Common Implementation Strategy for the Water Framework Directive (2000/60/EC)

Technical Report

EUROPEAN ACTION PROGRAMME ON FLOOD RISK MANAGEMENT

THE IMPACTS OF COASTAL FLOODING, FLOOD MAPPING AND PLANNING

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Note: This assessment has been carried out by a consultant under the framework of a support contract with DG Environment. It does not necessarily reflect the opinion of DG Environment or other Commission services.

CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

Flooding represents the most significant threat to coastal communities on many parts of the European coastline. The potential risk to human life, economic assets and the environment is already significant and increasing due to natural factors such as erosion, climate changes, etc. and anthropogenic factors such as coastal urban development, etc.

The European Union is moving forward on an action programme on Flood Risk Management (FRM), and the proposal for a Directive on flood mapping and flood risk management plans (the proposed Floods Directive) is an important part of this programme.

This report has been prepared by WRc at the request of the European Commission within the support contract for the implementation of the Water Framework Directive (WFD). The report is to contribute to the Impact Assessment of the European action programme on FRM in the elements of flood mapping and flood risk management planning in strategic planning to combat ***coastal flooding*** resulting mostly from marine sources. It is based on literature reviews and case studies of economic, social and environmental impacts as well as benefits for a planned approach to flood risk management.

There are three elements for action by the EC regarding flood risk maps and management plans:

1. Do nothing;
2. Promote flood mapping;
3. Promote the preparation and implementation of flood risk management plans.

An important issue regarding Do nothing is that if individual MS acting alone fail to fully recognise the importance of coastal flood and erosion protection within a wider international context, the necessary resources to implement protection might not become available.

For Element 1, individual MS with varying levels of coastal flood risk would adopt their individual response to an increasing threat. Eurosion estimated that in 2001 public expenditure dedicated to coastline protection in Europe was of the order of Euros 3,200 million[2]. This expenditure should be considered against the fact that the population living in European coastal municipalities has reached 70 million inhabitants in 2001, and the total value of economic assets located within 500 metres of the European coastline including beaches, agricultural land and industrial facilities was estimated at Euros 500 to 1,000 billion in 2000. Further, the value of the natural ecosystem function (i.e. ecosystem services benefits such as gas and climate regulation, water regulation and supply, erosion and pollution prevention) at the coast has been valued at 240 billion Euros per annum [1] (for 15 Member States before 2004 expansion and based on 1990s data)

[1] FIRN CRICHTON ROBERTS et al. November 2000. An assessment of the Socio-Economic Costa and Benefits of Integrated Coastal Zone Management

It generally appears that across Europe present levels of expenditure on coastal defences (capital and maintenance) will not keep pace with an increasing coastal and flooding problem, and that existing coastal defences could be destroyed or damaged in future events leading to a greater number of people and properties suffering from flooding as well as the destruction of valuable natural environments.

To continue with the current approach to coastal erosion and flood defence may be unacceptable for European society as a whole, (**Impacts of flood defences),** especially as the balance of coastal defence costs and their associated benefits is, in general poorly addressed in Europe.

The cost of coastal flood mapping (Element 2) depends on what material exists already, the level of detail that is considered appropriate and how to take account of existing flood defences. With good information and using GIS systems, indicating areas of low-lying land is relatively straightforward, but confirming the actual probability of inundation is more complicated.

The closest example of a flood risk management plan is the shoreline management plan (SMP) developed in the UK. It is however not possible to put a figure on the cost of producing an SMP, partly because of the variation in complexity of the individual cells involved, partly because of the background studies previously carried out in order to facilitate production (e.g. definition of the cells, preparation of guidance) by a number of different organisations, and partly because it is not known how the number of different stakeholders involved in the production of the SMP cost their efforts. The preparation of SMPs is an ongoing process in the UK.

Another example is integrated coastal zone management (ICZM)[1]. It is reported that the resulting benefits of both Low Level (Euros 50/km of coastline – see Footnote) and High Level (Euros 250/km of coastline – see Footnote) ICZM initiatives far outweigh the costs. In terms of annual value, the net benefits of ICZM initiatives ranged from Euros 127.1 million (benefit: cost ratio of 13.6:1) to Euros 659.8 million (8.6:1) using a very conservative approach to valuing benefits, which exclude organisational and planning efficiency gains, improved resource use and greater economic and environmental sustainability of coastal communities.

This review reveals that there are different approaches to considering coastal flooding and erosion by the various MS depending inter alia on history, culture and funding. As a result the levels of protection vary, funding and implementation responsibility vary, and techniques used and information available varies.

FOOTNOTE Reference 1 used High and Low level ICZM expenditures as two scenarios for their estimates of the cost component of socio-economic benefits. This was because a survey undertaken on ICZM expenditure revealed a variety of annualised and standardised total costs for ICZM ranging from Euros 50 to 2,700. The marginal costs of additional kilometres of coastline clustered into two broad groups with maxima around Euros 50 and 250. In estimating ICZM costs for MS the study therefore defined two scenarios as Low Level costing Euros 0.5 million plus Euros 50m per kilometre of coastline and High Level costing Euros 5 million plus Euros 250 per kilometre of coastline. Both scenarios exclude the cost of constructing sea walls or coastal defence structures, as these are justified on a case-by-case basis and funding was assumed to be separately sourced.

It also appears that the level of public awareness of flooding risk and the implications of coastal defence schemes is generally low, although recent flooding events have raised its profile.

Planning coastal management with all stakeholders involved in a wide geographical area has been accepted as the best way forward in some Member States as a better option than localised development of schemes but it is not possible to make a rigorous financial or economic case for this approach. We can however indicate some reasons for the adoption of such an approach.

The UK Environment Agency is reported to spend approximately Euros 3 million per year on raising awareness about flooding issues. In 2004, the funding provided by the Government to the Meteorological Office to operate the National Severe Weather Service was approximately Euros 3.0 millions. The Environment Agency submitted a new ten-year Flood Warning Investment Strategy to the Government in November 2003 at a cost of Euros 360 millions and this was agreed by the Treasury in April 2004. It has been estimated that the new strategy will cost approximately Euros 25 per property per year to provide the flood warning service to 80% of properties at risk of flooding from rivers and the sea.

From both the technical and economic point of view, coastal flood protection and flooding are not purely local issues; regional, national and international factors are also present. It is important to appraise the cost of providing coastal flooding and erosion protection measures, and the cost of studies that are needed determine the appropriate protection, in a balanced way against the benefits (which in the case of flooding are themselves averted costs) that are derived in the long term. Various techniques of economic analysis have been used to carry out such appraisals, and substantial research done into identifying all the factors involved and methods of considering them.

The need for integrated planning in the coastal zone supported by economic analysis of coastal flood defence schemes is recognised by many Member States and can illustrate issues such as:

- The longer the time span considered such as 50 and 100 years rather than 25 years, the greater the benefits of managed realignment become as the habitat becomes well established and the benefits of habitat creation and carbon sequestration can be considered;

- The financial basis and timing of compensation are key to ensuring acceptance of managed realignment in some areas;

- Defining common policies and strategies is a major challenge and opportunity for improved coastal flood risk management to avoid past experiences of the lack of consideration of all relevant factors that skewed appraisals in favour of investing in flood defence work rather than options working with the ecology of the area;

- In a cost-effective analysis, traditional embankment strengthening was shown to be cheaper than alternative measures that had greater ecological benefits. However including the predicted long-term ecological benefits in a multi-criteria analysis reversed this ranking, whilst extended cost-benefit analysis showed that the

alternative flood protection measures resulted in a "welfare loss" because of their significantly higher economic costs.

It is widely recognised that protection against floods and erosion cannot be limited to protecting individual assets and determined in isolation, since experience has shown that local flood protection measures can have negative effects further down the coast. It is important to look at an integrated plan to promote flood defense measures on a zonal basis cutting across administrative boundaries.

1. INTRODUCTION

Europe has a wide variety of coastal zone types with different natural, economic and social conditions, the economic, social and environmental importance of which has long been acknowledged.

The underlying geology forming the coast ranges from hard, ancient igneous rocks to soft, recent sediments. The wave energy environment includes the high energy North Atlantic Ocean and the relatively calm Baltic and Mediterranean seas, in addition a large range of climate types are experienced.

The coastline is an active geomorphological environment where erosion (and subsequent deposition) is a complex, naturally occurring process that is linked to the issue of coastal flooding. The coast has also always suffered from the threat of coastal erosion and flooding which currently has the potential to impact on several thousands of square kilometres and millions of people. Some European countries (e.g. Northern Germany, Eastern England the Netherlands and Belgium) are particularly vulnerable to inundation by the sea, and extensive flood protection infrastructure has been developed to counter the threat of flooding and erosion in particularly low-lying areas. Failure or overtopping of these defences can have disastrous consequences. In other areas, deposition of sediment from rivers and coastal currents causes problems for navigation.

Coastal areas have always held an attraction for human habitation and economic development (e.g. fishing, tourism and leisure, oil and gas extraction etc.) and the risks and conflicts that arise from settlement in such areas are generally well known (even though not fully understood). The coast is, and will continue to be, a very important area for the human population and is subject to a variety of pressures that may conflict with each other.

Flooding represents the most significant threat to coastal communities in many parts of European coastline. The potential risk to human life, economic assets and the environment is large and increasing due to natural factors such as erosion, climate changes, etc. and anthropogenic factors such as coastal urban development, etc.

Coastal erosion induced by human activities have surpassed in Europe coastal erosion driven by natural factors[2]. Human induced coastal erosion mainly proceeds from the cumulative and indirect impacts of small and medium size projects, as well as from river damming and the reduction of sediment delivery to coastal areas. However little attention is being paid to these impacts by project developers, Environmental Impact Assessment practitioners and competent authorities.

The protection against floods can no longer be limited to protecting some individual assets and can no longer be taken in isolation since, as mentioned above, experience has shown that local flood protection measures can have negative effects further down the coast. It is

[2] EUROSION May 2004 Living with coastal erosion in Europe: Sediment and Space for Sustainability Part IV – A guide to coastal erosion management practices in Europe: Lessons Learned.

important to look at an integrated plan especially for transboundary areas, where co-operation is needed and it is necessary to promote flood defence measures on a zonal basis cutting across regional boundaries and country borders.

It is important to appraise the cost of providing coastal flooding and erosion protection measures, and the cost of studies that are needed determine the appropriate protection, in a balanced way against the benefits (which in the case of flooding are themselves averted costs) that are derived in the long term. This is by no means a simple task, and several methods of economic analysis are potentially relevant. This report does not attempt to comment on the appropriate form of economic analysis, but collates information from current practice amongst the MS to demonstrate recent or current approaches in order to assist in considering an appropriate way forward.

Given the current state of economic development in Europe, and an increasing commitment to making this development sustainable, appropriate action to effectively deal with the coastal flooding and erosion issues is clearly required.

The EU is moving forward on an action programme on flood risk management, and the proposal for an EC directive on flood mapping and flood risk management plan (the proposed Floods Directive) is an important part of this programme.

The objective of the proposed Floods Directive is to reduce and manage the risks of floods to people, property and environment by ***concerted, coordinated action at river basin level and in coastal zones***.

The Flood Risk Management Plans considered under the proposed Floods Directive and River Basin Management Plans under the WFD are elements of integrated river basin and coastal management which should be developed in synergy through linkages between the two processes.

This report has been prepared by WRc at the request of the European Commission within the support contract for the implementation of the Water Framework Directive (WFD). The report is to support the Impact Assessment of the European action programme on Flood Risk Management, in particular the elements of flood mapping and flood risk management planning.

This report focuses on the preparation of maps and plans for use in strategic planning to combat ***coastal flooding*** resulting mostly from marine sources. It is based on literature review and case studies of economic, social and environmental impacts as well as benefits for a planned approach to flood risk management.

2. EUROPE'S COASTLINE

2.1 Social and Economic Importance of the Coast

The European Union's coastline extends for some 101,000 km across 20 of the 25 Member States Over the past 50 years the population living in European coastal municipalities has more than doubled to reach 70 million inhabitants in 2001[3] .

The European coastline is an extremely valuable economic asset. The key economic sectors in coastal zones were identified as tourism and leisure, agriculture and food, sea fisheries, ports and shipping and residential housing being most common.

Many major towns and cities are located adjacent to the sea, together with the associated commercial and industrial development. These towns and cities have provided points of access to the sea to facilitate exploitation of the land and marine resources, and trade using sea routes has been vital to the economic well being of much of Europe. There are also important agricultural areas adjacent to the sea. The popularity of the coast as a location for recreation and leisure activities is also high and continuing to grow as living standards rise.

An analysis of land cover data from 17 Member States[4] has shown that an increase in artificial surfaces was the biggest land use change between 1990-2000. The most significant development pressures were housing, services and recreation with residential urban sprawl, being the largest single contributory factor. Although not all new developments are on the coast, nor will all those on the coast be vulnerable to flooding or erosion, the continued growth in urbanisation would suggest that the total number of built assets at risk is increasing. Even where new developments occur behind actively defended coastlines, the probability of flooding can never be completely eliminated, and so the consequences of flooding will increase. Where growth in urbanisation is slow or static, the desirability of certain coastal locations, and restrictions on expansion has driven up property values in some areas.

The total value of economic assets located within 500 metres of the European coastline including beaches, agricultural land and industrial facilities was estimated at Euros 500 to 1,000 billion in 2000. In Greece for example, EUROSION[5] estimates that 70% of the country's population, 80% of the national industry and 90% of total tourism income derives from the coastal area.

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[3] EUROSION May 2004 Living with coastal erosion in Europe: Sediment and Space for Sustainability Part I – Major findings and Policy Recommendations of the Eurosion project.

[4] European Environment Agency November 2004 *State of the Coasts in Europe. Towards an EEA assessment report. Breton F.*

[5] EUROSION September 2002 TRENDS OF COASTAL EROSION IN EUROPE.

2.2 Environmental Importance

It is not surprising that a great diversity of natural habitats are found along the coastline, on which have been superimposed several thousand years of human settlement taking advantage of the resources that exist there.

The coast is extremely valuable for habitats and species. There are over 2000 Natura 2000 sites (2004) designated within 10km of the European coast and for many Member States habitats in this coastal strip make up a large proportion of the total surface area designated.

Coastal flooding is a natural process that creates and sustains a range of habitats that span the transition between fresh and seawater. As a result flooding cannot be considered as a threat to the environment in a natural setting.

The use of engineered coastal flood defence schemes can lead to the loss of the natural succession of habitats thus impoverishing the biodiversity. On the other hand, in some places, freshwater wetland sites have developed behind coastal flood defences that have been in place for generations, if not centuries. While the habitats on such sites may not be unique to coastal settings, their value, in nature conservation terms is often significant. Indeed, given the widespread loss of European wetlands, the fragments that remain on the coastal fringe may be considered to have grown in value over time, hosting a range of species (fauna and flora) of European importance.

The value of natural ecosystem function (ecosystem services benefits e.g. gas and climate regulation, water regulation and supply, erosion and pollution prevention - derived from 12 biomes present in Europe for which monetary values have been estimated) at the coast has been valued at 240 billion Euros per annum [6] (for 15 Member States before 2004 expansion and based on 1990s data) a figure largely attributed to the benefits of estuaries, continental shelf and tidal marshes. This would make coastal zones the most valuable areas within the European Union, although the report states that the values should be treated "with caution given the basis of their compilation and calculation " but that they "strongly suggest that Europe's marine, coastal and estuarine waters are of fundamental economic importance to the EU's people and communities" and that " they are of far greater importance than the landward areas". This is despite the fact that these figures might be an overestimate because of an over representation of the ecosystem services benefits generated by estuaries in the sample areas.

[6] FIRN CRICHTON ROBERTS et al. November 2000. An assessment of the Socio-Economic Costa and Benefits of Integrated Coastal Zone Management

3. COASTAL FLOOD RISK

According to EUROSION[2], flooding represents the most significant threat to coastal communities, with *"several thousands of square kilometres and millions of people"* potentially at risk. The concept of risk is commonly described as a function of the ***probability*** and ***consequences*** of an event. Taking this definition, coastal flood and erosion risk will therefore change as for any particular area both the probability and/or consequences will change through time.

Coastal flooding needs careful definition, as the causes of flooding are complex and often interrelated. Coastal flooding can include:

- Flooding arising from inundation by the sea;
- Flooding in urban areas adjacent to the coast as a result of overloading of storm drainage systems;
- Flooding along the coast by rivers overflowing their banks;
- Flooding along the coast as a result of locally heavy rainfall;
- Combinations of the above.

This report is mainly concerned with flooding resulting from inundation by the sea, although the links to other causes are taken into account.

Coastal erosion and flooding can be difficult to separate, for example sea walls may provide protection against erosion and the flooding of low-lying areas. An importance difference is that erosion is an on-going, sequential process that can be delayed but is very difficult to permanently halt without continuous maintenance measures. Flooding protection against a specified event tends to be more permanent. Flooding and erosion are different, but the coastal processes that create the one may enhance or reduce the other. Because of this interaction, it is important to take an integrated approach to shoreline management over an extensive geographical area.

3.1 Factors controlling the probability of coastal flooding

Coastal flooding due to inundation by seawater can occur as the result of a number of processes, often acting in combination. At its simplest flooding occurs when sea levels and wave run-up[7] exceed the height of natural land profile, or artificial sea defences. Water then spills inland to a greater degree than "normal". Flooding can also occur as the result of structural failure (breaching) of defences sometimes combined with the overtopping described previously, both natural and artificial.

[7] Wave run-up is the phenomenon in which the crest of a wave hitting a slope may run up that slope to a level higher than the original wave crest.

Therefore the key factors driving up the ***probability*** of flooding are those that increase the likelihood of these modes of failure and include:

- Climate change;
- Relative land / sea movements;
- Changes in sediment supply and erosion; and
- Human developments (either coastal or inland) that have an impact on the above factors;
- Poor design / maintenance of coastal defence structures.

Each of these factors will be reviewed in turn below although they can act in combination, but their most general effect is to cause an extensive or local rise in relative sea level.

Sea-level rise will increase the damage caused by storms because mean water level (the base level for storm effects) is higher, waves can attack higher on the shore profile, and coastal erosion often is accelerated, bringing structures nearer the shoreline and potentially removing protection offered by dunes and other protective features.

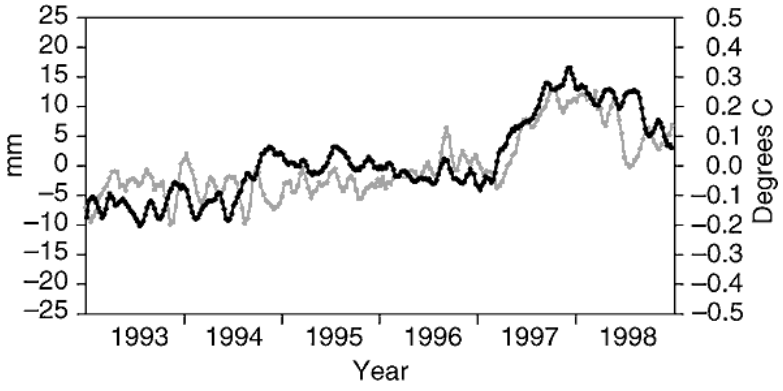
Studies have suggested that disaster prevention facilities such as coastal dikes, water gates, and drainage systems and coastal protection structures such as seawalls, breakwaters, and groins will become less functional because of sea-level rise and may lose their stability. A common concern relates to the bearing capacity of the soil foundation for structures. For instance, the increased water table resulting from sea-level rise decreases the bearing capacity of the soil foundation and increases the possibility of liquefaction, which results in higher instability of coastal infrastructures to earthquakes[8].

3.1.1 Climate Change

Climate change drives sea level rise through a combination of the thermal expansion of seawater, and the retreat of mountain glaciers and the melting of polar ice-sheets in response to global warming. Increased rainfall and storminess due to climatic change can also influence coastal flooding.

Global mean sea level has risen by about 0.1-0.2 mm per annum in the past 3000 years. By contrast, in the past century levels have risen by 1-2 mm per annum, in a trend that has been shown to closely mimic fluctuations in global surface air temperature in the recent past.

[8] Shaw, J., R.B. Taylor, S. Solomon, H.A. Christian, and D.L. Forbes, 1998a: Potential impacts of global sea-level rise on Canadian coasts. The Canadian Geographer, 42, 365-379.



The EUROSION project adopted the term *Accelerated Sea Level Rise* (ASLR) to differentiate climatic change effects from local human impacts and change in relative sea level observed as a result of natural shifts in land level. IPPC estimates suggest that the ASLR component of sea level rise will range from 13-68 cm by 2050[9].

The impact of increased precipitation on coastal flood risk is most evident in estuaries where water levels are influenced by river flows in combination with tide and sea state. Over the longer term, changes in the pattern and quantity of precipitation will affect flow dynamics and exert influence wider coastal processes by altering sediment supply and even seawater level and density in enclosed seas such as the Mediterranean.

Observations from the 20th Century show precipitation in Northern Europe has increased by 10-40% while southern regions have experienced a decrease of up to 20%[10]. Predictions suggest that climate change will lead to widespread increases in annual precipitation in Northern Europe and small decreases in Southern Europe.

These average figures hide marked seasonal variations. Models suggest that most of Europe will get wetter in the winter season (between +1 and +4% per decade); the exception is the Balkans and Turkey, where winters become drier. In summer, there is a strong gradient of change between Northern Europe (wetting of as much as +2% per decade) and Southern Europe (drying of as much as –5% per decade).[8]

The IPCC report that the recent increases in storminess in the North East Atlantic Ocean are no greater than those observed in the early 20th Century and that recent observed fluctuations in wave height are consistent with interdecadel values and do not form part of a long term trend.[9]

IPCC scenario predictions do not explicitly quantify daily changes in weather extremes but the panel concluded that it is *likely* that extreme precipitation events will increase in frequency and that it is possible that gale frequencies will increase. As noted by EUROSION[4], this implies the occurrence of bigger storm surges and more extreme waves around northern Europe.

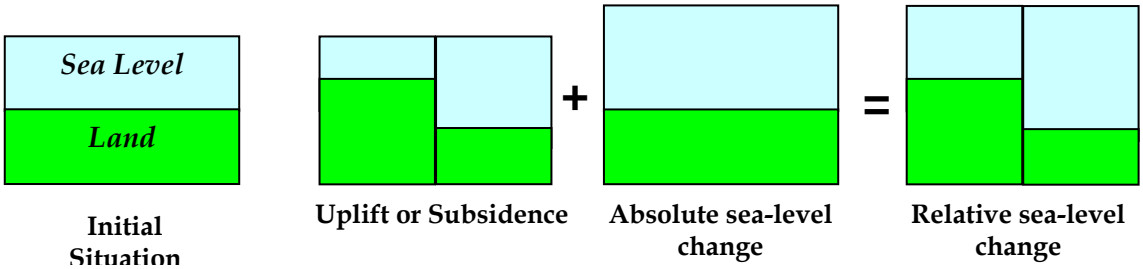
9 IPCC 2001 http://www.grida.no/climate/ipcc_tar/wg2/495.htm

10 IPCC 2001 (http://www.grida.no/climate/ipcc_tar/wg2/494.htm)

3.1.2 Vertical Land Movements

Vertical land movements are an important consideration in coastal flood risk as they can act to either exacerbate or mitigate the change in absolute sea level. Vertical land movements may occur as a result of tectonic activity, glacial isostatic rebound and local subsidence/uplift.

These processes act with different magnitudes across Europe and estimates of the combined



impacts by 2080 are presented in Table 3.1 below.

Table 3.1 Estimates of Natural Vertical Land Movement (mm) for the 2080s

Belgium	-5	Italy	-1
Denmark	+5	The Netherlands	-5
Finland	+65 (+-30)	Portugal	-5
France	-5	Spain	-4
Germany	-5	Sweden	+50 (+-45)
Greece	-5	UK	0 (+-15)
Ireland	-5		

Note: Taken from Eurosion [4] after Parry M L (Ed), 1994 Assessment of Potential Effects and Adaptions for Climate Change in Europe. The Acacia Project, Jackson Environment Institute, University of East Anglia, UK.

3.1.3 Changes in Sediment Supply and Erosion

The issue of coastal flooding is inextricably linked to that of coastal erosion. Natural inter-tidal habitats and beaches as well as artificially constructed or induced features can play an important role in absorbing wave energy. Change in vertical or longitudinal profiles as a result of material loss through ***coastal squeeze*** (the process whereby the combined effect of coastal erosion and human activities of infrastructure development and the erection of defences to protect it have created an artificially narrow coastal zone) or other reasons can increase the risk of wave overtopping. Erosion can also undermine or circumvent and weaken engineered and natural defence structures increasing the risk of catastrophic breaches.

The regulation of rivers can also be extremely important in relation to the total sediment budget available at the coast. EUROSION[2] reports that for some southern European rivers (e.g. Ebro, Douro, Urumea, Rhone) damming has effectively sealed sediment flows resulting

in a drop of over 90% in upstream sediment delivery resulting in an increase in erosion at the river deltas and further downstream.

3.1.4 Human Developments

Human induced factors that can increase coastal flooding risk include, coastal engineering, land claim, river basin regulation and dredging. Lack of understanding of the complexity of shoreline processes in the past has sometimes resulted in engineering and protection measures transferring problems along the coast and not achieving a permanent solution.

EUROSION[2] points out the fruitless efforts undertaken in the Camargue region of southern France to stop coastal erosion using defences, which have already become partly submerged.

3.1.5 Design and Maintenance of Structures

As with any engineering structure, coastal defences need to be carefully designed and maintained if they are to correctly serve their purpose. Poor design and / or inadequate maintenance can lead to failure under less than design conditions.

Past measures to manage coastal erosion have generally been designed from a local perspective: they have ignored the influence of non-local forcing agents and have disregarded the sediment transport processes within the larger coastal system. As a consequence, they have locally aggravated coastal erosion problems, and have triggered new erosion problems in other places.

3.2 Factors controlling the consequences of flooding

The ***consequence*** component of coastal flood risk can increase where new assets are placed in flood risk areas, or where the value of existing assets increases. In this context it is important to underline that *value* is not just a measure of economic worth (monetary value) it also includes social and environmental values that may not be readably amenable to economic valuation. Social and environmental impacts may in some cases be quantified in financial and economic terms e.g. willingness to pay / avoid impacts on biodiversity; travel cost methods (value of coastal nature reserves), economic impact analysis of expenditure in coastal areas (tourism, leisure, fishing, coastal industries and businesses) both quantitative and qualitative impacts.

4. ECONOMIC, SOCIAL AND ENVIRONMENTAL IMPACTS (COSTS AND BENEFITS) OF THE DIFFERENT OPTIONS

4.1 Elements

There are three elements for action by the EC regarding the preparation of coastal flooding and erosion flood risk maps and management plans:

1. Do nothing;
2. Promote flood mapping;
3. Promote the preparation of flood risk management plans.

It would also be possible to pursue elements 2 and 3 simultaneously as there is an obvious synergy between these items.

4.2 Expected impacts of the different elements

4.2.1 Elements 1 – Do Nothing

In the context of the current European Action Programme on Flood Risk Management, this element is considered to mean doing nothing to plan or act in an integrated and strategic way. Individuals, local and regional authorities and Member States may all continue to consider coastal flood risk management, but with little or no co-operation across boundaries of land ownership, administrative responsibility or national borders.

An important issue for a Do Nothing strategy is that if individual MS acting alone fail to fully recognise the importance of coastal flood and erosion protection within a wider international context, the necessary resources to implement protection might not become available.

Under Element 1, individual Member States will still have to deal with coastal flooding and erosion, the impacts of which are likely to increase in the future. However at the individual MS level there is also a Do Nothing option, which can mean either taking no action at all in relation to the problem or, more commonly, maintaining the status quo of their current policy on coastal flooding and erosion which may or may not include mapping and planning.

It generally appears that across Europe present levels of expenditure on coastal defences (capital and maintenance) (Table 4.2) will not keep pace with an increasing coastal erosion and flooding problem, and that existing coastal defences could be destroyed leading to a greater number of people and properties being at high risk from coastal flooding as well as destruction of valuable natural environments. (**Impacts of coastal flooding**).

To continue with this approach may be unacceptable for European society as a whole, (**Impacts of flood defences**), especially as the balance of coastal defence costs and their associated benefits is, in general, poorly addressed in Europe.

a) Impact of coastal flooding

Much research has been carried out in the UK over the past 20 years or so into the economics of flooding and its prevention, and ways of quantifying many of the factors involved in flood losses and in the construction of protection schemes. The Flood Hazard Research Centre (FHRC) of Middlesex University has undertaken much of this work. In 1992 FHRC published "The Economics of Coastal Management" – the Yellow Manual - to aid and improve decision making about investment at the coast in policies, plans or schemes to alleviate coastal flooding and erosion. The manual presents a detailed guide to benefit-cost analysis in coastal areas, and follows on from previous work on river flooding. It is noteworthy that the preface to the manual states regarding the coast:

> …there are many more interdependencies that exist (than rivers), and many more delicate balances between the forces of nature…..projects that affect the coastal zone need to be scrutinised very carefully….'

The US Corps of Engineers has also produced a manual - *Coastal Engineering Manual Part V* - which gives a very good overview of economic analyses of coastal protection measures.

The impacts of flooding considered in these manuals consider not only the direct damages/losses to land and properties and businesses, but disruption to transport, etc. and also health and social effects including loss of life, long term stress and worry, evacuation costs, loss and damage to memorabilia such as photographs. The effects of flooding on individuals, households, and communities are complex and long lasting, continuing long after the floodwaters have receded. Many of these effects are not possible to evaluate in monetary terms, and there are also impacts on economic activities, businesses, employment, destruction (and sometimes the creation or maintenance) of habitats – impacts on biodiversity etc.

Since the 1980s the FHRC has carried out a number of studies on the health and social effects of (river) flooding. More recent studies have involved qualitative research with two communities flooded in 1998, and seven communities flooded in 2000. These studies covered communities with varying socio-economic backgrounds and who experienced flood events of varying characteristics and impacts. The research showed that the effects of flooding on individuals, households, and communities are complex and long lasting, continuing long after the floodwaters have receded. Many of these effects are known as 'intangibles', i.e. those which are not possible to evaluate in monetary terms, such as loss of memorabilia, the perceived loss of security in the home, and the physical and psychological effects on people's health and well-being. The research has focused upon how people cope with the flood events and the long recovery process in an attempt to determine the type of support needed by communities, and ways in which flood impacts can be reduced.

Estimates of number and values of people and properties at risk of flooding across Europe is summarised in Table 4.1 below.

In the UK, the 1999 National Flood Claims Database indicated that the cost of damage by a flood depth of 0.6m to a typical house is Euros 24,000 of building losses and Euros 13,000 of content losses.

The EUROSION[11] project concluded the risk posed by coastal erosion has increased over the 15-year period between 1986 and 2001, with at least 875 km of coast identified as newly eroding over that period (the analysis is based on the enlarged EU coastline including countries that joined in 2004, but only reflects a small part of the EU coastline with proven changes – many data observed in 1986 were not certain and some sections not covered) Sixty three percent of these were found within 30 km of an engineered frontage. The remaining 37% tend to be found in higher densities in areas where sea level has risen more than 20 cm in the last 100 years and is likely to raise another 80 cm this century.

A project[12] of common North Sea Region coastal defence authorities from 2002 to 2005 declares there although for decades no major disaster has happened, the risk is ever present and up to 40,000 km^2 in the southern North Sea Region where 14 million people live and work could potentially be affected by flooding

Studies[13] for the UN-IPCC estimate that the number of people in Europe subject to an actual coastal erosion or flood risk by 2020 would exceed 158,000 while half of Europe's coastal wetlands (4500 km^2) are expected to disappear as a result of sea level rise. The Mediterranean coast is noted by UN-IPPC to be particularly at risk on both these counts. The cost of coastal erosion in Europe is estimated to average Euros 5,400 million per year between 1990 and 2020.

In England and Wales, DEFRA (the UK Environment Department) reported in 2001 [14] that 1.1 million residencies, and 83,000 commercial properties were in coastal flood and erosion risk areas, equivalent to 3 to 4 million people, as well as 0.5 million hectares of agricultural land. The capital value of the property (major part) and agricultural assets at risk was estimated to be Euros 203 billion. The potential annual average damages were calculated to be approximately Euros 2.5 billion per year.

In England and Wales, the present-day actual average annual damage from river and coastal flooding is estimated to be over Euros 1,450 million. If flood management policies and expenditure were unchanged, by the 2080's, the annual flood losses would increase under every scenario studied in a recent report, even excluding consequential losses such as disruption to transport. Present levels of expenditure on coastal defence will not keep pace with coastal erosion and up to one-third of existing coastal defences could be destroyed. The number of people at high risk from river and coastal flooding could more than double by 2080, with significant threats also the natural environment, particularly coastal grazing marsh.[15]

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[11] Eurosion, 2004 *Living with coastal erosion in Europe: Sediment and Space for Sustainability. Part 1 – Major Findings and Policy Recommendations of the Eurosion Project, and Part 2 Maps and Statistics.*

[12] COMRISK Subproject 1 Evaluation of policies and strategies for coastal risk management. Final report. December 2004.

[13] Salman et al Coastal Erosion Policies:Defining the Issues. EUROSION Scoping Study 2002.

[14] UK Government Department - Defra, National Appraisal of Assets at Risk from Flooding and Coastal Erosion, including the potential impact of climate change. Final Report. July 2001.

[15] The Foresight Report. UK Government Department of Trade and Industry 2004.

NADNAC [16] states that the capital value of assets at risk of flooding and coastal erosion in England in 2004 was Euros 344 billion, including agricultural land, residential property (84%) and commercial property.

The German state of Schleswig-Holstein is one of two states with a coastline, and borders both the North and Baltic seas. It has about 3,800 km^2 of flood prone coastal lowlands, where 345,000 people live and assets worth Euros 46 billion are concentrated. The flood prone area is predominantly along the North Sea coast [17] where there is a long tradition of coastal defence, and normally a high level of protection is demanded. This contrasts with a more sceptical attitude towards coastal defence on the Baltic coast, where comprehensive construction of sea walls only started in the 1870's, and there are worries it might negatively interfere with major sources of income such as tourism and harbour industries.

Two-thirds of the Netherlands covering some 25,000 km^2 is at risk of flooding[18] comprising large, densely populated polders accommodating most of the Dutch population and economy. The very existence of the Netherlands is dependent on reliable flood protection structures; protection against flooding is thus a national issue and political task embedded in the constitution. The capital value at risk in the Netherlands was estimated at Euros 2,000 billion in 1992.

Table 4.1 Estimates of People and Assets at risk from Coastal Flooding

Member states	**People (x 10^6)**	**Properties (number/area)**			**Values (x10^9 Euros)**
		Residencies (x10^6)	**Commerces (x10^6)**	**Agri land (x10^6ha)**	
England and Wales (2001)	3 – 4	1.1	0.083	0.5	203
Schleswig-Holstein (Germany)	0.345	-	-	-	46
Netherlands	-	-	-	-	2000 (1992)

[16] National Assessment of Defence Needs and Costs for flood and coastal erosion management (NADNAC) Summary report Defra. June 2004.

[17] Hofstede J A new coastal defence master plan for Schleswig-Holstein. Coastline Reports 1 (2004).

[18] RIKZ Flooding risk in coastal areas. Jorissen et al December 2000.

b) Impact of flood defences

There are a variety of structural measures (and substantial guidance on their design and application) that can be used for the control of coastal flooding and erosion including:

- Breakwaters and seawalls to oppose wave energy;
- Groynes designed to increase sediment storage and control longshore drift;
- Flood embankments and barrages designed as watertight barriers.

Non-structural measures include:

- Artificial beach nourishment;
- Dune building, cliff strengthening, and beach ridge restructuring;
- Plantations of shrubs and grass.

In practice most coastal defence projects incorporate aspects of both these approaches. In recent years shoreline management using non-structural methods has grown in popularity, using the dynamic nature of the coastal environment to advantage. Such methods also tend to have a lesser adverse impact on the environment and may require less maintenance.

In England and Wales, the concept of managed realignment of coastal defence has been introduced in recent years; involving setting back the line of actively maintained defences to a new line inland of the original. Managed realignment creates space for new, inter-tidal habitats such as salt marshes, which are effective dissipaters of wave energy. Indicative estimates suggest that that with 80-m wide inter-tidal saltings, the height of a sea wall can be reduced from 12m to 3m with a construction cost saving factor of 12.5 per metre length[19]. In addition there are also important nature conservation benefits (biodiversity support), recreation and leisure opportunities, pollution reduction (saltmarshes act as pollution sinks) and reduced maintenance costs due to lower sea defence heights and a less aggressive wave environment.

In the UK, the Government commissioned a review of Managed Realignment in 2002[20]. It reports:

> There are potentially significant net benefits from Managed Realignment. Some, but not all, of these are accounted for in economic terms using DEFRA's current project appraisal methods.

(available at http://www.defra.gov.uk/environ/fcd/pubs/pagn/default.htm)

[19] Rupp S et al (FHRC) Managed Realignment of Coastal Flood Defences: A comparison between England and Germany. Proceedings of "Dealing with Flood Risk" 2002.

[20] Defra / Environment Agency Flood and Coastal Defence R & D Programme. Managed Realignment Review Project Report FD 2008, August 2002.

> The main economic benefits are reduced defence costs, due to both shorter defences and the role of inter-tidal habitats in wave energy reduction. Standard project appraisals aim to account for these benefits but currently existing scientific information on wave energy dissipation over inter-tidal surfaces is not fully utilised in predicting how much lower defences realigned inland could be for different water depths. However, inter-tidal habitats also provide other important products and services that, even though they are often not marketed, have significant economic social value. There have been few valuation studies specific to Managed Realignment. One study of wetland values showed that the function with highest value is likely to be flood control, followed by water generation (surface and groundwater recharge, which might not be significant in the context of Managed Realignment), water quality improvement, and finally biodiversity support.

The UK Government Review[19] also states:

> There is still considerable uncertainty regarding benefits and costs of managed realignment case studies show the costs can be higher than expected as it is difficult to predict the success of habitat recreation, further necessary works, or maintenance costs and planning complexities. The benefits are not always clear. There is no consensus amongst ecologists whether managed retreat leads to higher quality habitats the potential costs of unmanaged realignment are likely to depend on risk communication and accompanying safety measures.

However, as FHRC 2002[18] pointed out, the application of managed realignment over the next few decades is likely to be variable across Europe. For example, on Germany's North Sea coast where defences are generally in excellent condition it is not likely to be a viable option. Similarly, in the Netherlands a decision has been taken not to allow the coastline to move further landwards than its position of 1990.

The impacts of flood defences can be evaluated in terms of:

- Cost (capital for infrastructure and ongoing maintenance costs);
- Estimated benefits (the avoided costs described above);
- Estimated impacts to the environment (both costs and benefits).

<u>Cost of flood defences (present and future):</u>

In the UK as a whole, there is an annual spend of about Euros 1200 million on flood and coastal defences[20].

NADNAC[14] states that a total of approximately Euros 465 million will be invested in flood and coastal defence infrastructure in 2005/06 in England, and that typical annual flood and coastal defence investment requirements for the next 100 years will be of the order of Euros 540 million if assets remain constant at year 2000 levels. This excludes regulation of the flood potential area to prevent inappropriate development, flood warning and emergency response, strategic planning and administration. NADNAC does not consider increasing damage cost due to socio-economic development, climatic change, impacts on major transport and social

infrastructure, higher standards of protection. The assessment of funding requirements is therefore more likely to be too low rather than too high. The overall benefit cost ratio for flood defences including capital, maintenance, improvements and operations for the preferred scenario (Justified Improve Higher) is 1.5:1 for coast protection over a 100 year period.

EUROSION[2] states that in 2001, public expenditure dedicated to coastline protection in Europe against the risk of erosion and flooding reached an estimated Euros 3,200 million and that this figure does not reflect the hidden costs induced by human activities in the long term. The figure is stated to cover new investments made in 2001 (53%), costs for maintaining existing protection schemes and monitoring the coastline (38%) and provision for purchasing coastal lands at risk (9%).

Ven Wnieuws[21] states that over the past 40 years, some 20 billion Dutch guilders (Euros 9 billion) have been spent on flood defences in the Netherlands. The annual maintenance costs for flood defences are approximately 100 million guilders (Euros 45 million), with about 60 million guilders (Euros 27 million) spent to maintain the coastline in position. About half of the 15 million inhabitants live at or below mean sea level.

EUROSION[2] gives a figure of Euros 45 million per year being spent in the Netherlands on beach nourishment from 2001 onwards to maintain the coastline of 1990 and counteract all erosion.

The Coastal Zone Management Subgroup of the IPCC quoted in [4] has estimated that in Poland, a one-metre rise in sea level (by the year 2100) would increase by a factor of 10 the annual risk of flooding the highly productive deltaic areas, and would triple the rate of coastal erosion. Without further protection, the one metre rise would cause an annual inundation of 1,500 km^2 of agricultural land with a value of Euros 2.5 billion, as well as highly valuable historic, cultural and industrial centres covering 25 km^2. An impact study in 1991/92 suggested that about 200,000 people are estimated to be likely to experience flooding if there was a one metre rise in sea level. Full coastal protection costs were estimated to be Euros 1.2 billion.

In France, EUROSION[4] estimates that almost 14 million Euros per annum will be spent on coastal protection, and that about 550km of coastline are currently protected by some form of defence structure representing a total investment of Euros 760 million. In one low lying area in waster France, a 0.5 m rise in sea level is estimated to lead to Euros 25 million extra flooding damage in the developed areas. The response strategies are estimated to cost over Euros 100 million over the next 100 years and would protect 2500 jobs and Euros 10 million in annual revenues from the tourist industry alone.

In Greece, EUROSION[4] estimates that coastal protection costs can reach Euros 180 million in a particular year (0.11% of the national income), with Euros 1100 million actually allocated to coast protection in the period 1990 to 2020.

Spain was estimated by EUROSION[4] to spend Euros 176 million each year on sand nourishment (1993-1997) and Malta currently (1993) Euros 5.5 million on coastal protection.

[21] Ven Wnieuws 1996 Presentation.

Table 4.2 Flood defence expenditure

Member States	Capital expenditure (billion euros)	Annual Maintenance costs (billion euro/year)	Reference
Poland 1992	1.25	-	IPCC To deal with 1 metre rise in sea level.
Schleswig-Holstein – present.(See Section 4.2.3)	-	0.045	Hofstede 2004
Schleswig-Holstein - future estimate.	0.282	0.017	Hofstede 2004
Netherlands (1996 - over the past 40 years)	9	.045	Ven wniuews 1996, Eurosion 2004
UK (2005/06)	0.465 annually	-	NADNAC 2004
UK (For the next 100 years)	0.540 annually	-	NADNAC 2004
France - current	0.014 (annually)		Eurosion 2004
France - part – next 100 years	0.1		Eurosion 2004 – to protect against 0.5m rise in sea level.
Greece - current	0.18 (annually) 1.1 (in total between 1990 and 2020)		Eurosion 2004
Spain	-	0.176 (on beach nourishment) (1993-1997)	Eurosion 2004
Malta	0.0055 (annual)		Eurosion 2004

Benefit Cost Analyses

The Tyndall Centre of the University of East Anglia carried out a study of managed realignment options in the Blackwater estuary in eastern England in 2005[22]. This included a cost benefit analysis (CBA) over 25, 50 and 100-year time spans. The study showed that the "hold the line" scenario represented an overall cost to society, whereas the managed realignment option produced positive benefits over a 100-year period (recommended by the UK Government for project appraisals). The complexities of the CBA are discussed, and

[22] Shepherd D. et al Tyndall Centre for Climate Change Research, Technical Report 21, March 2005.

values of the typical costs presented for items such as average realignment capital works, land values, maintenance costs, and value of the created intertidal habitat. The study states that the longer the time span considered such as 50 and 100 years rather than 25 years, the greater the benefits of managed realignment become as the habitat becomes well established and the benefits of habitat creation and carbon sequestration can be considered. The value ascribed to habitat creation has a significant impact as to whether a project should be adopted through the appraisal system.

EUROSION[2] also discusses the lessons learned from managed realignment case studies rather than maintaining defences for two sites in England (Essex and Sussex) and France (notably Criel sur Mer) where cost-benefit analysis demonstrated that the cost of protection (ranging from Euros 1 to 5 million for a typical 10 year period) was not appropriate for 10 to 15 houses each with a market value of Euros 200,000 from an economic viewpoint. Furthermore, managed realignment may constitute a sounder environmental solution as cliff erosion is not halted and continues to provide sediments for further downdrift. The financial basis and timing of compensation are key to ensuring acceptance of managed realignment in some areas.

Brouwer et al[23] come to a similar conclusion in a study in the Netherlands of the Rhine and Meuse delta. In a cost-effective analysis, traditional embankment strengthening was shown to be cheaper than alternative measures that had greater ecological benefits. However including the predicted long-term ecological benefits in a multi-criteria analysis reversed this ranking. Yet further, extended CBA showed that the alternative flood protection measures resulted in a "welfare loss" because of their significantly higher economic costs.

FHRC[24] has carried out a series of studies designed to identify the recreation benefits of coastal protection schemes using a contingent valuation approach developed by FHRC, the value of enjoyment per visit method. A particular interest of the research at Corton in Suffolk completed in 2001 was that one of the options appraised involved managed realignment on the developed coast. Residents and visitors were found to be strongly in favour of a coastal protection scheme rather than allowing nature to take its course on their coast[25]. This compares with the SMP for Corton which states that the exposure of the coastline (on the east coast of England) means that technically it has already become increasingly difficult to hold the present shoreline position, with beaches becoming virtually impossible to retain due to the prominent position of the frontage. There is also insufficient economic justification for providing defence against ongoing erosion, although there will be loss of property and associated infrastructure within the village.

Van der Meulen[25] reports on a proposed project to restore the Haringvliet estuary in southwest Netherlands. The estuary was closed by a dam after the 1953 floods disaster as part of the Delta plan, but caused severe damage to the estuarine system, once a unique freshwater tidal marsh. The Dutch government now wants to change the use of the sluices in the dam to

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[23] Brouwer R et al Living with Floods: An Integrated Assessment of Land Use Changes and Floodplain Restoration as Alternative Flood Protection Measures in the Netherlands. CSERGE Working Paper ECM 01-06

[24] Middlesex University, Flood Hazard Research Centre, website.

[25] A. van der Meulen, From Sluices ajar to Controlled Tides :Revovery of an estuary. Coastline, vol.9 no.2000-2

allow the area to recover. Three alternatives were compared to the existing situation. The most expensive scheme had estimated costs of compensating measures of about Euros 460 million, compared to an alternative scheme with costs estimated to be Euros 170 million which allowed a lesser extent of ecological recovery. The extra costs of the expensive scheme are not justified and the cheaper scheme is being progressed.

4.2.2 Element 2 – Flood Mapping

The long term prevention and control of coastal flooding is not straightforward and requires significant analysis involving a range of technical expertise and involvement of a large number of stakeholders.

A prime requirement is an analysis of the present and future risks and the presentation of these risks in a clear, cogent manner including in the form of maps. Maps will facilitate better future management of the risks of floods within the overall land use and integrated coastal management planning. However the cost of preparing the plans must be considered in relation to the benefits of doing them.

Cost of producing maps

The Environment Agency of England and Wales have recently completed a coastal "extreme flood risk zone" modelling and mapping study of all of England and Wales at a quoted cost of approximately Euros 500,000 most of which was for data manipulation to achieve the required GIS format. The modelling is described as "national generalised modelling" and used a broad scale-modelling tool linked to a digital terrain model in a geographical information system. The maps show the areas that could be affected by flooding if there were no flood defences from a once in 200-year flood and a once in 1000-year flood.

The cost given above does ***not*** include for:

- Obtaining any raw data (cadastral survey, bathymetry, tide gauging etc), as maximum use was made of existing broad scale data;
- Obtaining the GIS and digital terrain model of the UK (again use was made of an existing model used in other projects);
- Pilot studies to assist in defining the specification for the work.

It is not been possible to attribute costs to these items.

In December 2000 the Environment Agency added indicative floodplain maps to its web site (www.environment-agency.gov.uk/maps/info/floodmaps/) allowing people with access to the Internet to check out which areas of England and Wales are at potential risk of flooding from rivers and the sea. A difficulty was that the initial, indicative maps were not very accurate and did not show the effects of flood defences to ameliorate flooding. The Environment Agency published second-generation flood maps in 2004 showing the extent of some (recent) flood defences, and significant, moderate or low likelihood of flooding taking

account of all flood defences. Further work is in progress including using airborne surveys to obtain better digital terrain information.

4.2.3 Element 3 – Flood risk management plans

The element for flood risk management plans has impacts regarding development costs, implementation costs and investment required for the different aspects of a flood management plans; i.e. prevention, protection, preparedness, emergency response and recovery.

This section is a mixture of a review of strategies adopted in some member States (UK, NL, DE, DK) and on specific case studies such as:

- Shoreline Management Plans - SMPs (UK);
- Plan Bleu;
- Integrated coastal zone management (ICZM) initiatives.

United Kingdom

The UK Government emphasises the need for a strategic approach and long-term view to coastal management covering a wide geographical area to encourage sustainability. However this is recognised as not being a reason to promote blanket standards or works that would not otherwise be worthwhile.

In England and Wales, since the mid 1990's the Government has encouraged coastal managers and decision makers to work together in groups to prepare Shoreline Management Plan's (SMPs) for defined discrete lengths of coastline (cells). An SMP is considered to be a high-level document that forms an important element of the Strategy for Flood and Coastal Defence, and the first generation of SMPs have been completed. The cells were defined on the basis of coastal processes and it was often necessary for the relevant operating authorities to work jointly with neighbouring authorities as voluntary coastal groups to produce an SMP. One operating authority was nominated as lead.

The Government published an updated Guide for Coastal Defence Authorities in 2001 following a review of the first generation of SMPs and after consultation with the involved authorities. This guide concluded that further research was needed into how the coast would evolve. As a result of this further research being undertaken, interim guidance has published by the Government on the preparation of the next generation of SMPs – a total of over 30 SMP2s – which are presently in the course of preparation.

Appendix A contains a copy of the first generation SMP for a part of East Anglia, together with some of the Appendices indicating the approach used for the appraisal of coastal defence schemes.

It is not possible to put a figure on the cost of producing an SMP, partly because of the variation in complexity of the individual cells involved, partly because various background studies have also been carried out in order to facilitate production (e.g. definition of the cells,

preparation of guidance) by a number of different organisations, and partly because it is not know how the number of different stakeholders involved in the production of the SMP cost their efforts. However clearly, it is not a trivial cost and is an ongoing process.

Catchment Flood Management Plans (CFMPs) are also being prepared for England and Wales taking an all-embracing long term look at a river catchment, and these and SMPs will probably be brought together under the requirements of the Water Framework for River Basin Management Plans.

Netherlands

In the Netherlands, due to the obvious need for protection and awareness of the extent of the coastal flooding problem, a statutory safety level is laid down in legislation and has to be taken into account when designing and managing flood protection structures. This centralised and prescriptive type of policy is apparently unique in Europe. The Ministry of Transport, Public Works and Water Management sets the policy and legislation framework including safety standards. The Ministry is also responsible for managing the coastline and a limited number of flood protection structures. Local water boards play a key role in constructing and managing the vast majority of flood protection structures. Safety standards in the Netherlands coastal area range from 2,000 to 10,000 years.

Germany

In Germany, the federal government as well as the federal states have joint responsibility for most areas of the coastal planning process. The states have a high degree of freedom in establishing their own legislative structure and laws. There is no federal policy or strategy for coastal zone management in Germany, however as coastal defences have national consequences, the federal government co-finances capital measures with 70% of the costs. Maintenance is financed wholly by the states. The national budget for coastal defences is reviewed every year, and prioritisation based on safety and the magnitude of possible consequences, using maps of population and the capital values of assets.

In 2001 the State Government of Schleswig-Holstein adopted for the first time a new master plan for integrated coastal defence management (see Section 4.2 above). The plan defines 10 development goals. The plan recognizes that coastal defence cannot be executed on a purely benefit-cost basis, but because of restricted public finances, priorities need to be set on the basis of risk assumptions. Project appraisal is based on cost-efficiency rather than benefit cost with no debate as to the need and maintenance of flood defence works. Hence coastal defences in Schleswig-Holstein are generally in excellent condition. (FHRC 2002)[18].

In Schleswig-Holstein, the current annual expenditure for coastal defence in the area is of the order of Euros 45 million[17] . In the Master Plan for the area, a capital spending programme of Euros 282 millions is included, and in addition annual costs for maintenance, sand nourishment and small measures of about Euros 17 million is anticipated. The implementation of the capital spending programme is anticipated to take at least 15 years.

Denmark

In Denmark, the performance of flood defences is embedded in a framework of the Danish Coastal Authority and its parent the Ministry of Transport. The national Coastal Protection Act allows coastal protection where necessary, but promotes natural processes where possible. Guidelines are focussed on finding the optimal technical solution to protect the value of the assets at stake whilst minimising disruption to the natural environment. (COMRISK 2004)[26]

Mediterranean Area

As an example of regional coordination, the Blue Plan is an interesting case study. The Blue Plan for the Environment and Development in the Mediterranean is a non-governmental, non-profit organisation that works under the auspices of the United Nations Environment Programme and is funded by the Mediterranean Action Plan. Blue Plan provides a package of data as well as systemic and prospective studies, combined in certain cases with proposals for action, which are intended to provide the Mediterranean countries with useful information for implementing sustainable socio-economic development that does not result in degradation of the environment. The Blue Plan's work covers all the coastal regions of the Mediterranean Sea, and recognises the pressures on these coastal areas induced by rapid urban development and tourism. It was not possible to find more detailed information on the costs and benefits.

a) Benefits of a Planned Approach

The importance of good knowledge of the extent of potential flood risk areas and the preparation of integrated flood management plans is being recognised by the responsible authorities as vital for the correct economic appraisal of the public benefits of individual projects.

It has been recognised in several studies that defining common policies and strategies is a major challenge and opportunity for improved coastal flood risk management to avoid past experiences of the lack of consideration of all relevant factors that skewed appraisals in favour of investing in flood defence work rather than options working with the ecology of the area.

In the UK, the Government has encouraged the formation of voluntary coastal defence groups which have an important role in the development of shoreline management plans (SMPs). An SMP provides a large-scale assessment of the risks associated with coastal processes, and presents a long-term policy framework to reduce these risks to people and the environment in a sustainable manner. Maps of areas with current and future potential to be affected by flooding are a vital item of baseline information.

Also in recent years, the increasing pressures on European coastal regions has been recognised, and the EC has called on MS to put into place national strategies for integrated coastal zone management (ICZM). ICZM involves managing the coast through the cooperation of the different agencies and groups involved to try and resolve issues of potential conflict. Coastal erosion and flood protection are major issues to be addressed in ICZM initiatives as well as pressures including tourism and leisure, water pollution, habitat

[26] COMRISK 2004 Subproject 1 Evaluation of policies and strategies for coastal risk management. Final Report.

loss and urban expansion. Again, to facilitate such initiatives, baseline information and data will be required including inter alia maps showing flood risk areas.

ICZM initiatives have generated important qualitative benefits for their stakeholders and communities[5]. Given the value of the ecosystem benefits generated by Europe's coastal zone, investment in ICZM policy initiatives has a comparatively high rate of return compared to non-coastal projects in other areas of the EU.

The resulting benefits of both Low Level (Euros 50/km of coastline – see Footnote on page 2) and High Level (Euros 250/km of coastline – see Footnote on page 2) ICZM initiatives far outweigh the costs[5]. In terms of annual value, the net benefits of ICZM initiatives ranged from Euros 127.1 million (benefit: cost ratio of 13.6:1) to Euros 659.8 million (8.6:1) using a very conservative approach to valuing benefits, which exclude organisational and planning efficiency gains, improved resource use and greater economic and environmental sustainability of coastal communities.

Firn, Crichton and Roberts[5] state "The sustainability of European ICZM management is critical to enhancing the economic and environmental sustainability of Europe's coastal zones; … the public and transnational nature of the socio-economic benefits generated by ICZM will depend upon national government and EC funding and policy support in the medium-term."

For the low level and high level scenarios, the following ICZM costs and benefits are presented in Table 4.3 taken from Reference[5]:

Table 4.3 Scaled Up Value of ICZM Costs and Benefits, Annual Value, Thousands of Euros

MS	ICZM Costs – Low Level	Net ICZM Benefit – Low Level	ICZM Costs – High Level	Net ICZM Benefit – High Level
UK	1,163	30,586	8,407	154,309
France	696	16,822	6,073	110,065
Italy	777	14,395	6,480	95,798
Sweden	685	13,310	6,019	45,003
Spain	776	12,702	6,472	69,592
Finland	649	7,969	5,838	24,906
Germany	642	7,136	5,804	53,814
Eire	593	6,314	5,530	18,650
Netherlands	542	5,853	5,302	29,446

Denmark	694	4,733	6,061	18,481
Greece	1,228	2,628	8,731	13,180
Portugal	606	2,116	5,624	7,637
Belgium	522	1,069	5,202	9,309

b) Cost / investments for Protection and Preparedness

Protection

Protection means taking measures, both structural and non-structural. This is the cost for flood defences, and is discussed in the preceding sections.

Preparedness

Preparedness against coastal flooding and erosion involves providing flood forecasting and early warning, raising awareness of the population and competent authorities beforehand about flood hazard and risks; preparing and maintaining appropriate emergency response plans; increasing resilience (ability to react to and recover from flooding); recommending what to do in the event of a flood.'

In 1999 in England and Wales a customer dial up telephone service – Flood Line - was set up and extended to Scotland in 2001. One of the main drivers for this was the withdrawal of the service by the Police using loudhailers and door to door calling. Warnings are disseminated by telephone to pre-registered properties. In a fluvial flooding event during autumn 2000, the Flood Line is reported to have received 467,200 calls costing the Environment Agency Euros 440,000. The Environment Agency is also reported to spend approximately Euros 3 million per year showing people how to take action to protect their property, for example fitting flood boards or airbrick covers.

The UK Government funds both a national Tide Gauge Network that measures and archives sea levels around the UK coast, and the Meteorological Office to provide daily forecasts of surge and wave conditions that are used by the Environment Agency in combination with tide levels and local knowledge to provide coastal flood warnings. In 2004, the funding provided by the Government to the Meteorological Office to operate the National Severe Weather Service was approximately Euros 3.0 millions. Benefit cost analysis has been used by the Government to justify investment in flood warning systems, including recognition of the intangible social benefits due to health and welfare, although it is stated that to date this has not been necessary to justify investment.

The Environment Agency submitted a new ten-year Flood Warning Investment Strategy to the Government in November 2003 at a cost of Euros 360 millions and this was agreed by the Treasury in April 2004. It has been estimated that the new strategy will cost approximately Euros 25 per property per year to provide the flood warning service to 80% of properties at

risk of flooding from rivers and the sea. In Scotland, the Environment Agency has also developed a cost benefit procedure which it is applying to setting up and running flood-warning schemes, and will review the cost effectiveness of schemes based on this. For new schemes, voluntary funding contributions will be sought from relevant local authorities and the business community who benefit.

Resilience to flooding can be an added cost built into the infrastructure in hazard prone areas to some degree, for example raised, watertight entries to buildings, building transport arteries on raised embankments. Research is currently in progress in the UK on this matter but the costs of measures are not yet available.

Risk Management Solutions (RMS)[27] present an interesting retrospective on the 1953 floods that struck the east coast of England and the southwest coast of the Netherlands, causing the worst natural disaster in Northern Europe for two centuries. 307 lives were lost in the UK and over 1800 people drowned in the Netherlands. In 2003 prices, the material damage alone has been estimated in England as Euros 1.5 billions. All the damaged flood defences were permanently renovated and subsequently raised and strengthened to protect the main concentrations of population against storm surges with a return period of up to 1 in 1000 years. The possibility of another surge flood along the Thames, led to the construction of the Thames barrier to protect London at a cost of over Euros 1.5 billion, together with a national flood-warning organisation.

RMS estimate that the insured property loss in 2003 with the same extent of flooding would be over Euros 10 billion split approximately between losses to residential buildings and contents and commercial and industrial properties. This figure does not take account of improvements to coastal defences since 1953, including the Thames Barrier, which would significantly reduce this figure.

In the Netherlands damage was estimated at the time to be Euros 250 million, with Euros 90 million damage to the flood defences, and prompted the Dutch Government to undertake a massive flood protection plan, the Delta Works which was not finally completed until 1997.

[27] 1953 UK Floods – a 50-year Retrospective. Risk Management Solutions 2003.

5. SUMMARY AND CONCLUSIONS

The economic, social and environmental importance of the European coastline has long been acknowledged, with the total value of economic assets located within 500 metres of the European coastline including beaches, agricultural land and industrial facilities estimated at Euros 500 to 1,000 billion in 2000. Flooding represents the most significant current threat to coastal communities on many parts of the European coastline, and the potential risk to human life, economic assets and the environment is increasing due to natural factors such as erosion, climate changes, etc. and anthropogenic factors such as coastal urban development, etc.

It generally appears that across Europe present levels of expenditure on coastal defences (capital and maintenance) will not keep pace with an increasing coastal and flooding problem, and that existing coastal defences could be destroyed or damaged in future events leading to a greater number of people and properties suffering from flooding as well as the destruction of valuable natural environments.

To continue with the current approach to coastal erosion and flood defence may be unacceptable for European society as a whole, especially as the balance of coastal defence costs and the associated benefits is, in general poorly addressed in Europe.

The European Union is moving forward on an action programme on FRM, and the proposal for a Directive on flood mapping and flood risk management plans is an important part of this programme.

This review of current practice clearly reveals there are different approaches to considering coastal flooding and erosion by the various MS depending inter alia on history, culture and funding levels. As a result, the levels of protection vary, funding and implementation responsibility vary, and the techniques used and information available varies.

It also appears that the level of public awareness of flooding risk and the implications of coastal defence schemes is low as evidenced by comments by the European Environmental Bureau, Worldwide Fund for Nature and Scottish Executive, and UK Environment Agency requesting funding for research into public awareness effectiveness campaigns.

Planning coastal management with all stakeholders involved in a wider geographical area has been accepted in some MS as a better option than localised development of schemes, but it is not possible to make a rigorous financial or economic case for this approach.

From both the technical and economic point of view, coastal flood protection and flooding are not purely local issues; regional, national and international factors are also present. The need for integrated planning in the coastal zone supported by economic analysis of coastal flood defence schemes is recognised by many MS and can illustrate issues such as:

- The longer the time span considered such as 50 and 100 years rather than 25 years, the greater the benefits of managed realignment become as the habitat becomes well established and the benefits of habitat creation and carbon sequestration can be considered;

- The financial basis and timing of compensation are key to ensuring acceptance of managed realignment in some areas;

- Defining common policies and strategies is a major challenge and opportunity for improved coastal flood risk management to avoid past experiences of the lack of consideration of all relevant factors that skewed appraisals in favour of investing in flood defence work rather than options working with the ecology of the area;

- In a cost-effective analysis, traditional embankment strengthening was shown to be cheaper than alternative measures that had greater ecological benefits. However including the predicted long-term ecological benefits in a multi-criteria analysis reversed this ranking, whilst extended CBA showed that the alternative flood protection measures resulted in a "welfare loss" because of their significantly higher economic costs.

There are three elements for action by the EC regarding the preparation of coastal flooding and erosion flood risk maps and management plans:

1. Do nothing;

2. Promote flood mapping;

3. Promote the preparation of flood risk management plans.

An important issue regarding Do nothing is that if individual MS acting alone fail to fully recognise the importance of coastal flood and erosion protection within a wider international context, the necessary resources to implement protection might not become available.

For Element 1, individual MS with varying levels of coastal flood risk would adopt their individual response to an increasing threat. Eurosion estimated that in 2001 public expenditure dedicated to coastline protection in Europe was of the order of Euros 3,200 million. This expenditure should be considered against the fact that the population living in European coastal municipalities has reached 70 million inhabitants in 2000. The value of the natural ecosystem function (i.e. ecosystem services benefits such as gas and climate regulation, water regulation and supply, erosion and pollution prevention) at the coast has been valued at 240 billion Euros per annum (for 15 Member States before 2004 expansion and based on 1990s data)

The cost of coastal flood mapping (Element 2) depends on what material exists already, the level of detail that is considered appropriate and how to take account of existing flood defences. Experience in England and Wales suggests that even with good map backgrounds, it will take several years to combine this in a useful way with historic or modelled flood information. With good information and using GIS systems, indicating areas of low-lying land is relatively straightforward, but confirming the actual probability of inundation is more complicated.

The closest example of a flood risk management plan is the shoreline management plan (SMP) developed in the UK. It is however not possible to put a figure on the cost of producing an SMP, partly because of the variation in complexity of the individual cells involved, partly

because of the background studies previously carried out in order to facilitate production (e.g. definition of the cells, preparation of guidance) by a number of different organisations, and partly because it is not known how the number of different stakeholders involved in the production of the SMP cost their efforts. However clearly, it is not a trivial cost and is an ongoing process.

It is reported that the resulting benefits of both Low Level (Euros 50/km of coastline – see Footnote on page 2) and High Level (Euros 250/km of coastline – see Footnote on page 2) ICZM initiatives far outweigh the costs. In terms of annual value, the net benefits of ICZM initiatives ranged from Euros 127.1 million (benefit: cost ratio of 13.6:1) to Euros 659.8 million (8.6:1) using a very conservative approach to valuing benefits, which exclude organisational and planning efficiency gains, improved resource use and greater economic and environmental sustainability of coastal communities.

Flood maps are an essential item of information for flood risk management plans which themselves may be integrated into comprehensive, integrated coastal zone management plans, however note that in England and Wales a difficulty was that the initial, indicative maps were not very accurate and did not show the effects of flood defences. A second-generation of flood maps showing the extent of some (recent) flood defences, and significant, moderate or low likelihood of flooding taking account of all flood defences has since been produced.

The option for flood risk management plans has impacts regarding development costs, implementation costs and investment required for the different aspects of a flood management plans; i.e. prevention, protection, preparedness, emergency response and recovery. It was not possible to make a rigorous financial or economic case for this approach. It is however possible to indicate some reasons for the adoption of such an approach.

Protection means taking measures, both structural and non-structural. This is the cost for flood defences, and is the same as for Element 1. Preparedness against coastal flooding and erosion involves providing flood forecasting and early warning, raising awareness of the population and competent authorities beforehand about flood hazard and risks; preparing and maintaining appropriate emergency response plans; increasing resilience (the ability to react to and recover from flooding); recommending what to do in the event of a flood.

The UK Environment Agency is reported to spend approximately Euros 3 million per year on raising awareness. In 2004, the funding provided by the UK Government to the Meteorological Office to operate the National Severe Weather Service was approximately Euros 3.0 millions. The Environment Agency submitted a new ten-year Flood Warning Investment Strategy to the Government in November 2003 at a cost of Euros 360 millions. It has been estimated that the new strategy will cost approximately Euros 25 per property per year to provide the flood warning service to 80% of properties at risk of flooding from rivers and the sea.

It is important to appraise the cost of providing coastal flooding and erosion protection measures, and the cost of studies that are needed determine the appropriate protection, in a balanced way against the benefits (which in the case of flooding are themselves averted costs) that are derived in the long term. Various techniques of economic analysis have been used to

carry out such appraisals, and substantial research done into identifying all the factors involved and methods of considering them.

It is widely recognised that protection against floods and erosion cannot be limited to protecting individual assets and determined in isolation, since experience has shown that local flood protection measures can have negative effects further down the coast. It is important to look at an integrated plan to promote flood defence measures on a zonal basis cutting across administrative boundaries.

ANNEX 1 EXAMPLES OF SHORELINE MANAGEMENT PLANS

NOTE: Embedded PDF document. These examples are available on the ACAG website at www.acag.org.uk

at Doc1

Kelling to Lowestoft Ness Shoreline Management Plan
SMP Document for consultation November 2004

at Doc1

Kelling to Lowestoft Ness Shoreline Management Plan Appendix H: Economic Appraisal and Sensitivity Testing