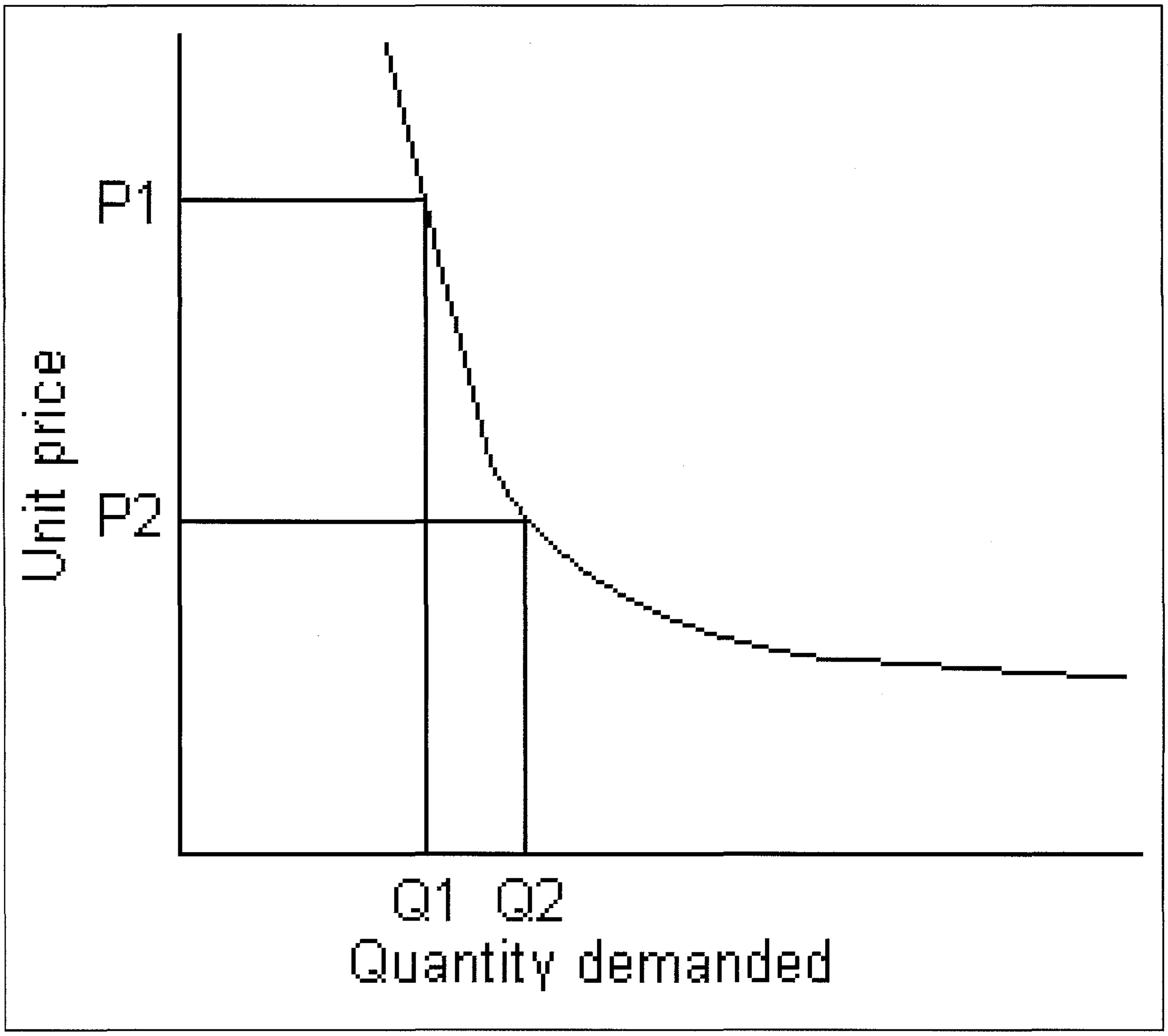
Some basic concepts of conventional economics

- "Utility" and "marginal utility"
- Demand
- Supply
- GDP and GNP

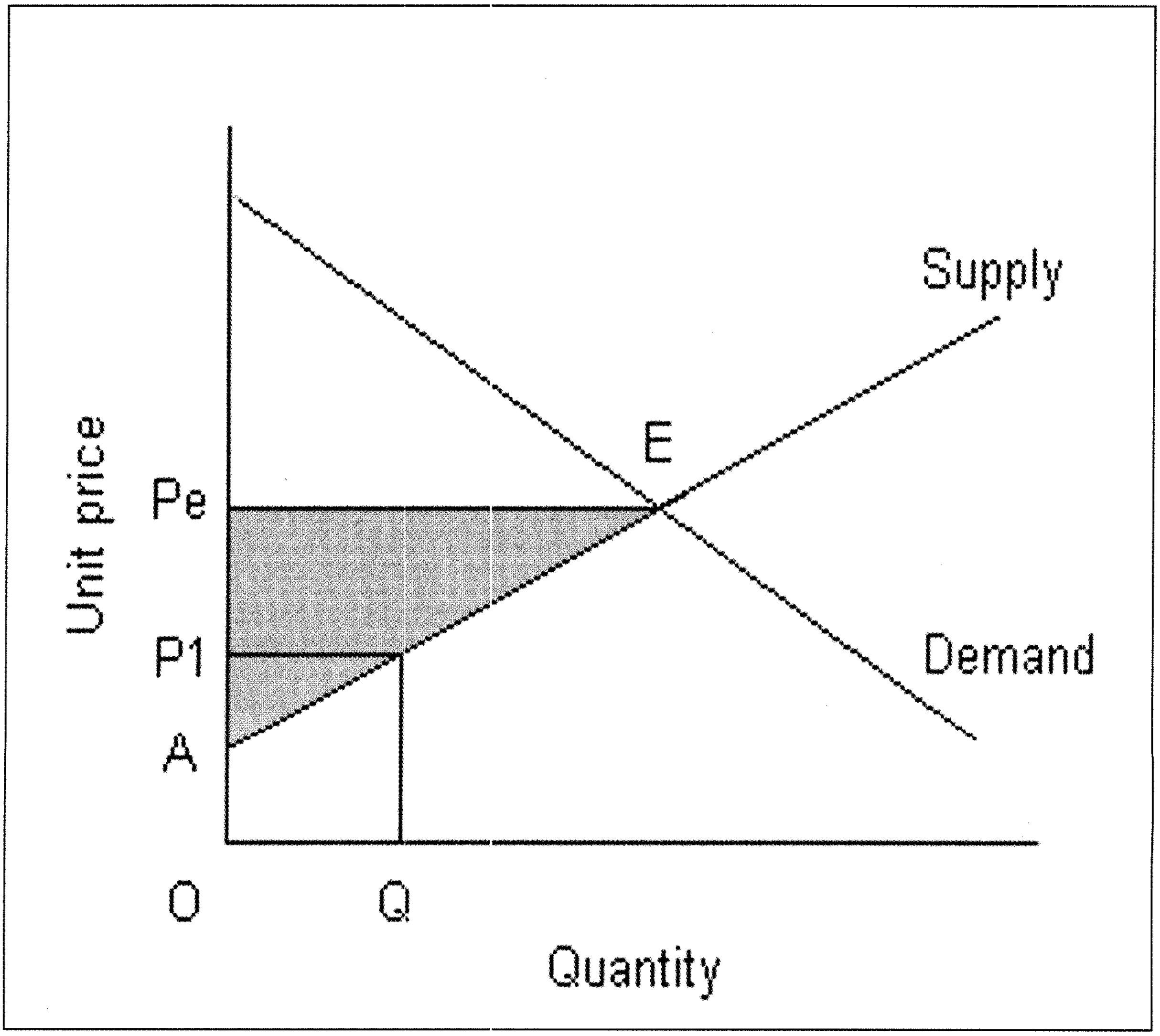
Major factors affecting demand

- Real disposable income (RDI)
- Income distribution
- Price changes
- Changes in trends and fashion
- Advances in technology
- Advertising
- Availability of credit

Price-elasticity curve



Producer surplus and market equilibrium price



Major factors affecting supply

- Changes in factors prices
- Prices of other goods
- Taxes and subsidies
- Advances in technology
- Weather
- Natural and man-made disasters

A strong need for environmental economics

Environmental economics is concerned with *non-market goods* (clean air, scenic beauty, noise-free environment, *etc.*) **for which, unlike traditional market goods ...**

there is *no well-defined market* where these could be purchased or sold.

Some basic concepts of environmental economics

- Economic externality and internalization
- Willingness to pay
- Willingness to accept
- Marginal abatement cost
- ‘Polluter Pays’ principle
- ‘Precautionary’ principle
- Cost-benefit analysis

Some methods for valuing environmental goods

- ❑ The contingent valuation method
- ❑ The hedonic pricing approach
- ❑ The travel cost method

Major differences between "conventional" and "environmental" economics

- Market and non-market goods
- Ownership
- Economic externality
- The temporal dimension

Economics and sustainable development

- requirements of sustainable development diametrically opposed to those of conventional economics
- economics advocates increasingly greater production and consumption
- also opposed to requirements of environmental economics, since this operates within general framework of conventional economics

“Weak” and “strong” sustainability

Weak sustainability:

assumes there is a perfect *substitutability* between environmental and man-made capital

Strong sustainability:

makes a fundamental distinction between environmental and man-made capital

Initiatives and tools for ensuring sustainability

- "Act locally and think globally"
- Local Agenda 21
- Indicators of sustainability

4

Environmental planning for conservation on the coastal zone

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Rationale

Mediterranean provided human populations with multitude of benefits

Severe degradation of littoral consequent to significant resource conflict

- ❑ pressures exerted by demographic growth on coastal ecosystems
- ❑ notable changes in land-use patterns during last four decades

Unsustainable demands due to human expansion

- ❑ may eventually outpace system's ability to recuperate
- ❑ far-reaching consequences on future economic growth
- ❑ some 38% of region's inhabitants occupy coastal areas
- ❑ by 2025, projections indicate coastal populations likely to more than double
- ❑ tourist numbers projected to reach 260 million p.a.
- ❑ tourist industry manifests major socio-cultural force with potential to reconfigure national economies and way of life

Need for conservation areas

Need to evaluate funding priorities for 'economic development' of natural resources

need to determine what percentages are utilized for:

- *conservation*
- *exploitation of the resource*

Coastal zone sustains significant damages from other sources (apart from unplanned development) namely: *environmentally hazardous industries*

- adversely affecting coastal habitats and biota
- lead to increased land-use conflict

Field of coastal and marine areas' conservation relatively new

- coastal/marine conservation areas are so open/difficult to demarcate
- methods developed for managing terrestrial sites cannot easily be applied

Mediterranean coastal ecosystems

Mediterranean Basin supports a variety of ecosystems, unique in diversity and richness

- **Biodiversity generally much richer in the Mediterranean** (including southern Europe, north Africa and the Levant) **than in rest of Europe** (Synge, 1993)
- **Region also supports abundance of endemism that is absent further north**
- **Mediterranean coastal ecosystems are of special interest both biologically and economically.** Some notable biological reasons include:
  - The Mediterranean Basin features many unique ecosystems, supporting some 25,000 species, half of which are endemic (Leon *et al.*, 1985)
  - Mediterranean coastal ecosystems are considered to be transitional between tropical ecosystems and boreal ecosystems (Batisse, 1990)
  - Components, which constitute these ecosystems, have long association with human agency, and can thus provide baseline data to determine impacts on biodiversity. Such info is important in managing biodiversity (Mooney, 1988)
- **Notwithstanding, Med. conservation areas have less overall coverage than northern counterparts, and, afforded meagre protection.** Due to:
  - *lack of financial resources allocated for conservation*
  - *weak institutional backing*
  - *the lack of public support for the protection of nature*

Approaches to planning and management

Traditional approach to planning/managing coastal zone: to target resource-specific activities, predominantly, activities of an economic nature

Result: conservation planning not appropriately addressed

- Conflicts resulting from resource exploitation
  greater awareness and marked increase in international cooperation
  instigated shift towards integrated environmental planning/management
  - such innovative approach complements traditional focus of regulation

Managing coastal areas: planning and management of various coastal zone elements ensures adequate safeguard of existing resources

- Interdisciplinary approach that may be applied at local/national/regional level
  - dynamic process in which co-ordinated strategies are developed and implemented in support of natural resource conservation

ICAM

- **Primarily, ICAM aims to:**

- **provide strategic planning for coastal region**
- **promote responsible use of resources using environmentally sound technologies**
- **balance demand for coastal resources and resolve conflicts of use**

- **ICAM defines coastal zone as *the unit* for planning purposes**

- **For management purposes, ICAM considers terrestrial and marine components as *one entity***

- **ICAM to be seen as pro-active mechanism**

- **provision of multidisciplinary approach to planning and management**
- **encourage *communication, collaboration* and *coordination* between: planners, reserve managers, and all other stakeholders**

- *'public's right to know'* often neglected concept, on Basin's southern shores

- **Four major sources of potential threats to coastal conservation areas include:**

  - **Development**
  - **Encroachment**
  - **Natural and man-induced disasters**
  - **Inadequate liaison - management failure**

Ecosystem management

One of the important functions of conservation areas is to provide a relatively undisturbed environment that can be observed over time in its natural state

- **Ecosystem approach to management only achieved with adequate backing data**
  - **contrary will lead to haphazard management decisions**
  - **inability to determine carrying capacities of ecosystems under protection**

- **Inventorying/monitoring natural and man-induced changes establish baseline for describing patterns of change within ecosystem**
  - **monitoring biological conditions shed information about land-use patterns**

- **Data: gathered, analysed and incorporated into management plans**
  - **monitoring programme may consist of a number of data gathering techniques**
  - **identify wide range of impacts occur consequent to activities further afield**
    - typical activities that impact conservation areas include deforestation, agricultural expansion, grazing, road construction, *etc.*

- **Develop conservation plans into comprehensive *area management programme***
  - **achieved only through *system planning***

Planning a system of conservation areas

System planning process should provide overview of prevailing problems, issues and conflicts encountered by ecosystems, supporting habitats and biota, and people

Good point of convergence for conservation and development

Every effort to integrate the two:

❖ *" For development, system planning indicates areas needing special management to sustain both human development and environmental stability, and it indicates how, where, and when certain development activities will have negative and positive effects on the environment"*;

❖ *" For conservation, it indicates the present and future vulnerabilities of renewable resources and identifies habitat areas most urgently in need of protection. The result of system planning is selecting specific sites for protection and defining their purposes and objectives"* (Salm, 1984).

System planning consists of three primary components

❑ **follows basic sequential order to plan-making of *Survey/Analysis/Plan*:**

- **habitat-type classification;**
- **identification of candidate areas;** and
- **site selection for conservation.**

Conservation areas programme

Assuming legislative structures and preliminary objectives exist, *system planning* can come into play, fitting into evolution of conservation area programme

Typical sequence of programme development:

- ***Policy/legislation:*** formalizes administrative decision to commence conservation programme, and, as a result, sets goals for its implementation.

- ***Preliminary planning:*** interprets legal framework; sets planning agenda; identifies the multidisciplinary planning team; and defines objectives.

- ***System planning:*** identifies issues and conflicts; classifies habitat-types; and provides criteria for site identification.

- ***Site planning:*** provides comprehensive implementation schedule, including design proposal with appropriate delineation, and management plan for each sector of protected area. Site planning also makes provision for future revisions.

- ***Implementation and management:*** phase responsible for operational management and development components, and, where necessary, makes recommendations for future improvement. [adapted from Salm, 1984]

The conservation area: site planning and management

Conservation area development requires specific planning prior to undertaking management-related phase

- **Charting of management plans takes place during *site planning;* follows initial phases of planning process, namely:**
  - *the administrative decision which establishes mandate*;
  - *defining of objectives*; and
  - *completion of the system planning process.*

- **Exceedingly relevant to differentiate between *planning* and *management* phases:**

- ***planning*** phase provides mechanism for decision-making on resource-allocation
  - through the design (*or* zoning = method to control access in sensitive coastal areas, and to limit impact) and management criteria

- ***management*** addresses day-to-day operations required to satisfy **management and planning** objectives

Plan-making for conservation areas

Process commences with scientific surveys being undertaken by multidisciplinary team of specialists, conducting studies of each sector within the conservation area

- **Purpose is to determine and/or identify:**
  - type/exact location of localized and/or threatened habitats;
  - habitat-type's vulnerability and status;
  - existence of specific characteristics e.g. diversity, population size, degree of spp. dependence.

  - type/extent of land-uses, conflicts, and other anthropogenic activities;
  - potential effects on habitats and biota occurring on site;
  - level of dependence of *resource users* and *affected locals* on current uses;
  - all activities which may result in degradation of existing habitats, subsequently leading to depletion in species' numbers.

  - existing/potential threats taking place immediately beyond the area's delimitation.

note: *With above data in hand, subsequent development may progress according to specific guidelines*

Management objectives

The prime objective of conservation areas is to afford protection to supporting elements, which maintain natural processes

- **Pro-active and integrated management programme may:**
  - enhance social, aesthetic and cultural fabric of particular area and its surroundings
  - encourage education and research
- **Economic activity may be encouraged in large conservation areas**

Zone delineation approach

Zoning for management purposes should be carried out during early stages so that different sectoral activities can be planned and controlled according to defined objectives

- **Intensive management practice may be required in some areas, while other sectors will require limited attention**
- **Zoning allows better understanding/protection of core areas/buffer zones**
  - necessitating monitoring of human impact
  - efficient allocation of personnel, equipment and funds

The management plan

Effective management practice may not require a plan to commence operations, but needs a defined agenda to develop

- **Value of formalized document: explicit mandate to follow course of action**

- **Management plan also serves as blueprint for routine operational tasks**

- instrumental in establishing philosophy of management
  → serving as reference point during *plan's* life span
- plan *must not* set unattainable goals for management of resources
- encouraging false expectations will damage success of project

  - **management plan should feature mechanism for measuring its effectiveness**
  - **plans structured to allow adequate manoeuvrability for modification and revision, as new data is evaluated during implementation phase**
  - **essential that management plans make known their intended life spans**

Need for cost-effective intervention

Need to allocate financial/human resources among competing sectoral needs

- **Setting of priorities for action includes defining cost-effective interventions**
  - urgent action required to solve priority problems also a political matter
  - depends on:

- availability of funds, political visibility, balance of regional and sectoral interests; and
- willingness and capability of local government agencies to implement *management plan*

Approaches to environmental strategies

- **Plan-making may be broadened to integrate sociodevelopmental concerns**
  - Successful strategies involve three elements:
    - **identifying priority problems**
    - **defining priority actions**
    - **ensuring effective implementation**

- **To implement environmental strategies with success, a multifaceted plan must come into play, bringing together:**
    - ***nature conservation;***
    - ***management of natural resources, through existing legislation;*** and
    - ***socio-economic requirements of stakeholders***.

- **Every effort to seek common ground among opposing interest groups**
  - neither nature conservation nor economic activity can be efficiently managed without interaction between the two

Broad objectives for an action framework

Improvements are required in current analysis of natural resource and development issues, so that their relevance to economic, social and cultural impacts can be clearly demonstrated

- **Key elements responsible for prevailing situation in most developing countries:**
  - Lack of streamlining among national environmental agencies
  - inadequate legal instruments coupled by ineffective enforcement
  - weak public information systems: inadequate flow of info to public
  - lack of grassroots involvement including weak consultations with NGOs
  - Environmental education - too low a priority

- **Clear linkages between these issues, ecosystem conservation, and sustainable land-use practices**

- **Techniques to quantify value of environmental services/long-term costs of resource degradation need to be developed in line with local requirements**

- Creation of incentives, decentralization of management systems and increased involvement of industry and NGOs need to be included in improved national policies (Cassar, 1994)
- National planning systems need to be enhanced so as to function within a multi-sectoral set of priorities, and be responsive to environmental needs

Strategic processes in planning

- **The strategic planning process should include:**
  - ***information assembly and analysis;***
  - ***policy formulation;***
  - ***action planning;***
  - ***implementation;*** and
  - ***monitoring and evaluation.***

  - each of these components is driven and facilitated by *participation* and *communication*

- **Basic management mechanism for most strategies: *steering committee***

- specialists/secretariat based within established national environmental agency
- composition, size, terms of reference and functions vary according to specific tasks
- creation of basic rules as initial strategy phase can be time of frustration
  - *well-targeted*, *decisive* but *diplomatic management* in early stages determine level of plan's success in its later phases

Political support

Decisions of when and where to declare protected areas, or how much money should be allocated, fall within the domain of politicians

Informed public could:

- influence decisions on conservation issues
- rally political support necessary to declare and maintain protected areas (Barzetti, 1993).
- public support for conservation areas can take the form of direct or indirect pressure:

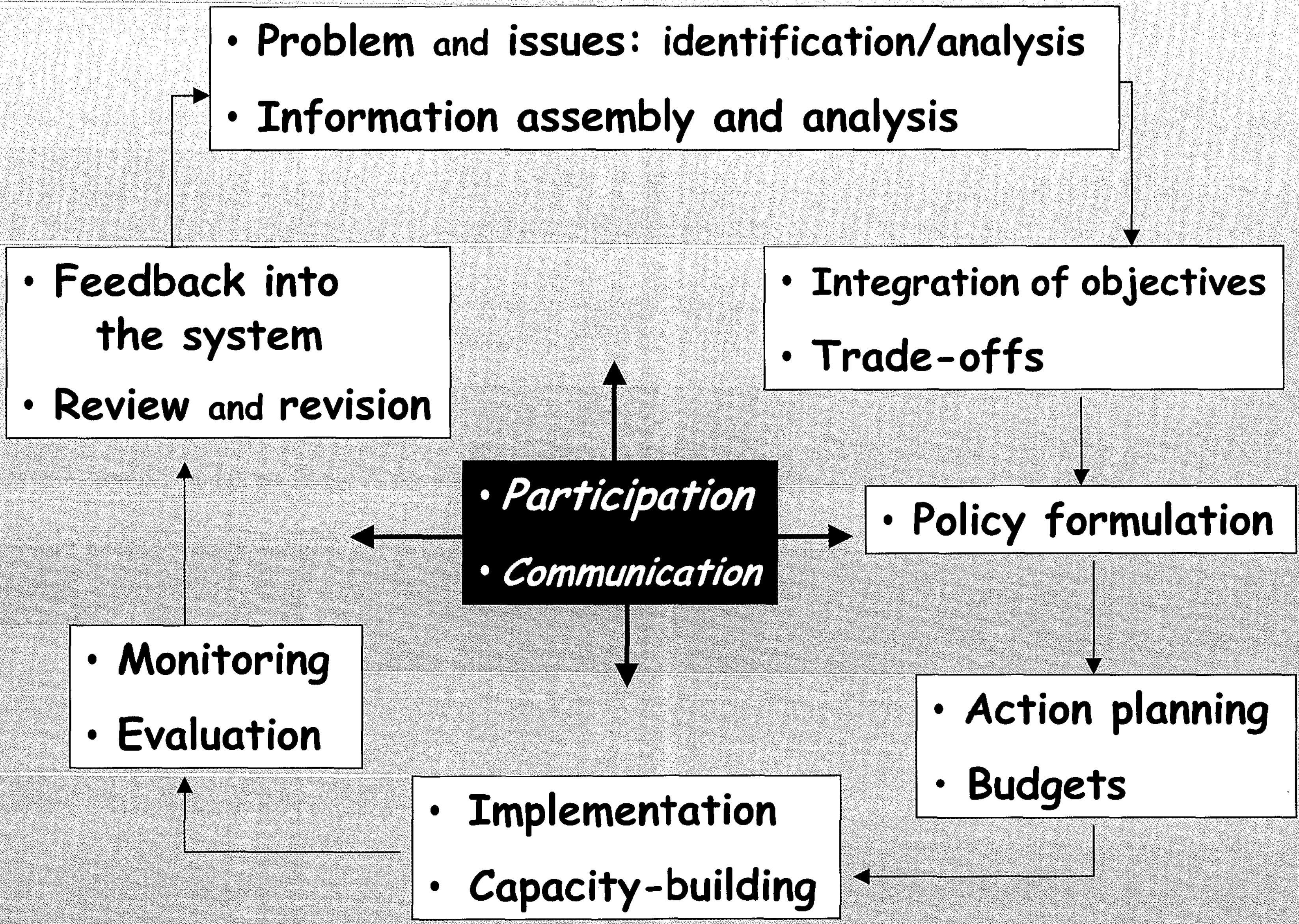
  - **Direct pressure may involve provision of info to politicians that will enable them to convince their peers of importance of establishing protected areas.**

  - **Indirect pressure often takes the form of public opinion that influences political decisions. In this arena NGOs play a crucial role, since they tend to be independent of official political and economic interests. Additionally, NGOs represent a sector of the population** (Barzetti, 1993).

- derive support from among 'affected locals' and resource users in and around protected areas
  - those benefiting from protected area will 'defend' it against incompatible uses
  - support management structures designed to maintain resources from which their benefits derive

Communication and *participation:* key driving forces of all elements of strategic planning process

- stakeholders to be kept informed of/consulted on every level of development to avoid antagonism that may prejudice project at later stage



The different components, that make up the strategy cycle (CAREW-REID et al., 1994)

Conflict resolution

Resistance to conservation schemes due to lack of information, egoism, political instigation or genuine concern, often leads to conflict between affected stakeholders and government agencies and environmental NGOs

- **Once an individual or group takes a position and defends it strongly, it may prove difficult to convince opposing parties to back down**

- **Good conflict resolution needs to distinguish between *interests* and *positions***
  - **an interest is a fundamental need or concern**
  - **a position is an idea put forth to further one's interests** (Lewis, 1993).

example: a farmer growing crops on agricultural land adjacent to sand dune system finds that aeolian material is affecting his yield.

- His first position: plant fast growing alien tree species such as *Eucalyptus* or *Acacia* on dune ridges to prevent sand blowing over his land. In doing so, newly planted trees would effectively compete with dune vegetation and also affect the area's hydrological balance, in view of the large amounts of water these particular species are reputed to utilize.

- Alternative positions would be to fence in his crops or to request the authorities compensation for damages. Thus, the farmer's interest is the same, i.e., of protecting his crops, but his position may change.

In addition to focusing on each party's interests rather than positions, the issue of *power* in the conflict also needs to be addressed

- **Need to be conscious of *real* and *perceived* power of stakeholders involved in conflict, as they will act according to their own perceptions of power balance** (Lewis, 1993).

- **Ensure that all significantly affected stakeholders are included in resolution discussions**
  - understanding interest and power positions will go a long way towards resolving existing disputes

- **Best to avoid conflict:**
  - ***First, by consulting with potentially affected stakeholders and include their active participation in the conservation area's management issues***; and
  - ***Secondly, by being somewhat flexible and adaptable to local circumstances.***

NGO involvement

Although conservation areas fall within central government jurisdiction, it is worth considering vesting environmental NGOs with management and upkeep responsibilities

- **Central government constraints in managing protected areas alone, include:**
  - funding often falls victim to short-term national development goals
    - *conservation areas end up without management plans or adequately trained personnel*
  - conservation areas require inputs from different disciplines for their effective management

- **Conservation NGOs increasingly more active in collaborating with government environmental agencies**
  - NGOs have advantages that compliment official management efforts:
    - ✓ **NGOs less bureaucratic than official agencies; therefore more flexible in their management**
    - ✓ **NGOs may have more hands-on and scientific expertise than government departments**
    - ✓ **NGOs have access to funding sources not usually offered to governments**
    - ✓ **NGOs can raise funds for direct use in conservation areas as opposed to government**
    - ✓ **NGOs are usually less politically influenced than government departments**

NGOs may actively become involved in the management of conservation areas

- **More effective management models: *intervention-oriented* or *interactive***
  - first option involves seeking of international aid by a national NGO in order to proceed with its conservation agenda
  - second option involves mutual sharing of tasks in executing a management plan

example: **government is landowner but cedes the management functions, under appropriate supervision, to a competent NGO or body of NGOs.**

Management effectiveness

In places of extreme land-use conflict, e.g. small islands, habitat and species conservation is vastly difficult. A high population density makes huge demands on natural resources, particularly the coastal zone

- **Management effectiveness is diluted, the larger the conservation area**

- **Challenge to effective *site management* is to establish zoning schemes that identify priority sites for specific uses and enhanced protection levels:**
  - international delineation criteria to be used on the macro-scale
  - on the micro level, existing national criteria, e.g. *Areas of Ecological Importance* (AEIs) *and Sites of Scientific Importance* (SSIs), used to highlight small but important ecological areas

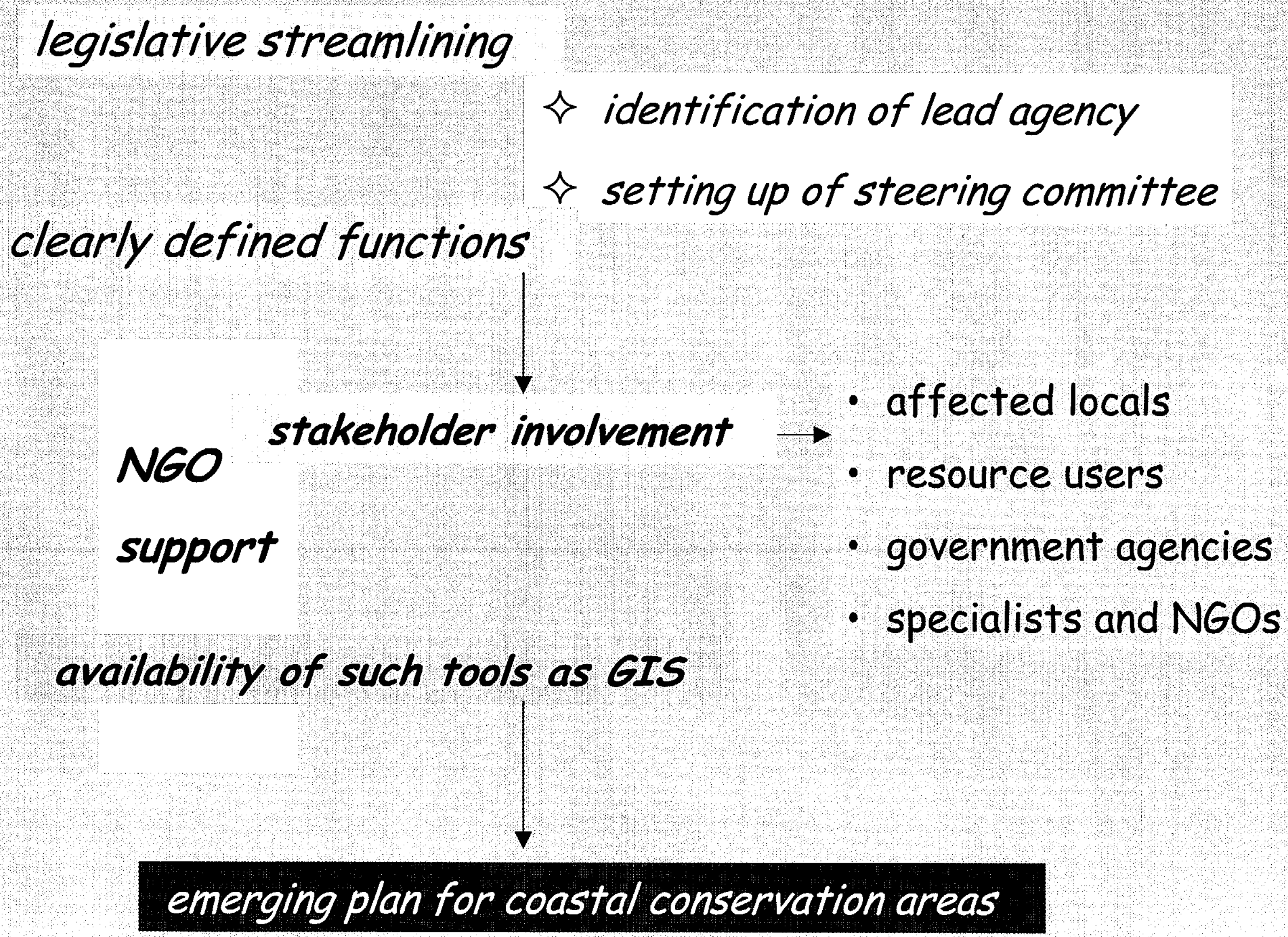
example: **such a system can effectively be put into action in a number of localities, that are important both socio-economically and conservation-wise.**

Biodiversity corridors

In locations where rare or endangered coastal habitats are scattered throughout the area and subjected to anthropogenic pressures through unsustainable activities, some form of 'contact' between different ecological communities/populations should be ensured

- **Seek to design *biodiversity corridors* to connect various habitats to ascertain natural genetic dispersal**

- **Ensure that biodiversity corridors are respected**
  - insufficient to delineate boundaries and embark on a buffer zone management programme
  - imperative that the cooperation of local resource users is sought
  - conservation area system plans should, in the end, be product of informed consensus among <u>all</u> interested parties



Some of the main elements required for plan-making and subsequent management of conservation areas

5

Environmental appraisal: planning and management tools and processes—environmental impact assessment and strategic environmental assessment

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The principles of EIA

EIA is:

a procedure designed to provide information about the potential impact on the environment of a proposed new development.

EIA may:

consider alternatives to the development;

consider wider policy and resource issues;

consider methods of reducing impact and related costs.

EIA may:

provide a mechanism for all interested parties to be consulted;

Provide a framework within which agreement may be reached between the developers causing the impacts and those who are affected by the impacts.

Definitions of EIA

- "… an activity designed to identify and predict the impact on the biogeophysical environment and on man's health and well-being of legislative proposals, policies, programmes, projects and operational procedures, and to interpret and communicate information about the impacts".

- "… to identify, predict and to describe in appropriate terms the pros and cons of a proposed development. To be useful, the assessment needs to be communicated in terms understandable by the community and decision-makers and the pros and cons should be identified on the basis of criteria relevant to the countries affected".

- "… an assessment of all relevant environmental and resulting social effects which would result from a project".

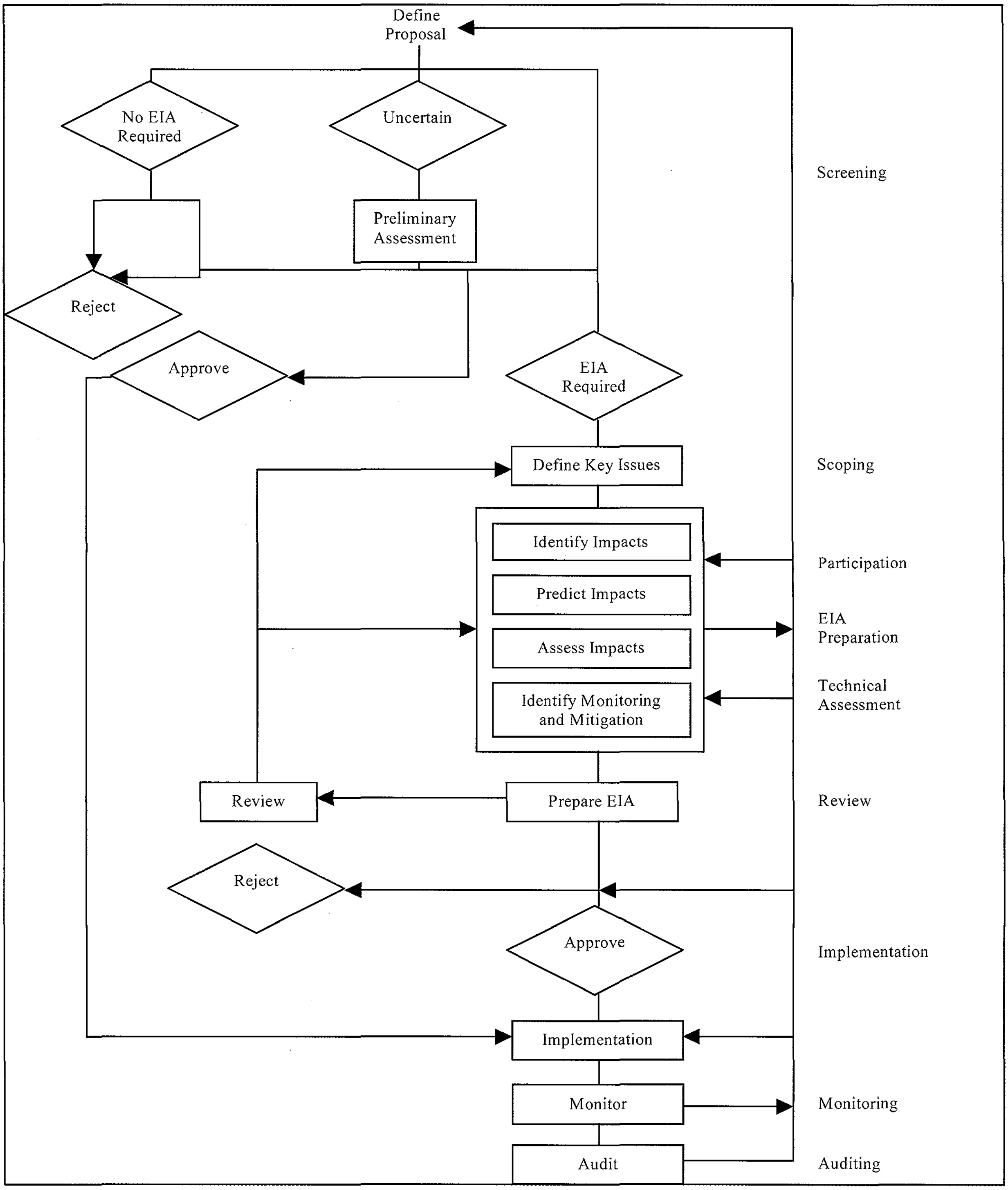
- "… an assessment consists in establishing quantitative values for selected parameters which indicated the quality of the environment before, during and after the action".

- "… the systematic examination of the environmental consequences of projects, policies, plans and programmes. Its main aim is to provide decision-makers with an account of the implications of alternative courses of action before a decision is made".

Development of environmental assessment

Approx. Date	Innovations in Techniques and Procedures
Pre – 1970	Analytical techniques: largely confined to economic and engineering feasibility studies; narrow emphasis on efficiency criteria and safety of life and property ; no real opportunity for public review.
c. 1970	Multiple objective benefit-cost analysis; emphasis on systematic accounting of gains and losses and their distribution; reinforced through planning, programming and budgeting review; environmental and social consequences not incorporated.
1970 – 1975	EIA primarily focused on description and "prediction" of ecological/land use change; formal opportunities for public scrutiny and review established; emphasis on accountability and control of project design and mitigation.
1975 – 1980	Multi-dimensional EIA, incorporating social impact assessment (SIA) of changes in community infrastructure, services and life-style; public participation becomes integral part of project planning; increasing emphasis on project justification in review process; risk analysis of hazardous facilities and unproven technology in frontier areas.
1980 – 1992	Attention given to establishing better linkages between impact assessment and policy-planning and implementation-management phases; research focus on effects monitoring, post-project audit and process evaluation; search begins for more disciplined scoping and focusing procedures and less protected forms of consultation based on negotiation and mediator.
1992 – onwards	Role of EIA in achieving objectives of sustainable development. Applying EIA to policies, land use and coastal management plans. Strategic Environmental Assessment (SEA). Role in company environmental strategies and policies.

Main stages in the EIA process



EIA stages

➢ ***Screening*** is undertaken to decide which projects should be subject to environmental assessment. Criteria used include threshold, size of project and sensitivity of the environment.

➢ ***Scoping*** is the process which defines the key issues which should be included in the environmental assessment. Many early EIAs were criticized because they were encyclopaedic and included irrelevant information.

➢ ***EIA preparation*** is the scientific and objective analysis of the scale, significance and importance of impacts identified. Various methods have been developed to execute this task.

➢ ***Review***. As environmental assessments are normally produced by the project proponent, it is usual for a review to be undertaken by a government agency or an independent review panel. The review panel guides the study and then advises the decision-makers.

➢ ***Monitoring*** is normally adopted as a mechanism to check that any conditions imposed on the project are being enforced or to check the quality of the affected environment.

➢ ***Auditing*** is now being developed to test the scientific accuracy of impact predictions and as a check on environmental management practices.

Scoping: establishing the "scope" of an EIA

Scoping is a procedure to establish the key issues that should be included in an EIA and to help formulate the terms of reference.

It has five basic objectives:

- to identify the concerns and issues which warrant attention
- to provide an opportunity for public involvement
- to provide a detailed brief for investigating the key issues associated with the scheme
- to facilitate the efficient preparation of an environmental impact statement
- to save time

Complexity of impacts

- Impacts on one component may well have effects on other components
- Indirect impacts (also called secondary, higher-order or knock-on impacts) may be difficult to identify, evaluate or predict, but should not be excluded from impact studies
- Some impact studies are irreversible, others are reversible
- Probability of an impact occurring is uncertain and is described generally
- Use of statistical probability has been applied mainly to risk assessment

Functions of the review authority may include:

- the "scope" of the assessment, i.e. which projects should be subjected to a full or partial EIA;
- general or specific guidelines and advise on methods of EIA;
- formulating the terms of reference and initiate a detailed EIA;
- ensuring that the EIA has been adequately completed within the terms of reference;
- submitting the EIS together with any separate contributions from other organizations, with recommendations to the appropriate authorizing agency; and,
- acting as a focus for the exchange of information and opinions concerning environmental affairs.

EIA follow-up: 4 key components

- ***Surveillance*** and inspection to ensure terms and conditions are being followed in project construction

- ***Monitoring*** to check for compliance with standards, to test the effectiveness of mitigation and other protective measures, and to detect potentially damaging changes

- ***Management*** to respond to unforeseen events or to offset larger-than-predicted effects (e.g. by employing contingency plans or revising environmental management plans)

- ***Auditing/evaluation*** to review aspects of EIA practice and performance; and, to provide feedback for process improvement (e.g. mitigation measures, administrative procedures)

[B Sadler, IAIA Effectiveness Study]

Financial benefits of EIA

- Avoidance of costly delays and unanticipated problems
- Identification of less damaging alternative (may also be cheaper to construct/operate)
- Cleaner, safer working environment and better staff productivity
- Mitigation measures which involve recycling/recovery

Strategic environmental assessment (SEA) benefits

- Encourage consideration of alternatives which may be ruled out or ignored in project-EIA
- Assist in selecting appropriate sites for projects subsequently subject to EIA
- Highlight and anticipate potential environment problems, thus facilitate long-range environmental planning
- Facilitate a more effective assessment of cumulative, indirect, synergistic, delayed, regional, transboundary or global impacts
- Reduce the time and effort required for project EIA by identifying issues, initiating baseline studies and assembling data at an earlier stage (by implementing SEA, some project EIAs may not be needed)
- Enable an assessment of the environment effects of policies which may not be translated into specific projects
- Contribute to the formulation of environmentally-sustainable policies

SEA – A general framework

- Screening
- Scoping
- Baseline information
- Impact prediction
- Impact evaluation
- EIS report
- Review
- Monitoring

Procedural and methodological difference between SEA and EIA

Procedural differences arise from timing at which SEA and EIA are triggered in the planning and decision-making process.

Five key issues can be identified:

- ***Confidentiality:*** The draft contents of certain policies, plans and programmes, may be considered too sensitive to be released for public consultation prior to their approval.

  As in the case of EIA, this may be handled by exemptions from certain consultation arrangements in cases where confidentiality may justify such a strategy.

- ***Constitutional issues:*** Certain actions are approved by cabinets acting under conditions of collective ministerial responsibility. If these were subject to legal SEA procedures, cabinet decisions may be open to challenge in court.

- ***Procedural deficiencies:*** In order to be fully effective, SEA should be integrated into existing procedures at key decision-making points for policies, plans and programmes. These procedures need to meet SEA requirements concerning the provision of documentation provided by the proponent, and the form of the consultation and the use of this information in the decision-making.

- *Proponent-competent authority relationship:* In many instances, the proponent may be the same organization as the competent authority. One means of safe-guarding the objectivity and quality of the EIA process, in this type of situation, may be to submit the EIS to review by an independent environmental authority or commission.

- *Curtailment of competencies:* SEA may be resisted by some government departments as an intrusion into their areas of competence. Whilst SEA (like EIA) is not intended to change the decision-making responsibilities of competent authorities, there is little doubt that the introduction of SEA, particularly at national policy-making level, is a highly sensitive issue.

It provides a real challenge to governments and, more particularly, departments with developmental responsibilities, to demonstrate that environmental factors have been given proper consideration.

Example: *SEA* of flood defence schemes in coastal areas

Strategic Environmental Objectives

"Environmental acceptability and enhancement criteria" have been developed as part of the SEA through consultation with a wide range of interested parties. These criteria provide objectives within which works will be planned and monitoring undertaken.

Listed below are some of the criteria from the SEA, indicating the range of topics covered:

- ☐ no damage, direct or indirect, to the integrity of internationally important conservation sites or overall change in the area or quality of existing habitats;
- ☐ no significant increase in flood frequency or depth in undefended areas or to undefended property;
- ☐ no significant upstream movement in the limit of saline intrusion;
- ☐ no new hazard to navigation;
- ☐ no loss of footpath length or quality.

Regional EA

- Used when number of activities with potentially cumulative impacts are planned for localised area
- More efficient than series of project-specific EIA
- More efficient at identifying issues involving cumulative impacts or interactions among projects
- Allows regions to be defined on appropriate basis (physical or biological for projects, administrative for institutions)
- Compare alternative growth scenarios
- Recommend sustainable development patterns

Sectoral EA

- Used for design of sectoral investment programmes

- Particularly suitable for:

  - reviewing sector investment alternatives

  - analysing environmental effects of sector policy changes

  - assessing requirements for environmental review, implementation and monitoring at sectoral levels

  - assessing environmental management capacities of sectoral institutions

  - assessing cumulative impacts of multiple, similar projects which do not merit individual EIAs

Environmental assessment in practice

Two trends stand out in the advances made to-date in EA process development and application:

- **widespread establishment of EA systems by many developing countries and by countries in transition**

- **the emergence of a second-generation, integrated, strategic EA process in several industrialised nations**

Three critical challenges to the contemporary practice of EA can be identified:

- **sharpening of EA as a tool for sustainability assurance, so as to provide guidance to the larger process of decision making**

- **ensuring the practical application of the integrated, second-generation EA process, particularly in the light of public sector resource constraints and the lack of consensus regarding sustainability criteria**

- **quality control into the EA processes to help bridge the gap between practice and potential**

6

Institutional arrangements for implementing integrated coastal area management

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THE COASTAL AREA

Coastal:

Sea-land interface

Coastal zone:

- Land affected by its proximity to the sea and vice versa
- Geographically narrow area
- Limits arbitrarily defined

Coastal area:

- Transitional area/environment between marine and terrestrial domains
- Geographically broader than coastal zone, including large ecosystems, territorial waters (12 nautical miles), and EEZ (200 nautical miles)

EFFECTS OF ECONOMIC ACTIVITIES ON COASTAL AREAS

- marine pollution
- freshwater pollution
- air pollution
- loss of marine resources
- loss of land resources (incl. visual value)
- loss of historical and archaeological resources
- loss of public access to the beach
- noise and congestion
- potential climatic change
- risks and hazards

SUSTAINABLE DEVELOPMENT AT A GLANCE

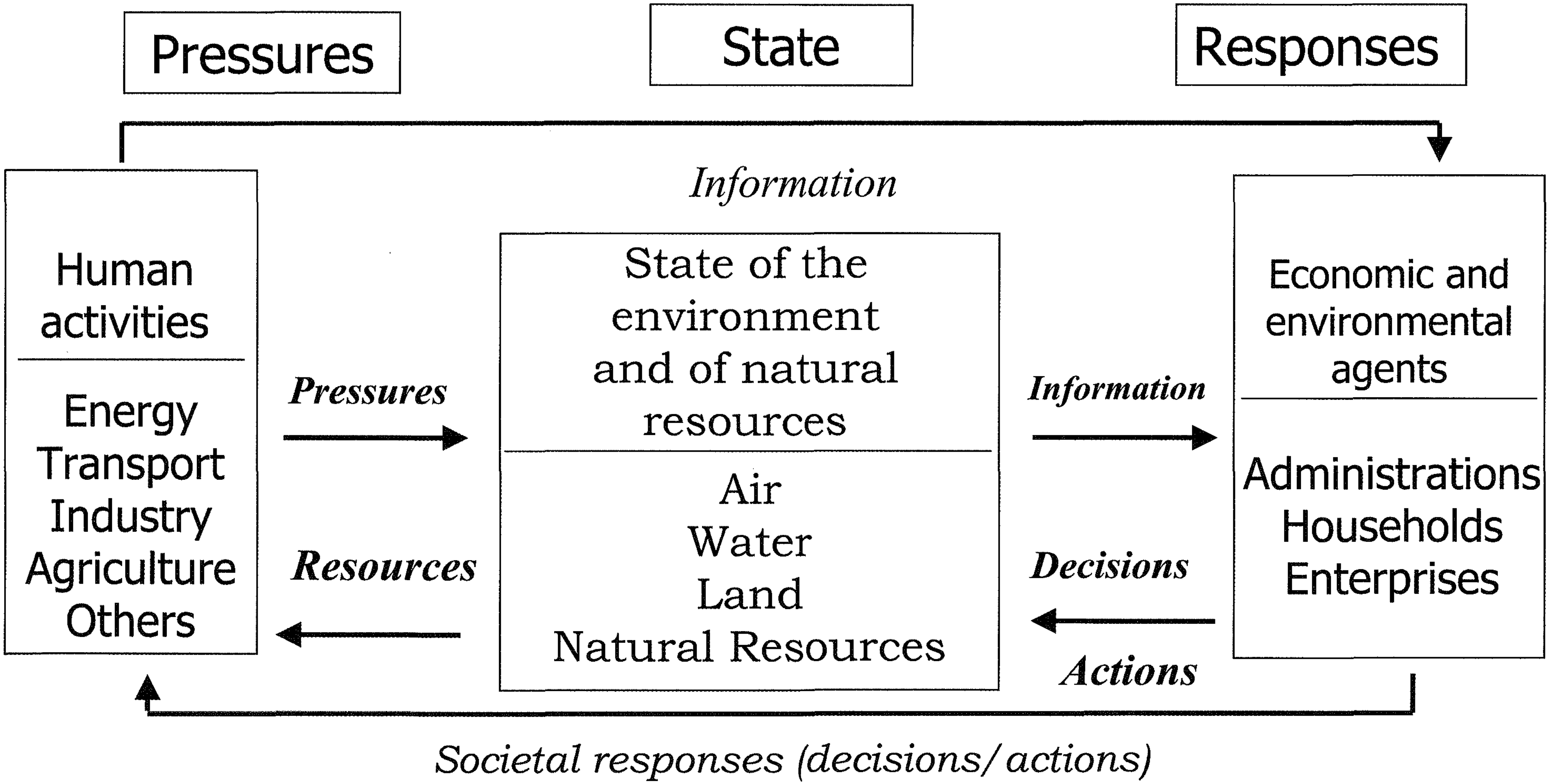
The concept:

Process of achieving economic and social development without compromising the health of natural ecosystems

Sustainable development perspectives:

- *Environmental* conservation
- Responsible *economic* development
- *Social* equity

SUSTAINABLE DEVELOPMENT and DECISION MAKING



INTEGRATED COASTAL AREA MANAGEMENT

- *ICAM:* a continuous, proactive/adaptive process for resource management in coastal areas

- *Fundamental to ICAM is:* comprehensive understanding of relationships between coastal resources, their uses and impacts on economy/environment

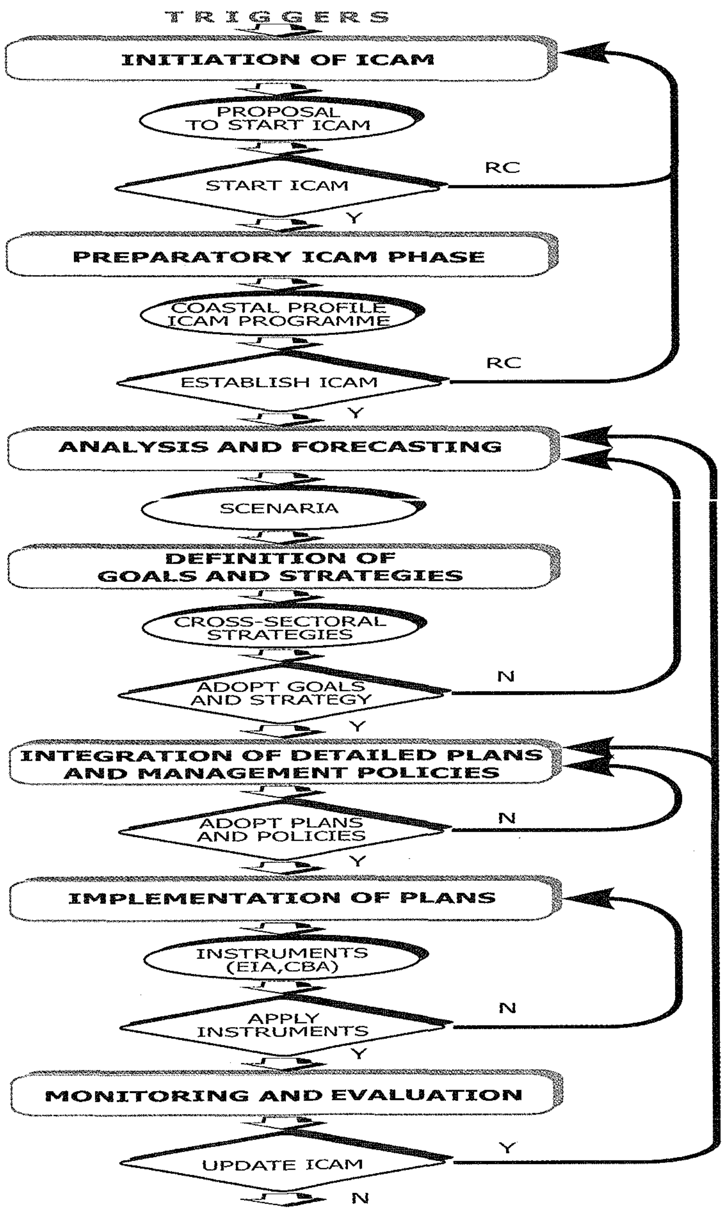
- *ICAM is not:* a substitute for sectoral planning, but focuses on sectoral activities' linkages to achieve comprehensive goals

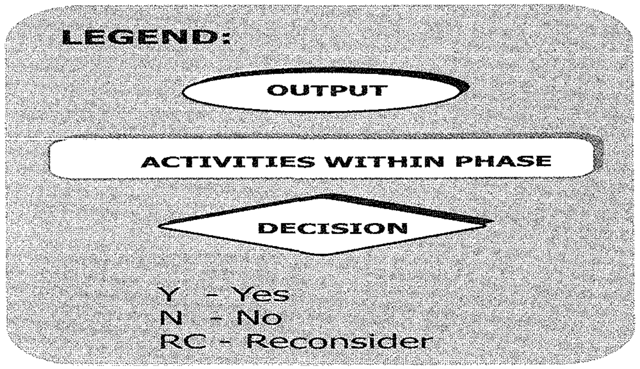
- *ICAM should focus on:* facilitating horizontal and vertical dialogue, agreements and compromise between all parties making use of coastal and marine resources

ATTRIBUTES OF ICAM

- A dynamic process, which requires continual updating and amendment, and not a one-time intervention
- A governance arrangement exists by which policies for making allocation decisions are established
- A governance arrangement that uses one or more management strategies to rationalize the allocation decisions in a systematic manner
- Management strategies based on a systems perspective, requiring a multisectoral approach for design and implementation
- A geographic boundary that is spatially defined within the sea-land interface

Flowchart for ICAM process





STAGES and PHASES OF ICAM

INITIATION

- budgetary availability
- legislative backing

PLANNING

- preparatory phase
- analysis/forecasting
- definition of goals and strategies
- integration of detailed plans and management policies

IMPLEMENTATION

- implementation of plans
- monitoring and evaluation

SUSTAINABILITY OF ICAM

- institutional arrangements
- legal arrangements
- financial mechanisms
- political support
- public participation

INSTITUTIONAL ARRANGEMENTS FOR ICAM

Roles of institutions for ICAM:

- *an executive role* for decision making
- *a judicial role* for enacting regulations, standards and procedure
- *a market role* allocating funds, offering incentives or subsidies

Selection of adequate institutional arrangements:

Dependent on a complexity of factors:

- ***Sectoral differentiation*** (governmental intervention in fisheries, shipping, port and harbour development, tourism, etc.)
- ***Geographical differentiation*** (changing governmental responsibilities length-wise along and perpendicular to the shoreline axis)
- ***Functional differentiation*** (national, regional and local level administration)

INTEGRATION *vs.* SECTORAL APPROACH

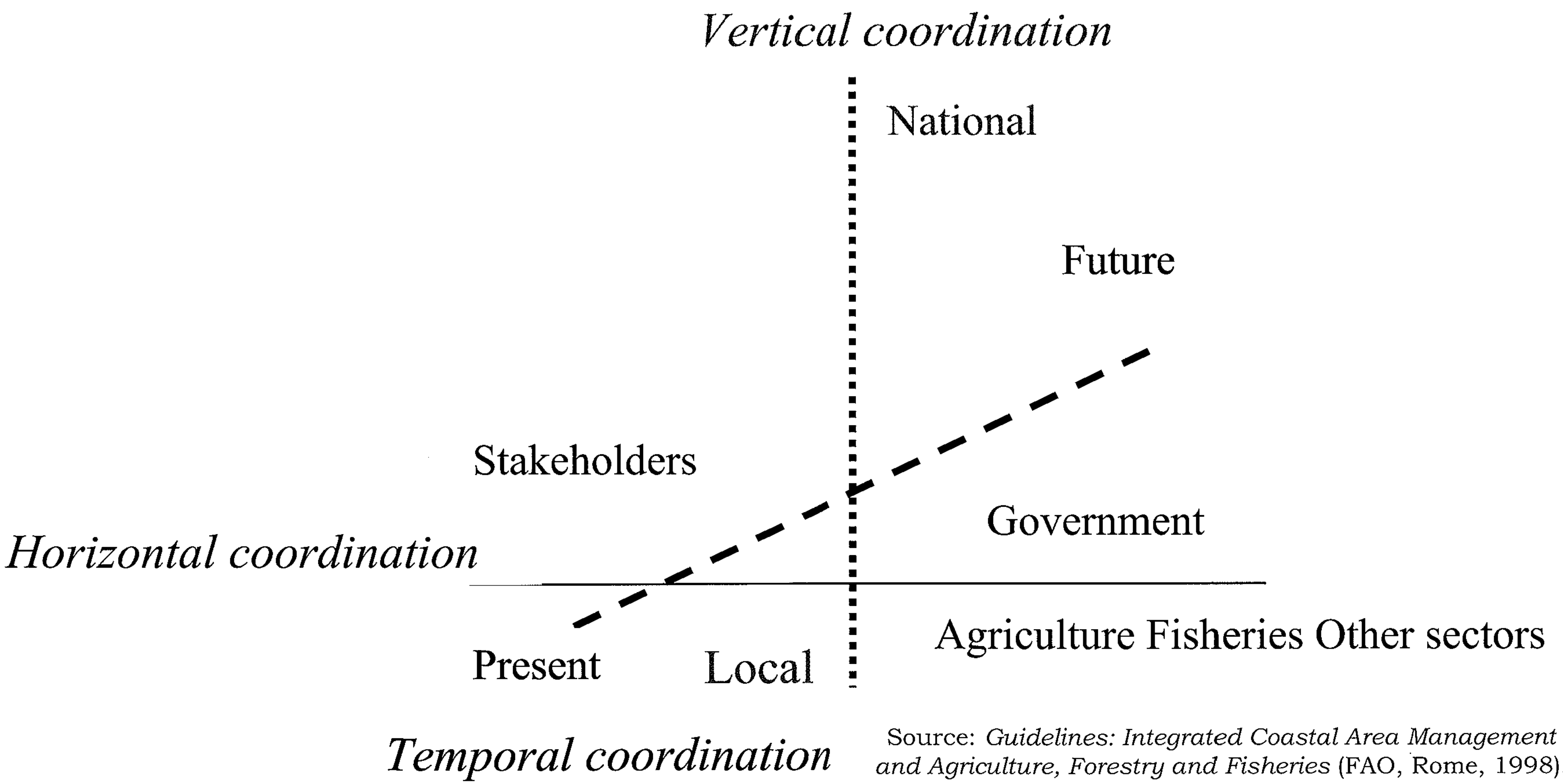
Sectorial solutions often "transfer" or sideline the problem

Managing complex systems requires integrated approach, which can:

- bring together multiple and overlapping interests of the coastal area
- harness coastal resources for maximum social and economic benefit for present and future generations
- consider sectoral activities holistically

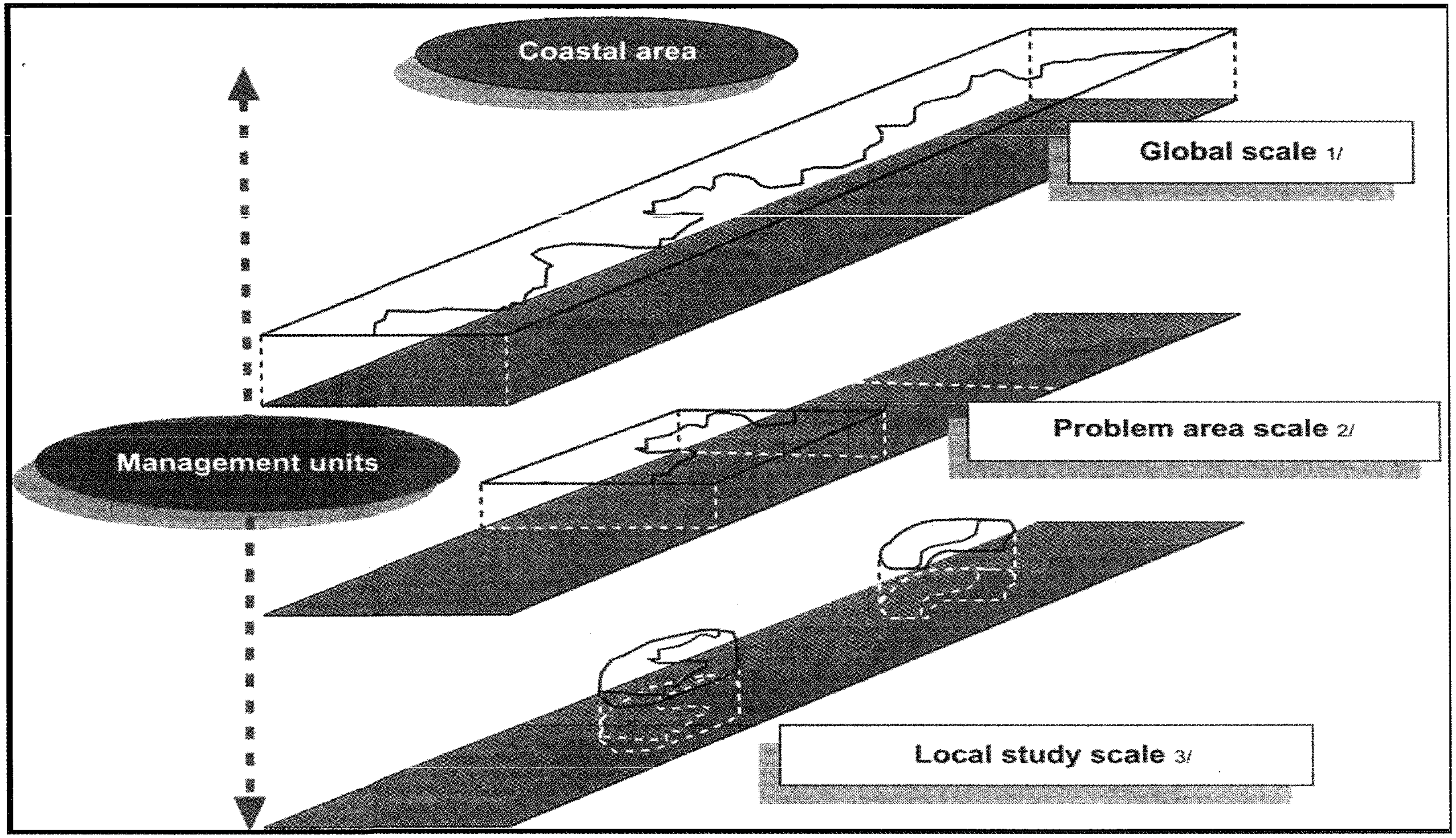
COORDINATION OF ICAM ACTIVITIES

Various levels of coordination needed for ICAM



Source: *Guidelines: Integrated Coastal Area Management and Agriculture, Forestry and Fisheries* (FAO, Rome, 1998).

DIFFERENT SPATIAL MANAGEMENT SCALES OF ICAM



STAKEHOLDERS IN ICAM

STATE OR PARASTATAL ORGANIZATIONS

- National (central) government
- Regional (state) government
- Local government
- Line agencies and ministries
- State-owned enterprises

STAKEHOLDERS WITH DOMINANT COMMERCIAL INTEREST

- Privately-owned enterprises
- Multinational corporations
- Coastal landowners

OTHER COASTAL STAKEHOLDERS

- United Nations agencies and international aid organizations
- National and international NGOs
- Social classes and consumer (users) groups
- Ethnic groups
- Political parties

TYPES OF INSTITUTIONAL ARRANGEMENTS

1. NEW CENTRALIZED GOVERNMENT AGENCY

(Examples: Sri Lanka, the British Virgin Islands and the State of California)

- Usually entrusted with jurisdiction over the coastal zone and power to enact, amend and complete an ICAM plan and to prepare necessary legislation.
- May be very effective in resolving conflicts between various stakeholders and harmonizing development of various coastal-dependent sectors.
- Requires the highest level of efforts and commitment and a substantial amount of human and financial capital.
- ***Constraint:*** existing line ministries may be reluctant to transfer duties and responsibilities to a new agency.

TYPES OF INSTITUTIONAL ARRANGEMENTS (continued)

2. LEAD AGENCY

(Examples: China, Costa Rica and United States of America)

- Leads to enhancing duties and responsibilities of existing agency.
- Problems may be overcome by giving lead agency a clear mandate and enough power to ensure cooperation between agencies.
- ***Constraint:*** appropriate only when sufficient laws and authorities exist for proper management of coastal resources.

TYPES OF INSTITUTIONAL ARRANGEMENTS (continued)

3. PERMANENT INTERMINISTERIAL OR INTERSECTORAL COUNCIL

(Examples: Ecuador, Indonesia, Thailand, Philippines)

• Usually having authority to devise a coastal management plan, issue guidelines for the integration and coordination of existing policies, and, develop appropriate laws.

• Setting up such councils is motivated by notion that no single agency has sufficient power, information, capacity and authority to fully implement ICAM plans.

• Proved to be more efficient in gathering data and writing ICAM guidelines than in implementation of ICAM policies on-site.

• ***Constraint:*** if not properly run, they may represent merely another layer of bureaucracy.

TYPES OF INSTITUTIONAL ARRANGEMENTS (continued)

4. NON-EXECUTIVE ADVISORY COMMITTEE

- Consists of several government agencies representatives and interest groups.

- Brief to examine specific coastal area management issues and advise an executive government agency.

- ***Advantages:*** brings valuable insights to coastal problems; does not require additional staff and includes non-government stakeholders.

TYPES OF INSTITUTIONAL ARRANGEMENTS (continued)

5. REGULAR INTERDEPARTMENTAL CONSULTATIONS

- Supplementary to a permanent interministerial council.

- Usually less powerful and more informative than problem-oriented.

TYPES OF INSTITUTIONAL ARRANGEMENTS (continued)

6. *AD HOC* PANELS

• More or less formal type of institutional arrangement for ICAM, supplementing lead agencies or interministerial councils.

• Provide significant understanding on scientific and/or management issues, through interdisciplinary fact-finding and discussion exercises.

• Created in many countries for specific coastal research agendas.

• Largely believed that significant progress in international environmental cooperation was made through multidisciplinary scientific investigations.

CHOOSING THE APPROPRIATE INSTITUTIONAL ARRANGEMENT

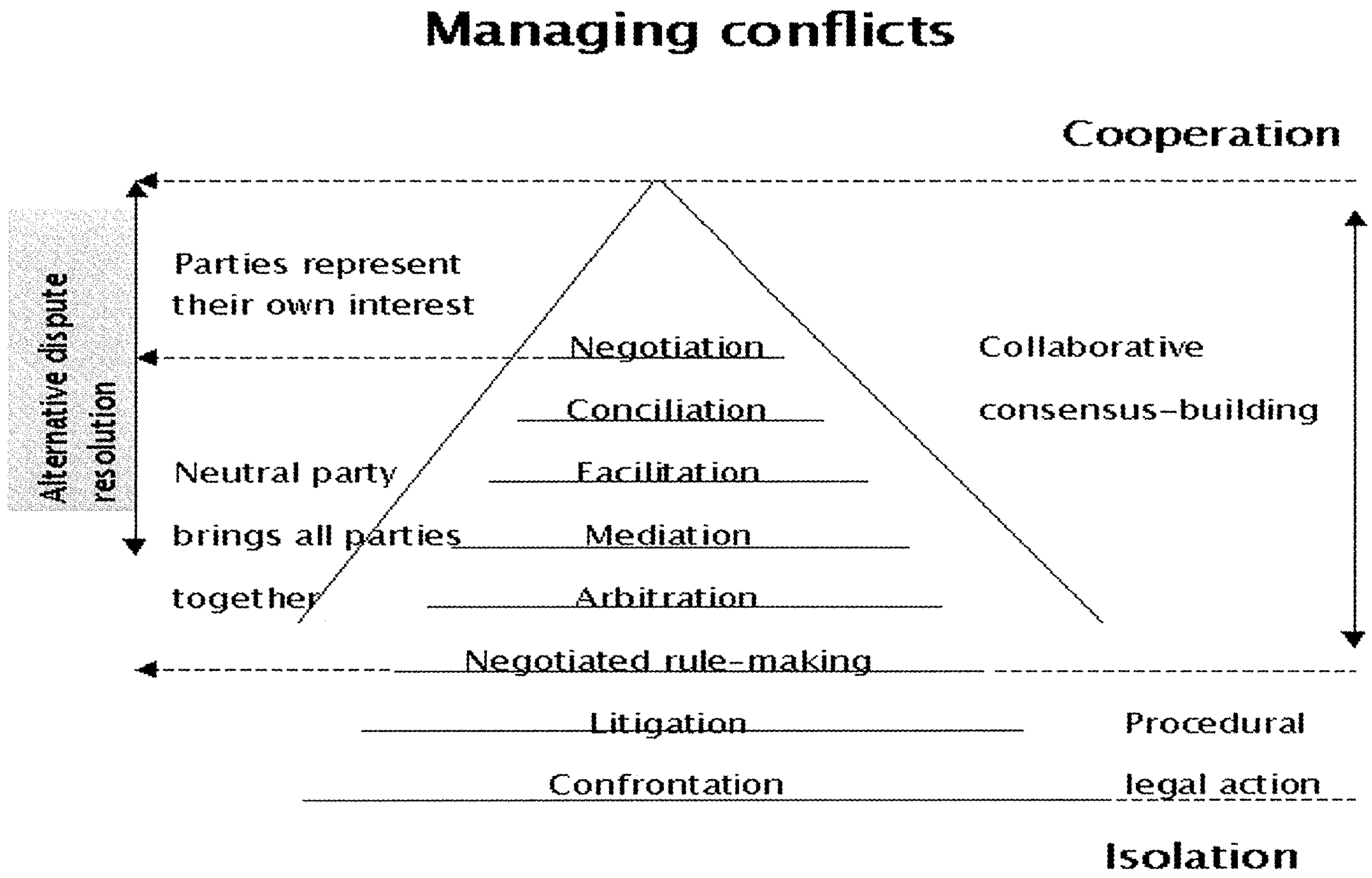
- No uniform key to the most appropriate type.

- A new centralized agency may be a good choice for countries with long history of ICAM, proper enacted coastal legislation and good integration of sectoral planning.

- Currently, most commonly used: coordinated institutional arrangement.

- Developing countries should commence with supplemental institutional arrangements, establishing more formal arrangements in parallel with enactment of laws, tools and techniques for ICAM and public awareness.

CONFLICT RESOLUTION TECHNIQUES IN ICAM



Source: *Guidelines: Integrated Coastal Area Management and Agriculture, Forestry and Fisheries* (FAO, Rome, 1998).

7

Decision support systems as a tool in coastal zone management

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Evolution of Information Systems

By 1960s information technology began to evolve and instant access to data was possible;

this led to the development of
<u>Management Information Systems (MIS).</u>
<u>Mallach,1994</u>

Management Information System (MIS)

Originally, a system which provided management information about all aspects of a firm's operations

Development of DSS

Further developments led to a new system, that evolved in the 1970s;

- this helped decision-makers to interact directly with computers to create information, useful in making unanticipated semi-structured and un-structured decisions. Hicks, 1993

- these became known as decision support systems.

Decision Support Systems

Essentially, a DSS assists policy-makers in making decisions

There are, however, several definitions of DSS.

DSS Definitions

A computer-based information system that affects or is intended to affect the manner by which people make decisions

[Silv, 1991]

DSS Definitions

A set of tools, data, models, and other relevant resources that managers and analysts may use to understand, evaluate and solve problems.

[KROE, 1992]

Decision Support Systems

What is a Decision?

A decision is a choice among alternatives.

A <u>decision statement</u>, a set of <u>alternatives</u> and <u>decision-making criteria</u> characterizes each decision.

Decision Support Systems

Decision statement: states what we are trying to decide

Alternatives: the possible decision we can make

Decision-making criteria: what we want to optimize in a decision

Decision Support Systems

Why take a decision:

- **There is a problem**
- **The problem is important and needs to be resolved**

Decision Support Systems

The Decision Process:

As defined by *Herbert Simon*, every decision has three phases:

- **<u>intelligence</u>**
- **<u>design</u>**
- **<u>choice</u>**

Decision Support Systems

The Intelligence phase:

finding, identifying and formulating the problem or situation that calls for a decision

(deciding what to decide)

Decision Support Systems

The design phase:

the design phase is where alternatives are developed:

- **What are the available options?**
- **Objectives for the decision need to be stated**

Decision Support Systems

The choice phase:

In the choice phase, alternatives that are developed in the design phase are evaluated.

Subsequently, a choice is made.

The end-product is a decision that may be carried out.

Decision Support Systems

Types of Decisions:

decisions can be categorized by the <u>nature</u> and <u>scope</u> of the decision.

[KEEN, 1978],

- **<u>Structured Decisions</u>**
- **<u>Unstructured Decisions</u>**
- **<u>Semi-structured Decisions</u>**

Structured Decision

A decision for which a well defined decision-making procedure exists

- a decision is structured if all three of its phases are structured

Unstructured Decision

A decision of which none of the three phases (intelligence, design and choice) is structured

Semi-structured Decision

A decision of which one or two of the three phases (intelligence, design and choice) is/are structured

Decision Support Systems

The three levels of decision scope are the following :

<u>Strategic decision</u>

<u>Tactical decision</u>

<u>Operational decision</u>

[ANTH, 1965]

Strategic decision:

a decision that affects the entire organization, or a major part of it, for a long period of time.

The effects usually encompass: organizational objectives and policies.

Generally made at upper levels of organizational management.

Tactical decision:

a decision that influences how a part of the organization does business for a limited time into the future.

takes place within the context of previous strategic decisions

usually made by middle managers

Operational decision:

a decision that affects activities taking place in the organization at the present time, but, has either little or no impact on the future; and, if it does, it is made within the confines of a controlling policy.

relates to activities whose tasks, goals, and resources have already been defined prior to strategic and tactical decisions.

made by lower level managers or by non-managerial personnel.

The anatomy of a decision

The following are the main steps that should occur when applying a decision-making process

- Problem definition
- Identify the criteria
- Identify strategy variables
- Assign weighting to each criteria
- Assign weighting to each variable on each criterion
- Formulate the strategy
- Compute the optimal strategy

Group Decision support Systems (GDSS):

A group Decision Support System (GDSS) is one whose design, structure, and usage reflect the way in which people cooperate to make a particular decision or type of decision.

Group Decision support Systems (GDSS):

Reasons for GDSS:

<u>**Organizational reasons**</u>

<u>**Technical reasons**</u>

Group Decision Support System (GDSS):

Organizational reasons:

The decision-making environment has become more complex and, as a result, it has increased the complexity of many aspects of decisions *per se*.

Technical reasons:

Fast telecommunications links (including high-speed networks), a necessity for many group DSS, are becoming more accessible and less expensive.

Group output:

"The tendency of some groups, who work together over a period of time, to produce poorly reasoned decisions"

[Janis, 1972]

"The tendency of the group's members to fall into similar thought patterns and to disapprove, implicitly or explicitly, opinions that do not conform to these patterns."

[Mallach, 1994]

8

Integrated coastal zone management as a toolbox for environmentally sustainable industrial development in coastal areas

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Human pressures on coastal areas

❖Significant proportion of global human population lives in close proximity to coastal zone, often in the vicinity of large coastal plains, river deltas and estuaries, and is frequently dependent on the fishing industry for food, employment and wealth generation.

❖Coastal zones are areas where conflicting pressures between economic and social activity and the maintenance of environmental quality exist.

❖Coastal zones receive a multitude of waste inputs originating from industrial and municipal land-based sources.

A complex mix of other toxic chemical pollutants is also introduced through:

shipping activities
offshore petrochemical industries
atmospheric inputs of airborne pollution

An interdisciplinary approach

❖World's coastal regions often characterized by a very rich biodiversity; particularly in the tropics. Considerable changes already occurring in the ecology of many coastal regions as a result of natural and man-made changes, linked to industry and urbanization.

❖Changes are likely to be brought about by sea level rise and increased harmful UV radiation. Furthermore, continuing problems of water supply and sanitation, associated with pollution and water-related diseases, are likely to result in considerable human deprivation and death.

❖Dealing with the complexity of coastal problems through the implementation of effective Integrated Coastal Zone Management.

Assesses changes in coastal ecosystems using science-based information, linked to socio-economic benefits for countries bordering on large estuaries and deltas.

❖The methods are used in an integrated interdisciplinary way in order to address the consequences of ecosystem change and the ensuing implications for sustainable use and development of food resources, as well as the needs of industry and the impact on human health.

❖Effective coastal and estuarine management has the prerequisite of a sound foundation of scientific research and understanding of environmental processes.

What causes coastal and estuarine stress?

❖Natural forces such as sea level rise and coastal erosion

❖Coastal zone development - industry, transportation and ports, urban development, recreation and tourism

❖Mining and resource removal - industrial extraction of metals and other minerals over-fishing and the cutting of mangrove forests

❖Discharges - municipal and industrial outfalls, release of water used as ballast from ships, atmospheric deposits and land run-off

❖Illegal practices - dumping of waste and chemicals from ships and oil spills

What's at risk?

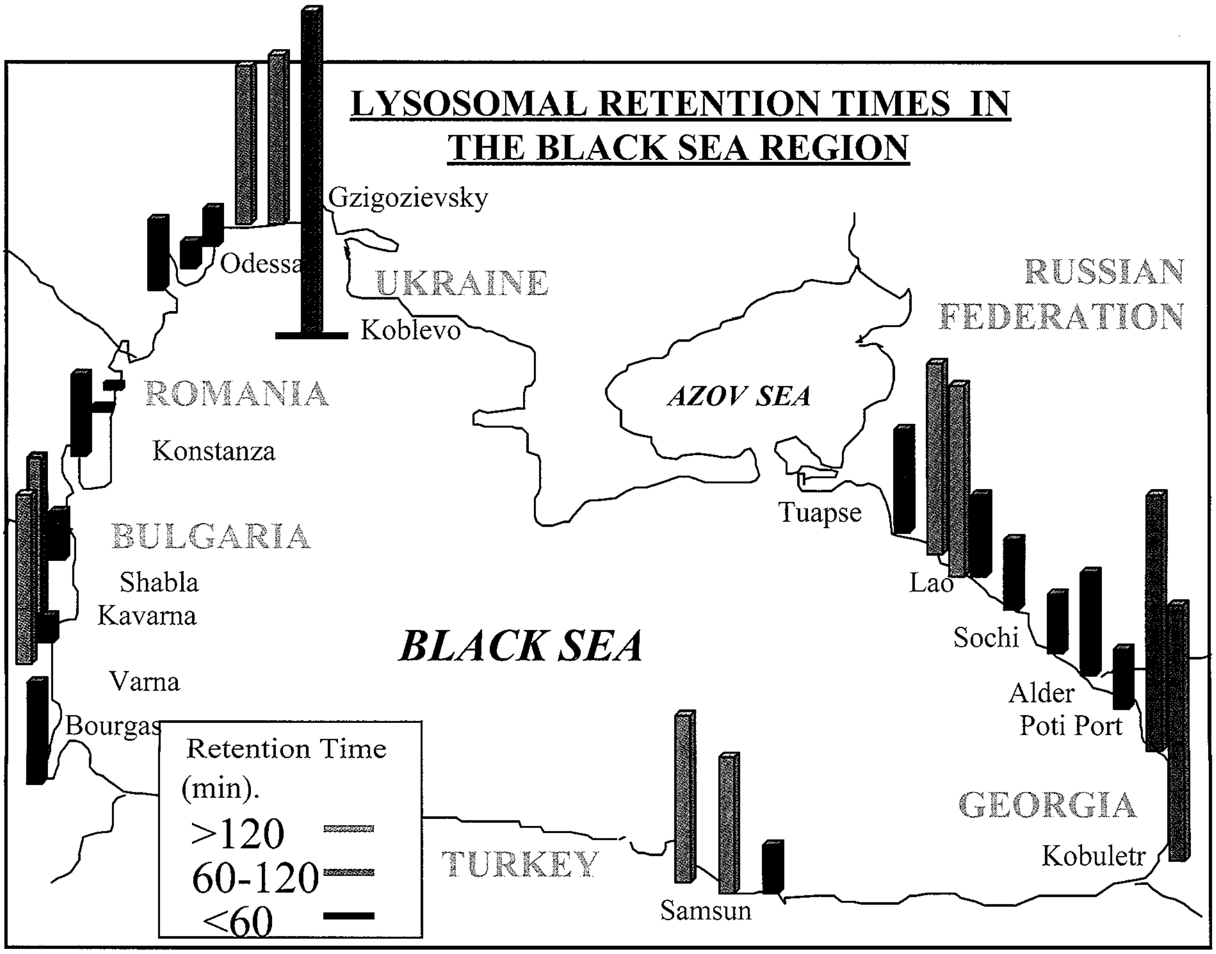
❖**Land-use and environmental resources** (e.g., salt marshes, coral reefs and deltas: under pressure from sea-level rise and coastal erosion)

❖**Coastal biodiversity** (loss of species: coastal rainforests and mangrove forests; fish and plankton populations: declining in some areas)

❖**Environmental quality** (e.g., shellfish growth studies and rapid biomarker tests can show where there are areas of contamination and harmful effects

❖**Environmental health** (e.g., contaminants with endocrine-disrupting properties leading to sex changes in some animals and reproductive pathologies, carcinogenic and mutagenic compounds impacting on plants and animals including humans)

❖**Aesthetic** (e.g., oil and litter on beaches)



NB: Koblevo is located in the Ukraine, it has been moved to be kept within the map confines.

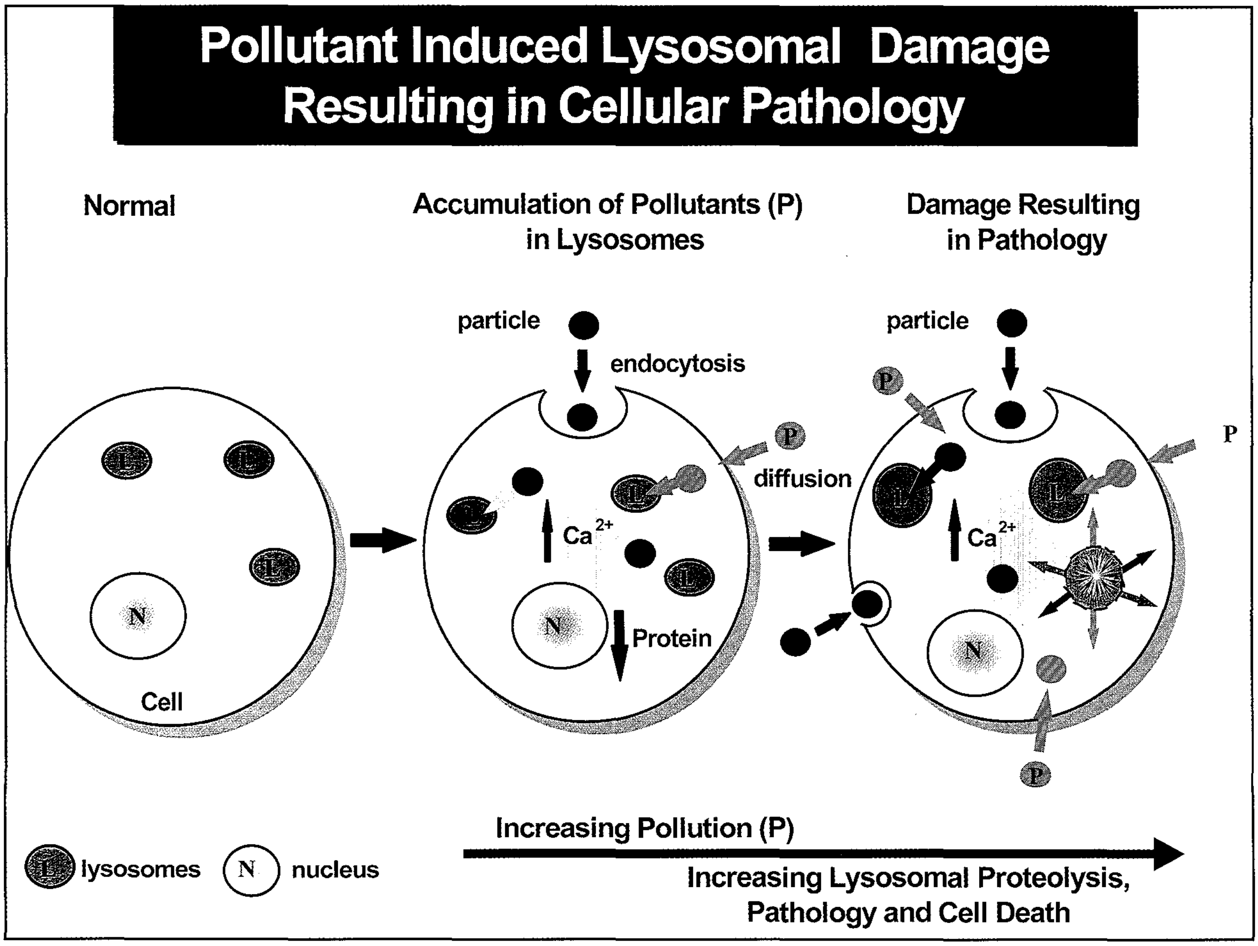
Application of lysosomal biomarker test to mussel blood cells in the Black Sea (Moore, M. N., *et al.*, 1998. The UNESCO-IOC Black Sea Mussel Watch: biological effects and contaminant residues, UNESCO-IOC report)

How to forecast and reduce risks?

Research is needed into specific problems to find the most cost-effective solutions.

In particular the following is required:

- ❖Innovative monitoring and surveillance techniques to understand extent of the problems (e.g., earth observation systems)
- ❖Research into understanding processes (e.g., physical, chemical and biological)
- ❖To develop models to determine appropriate control areas (e.g., the extent of high natural dispersion areas around discharge points)
- ❖To develop expert systems to link existing models with our experience and knowledge of the environment
- ❖To develop and use indicators to show effectiveness in moving towards sustainable development where there is a need to link environmental, social and economic measures



Uptake of xenobiotics, lysosomal accumulation and cell injury

(Moore, M.N. and Willows, R.I., 1998. Mar. Environ. Res., 46, 509-514)

Managing risk

Risk is sometimes greater than has been estimated because of incompleteness of data.

Effective coastal and estuarine management has the prerequisite of a sound foundation of scientific research and understanding of environmental processes.

Requires collaboration between environmental managers and research centres with the strategic capability to understand processes of change and the impact of human activities upon them.

Areas of collaboration need to include, among others, environmental monitoring and remote/satellite surveillance, risk assessment, interpretation of complex information and predictive modelling.

9

Process simulation and its environmental application

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Lecture overview:

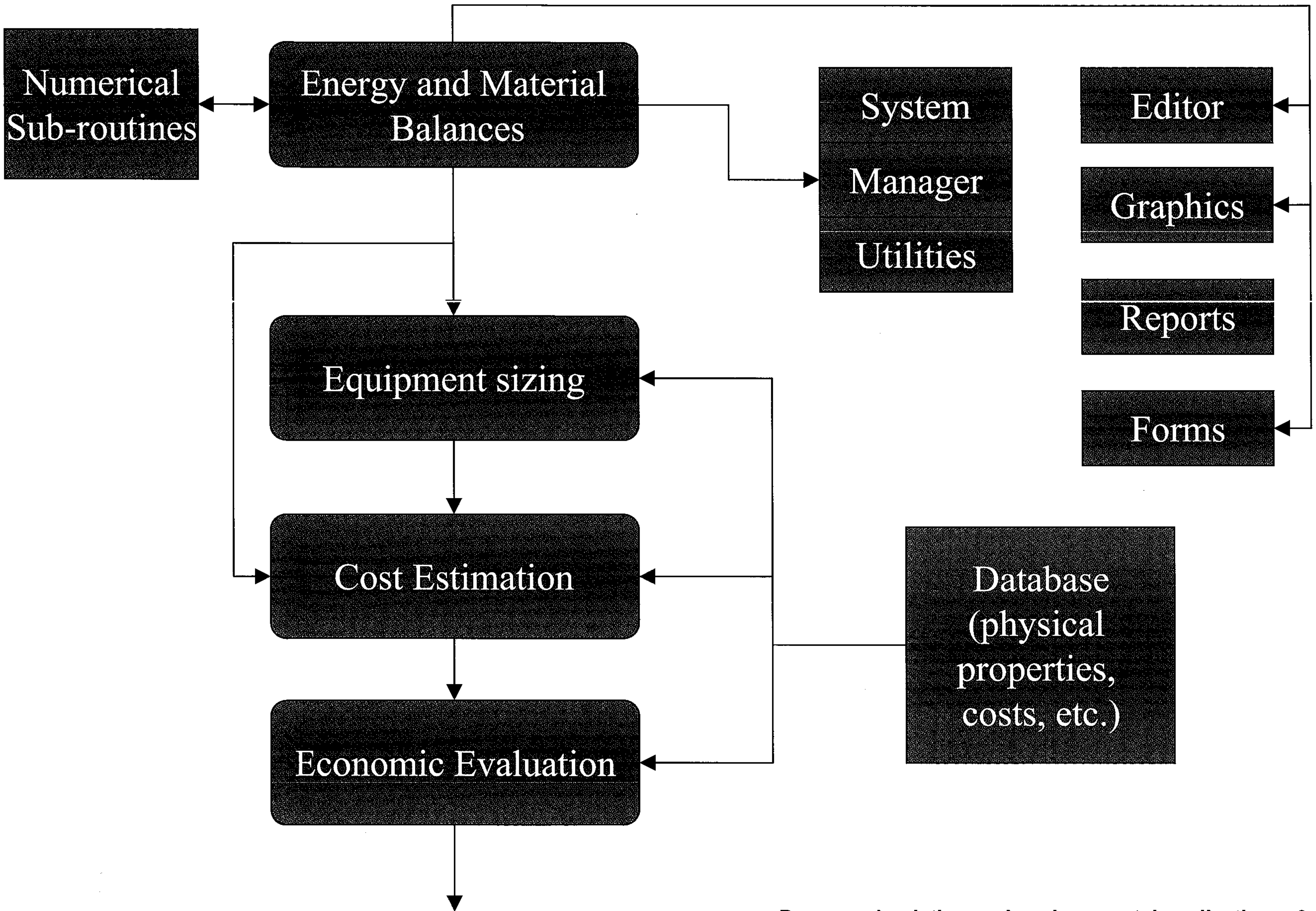
- Process simulation goals and definitions
- The use of process simulation in industry
- Software structure of a process simulator
- Procedures and obtainable results
- The user interface and inter-operability
- The hardware - operating systems
- Process simulation and Decision Support Systems
- Environment control: statements and strategy
- Pollution prevention techniques and process simulation
- Environmental applications and examples

Process simulation fundamentals: Solving material and energy balances using flowsheeting codes

Flowsheeting: steady state process material and energy balances

Flowsheeting package or code: the computer code

A typical flow-sheeting code: steady state



Mathematically speaking

- n non-linear material balances equations
- 1 energy balance non-linear equation
- set of differential - algebraic equations (dynamic simulators)
- In presence of:
  - Very many components
  - Complex thermo-physical models for phase equilibrium calculations
  - A high number of sub-systems (equipment)
  - Rather complex equipment (distillation column,...)
  - Recycle streams
  - Control loops

The fundamentals

- **Different possibilities for process simulation**
  - Steady state simulation: in which no accumulation terms are considered
  - Dynamic simulation: a simulation in the time domain
  - Integrated steady state - dynamic simulation
- **Different philosophy**
  - Process analysis
  - Process synthesis
  - Process design and simulation
- **Process simulation impact on industry: *knowledge management***
  - A way for ‘fixing’ engineering knowledge
  - The way engineering knowledge is used in processes
  - The design procedure of the process (plant)

From a traditional way of using process simulation ...

Flowsheet design

Definition of equipment-critical parameters

(such as distillation column stages, column diameter,...)

… to the comprehensive use of process simulation in the entire 'life' of the plant

Control strategies design

Process parameters optimization (= 'better' processes)

Time evolution of the process (start-up and shut-down)

(= risk analysis)

Operator training

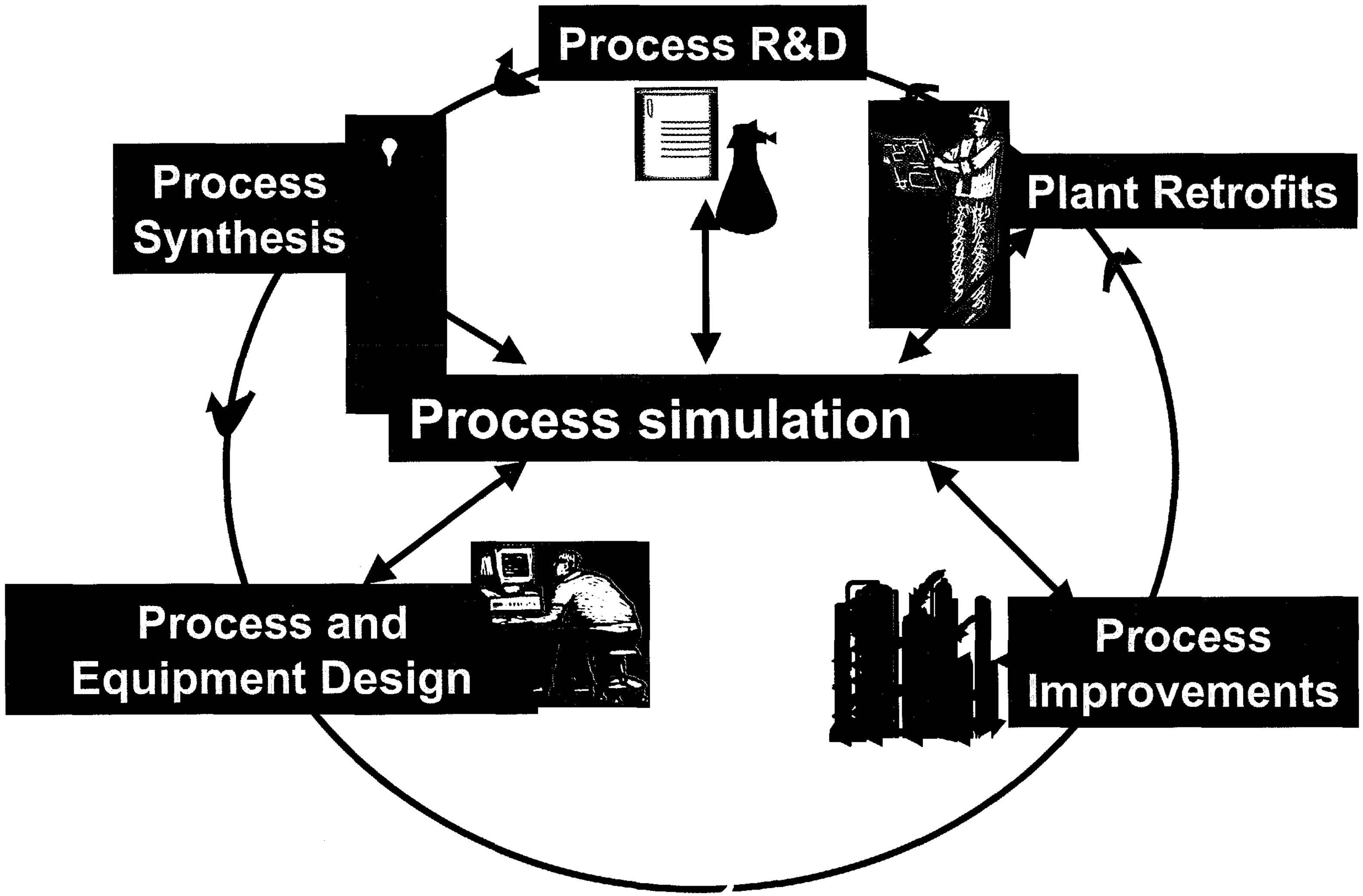
Definition of procedure to reduce the unsteady state operations

Benefits

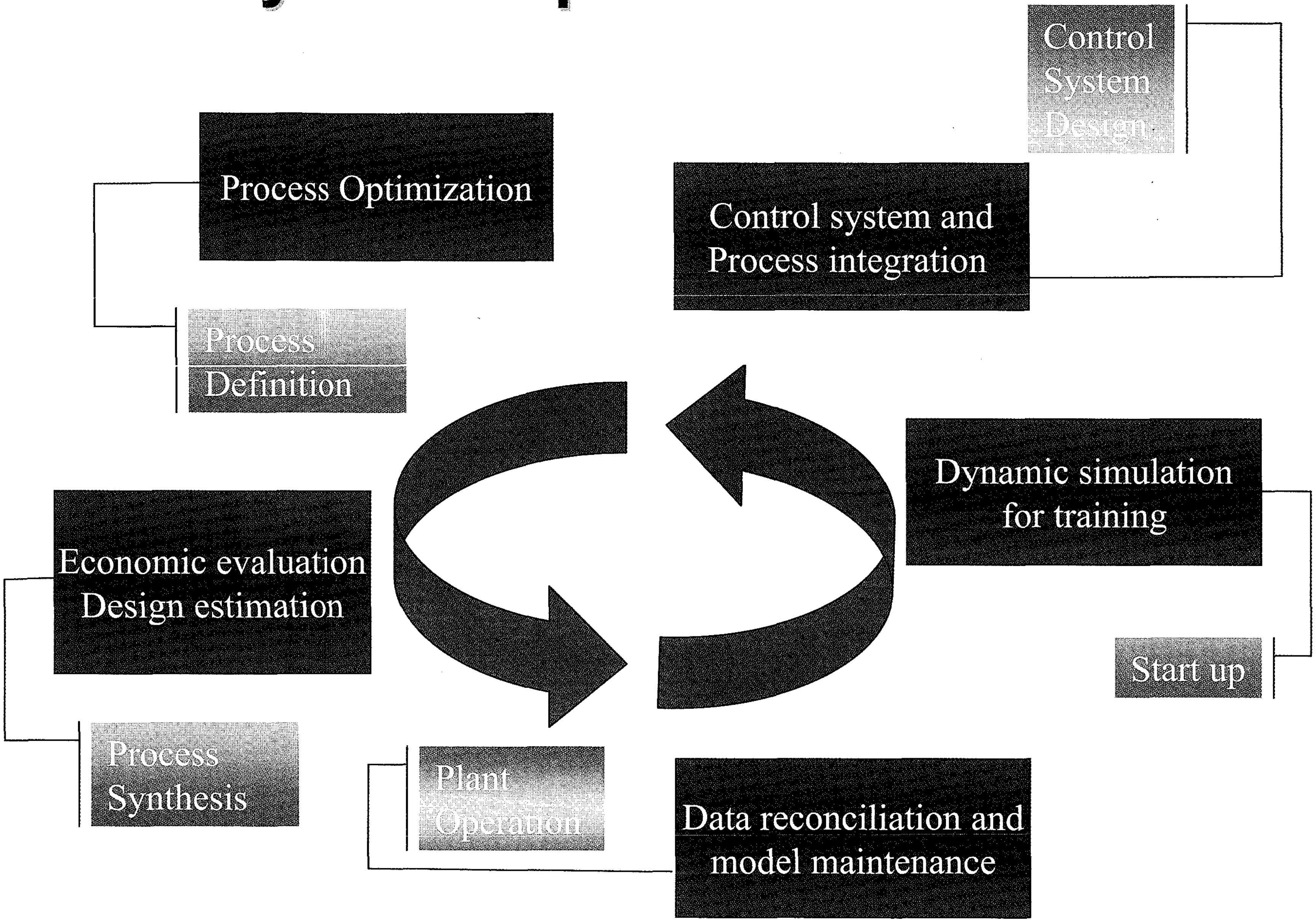
- Partial or total replacement of Pilot Plant operations
  - Reduction of number of runs
  - ‘Runs’ planning
- Reduction of *time* to market for the development of new processes
- Fast screening of process alternatives to select the best solution
  - economic aspects
  - environmental aspects
  - energy consumption aspects
  - flexibility of proposed process

To get those benefits one must critically simplify the process

Process Simulation and the Engineering Work Process



The 'life cycle' of a process



Process simulation: the procedure ...

- Identify the problem
- Obtain all the relevant information
  - Get process data: flow rates operative conditions
  - Get thermodynamic data:
    - In-house data
    - Data banks (Dechema, ...) or literature
    - Through test run on laboratory / pilot plant

  - Get kinetic data
    - directly from pilot plant
    - from excess Gibbs energy calculations (if possible)
    - directly from plant data

  - *TIP : avoid rigorous definition of kinetic model and use concept of yield and conversion wherever possible and reasonable*

... Process simulation: the procedure *(continued)*

- **Select the software**
  - **Steady-state simulation**
    - AspenPlus
    - ChemCad III
    - Design 2000
    - Hysim
    - Pro II
  - **Dynamic simulation:**
    - Speedup - Aspen Custom Model
    - Hysis
    - gPRON - ABACUSS
  - **Integrated solution**
    - Aspen Dynamic
    - Hysis

... Process simulation: the procedure *(continued)*

- **Select the hardware**
  - Operating systems
    - Client - server solutions
    - Client is Windows NT 4.0 and 5.0 (late 1999)
    - Server is Windows NT or UNIX
    - Office environment
  - Hardware
    - Client: PC Intel Pentium II 400Mhz - 32-64 MB RAM - SCSI Disks 8 GB - High quality monitor and video board
    - Server: Intel or RISC based systems - 512 MB RAM - SCSI RAID Disks, BU unit, ...

… Process simulation: the procedure *(continued)*

- Human resource capacity-building
  - Basic courses on process simulation

  Further training on:
  - Thermodynamic model selection
  - Specific topics (heat exchangers, batch, heat integration, cost analysis, …)
  - Economic factors
  - Energy consumption
  - Environmental impact/s
  - Operational procedure

Process simulation: the logical aspects of the procedure

- Components definition
- Physical - chemical properties definition
- Flowsheet connectivity
- Feed conditions definition
- Unit operation internal definitions
- Process specification definition
- Control parameters
- Equipment hold-up definition

Results obtainable

- Validation of phase equilibrium models for the real system to be used in similar conditions
- Verification of the process operating conditions
- Information on intermediate streams
- Enthalpy balances information
- Verification of the plant specifications
- Influence of the operative parameters on the process specifications
- De-bottlenecking process for each section
- *A priori* identification of process control strategies and tuning of instrumentation
- Possibility to verify security systems behaviour for variation of process condition

Applications of dynamic simulation

Continuous processes

- Concurrent process and control design
- Evaluation of alternative control strategies
- Troubleshooting process operability
- Verification of process safety

Batch processes

- Design of batch and semi-continuous processes

Online applications

- Calculation of inferential measurements
- Identification for model-based control
- Decision support

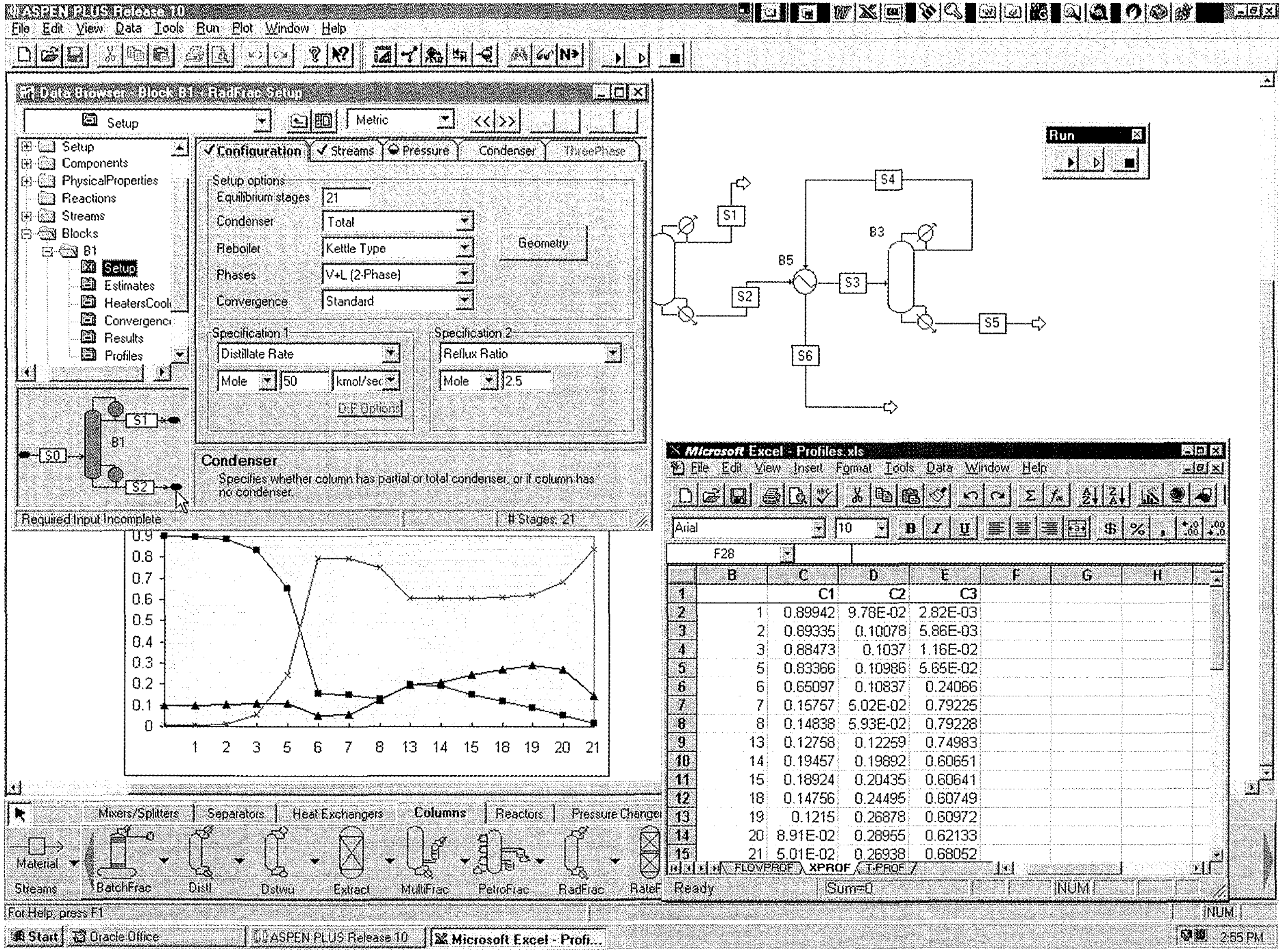
Benefits of dynamics modelling

- Lower capital investment avoidance and operating costs through better engineering decisions

- Throughput, product quality, safety and environmental improvements through improved process understanding

- Increased productivity through enhanced integration of engineering work processes

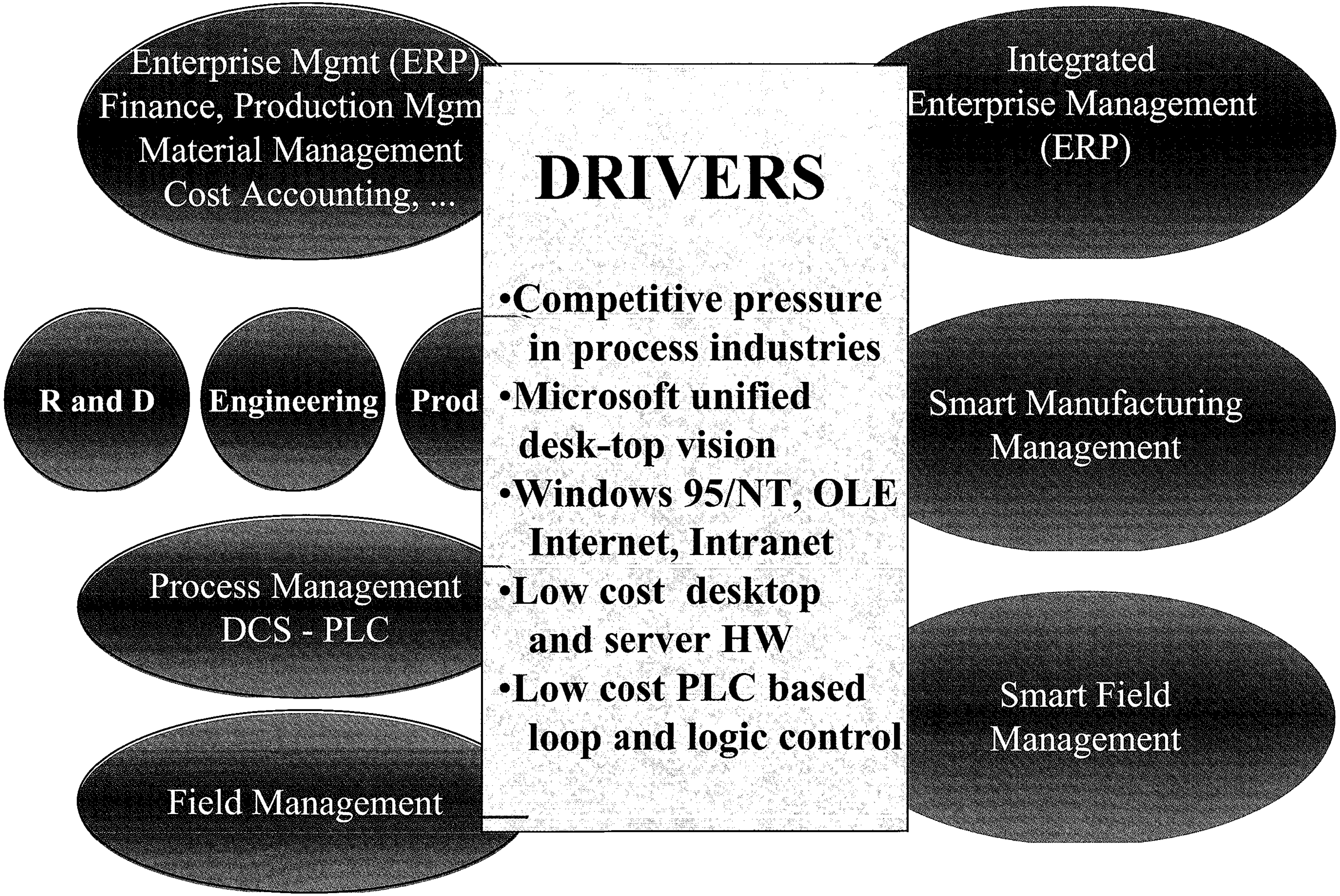
ASPEN PLUS 10.x user interface



Process simulation and Decision Support Systems

- Three layers of activities in the 'smart' manufacturing system:
  - Management control
  - Process simulation
    - Off-line
    - On-line
  - Control system
- Information distribution is made through interoperability of the software
- Crucial point in process simulation is optimization

The birth of the Smart Manufacturing System



Environment control: general context

- Pollution prevention in the chemical industry
  - Increasing cost of waste disposal
  - Growing number of environmental regulations
- Environmental policy as an integral component of the corporate strategy
- Waste minimization at their source leads to ...
  - cost savings
  - improved product yield and quality
  - reduced pollution
  - safer workplace conditions
  - fewer waste management needs
  - conservation of natural resources
- Waste treatment is often needed
- End-of-pipe approaches are more expensive but still necessary

Features of an environmental policy for process simulation ...

- Leadership
  - Plant/environmental health manager essential
  - Responsability for setting goals for reduction in generation of specific chemical wastes
- Material balance: aims at accounting for every quantity of a chemical that is:
  - shipped to the process
  - created or destroyed in the process
  - delivered as a product of the process/es
  - released as gaseous, liquid, or solid waste

… Features of a related environmental policy

- Cost accounting: assigns the pollution cost to individual process, such as:
  - pollution control
  - waste disposal
  - regulatory compliance
  - lost materials
  - insurance
  - future liabilities
  - public and customer relations dealing with waste issues

- Employee involvement at all levels
  - from top manager to production and maintenence workers (need for constant staff training at all levels)

Pollution prevention techniques

- Process changes
- Operation changes
- Equipment changes
- Chemical substitution
- Product substitution

Pollution prevention: operation changes

- Constant improvements in plant operations
  - material handling and equipment maintenance
  - better control of material use
  - employee practices
- to minimize
  - spills
  - process upsets
  - excessive use of chemicals
  - or other problems that can generate wastes
- in every stage of the process
  - storing
  - moving
  - mixing
  - reacting chemicals

Pollution prevention: other techniques

- Equipment changes
- Chemical substitutions
  - involve using raw materials that create fewer toxic and hazardous wastes during production process without necessarily changing the process itself
  - aiming at substituiting hazardous and toxic materials
- Product changes
  - involve designing the end product so its manufacture creates less toxic and hazardous waste
  - can be achieved without changing the fundamental manufacturing process (e.g. pellets rather than powder)

Benefits of process simulation

- The modelling of a chemical process enables the operations manager to efficiently analyse the process in terms of environmental impact
- Modelling plays an integral role in any company's environmental policy

Results in terms of environmental impact

- Compute the operating conditions to meet the discharge requirement
- Compute the performance, capital and operating costs for each equipment item
- Compute the properties of materials in a waste treatment process
- Prepare an integrated flowsheet that considers design constraints
- Automatically maximize performances, within process constraints
- Fit the parameters of the waste treatment models to experimental data
- Perform sensitivity calculations

Results: the integral role of modelling

- Complete material balance
- Identification of the costs and potential saving of pollution prevention options
- Effective vehicle of communication among managers, engineers, and production workers to describe the impact of initiating processes, operations or equipment changes.
- Model allows accurate support of pilot plant tests
- Process simulation aids in understanding process design and evaluates alternatives
- The waste treatment process can be optimized to identify the operating conditions for the most effective and economic treatment within regulatory constraints

SOME EXAMPLES AND APPLICATIONS

Coke-oven gas desulphurization

- **Goal**
  - to lower the hydrogen sulphide content of purified coke oven gas in coke plant
- **Simulation**
  - identify ways of optimizing process parameters to lower sulphur content
  - identification of new process conditions
- **Results**
  - decrease of sulphur dioxide emissions by 360 tons per year
  - 30% of the sulphur dioxide emissions reduction

Optimizing steam consuption for solvent recovery

- Goal
  - recovery of methylene chloride from waste
- Simulation
  - calculation of the steam consumption
  - identification of the optimum conditions
- Results
  - savings in steam usage realized without any major process or equipment changes

Improving the operations of a waste water treatment plant

- **Goal**
  - de-bottleneck the plant and determine how operating variables can be manipulated to improve effluent quality
- **Simulation**
  - identification of the clarifier as the bottleneck unit
- **Results**
  - additional capacity and operating changes in the clarifier can improve the capacity of the plant
  - evaluation of the impact of the plant loading on the effluent quality
  - study alternative operating tecniques (changing residence time, recycle, level of biomass) to lessen toxicity

10

Geographical information systems, remote sensing and decision support systems for coastal zone management

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INTRODUCTION

The Tunisian coast has, for years, absorbed the effects of human pressures, hosting a variety of activities including habitation, recreation, industrialization, tourism and shipping, among others.

Intensive resource-use resulted in environmental problems intricately linked to fragility of coastal ecosystems and non-rational resource use, the main causes of environmental degradation.

As a result, decision makers using an intersectoral approach to coastal management are confronted with the task of developing a planning system that aims to accommodate multiple, often conflicting, activities on the coast.

Geographical Information Systems (GIS) and Remote Sensing (RS) play an important role in planning and contribute to more effective coastal decision-making.

Environmental Planning and Coastal Zone Management

"Planning and management are based on a generic problem-solving process".

It involves various forms of analysis including simulation and modeling.

Based on these concepts, some requirements are necessary for environmental management:

- human and environmental safety
- efficient use of resources and waste management
- addressing societal expectations and concerns
- regulatory compliance
- respect towards habitats, biota and physical environment on which ecosystems depend

The coast and human society

The coastal zone is of extreme significance to human affairs.

The coast may impede or restrict the range of available options by acting as a barrier to trade and communications

"the real conflict of the beach is not between sea and shore but between man and nature" (Bartlett, 1993)

Management of coastal zones should be based on the ecosystem approach, which considers the physical, chemical and biological interaction among various components of the system in relation to anthropogenic exploitation.

Integrated Coastal Zone Management

Integrated Coastal Zone Management deals with the management of the coastal zone as a whole in relation to local, regional, national and international goals.

It implies interactions between various activities, sectors, and resource demands (WCC, 1993).

Although institutional cooperation is undoubtedly the way to success of an integrated approach, it is clear that the emergence of rational policy relies on accessibility to data drawn from a wide range of sectors and based on a variety of collection techniques.

GIS and ICZM

Adoption of geographic information systems (GIS) technology is not only appropriate but perhaps essential.

A GIS-based methodology takes into account the spatial dimension associated with the management process. The framework integrates several components, each designed to address a specific purpose:

- delimitation and classification of the coastal zone into homogenous management units, according to defined management objectives;

- identification of pressures/impacts in coastal areas;

- prediction of environmental and socio-economic impacts from alternative development actions/plans;

- definition of policies with the support of economic valuation and multi-criteria decision-making methods.

Information technology in ICZM

Given the complexities of coastal systems and the multidisciplinarity required for sound ICZM, integration of technologies is especially useful for optimal coastal management solutions.

Due to the complex dynamic and spatial nature of coastal zone systems, GIS are particularly suited for handling and analysing voluminous coastal zone data sets.

A Decision Support System may be defined as an integrated, interactive and flexible computer system that supports all phases of decision-making with a user-friendly interface, data and expert knowledge.

DSS have the capability of performing multi-criteria analysis (MCA) which deals with the evaluation of alternatives according to set of varying criteria.

Information technology in ICZM

Integration of GIS and DSS would be ideal to promote consistent decision-making and to evaluate coastal development alternatives to ensure ecological sustainability of the coastal zone.

Nyegers (1993) identifies two approaches to integrate GIS and DSS capabilities: the loose-coupling approach and the tight-coupling approach.

The former links GIS and DSS by a common file exchange module. The latter attempts to incorporate a shared database, a common user interface and MCA techniques within the GIS tool box, such that the GIS can evaluate the effects of decision through (spatial and temporal) simulation (Fabbri, 1996).

Multi-criteria evaluation

To meet a specific objective, several criteria will often need to be evaluated. Such procedures are called multi-criteria evaluations (MCE).

Two of the most common procedures for multi-criteria evaluation are weighted linear combination and concordance-discordance analysis (Carver, 1991).

The advantage of MCE is that it provides a flexible way of dealing with qualitative multi-dimensional environmental effects as a result of of decisions.

Even in the absence of monetary information, the point of departure of any multi-criteria analysis is the generation of a discrete set of alternatives, the formulation of a set of criteria, and the evaluation of an impact of each criterion for every alternative.

Pairwise comparison method

Where the decision maker is required to select the most important of each possible pair of effects.

Subsequently, comparison must be established in qualitative terms to what extend one effect is more important than the other one, in order to express the differences of importance.

Spatial Decision Support Systems

DSS has six characteristics:

1) explicit design to solve problems;

2) powerful and easy-to-handle user-interface;

3) ability to flexibly combine analytical models with data;

4) ability to explore the space analysis solution by building alternatives;

5) capability of supporting a variety of decision-making styles; and

6) allowing interactive and recursive problem-solving.

Capabilities and functions of Spatial DSS are to:

- provide mechanisms for the input of spatial data
- allow representation of the spatial relations and structures
- include the analytical techniques of spatial and geographical analysis
- provide output in a variety of spatial forms, including maps

Users of Spatial Decision Support Systems

SDSS is a computer-based information system used to support decision-making where it is not possible for an automated system to perform the entire decision process.

To enhance organizational efficiency and effectiveness, decision support must be developed for working groups since discussions and negotiations are an important dimension of decision making.

Users of SDSS may include individual or group decision-makers, technical advisers, planners, interest groups and 'the public' at large.

A case study

Multi-Criteria Evaluation for industrial siting

Concept:

Decisions about the siting of industries typically involve the application of a multi-criteria algorithm based on logical pairwise comparison.

GIS offers the opportunity to apply decision-making processes in a more enhanced and integrated context.

Aim:

To design suitability map of industrial sensitivity of the coastal zone of the region Tunis-Bizerte.

It consists of landscape e valuation for industrial siting and includes a GIS tool developed for the IDRISI geographic information system software.

Objective and methodology

Objective: Identification of suitable land for industrial development.

Methodology: Investigation of interactive effects by contributing factors and constraints that may enhance or decrease industrial susceptibility.

Factors contributing to the change of industrial susceptibility include:

- **Proximity to main industrial sites**
- **Proximity to main residential sites**
- **Proximity to main roads**
- **Proximity to water (sea, lakes and rivers)**
- **Proximity to protected forest and national parks**
- **Proximity to bares soils**

The output will consist of a number of categories, each reflecting its susceptibility to the installation of new industries.

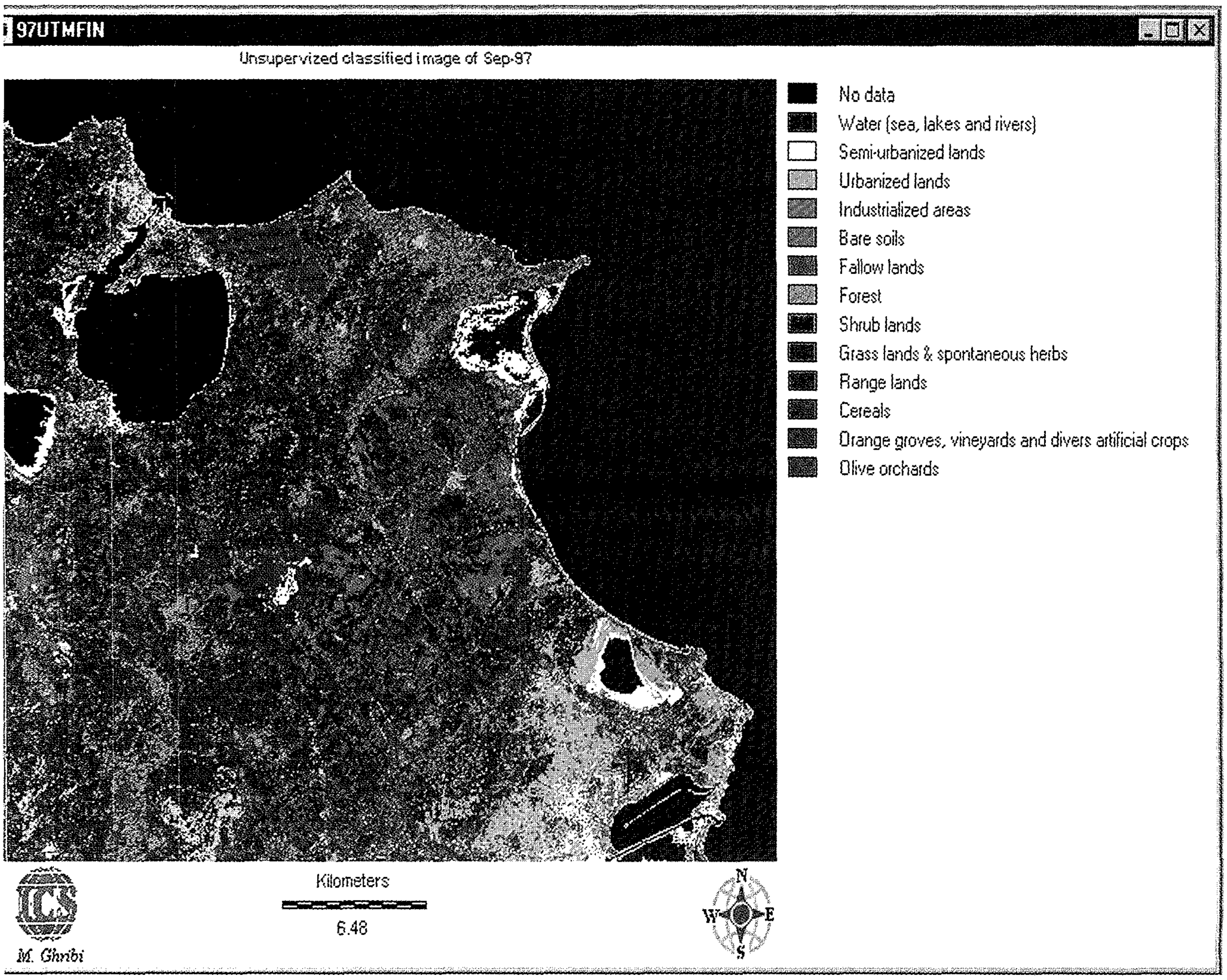

Figure 1: Classified Landsat image of Sept 1997

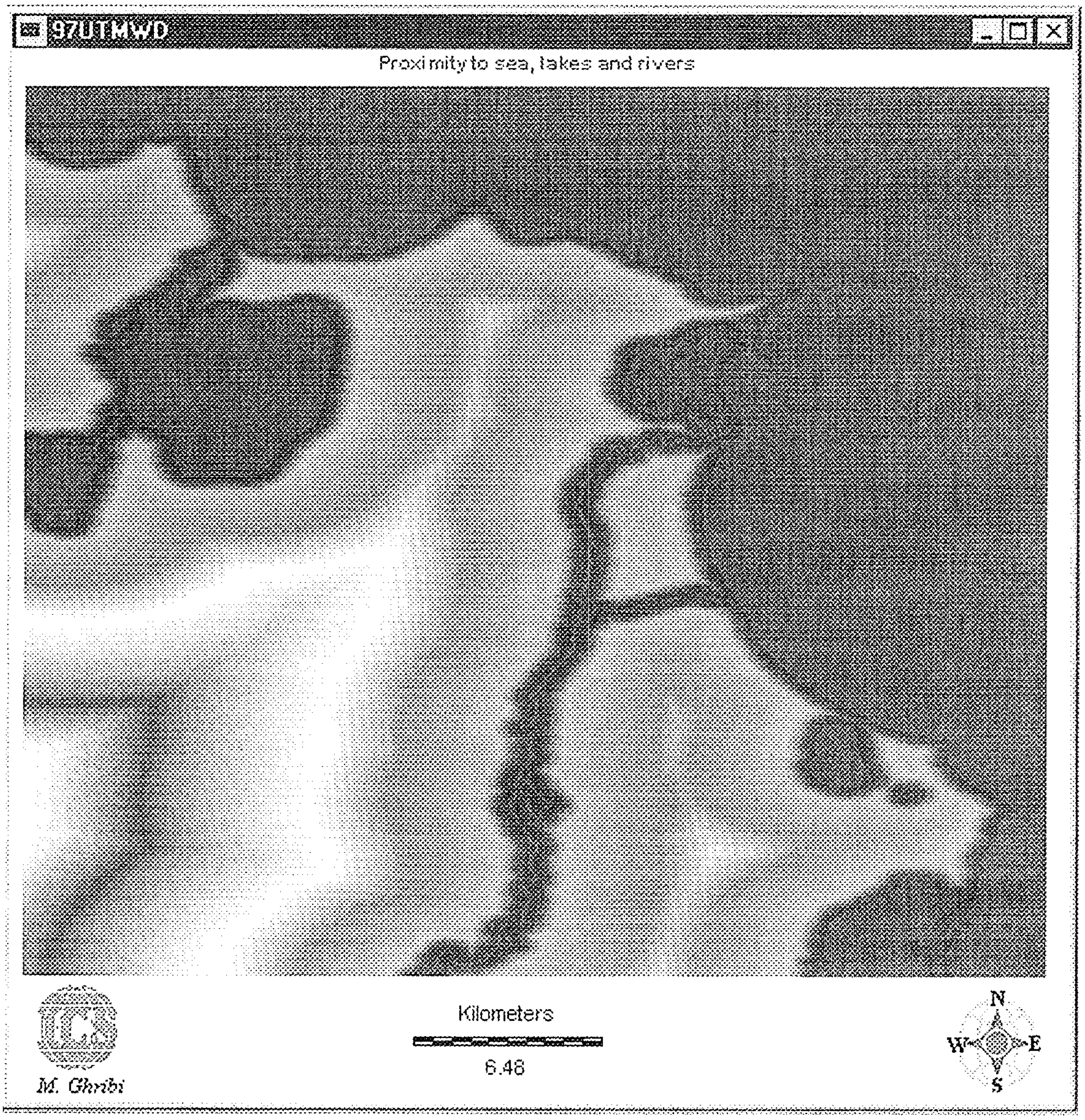

Figure 2: Proximity to water (sea, lakes and rivers)

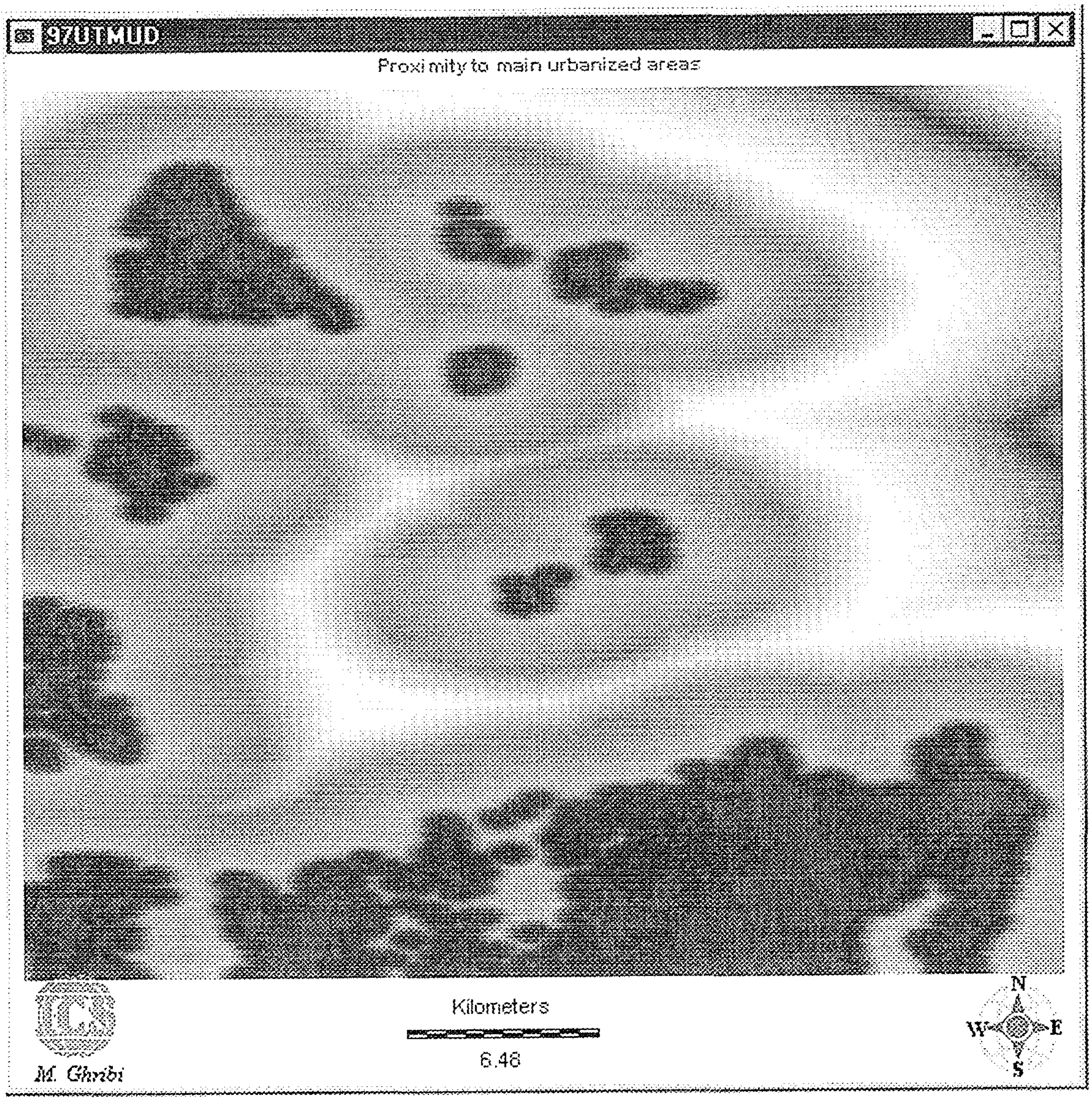

Figure 3: Proximity to urbanized areas

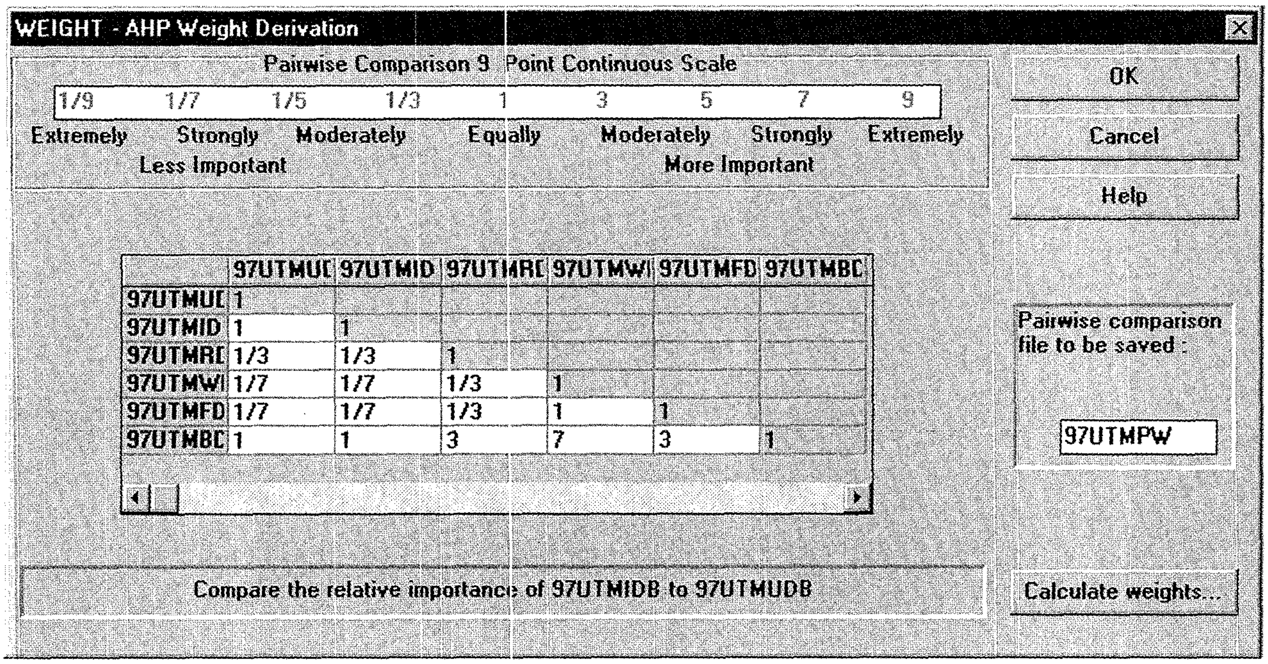

Figure 4: The continuous rating scale used for the pairwise comparison between factors

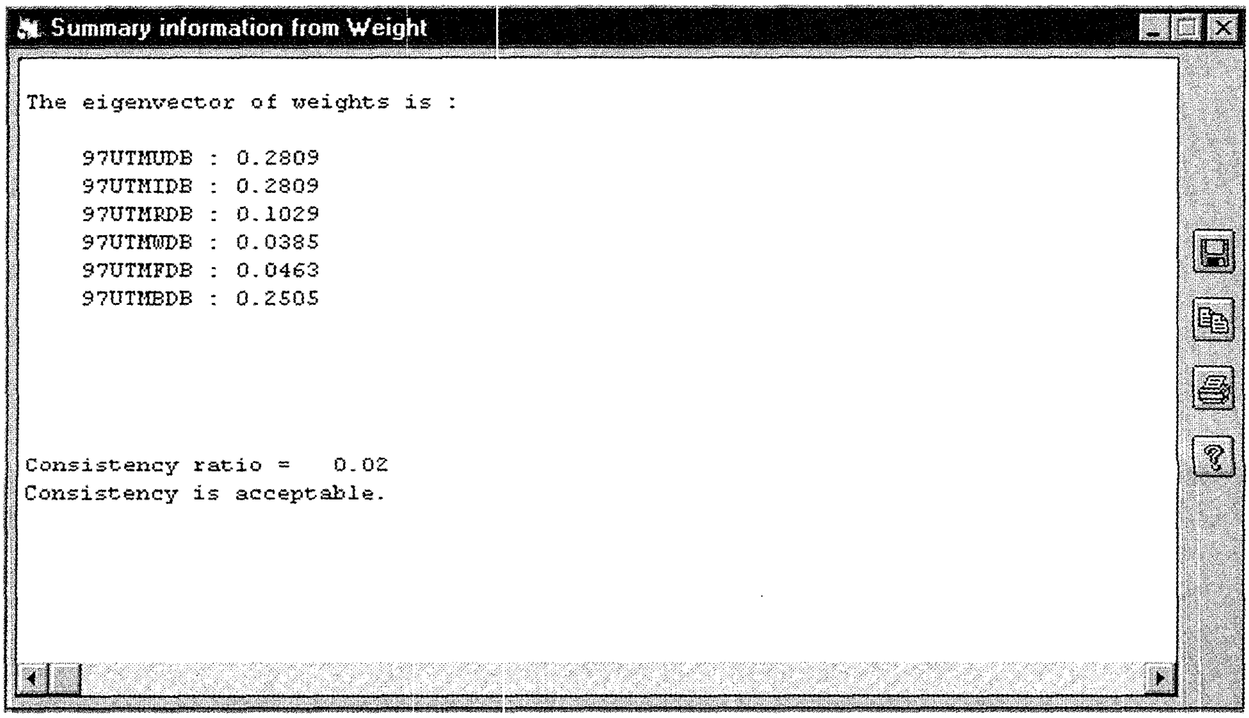

Figure 5: The principal Eigenvector of weights resulting from pairwise comparison between factors

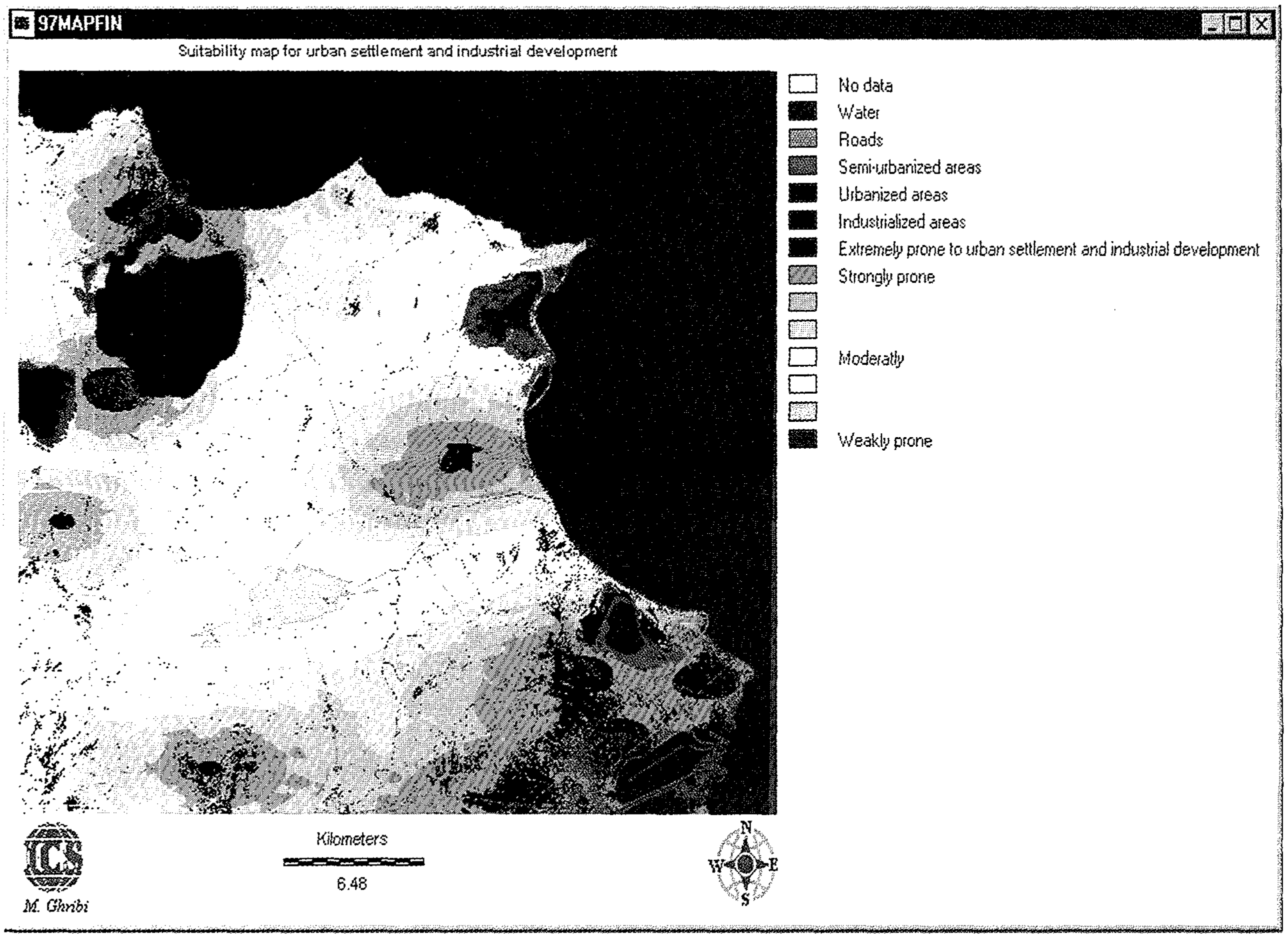

Figure 6: Industrial siting suitability map

Industrial suitability map

A suitability map, resulting from a multi-criteria evaluation, shows different classes for which the degree of susceptibility to accept new industrial plants varies from extremely prone areas to less prone.

Highly prone areas are characterized by their:

- proximity to existing industrial zone in which the probability of finding existing infrastructure and organized industrial system is high.

- proximity to residential and commercial sites that represent a necessity for social activity and in particular industrial activities according to the high number of workers in this domain.

- proximity to main roads and their connection with the market.

- natural allocation (coast, rivers, lakes, slope, *etc.*) which can represent an environmental delimitation.

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