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Project co-funded by the European Union and national funds of the participating countries

1 Abstract

The baseline for the Best Management Practices in Erosion Mitigation in Cyprus can be part of a new change in the law of "Ο περί Προστασίας της Παραλίας Νόμος (ΚΕΦ.59)" of Cyprus legislation. An overview of Current planning practices, International Examples and management frameworks from the Mediterranean Sea, Greece are also presented. The following principles are put forward as the basis for the development of management framework. These principles are founded on the current knowledge of coastal erosion. Those recommendations refer to new developments on the coastline and existing developed sections of the coast. Additional, planning guidelines that should reflect the principles above and be based on local coastal studies are presented. Following the international experience and proposed management plans, a set of guidelines are been proposed on a site specific basis. Since coastal planning based on coastal changes and erosion is not previously considered for most coastal local government areas in Cyprus, there is not a formal set of guidelines to be followed, decides the general setback lines for Beach and Coastline, which have been set without proper studies in most cases and do not consider the sea level rise parameter. For new developments innovative approaches are possible but for existing developed areas planning guidelines should incorporate the parameters like, the maximum expected storm surge on an open coast; the maximum inundation of the waves in a beach; the offshore wave height and wind speed in given area. Also, the potential storm impact, expressed as metres in cross section, is compared to historical data recorded, if there is any. In the short term, the only practical approach is to mitigate the response to the impact of severe storms and decadal periods of rapidly rising sea level using protective structures and beach nourishment. Such measures allow the adoption and implementation of longer term planning schemes. At some stage in the context of longer term responses, the option of mitigation may become economically untenable, and in the case of nourishment may be limited by sand supply primarily and economic limitation. In this case managed retreat may be considered. Moreover, Vulnerability and risk assessment techniques that could be followed are presented along with ongoing assessment and monitoring through managing a coastal systems a monitoring techniques – low cost approaches. Finally the establishment of a managing body for this issues are discussed.

2 INTRODUCTION

Access to wide sandy beaches and maintaining these beach conditions are critically important to the Cyprus community, beach tourism and coastal economies. Severe erosion from storm events not only endanger destroys property and infrastructure along the coast, but more importantly, through the loss of the "beach" destroys the foundation of coastal economies. Any rise in sea levels will make such impacts even more dramatic. The coastline is a very valuable commodity to many of coastal communities because it attracts economic activity. The economic activity is in the form of tourism and supporting industries, and from local recreational, social and cultural activity. Most of Cyprus population lives within a few kilometres of the coast and any adverse or beneficial effects on the beach and dune systems of the coastline will be felt most of the population either directly or indirectly. While coastal erosion issues can been seen Cyprus developed coastlines, there has not been a management plan or protocol to mitigate the impact of eroding coastlines. Such management plans have been developed in the United States, Australia, UK and other countries. If the projections (IPCC 2001) for climate change, rising sea levels and variability in the frequency and intensity of storms are correct, coastal realignment will be outside of recorded experience. Coastal economies may be faced with more erratic and severe business cycles and uncertain economic growth, especially for those economies dependent on quality beaches to sustain their existence. The level of economic activity in coastal areas can be linked to the existence and perceptions of existence (through the media) of 'a wide sandy beach'. The damage caused by major storms can be economically disastrous both in terms of the cost of rehabilitation, but also the downturn in tourist visitation. Loss of a beach can result in substantial local and non-local systemic economic effects, through lost recreational, industrial and environmental values, thus, proactive planning is the key to the future. Proactive planning is required to develop measures to reduce the impacts of these highly unpredictable events. While this approach may seem unnecessary and costly, such a precautionary approach will avoid the considerable cost of reactive responses or recovery measures. Unless there is a dramatic change, Gordon (2000) considers that this "laissez faire" approach to coastal management, especially during the last twenty years has condemned future generations to an unenviable legacy of liability and loss of beaches, public reserves and private property (Gordon 2000). Beach management strategies have being implemented on the various areas of Cyprus, dealing with short and medium term coastal variability. Although, those are sporadic approaches and are based on the construction of coastal defences to mitigate the impact and not in the prevention of the phenomena. Longer term policies

will need to be developed to deal with the potential loss of beaches and the lack of sand to replenish them. In the USA, as a response to erosion from rising sea levels, several States in the USA have legislated against the use of hard structures, opting instead for planning approaches (Zhang et al 2001).

There are still major gaps in our understanding of how the natural coastline dynamics (and hence the viability of beaches) will behave under extreme events, in adapting management strategies to these changes and to planning processes needed to prevent undesirable reactive measures.

3 Current planning practices

3.1 International Examples

In 1971, the Florida Legislature passed a law requiring coastal construction setback lines for counties along the sand beaches fronting the Atlantic Ocean and Gulf of Mexico. This legislation was introduced because Florida has 'a serious beach erosion problem' and some developments, such as vertical seawalls, had magnified erosive forces (Purpura 1972). The Florida legislation prohibits construction, excavation and dune and vegetation damage seaward of setback lines, established through a rigorous statutory assessment processes. Setback lines were established on the basis of technical studies, including historical data and field measurements of all relevant factors, such as dune elevations, erosion trends, storm surge, wave action, vegetation lines, coastal structures and inland development. The legislation also requires that setback lines are reviewed every five years or sooner if proven necessary (Purpura 1972). While Canada, in New Brunswick, remapped the coast to delineate vulnerable coastal features and defined setback for new development from this limit. Other Canadian provinces have adopted setback policies based on future coastal retreat estimates (IPCC 2001).

In Australia, state governments have adopted setback criteria for beachfront development, although these vary between States. South Australian setbacks are based on the 100 year erosion trend and storm surge flood level with a projected sea level rise of 0.3 metres by 2050, and development prohibited on sand dunes and vulnerable coastal cliffs. Major developments must be based on 200 year projections (RAC 1993). The Western Australian Government prohibits development within 100 metres of the shore, with additional

setbacks for erosion areas, based on the 100 year erosion trend. Beachfront setbacks are measured from the line of permanent vegetation at the base of the foredune, and estuarine setbacks are above the 100 year flood levels (RAC 1993). In Tasmania, development below 3 metres AHD (Australian height datum) must take account of erosion, storm surge and sea level rise projections. The 1988 Victorian Coastal Policy prohibits development on fragile or unstable areas (RAC 1993). The Coastal Policy requires coastal development to take account of coastal processes, particularly minimizing interference with sand movement in the beach system, prohibiting development in areas subject to marine erosion and requiring the design of major developments to reduce potentially undesirable impacts (Victorian Government 1988). Queensland setback levels were based on a 50 year erosion trend plus allowances for cyclonic erosion events, storm surges, scarp slumping and sea level rise, multiplied by a safety factor to retain a nominal foredune should these events occur. In 2000, the State Coastal Management Plan established an integrated approach to coastal management throughout the State. The New South Wales State Government Coastline Management Manual (1990) provides guidelines for local Councils to determine setbacks, based on a suggested minimum setback of new development above the 50 year erosion trend with a preferred setback based on the 100 year erosion trend (RAC 1993).

In the Baltic areas, the responsibility for planning of coastal protection schemes usually is located at a national level. The most frequently applied policy options in the coastal zone of the Baltic area are hold the line and limited intervention. Limited intervention is applied in areas where the threat to economic values is small; the advantages of dynamic coasts for nature conservation have also been acknowledged in the Baltic. Hold the line is still applied when high economic values are threatened by erosion, historically it was mainly executed with hard measures like seawalls, revetments, slope protection, groins and more sparsely detached breakwaters. However since the 1970s a shift towards the use of soft measures, nourishments started in Germany and Denmark. The last decade this shift has taken place in all Baltic area countries and the use of nourishments has increased significantly in the entire area. Hard measures turned out to be failing after some time by storm damage or increased foreshore erosion, and furthermore caused increased erosion downstream. Nourishments, although only temporary effective, have shown to be successful in mitigating the effects of interruption of longshore transport and not causing a disturbance of the natural equilibrium in the Baltic area. Repetition of nourishment is needed for effectiveness on the long-term. In the past, private landowners or local groups have often tried to protect their property individually in the Baltic Sea area. This

individual approach often resulted in unprofessional designs and a lack of maintenance causing quick deterioration of the structures, and a lack of common approach causing the problem to be moved but not solved. Through the failures of these coastal protections, the importance of a common approach, a design by professionals and good maintenance was acknowledged in the Baltic area. However, maintenance is still relatively poor and underestimated in some parts of the Baltic. Besides, or even instead of, measures to stop or slow down erosion, measures like foredune and forest maintenance are applied to mitigate the effects of storm surges in the Baltic. This strategy has shown to be cost effective mainly in low labour costs countries like the Baltic States. This is likely to change with entry to the EU, when labour costs probably increase. ICZM is in a very early stage in the Baltic Sea area, though some ICZM programs have started the past years (HELCOM, VASAB 2100). In some projects steps towards integral approach for the planning and financing process is seen (mainly in Denmark and Germany), furthermore the importance of other functions besides safety, like tourism and nature, has clearly been acknowledged but this has generally not yet been implemented in legislation and organization in the Baltic area.

In countries of the North Sea, the effect of sea level rise on coastal defence measures is recognized and coastal zone management plans are developed, in which the future erosion is taken into account. As a result of the economic situation, it is expected that these countries may be able to counteract the future erosion more easily. Historically the most frequently used policy option was to hold the line when safety of human lives and of economic investments are at stake. This was mainly executed with hard measures, but the last few decades the emphasis is shifting in the direction of soft measures (e.g. nourishments). Do nothing has historically been applied when no investments or human lives were threatened. Later, the option do nothing is also suggested when a coastal protection measure would cause too much negative effects at adjoining coastal stretches or when this option enhances the natural behaviour of coastlines and estuaries. In the North Sea countries in general a growing awareness of environmental issues has developed among the general public and politicians, especially during the last few decades. As a result of the economic situation and the rather high population, authorities are willing to invest in the preservation of areas that are valuable from an ecological point of view, such as salt marshes, mud flats and islands where bird colonies breed. A rehabilitation of the natural sea-land environment, new technical potentialities and political accents have made that since the seventies preference is given to “soft” measures, i.e. beach nourishment, respecting the natural dynamics of the shoreline (coast or estuary). A further advantage is the sufficient availability of

sediment in the relatively shallow North Sea. On the other hand, the long-term consequences of structural deepening of the foreshore due to sand extraction are not well known. A less accepted policy option is managed realignment. Large flooding in the past with loss of life and property left a legacy in present day attitude towards coastal zone management in low-lying countries in the North Sea region. The general perception of the necessary defence against the sea makes hinder the acceptance of the managed realignment option. Despite this, at least in South-East England a major change in policy in the direction of managed realignment is observed, which recognizes the implications of coastal squeeze with its loss of intertidal land and the value of recreating habitat both for nature conservation and as a contribution to a more sustainable sea defence.

In the North Sea area, most countries have a long tradition of coastal management and of integrated strategies. Compared to other countries in Europe, these countries have therefore made most progress in establishing ICZM, although national legislation concerning ICZM is not present yet in any of the North Sea countries. It is clear that there are moves to develop ICZM – either on a statutory or non-statutory basis –in all the North Sea countries.

The Atlantic Ocean borders Western Europe along the following EU-countries: the United Kingdom, Ireland, France, Spain and Portugal. The policy option 'hold the line' is often applied when seaside resorts or other recreational facilities are at risk. Especially in the southern countries France, Spain and Portugal but also often in the southern part of the United Kingdom and Ireland tourism plays a leading role at the protected sites. Furthermore, high population densities and economic investments are protected applying the policy option hold the line, like in the United Kingdom, Ireland and Portugal. 'Do nothing' and 'managed realignment' are possible at some of the seaside resorts and recreational facilities if the capital at risk is relatively low and the recreation facility or houses can be moved landward without too many problems. 'Do nothing' is usually applied at cliff coasts where no flooding risks are present and therefore the capital at risk is relatively low. In a flooding area, a new defence line is usually defined (thus "managed realignment"). At many sites along the Atlantic coast, a mix between hard and soft engineering solutions is adopted when dealing with erosion issues. Various types of hard solutions were applied in the cases considered. Although applied in nearly all cases, beach nourishments are executed on a much smaller scale (in terms of m^3) than in the North Sea and the Baltic Sea regions. Whereas in the North Sea regions soft measures are often taken to combat erosion,

along the Atlantic Ocean coasts the soft solutions are often combined with hard measures, probably due to the high energy conditions of the coast. Integrated Coastal Zone Management is still in an orienting phase in the Atlantic region. About half of the regions have developed some kind of progress in ICZM. Although national ICZM policies are not yet present in any of the Atlantic Sea countries, on a local scale it is implemented by means of for instance interregional cooperation (e.g. Normandy and Picardy, France). The ICZM-projects (OSPAR) mainly concern environmental issues and they are executed mainly on a local scale. Some of the TERRA and LIFE projects focus on coastal erosion issues.

3.2 Mediterranean Sea

Coastal management, since about 1960, resulted in some heavily engineered coastlines in the Mediterranean Sea, at places where human interests had to be protected. By building hard constructions, erosion was tried to stop. Although in many cases the works did not have the desired result, many seawalls and groins continued to be constructed, shifting thus the problem to the future or to neighbouring areas. As the pressure on the coastal zone due to human-induced activities and relative sea level rise keeps expanding, the need for sustainable solutions that do justice to the environmental values is growing. Over the last decades, a trend is visible towards more flexible solutions. Soft measures (nourishments) are being applied more often. A disadvantage of nourishment is a necessary repetition and possible (irreversible) damage to sea grass communities *(Posidonia Oceanica)*. Integrated Coastal Zone Management principles are not commonly used in the Mediterranean. Some of the cases illustrate management curtailed to the specific area.

Black Sea respect tourism is the most important factor for most sites on the Black Sea. The applied policies to deal with coastal erosion vary, from limited interventions; hold the line, to do nothing. In the Danube delta only a small percentage of the beaches are kept at their place (hold the line) and the remainder is allowed to prograde and retreat (do nothing). This follows from the role of the Danube delta as an ecologic, rather than in economic important area. The hold the line option is applied in Bulgaria and Romania, where economic factors are at risk. Technical measures on the Black Sea shores are mainly hard, experience with nourishments are limited and not very positive. The not-so-positive experience is related to the technical details of the particular nourishment, and not with technique in general. Hard measures vary from dikes and sea walls to detached breakwaters. The effectiveness of the hard measures varies strongly on their design in

relation with the erosion problem. Future developments follow the trends that are observed today. Pressure on the shorelines will undoubtedly increase, when inhabitation and tourism increases as the economy in Bulgaria and Romania grows. An accelerated rise in sea level may add to the already existing problems. Integrated Coastal Zone Management is starting in Bulgaria and in Romania. Coastal zone management plans are being developed, with strategies to deal with erosion and environmental rehabilitation.

3.3 Cyprus

Coastal defence covers two related but distinct issues: (i) coast protection, concerned with works designed to manage or prevent erosion of the coastline; and (ii) sea defence, which relates to schemes intended to manage or prevent flooding or inundation of the coastline. Today, coast protection works are the most common type of coastal defence, mainly consisting of structures designed to resistnatural processes, such as wave action and sediment movement; commonly called “hard engineering” options, they include various constructions such as vertical sea walls, groynes, breakwaters, revetments, flood embankments, placement of gabions and rock armouring. Along the Cyprus coast, vertical seawalls (built of concrete or rock) usually accompany and protect coastal roads. In many cases, especially where the beach zone is narrow, rock armouring is used to protect the toe of the seawall against undermining. The most common ‘hard’ defence currently employed to protect private property and infrastructure of low importance and economic value is designed walls and revetments constructed of boulders of a rather uniform size (rock armouring), typically many tones in weight. Similar structures, formed from precast concrete blocks, are commonly used for the protection against coastline retreat of reclaimed coastal lands, coastal installations of greater importance, or areas of higher aesthetic value. In rare cases, gabions (wire baskets filled with stone and stacked vertically or damped horizontally) have been used temporarily for shore zone stabilization. In other cases, the dumping of piles of rocks tipped over the coastal edge has been applied to prevent further erosion in areas of low conservation value. The second most popular protection method during the past decades has been the construction of groynes, generally perpendicular to the coastline, designed to intercept sand and gravel movement along the beach; these have usually been constructed of boulders with a concrete or asphalt top pavement in areas of high wave activity, or of timber in beach zones that experience relatively low wave energy. Recently, concrete-filled geotextile tubes have been used for the construction of less obtrusive

groynes in recreational beaches, with limited success especially in beaches with significant on-offshore transport. During the last one or two decades the construction of groynes is being gradually abandoned, mainly due to their limited success in areas with low longshore sediment transport rates, their obtrusiveness and problems with downdrift erosion. In open beaches with a significant onshore component in the nearshore wave energy field, the construction of emerged shore-parallel offshore breakwaters has been quite successful. Submerged offshore breakwaters are becoming increasingly popular during the last two decades and in some cases they have successfully replaced existing groynes systems.In areas with a high conservation value, “soft engineering” options are often preferred. These are designed to emulate, harnessor manipulatenatural processes. The most commonly used “soft” protection methods are beach nourishment or recharge, sediment recycling and stabilization of coastal dunes with vegetation. Beach nourishment (addition of sand or gravel to a beach to restore former levels or to improve current ones) has been used primarily for the maintenance or creation beaches associated with large hotel units or coastal recreational facilities, either as a standalone measure or in conjunction with a “hard protection” measure, usually a detached submerged breakwater. In many cases, such actions were undertaken during the low-season touristic periods either without the required permissions or by public authorities without proper studies. Sediment recycling (transport of beach sediment from the down-drift end of a beach back to its up-drift end) has been used in beaches with significant longshore sediment transport. Additionally, other semi-technical semi-managerial schemes may be considered, that incorporate coastal defences by combining elements of hard and soft engineering and a managed back retreat (removal of coastal defences inland to permit the natural evolution of a beach and, if the coastline is retreating farther, supply of beach sediment).

3.4 Problems with current coastline planning

In Cyprus there is no planning horizon for dynamic coastlines management influenced by climate change. Each case is examined individually and any action that is decided to be taken is not linked with nearby actions. Also, there is no timeframe in planning the actions. Studies that are been made in order to address the coastal erosion problems usually refer to a 10 years period. Commonly used timeframes in management plans worldwide use a minimum of 25 years period for coastline resource plans, and 100 years for coastline management plans (Pittock 2003). Sea level rise is the long term dominant driver of inland coastal movement

and change. Various authorities including (IPCC 2014) consider that, regardless of response strategies for global warming, sea level will continue to rise for at least several centuries. The projected smooth curves of sea level rise (IPCC 2001) are only projected trends. Sea level will be influenced by annual variations of NAO (Tsimplis et al 2008) and will result in periods of more intense storminess and periods of destructive erosion. The issues raised by the dynamic variability and lack of predictability, in both sea level rise and variations in storminess, suggest that future coastline planning will need to be over much longer time horizons and more flexible than past approaches. From the combination of natural variability and projected climate, it is suggested that coastline planning needs to be "ongoing" with continuous monitoring. Strategic reviews should be over flexible time periods and respond to any detection of changes in climatic conditions.

3.4.1 Ongoing planning

The long term nature of coastline change indicates that the coastal planning process needs to span many generations, political changes and successive administrations of government at all levels. This is a major change in the concept of past coastal planning which tended to respond to events. There is a lack of strategic preparation for periods with higher storminess and increased erosion potential. Future high storminess periods would leave the developed sections of the coast vulnerable to potentially devastating impacts from loss of coastline infrastructure, loss of beaches and subsequent reduction of tourist income. Continuing sea level rise means that under these conditions these places on the coast that are currently eroding, , will eroded at a faster rate and that other places, not currently subject to erosion, will commence to erode.

3.4.2 Precautionary principle

Sustainable planning requires consideration of the precautionary principle, both from theoretical and practical point of view. There is need to plan for the worst case scenario and for precautionary reasons the higher projections should be considered for planning (Walsh 2004). Application of both "precautionary" and "worst case" approaches to coastal planning is driven by the awareness that any underestimate of the eventual sea level rise would be disastrous for coastal communities, with the potential for serious long term economic impacts.

3.4.3 Legislation and legal considerations

The baseline for the Best Management Practices in Erosion Mitigation in Cyprus can be part of a new change in the law of "Ο περί Προστασίας της Παραλίας Νόμος (ΚΕΦ.59)" of Cyprus legislation. Among other things, the law regulates the inland limits of the seashore and beach zones, where private construction is strictly prohibited. The seashore limit is defined, as a line connecting the points of the usual maximum wave run up on the beach face and the beach zone extends up to 50 m landwards of the seashore limit. The beach zone is regarded as public property that has to be accessible by anyone. Permanent constructions in the seashore and beach zones are prohibited, with a few exceptions for public interest, safety and national security reasons. Protection of the beach zone from erosion is briefly addressed. The constitutional mandate that the state guarantees the protection of life and private property of its citizens ensures permission for the construction of coastal protection structures, but only structures protecting public property are paid by the state. In order to secure a sustainable coastal development and to protect life and property, a full environmental impact assessment study is required for any coastal zone construction.

A general issue that is raised by the Cyprus legislations is that Coastal management is governed by a wide range of laws, which, in several cases, have not been modernized, with the result that fragmented different bodies without a co-ordination mechanism. The absence of a national strategy management of beaches further complicates the situation, as there are often conflicting objectives among the actors involved. Legislation has also been positive gaps and overlaps of responsibilities. The designated "bathers areas" are not entirely consistent with "bathing water areas". There is no single national strategy for beach management in Cyprus has been defined. With purpose the establishment of an integrated coastal zone management program, the Comp implemented the CAMP-Cyprus Coastal Zone Management Program as the national one Strategy for Integrated Coastal Zone Management. The contributions of the have not been implemented due to budgetary constraints. Although the Protocol on Integrated Coastal Zone Management Mediterranean region has been ratified by the EU, Cyprus has not yet ratified it because of incompatibility of its provisions with the Protection of the Beach Law, in relation to the area of building bans. During the period 1963-2008, the coasts of Cyprus suffered erosion of a total area of 2.2 tons, due to anthropogenic interventions and natural phenomena. Particularly, the coastline of Cyprus has suffered an average erosion of 14.0 meters during the period 1963-2008 (from a maximum of 260 meters erosion to a minimum of 3.5 meters), on a

front with a total length of 92.338 meters, i.e. 19.8% of the coastline. However, no assessment study has been conducted in relation to the coastal regions of Cyprus exposed to the phenomena of erosion.

The authorities did not evaluate the illegal coastal protection projects identified, with the exception of the areas for which coastguard studies have been prepared nor were prepared evaluation reports on the effectiveness of coastal protection projects made. The construction of coastal defencestructures, that minimize the transport of sediment to the sea by rivers, contributing to the phenomenon of coastal erosion, consists a problem that may be possible to treat with the construction of pre-dams to trap sediments upstream of the main dams and their use to feed the beaches.

4 Management frameworks

The following principles are put forward as the basis for the development of management framework. These principles are founded on the current knowledge of coastal erosion processes and are based on the sustainable development of the coastal tourism industry in Cyprus.

4.1.1 New developments on the coastline

One of the first issues that a management plan should address, is the new developments on the coastline. A strategy that was proposed by IPCC (2001) is the managed retreat. In this, new development plans are restricted within a certain distance of the present shoreline. The distance of this no development zone corresponds to the distance which is “determined by the expected shoreline movement during the life of the structure”. The problem with this approach is that the average or trend of projected sea level rise would be used for this calculation, but as demonstrated above, actual sea level will be higher or lower and regional location. This makes difficult to determine this zone in accuracy. Although, the concept remains valid the principle that should be followed is that in calculating setbacks, between proposed new developments and the active coastal zone a very conservative approach is justified, and one that provides the maximum practical space. These setbacks could be modified if other planning measures exist. For example density controls, building restrictions (eg. light removable buildings) near the coastline. Light removable buildings allow the development to be removed from the coastline in a storm event and during non-tourism periods. Such set back line have been already adopted in the United States and Australia.

4.1.2 Existing developed sections of the coast

For the existing developed areas, the vulnerability in terms of coastal erosion should be identified. For those areas that are found to de generally vulnerable, the balance between maintaining these existing developments and beach management needs to be reviewed. For this, a review and upgrade of any past mitigation measures, beach management, and planning mechanisms to limit impacts of erosion on beach amenity or accept a loss of beach amenity, for those areas is needed. In areas where no management plans exist, strategies for dealing with major coastline erosion, inundation events and potential loss of some existing developments, are need to be developed under a general management plan. The management plan will have to address also issues of beach amenity loss, as it is a critical feature of many coastal areas for local economies.

5 Planning guidelines

Planning guidelines should reflect the principles above and be based on local coastal studies. Following the international experience and proposed management plans, a set of guidelines are been proposed on a site specific basis. Since coastal planning based on coastal changes and erosion is not previously considered for most coastal local government areas in Cyprus, there is not a formal set of guidelines to be followed, decides the general setback lines for Beach and Coastline, which have been set without proper studies in most cases and do not consider the sea level rise parameter.

For new developments innovative approaches are possible but for existing developed areas planning guidelines should incorporate the parameters like, the *m*aximum expected storm surge on an open coast; the maximum inundation of the waves in a beach; the offshore wave height and wind speed in given area. Also, the potential storm impact, expressed as metres in cross section, is compared to historical recorded data, if there is any. In the short term the only practical approach is to mitigate the response to the impact of severe storms and decadal periods of rapidly rising sea level using protective structures and beach nourishment. Such measures allow the adoption of and implementation of longer term planning schemes.At some stage in the context of longer term responses, the option of mitigation may become economically untenable, and in the case of nourishment may be limited by sand supply primarily and economic limitation. In this case managed retreat may be considered.

5.1 Vulnerability and risk assessment

First an assessment of the vulnerability of the coastline to erosion and inundation should be made in order to identify areas with increased risk and vulnerability. Vulnerable areas must be identified in order to exclude them for future investment plans, or to estimate the actual investment cost of their protection and development. Furthermore, developed coastal areas must be studied with respect to their protection and/or relocation of existing infrastructure. The identification of the vulnerability of the Cyprus coast to sea level rise and associated erosion can be made with the use of the Coastal vulnerability Index for Cretan coast (Deliverable D3.3.5), while in the case of the most vulnerable to erosion beach zones, the Beach Vulnerability Index (Alexandrakis & Poulos 2014) can be applied . An estimation of the value of the beach zone will must be

made. A hedonic pricing method can be used, which is the most common method used by economists to estimate the value of environmental amenities that are reflected in property values.

Subsequently, a risk assessment will be made in terms of economic value (present growth and aspect of future development); this will improve the resilience of the existing infrastructure (touristic) and socio-economic activities and provide to the stakeholders (governmental agencies and private sector corporations), reliable data for sustainable future coastal zone management (e.g. Land use planning, investment risk reduction, insurance cost estimation). The results must be in the form of digital vulnerability and risk maps. Based on the analysis of the socio economic characteristics of the region and the calculation of risk, the areas must be prioritized as to the need for interventions to address erosion. The ranking must be based on the physical dangers of the area and the expected socio - economic impact.

5.2 Identifying the risks of beach erosion on Tourism

With its traditional use of natural resources and climate-based activities, tourism is considered to be a highly climate-sensitive economic sector similar to agriculture, insurance, energy, and transportation. Climate change is no longer considered an obscure future event for tourism, as its varied impacts are becoming more evident at destinations around the world. As a result, climatic change is already influencing decision making in this global industry. There are four broad categories of climate change impacts that will affect tourism destinations, their competitiveness, resilience and sustainability.

Direct climatic impacts: Climate is a principal resource for tourism. It co-determines the suitability of locations for a wide range of tourist activities, is a principal driver of seasonality and in operating costs, such as heating-cooling, snowmaking, irrigation, food and water supply, as well as insurance costs. Thus, changes in the length and quality of climate dependent tourism seasons, such as the tourism in Cyprus were it is based in the sea - sun-sea model. As an Indirect impacts it is consider to be the increased natural hazards, coastal erosion and wave inundation. Those can result in damage to infrastructure and aesthetic degradation and reduced capacity of the beaches, making the beach tourism “product” less attractive. This results to higher risk to future economic growth and to the political stability of vulnerable areas (Stern 2006, Simpson and Hall 2008).

5.3 Ongoing assessment and monitoring

Managing a coastal system effectively requires data on the initial character of the system, changes over a range of timescales and the factors which cause change. The data is required to be able to identify and understand change, guide the planning of management operations and assess the performance and impacts of management. There are several steps required to develop a useful database. A desk study must be completed to determine what information exists already, a baseline survey must be undertaken to establish the situation against which future change will be compared, and a program of ongoing monitoring must be implemented to assess change and guide future management. The desk study should include a review of maps, aerial photographs, surveys, published reports (Alexandrakis 2014) and any other documents that may reveal information relating to the past evolution of the shoreline, possibly including records of storms, shoreline construction works. This information will help in understanding the present and may guide the monitoring programme. Ongoing monitoring must include a subset of the baseline measurements and may include surveys at a range of different frequencies (e.g. water levels, on site observations, seasonal profiling, annual aerial photography, bathymetric surveys). The monitoring program must be appropriate to the site, cost effective, flexible and must provide the amount and quality of data required by the coastal manager. Monitoring can help determine whether erosion is cyclical or part of a long-term trend. The measurement methods must be simple, low cost approaches.

5.4 Aims and objectives for monitoring

Monitoring must be driven by the need to provide appropriate data for coastal management. Firstly it is needed to understand the past short and long term trends in coastal evolution (e.g. sea level rise, tectonic and seismic effects). Secondly, the identification of potential problems must be made, in order to develop and implement a reasoned response. Thirdly, an assessment of future changes must be made by using the feedback from monitoring the coastline response in mitigation actions, in order to guide future management and suggesting refinements or alternatives.

5.5 Priorities for measurement

In each site that has been identified as vulnerable in the vulnerability identification stage will require initial measurement and ongoing monitoring, also areas were mitigation action have been take also will have to be included in the monitoring plan. Areas with high tourism value may have to be in programme more accurate, frequent and with high resolution measurements, including installation of wave/tide gauges and meteorological equipment, commissioning of topographic surveys and aerial photography, and development of computerized data storage and analysis systems. The possibilities for measurement will almost always exceed the budget, so priorities must be set.

5.6 Frequency and timing of measurements

Beaches evolve continually in response to waves, water levels, winds, human activities, etc. Rates of change vary from the micro-scale of wave periods, seasons and decades. Micro-scales are of little practical significance to beach management, so the most obvious changes will be as a result of storms (one or two days) or seasons (winter to summer). These relatively short term changes may mask the longer term evolution over decades. It is important that coastal monitoring recognizes these different scales. Baseline measurements must establish the existing situation, including the potential short-term variability of that situation. Once variability is understood, monitoring can concentrate on longer-term trends. Establishing the baseline for the shoreline may require frequent observations and elevation surveys every month for a year to define an envelope of variability.

The timing of some measurements is also important, particularly with respect to beach profile monitoring. If the intention is to measure the extremes of variability, surveys should be completed during or immediately after severe storms, when beaches will be drawn down, and also during periods of prolonged light swell and longshore winds when beach face is likely to be fully recovered. However, if the intention is to establish long term trends, the surveys should be undertaken when sea conditions are likely to show some consistency. For example, the monitoring program might call for beach profiles to be completed in seasonal variations.

Location of each measurement must be considered for the same reasons as timing. Establishing trends requires the measurement to be in the same points or profiles on each occasion. Changes of even a few metres alongshore in the location of a beach-dune profile may introduce uncertainty into the analysis, particularly if there are any distinct features on the beach such as rock outcrops, streams or structures.

5.7 Monitoring techniques – low cost approaches

Beaches are three-dimensional and irregular in form and do not lend themselves easily to analysis by standard surveying techniques. A set of x,y,z co-ordinates tells little about the evolution of a beach, while a comparison of a number of such surveys to determine annual changes. When managing beach systems, a simple evaluation of the approximate extent and frequency of coastal erosion or accretion is more important than an evaluation of the detailed volumes. Simple but effective techniques for monitoring using tape measures and cameras can be used. Also, simple surveying equipment, such as levels or Total Stations, can be used for the same purposes if available, but this will require some additional training in field methods and data processing.

Erosion of a beach often can be identified by retreats in the shoreline that are easily identified by cross-sections. Changes over time to this cross-section, and the lateral extent of change, will provide useful information about the dune evolution. If the retreats are localized then the erosional processes must also be localized. If there are widespread then erosion may be due to a large erosion mechanism. The intensity of erosion can clearly be related to the width of the retreat. In terms of evaluating beach evolution a combination of techniques are necessary to locate the erosion or accretion areas, quantify the extent, and determine the likely causes in order to evaluate the rate of change.

5.8 Establishing beach zones

Ideally, management operations require knowledge of sea level elevations, the extent of wave run-up under normal conditions and the potential maximum extent of run-up during storms. However, that kind of data is not available for the beaches and must be gathered by measurements. The limit of storm wave run-up on an

eroding beach can be defined by the elevation and position of the erosion, though waves may actually splash even further up the face. Occasional extreme events, combining a storm surge water level and severe wave conditions, will cause run-up and erosion even further up the beach face. The potential importance of defining these extremes depends on the level of risk acceptable at the site. Sites with important and valuable backshore assets may need to be protected by substantial defences.

5.9 Monitoring of re-profiled beach

Markers, used as datum for surveys, should set up for monitoring beach profiles. Markers post should be made by natural elements in order not to disturb the aesthetic of the beach, or to be natural markers like trees or buildings. The spacing may be greater for systems with uniform alongshore features or less for smaller or more complex systems. But, in any case, they must not be more than 500m distant. The posts should be located as accurately as possible on a 1:5000 scale map, in order to reposition the beach posts if they are lost. The distance and bearing from one to the other must be noted along with position relative to adjacent sets of markers or fixed points. Each marker must have a unique reference.

Surveys can be conducted in two ways. The simplest approach, applicable to small beaches with minor erosion problems, is to hand measure offsets from the marker posts using a distance and slope measurement instruments. In larger beaches with important backshore assets at risk should be surveyed in greater detail. A Total Station can be used to survey profiles. Cross-shore profiles can be measured relative to a line defined by a pair of well-established marker posts of known position and elevation to the water line. Survey lines should generally be approximately shore normal to limit the complexity of analysis. Results can be plotted, stored and analysed using a simple spreadsheet, or more complex survey analysis software. Hand held GPS (Global Positioning System) equipment is not yet sufficiently accurate to allow for adequate surveying, although future developments may alter this view. Differential GPS can be very accurate but will certainly require the services of trained surveyors.

5.10 Soring and processing the data

A database, functioning as a supporting tool for the estimation of the economic impact of beach erosion to tourism, must be developed. The database will focus in providing realistic data to the state of the environment of the coastline and beaches and to estimate the economic value of the beach, through a hedonic pricing econometric model. The database has to focus on the identification of the vulnerability of the coast to sea level rise and associated erosion, in terms of expected land loss and economic activity. To achieve this, a database with environmental and economic data has to be developed, as supporting tool for estimation of the economic impact to tourism. Such a multipurpose database needs to consider social, economic and environmental factors, which relationships can be better understood when distributed and analysed along the geographical space. The description of the HERMES Database will follow along with the conceptualization, design and implementation of a regional GIS database.

5.11 Conceptual Model

The HERMES database modelling is based on multipurpose approach, combing environmental and economic data. This is implemented through the estimation of the vulnerability of the coast in two scales. There are three types of data that are used: (a) Raw data, derived from maps and remote sensing products; field observations; laboratory analyses and social and economic features. (b) Analytical data, that are produced by analysing the previous categories and (c) thematic data, which, are created by interpreting the various types of data. In order to analyse large amounts of data in a variety of formats, produced by numerous methods, and with different levels of accuracy, the database has been developed in a GIS form, which is organized in four levels. In the first level the gathering of data is been made. The database comprises rough data typically derived from four sources: (a) maps and orthophoto maps; (b) field observations; (c) laboratory analyses and (d) social and economic features (non-spatial attributes). In the second level the organization of the data is been made. The data are organized into two categories based on the scale of observation. The first (larger) scale is used to calculate the vulnerability in the case of the total length of the Cretan shoreline, with the use of the CVI method of Thieler and Hammar-Klose (1999). Subsequently, a smaller scale focuses on highly vulnerable beaches with high touristic and economic value. For this, the BVI method (Alexandrakis and Poulos

2014) is used, in order to identify the key factors that result to beach erosion. Finally the economic value of vulnerable beaches is estimated with the use of a hedonic pricing method. In level 3, new thematic data can be generated for further utilization. The applications of the database are implemented in level 4. The database flow chart and the conceptual model are illustrated in Figure 1.

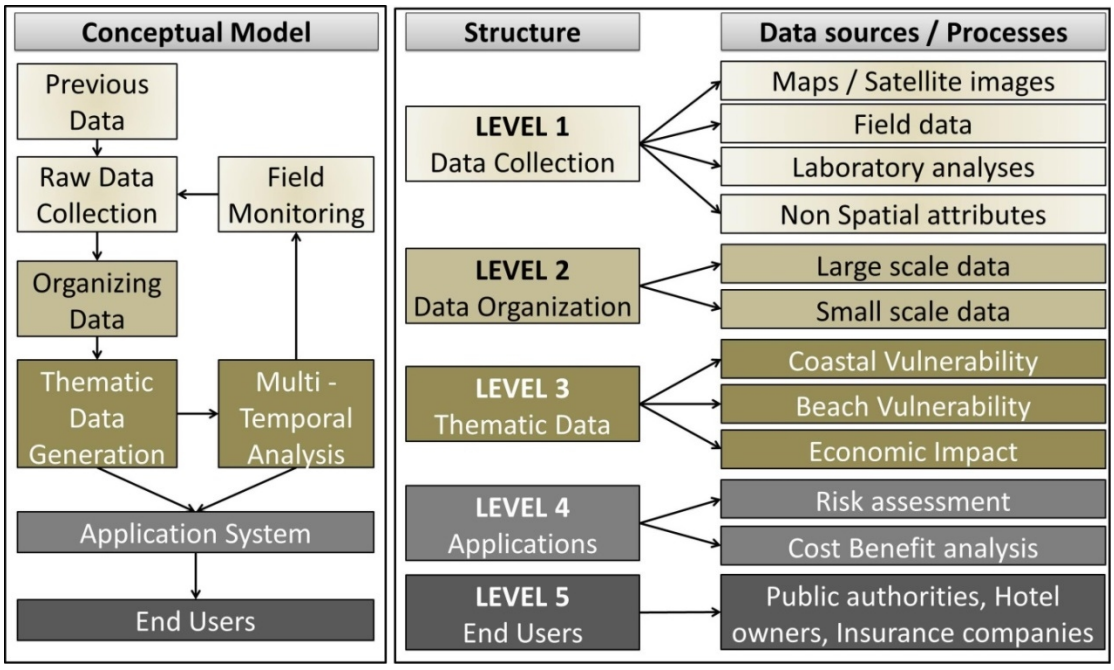

Figure 1: Conceptual model of the database

5.12 Database design, implementation and geographical coverage

For the purposes of the Cyprus coastal management project, the geographical coverage of the large scale dataset covers the area of the Cyprus shoreline and the area offshore. In this scale, data about elevation, geomorphology, sea level trends, shoreline displacement, tide ranges, and wave heights are used. The small scale data set covers the areas of the beach zones. Those data are derived by the numerical estimate of the processes that control beach evolution. The estimation of those processes depends on the calculation of other important variables, such as granulometry, wave characteristics and the geomorphology of beach zone (e.g. beach slope) and analytical data that are derived from those variables (e.g. wave run up). Also, the socio-economic data that will be used for the applications of the database, are included in this dataset. More

details of the relational database, as entities, relationships, tables, maps and, glossary of terms for data surveying are presented in the deliverable D3.3.4.

The outcome of the database is the identification of the most vulnerable and high risk touristic coastal areas and estimating the economic impact from beach land loss. Research of the economic implications of beach erosion were mainly focus in the cost of coastal protection measures and less in the income losses from tourism. The join environmental and economics approach of the problem can provide a management tool to mitigate the impact of beach erosion in tourism, through a realistic cost-benefit analysis for planning protection measures.

5.13 Managing risks from coastal hazards

5.13.1 Managed retreat

Managed retreat is designed to provide space between coastal developments and the dynamic shoreline. This avoids coastal hazards and prevent ecosystems being squeezed between rising seas and existing developments (IPCC 2001). Common managed retreat mechanisms include planning setbacks with a minimum distance from the shoreline, for new developments, density restrictions to limit new developments and rolling easements that permit development conditional on its removal when shorelines retreat (Titus 1998). Integrated coastal management policies may include all of these strategies (IPCC 2001).

5.13.2 Planning and setback lines

Setbacks can be used as a managed retreat strategy where the setback is moved inland in line with shoreline recession over time (IPCC 2001b). In the United States, rolling easement policies have been implemented in the states of Maine, Rhode Island, Massachusetts and South Carolina to enable inland migration of wetlands and beaches (IPCC 2001). The Dimensions of coastal investments are defined by the geomorphological variations, the maintenance of a wide sandy beach and ecological communities and by the allowing public access to coastline. The goals for this approach are to provide a wide sandy beach with offshore bars and surf breaks. Moreover, coastal planning must aim in not to trigger economic or legal impacts either for shoreline

landowners or the wider community and to be widely accepted in the community. This requires a satisfactory legislative position; in order to plan a response to rising sea levels over long time scales requires.

The Goals of legislative framework set out the general principal purpose to be achieved by the regulatory mechanism that the legislation puts in place. It may be that the policy of the legislation is to achieve sustainable development for the tourism industry and to provide an effect to a broader policy, towards sustainable development in coastal zone.

5.13.3 Creating a managing body

The current state of the beach tourism in Cyprus indicates an increasing demand for new developments in the coastline. This result to an increase in the anthropogenic pressures on the coastal environment, combined with climatic change and related coastal erosion increase the environmental risks. The need for concerted action, to address the above issues within a comprehensive plan for the protection and sustainable management for the developments in coastal areas in Cyprus,is profound and is accepted by stakeholders and citizens of the region. Given the complexity of the issues concerted action is required to address the numerous legislation, competitiveness of the users and uses, the creation operator of Managing authority is needed. Creating an Institutional Management Agency should take account and be supported under the Institutional Analysis and Development (Ostrom et al, 1994), according to which, the type, form and powers are determined by the operation of the existing situation, the field of action, patterns of interactions and the Policy outcomes. A Management Agency should regulate permanent human activities based on the goals of the laws and rules that are set and participate in key configuration management strategies of individual regions.

The operating framework, under which the type of Management Agency will form, depends on the environmental and anthropogenic system in which refers to, the rules and laws that must be implemented in order to achieve its objectives, the nature of the problems to be faced and the attitude of the community towards the issues that have to manage. The Management Agency can manage the consultation and cooperation with all stakeholders and social partners for formulating and a project environmental management policy. By this it will not only contribute to sustainable management of natural resources in the

region and regional sustainable development, introducing innovative measures of economic, social and environmental nature.

Management Body should include as activity areas the coastal areas in Cyprus Island and should also address many different types' problems of coastal erosion and protection and should be take account of both the expressed attitude of the local community to improve quality of life and the lack of a legal framework formed. In the decision making should take into account all the key stakeholders, in order to be developed into an effective structure. The main purpose of Management Agency is the design and implementation of an integrated program for environmental protection of coastal areas form erosion and the sustainable development of the tourism infrastructure and increase the tourism potential in the Island of Cyprus.

Based on the above framework, the Management Agency should incorporate all key stakeholders in a context of environmental governance, where the main objective is not only the decision, but also ensure the application them, and should have the following governing bodies

The Board is the body making all the decisions of the Management Agency and develops the action plan and supporting policies for implementation. The monitoring the implementation of these policies and the results in practice form the basis for corrective actions both in the preventive level the strategic and the operational level of functioning of the Board. Also, the Board shall prepare all internal rules of operation services and its committees. As chairman of the board an elected representative from the Region of Cyprus, assigned with issues of environments or tourism should be assigned. The members of the board should include representatives for the central government, which has the authority to issue permits for the developments and coastal defenses. Also, representatives for all coastal municipalities of Cyprus, local port authorities and external scientific advisors from the universities and research centers, should participate.

5.13.4 Financing - Economic Viability

With the establishment of the Management Authority be either a government subsidy or support through competitive projects or with the participation of the authorities that are included in the board. The economic viability can be ensured by the collection of fines related to illegal acts (eg illegal buildings) related to the environment conducted within the boundaries. By participating in available national and European environmental programs management, education etc. Also by the development of own resources through

actions such as environmental certification, innovation centers for environmental information and education, ecotourism,etc., according to plan entrepreneurship that should be develop.

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