THESEUS
Policy-Relevant Outcomes

THESEUS - (Innovative technologies for safer European coasts in a changing climate)

Index

Participating countries/organisations

IT	**UniBo**	Alma Mater Studiorum - Università di Bologna
ES	**UC**	Universidad de Cantabria
UK	**UOP**	University of Plymouth
DK	**AAU**	Aalborg Universitet
NL	**INFRAM**	INFRAM International BV
DE	**GKSS**	GKSS - Forschungszentrum Geesthacht GMBH
UK	**SOTON**	University of Southampton
FR	**UVSQ**	Université de Versailles St-Quentin-en-Yvelines
FR	**CETMEF**	Centre d'Etudes Techniques Maritimes Et Fluviale
UK	**MU**	Middlesex University Higher Education Corporation
PL	**IMGW**	Instytut Meteorologii I Gospodarki Wodnej
BG	**IO-BAS**	Institute of Oceanology - Bulgarian Academy Of Sciences
GR	**AUEB-RC**	Athens University of Economics and Business - Research Center
NL	**NIOZ**	Nederlandse Organisatie voor Wetenschappelijk Onderzoek
IT	**CORILA**	Consorzio per la gestione del centro di coordinamento delle attivita di ricerca inerenti il sistema lagunare di Venezia
PL	**IBW PAN**	Instytut Budownicta Wodnego Polskiej Akademii Nauk
UK	**BANGOR**	Bangor University
FR	**BRGM**	Bureau de Recherches Géologiques et Minières
DE	**HPA**	Hamburg Port Authority
FR	**EID**	EID- Mediterranée
LV	**UL**	Latvijas Universitate
IT	**ISPRA**	Istituto Superiore per la Ricerca e la Protezione Ambientale
BE	**VLIZ**	Vlaams Instituut Voor De Zee Vzw
GR	**AUTH**	Aristotelio Panepistimio Thessalonikis
BE	**KU Leuven**	Katholieke Universiteit Leuven
UA	**MHI**	Marine Hydrophysical Institute - Ukrainian National Academy Of Sciences
RU	**IORAS**	P.P. Shirshov Institute of Oceanology of Russian Academy of Sciences
USA	**UD**	University of Delaware
ME	**UNAM**	Universidad Nacional Autonoma De Mexico
CH	**SKLEC**	East China Normal University ECNU
TA	**NCKU**	National Cheng Kung University

THESEUS: Innovative technologies for safer European coasts in a changing climate

Policy Relevant Outcomes

Project Summary

THESEUS project

Title: THESEUS - Innovative technologies for safer European coasts in a changing climate

Type of R&D: Large Collaborative Integrated Project

PROGRAMME: FP7 Environment (including Climate Change), ENV2009-1

Starting/Ending date of project: December 2009 – November 2013

Coordinator: Dr. Barbara Zanuttigh, University of Bologna

EC Contribution: 6'530'000 €

Web-Link: www.theseusproject.eu

Project Project Repository/Archive:
www.theseusproject.eu/resources/documents
www.theseusproject.eu/resources/open-archive

Consortium: 31 partners from 18 countries

Authors: Barbara Zanuttigh (UniBo), Jaak Monbaliu (KU Leuven), Jean-Paul Vanderlinden (UVSQ), Susan Hanson (SOTON), Robert Nicholls (SOTON), Kathrin Bohn (SOTON), Chiara Dall'Angelo (CORILA), Pierpaolo Campostrini (CORILA), Louise Firth (NUI Galway), Katrin Bohn (BANGOR), Stephen Hawkins (BANGOR), Simon Hoggart (UoP), Tjeerd Bouma (NIOZ), Jim van Belzen (NIOZ), Daphnis De Pooter (VLIZ) and Simon Claus (VLIZ).

Responding to coastal disasters and enhancing resilience to coastal erosion and flooding needs a holistic, participatory and inter-disciplinary approach where science is embedded in the social, cultural and economic context in which coastal communities live. The THESEUS project developed such a systematic approach to delivering both a low-risk coast for human use and healthy habitats for evolving coastal zones subject to multiple change factors.

Policy-wise, the THESEUS project mainly addresses the EC Flood Directive which aims to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. However by studying how local biodiversity can contribute to coastal defence systems, THESEUS also addresses the EC Habitats Directive.

In this issue THESEUS tackles articles 4, 6, 7 and 14 of the EC Flood Directive with recommendations to the development of consolidated methodologies for risk assessment with analysis of drivers and impacts of changing flood risk and uncertainties in coastal processes, and for setting up and assessment of flood risk management plans. The THESEUS project also addresses article 10 of the EC Habitats Directive by looking at how local biodiversity can be promoted or conserved in artificial coastal defence structures.

THESEUS: Innovative technologies for safer European coasts in a changing climate

SCIENCE POLICY BRIEF 1

EC Flood Directive 2007/60/EC
Preliminary Flood Risk Assessment (Article 4; Article 14)

Project THESEUS

Promotion of "healthy" coasts for both development and the natural environment, taking into consideration governance structures, natural responses to coastal processes and perceptions of flood risk.

Development of an integrated methodology for risk assessment of coastal flooding and erosion, taking into account the changing climate and integrating the best technical and adaptive capacity in coastal management in a strategic framework; including response strategies and application.

Policy focus

Contribution to consolidated methodologies for risk assessment with analysis of drivers and impacts of changing flood risk and uncertainties in coastal processes.

Purpose of this policy brief

The EC Flood Directive aims to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. This policy brief is a contribution towards Chapter 2, Article 4 of the Directive which requires Member States to carry out an initial preliminary assessment of the flood system based on existing knowledge to assess potential risks. This requires:

- The choice of a conceptual model and development of a methodology which allows assessment of risk to be undertaken
- Consideration of topography, defences, existing and potential future water sources, hydrological and geomorphological characteristics
- Consideration of the social and ecological aspects of the coastal flood system in addition to the physical characteristics above
- Collating and use of available or readily derivable information
- Consideration of the historical occurrence of floods

This brief describes how the THESEUS project has addressed these issues to achieve a more comprehensive understanding of the coastal flood system.

Key policy milestones requiring technical / scientific support:

Based on available or readily derivable information, such as records and studies on long term developments, in particular the impacts of climate change on the occurrence of floods, a preliminary flood risk assessment shall be undertaken to provide an assessment of potential risks.
Preliminary flood assessment is due by 22 December 2011 (FD Article 4.2), updated by 22 December 2018 and every 6 years thereafter (FD Article 14.1).

Relevant THESEUS outputs and key findings

THESEUS key findings are based on the activities carried out in 8 representative case study sites around Europe: Varna spit (Bulgaria), Vistula delta plain (Poland), Elbe estuary (Germany), Scheldt estuary (Belgium/Netherlands), South Devon (UK), Gironde estuary (France), Santander spit (Spain) and Po Delta coastal plain (Italy).

Climate change is expected to result in sea-level rise and more severe storms. Based on THESEUS experience in the case study sites, the policy approach to address the consequences due to these issues, is not uniform across Europe. In some cases the option for responding reactively (wait for the flood) is selected, whereas in others policies are formulated in a more proactive way, including incorporating sea-level rise in the design of the flood defences. This difference in attitude is often related to:

- uncertainty or ignorance concerning current rates of sea-level change;
- limited funds, especially prior to disasters;
- differences in planning time horizons. The longer the time horizon considered, the more relevant are change factors such as sea-level rise to design.

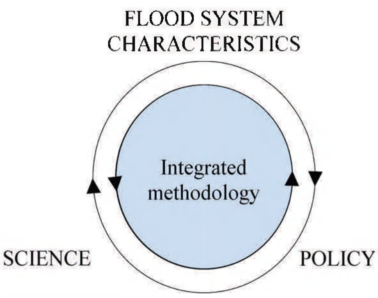

Figure 1.

Despite these differences, the development of flood risk assessments all require the consideration of the same factors. This includes consideration of the physical, social and ecological aspects of the flood system as these are strongly interlinked (see Figure 1) and can all affect the consequences of a flood event. The THESEUS project has adopted the Source-Pathway-Receptor-Consequence (SPRC) conceptual model which is capable of incorporating these influences along with the potential consequences of both climate change and engineering management techniques on the flood system.

Key findings which appeared across the sites were:

- A holistic approach taking account of physical, ecological and human factors, provides a more comprehensive understanding of flood risk including the options for mitigation. The SPRC conceptual model provides a useful basis for structuring existing knowledge and understanding into a framework which can be utilised within preliminary flood risk assessment and then management planning.
- Any assessment should start with establishing a comprehensive understanding of the current flood system in regard to flood risk management. This is particularly true when multiple agencies are involved in both decision-making and funding. The undertaking of this process helps in the development of linkages between the various institutions and clarifies the current governance structure especially where decision-making responsibilities lie.
- The existing flood policies reflect the importance of flood risk relative to other risks and flood history.
- Climate change is a relatively new factor driving concern. The way it is included in the flood policy differs essentially, ranging from neglect ("first see, then belief") to full incorporation (including the design and construction).
- The perception of risk may be different between the flood managers and those who

might be affected. This may affect future management decisions.

- Determining social vulnerability to flood risk is not a straightforward activity, as:
  - It is highly context-specific;
  - There is no single variable, which explains the vulnerability of specific social groups coherently and for all of the disaster phases;
  - Preparedness, risk awareness, capacity to receive help during the event and flood impact can all influence degrees of vulnerability.
- Mapping the existing flood system based on the coastal geomorphology, current land-use and natural habitats allows the inter-connectivity of the flood system to be determined. The effects of internal or external change on the flood system can then be assessed.
- It is widely recognised that flood risk management can be achieved by a combination of:
  - Reducing the probability of a flooding event (via soft or hard defences)
  - Reducing the impacts of flooding (via building construction for flood resilience)
  - Avoiding flooding (via focusing development outside the floodplain in planning policy)
  - Evacuation and 'preparedness' planning

In situations where the flood risk is considered dominant in the risk domain (like densily populated areas), there is a strong tendency to focus on the reduction of the probability of flooding by using coastal defences and nourishment schemes. Choosing for alternative approaches is then not widespread. In situations where the flood risk is considered as one of many risks, like Varna coast, Gironde and Exe to Sound estuaries, a more balancing approach between these flood reduction options can be observed.

A synthesis of THESEUS analysis of coastal risk assessment and mitigation solutions is published in the special issue on Coastal Engineering: "Coasts@Risks: THESEUS, a new wave in coastal protection", Elsevier, Volume 87, May 2014.

Recommendations to policy makers – Next steps

Although the variety of coastal sites along the European coast is enormous, the experience from this project indicates that the following should be recognised in order to achieve a robust preliminary assessment:

1. The societal/ecological aspects of the flood system are as important as the hydrological aspects; these should be given equal prominence in any assessment.
2. A conceptual model which incorporates the flood system and its influences as a whole should be utilised; this will allow for a wide range of management options to be considered (e.g. spatial planning, novel engineering techniques, natural habitats and processes) and allows the identification of areas where further, or more detailed, investigations are required.
3. An initial conceptual mapping of the flood system with its internal and external linkages can help promote communication and understanding of flood risk, especially when considering climate change influences.
4. Establishing flood hazard and risk maps of the current situation is essential, as these provide a benchmark against which future risk levels can be assessed.
5. To assist in short-term decision-making, long-term flood risk assessments should be prepared to identify potential impacts.
6. A network/group of all those with responsibilities in the flood prone area should be

established and regular contact maintained; it has to be clearly identified where responsibilities lie within the group; differences in flood risk understanding and perception should be determined and taken into consideration when making management decisions.

Related projects:

- MICORE (2011): www.micore.eu
- FLOODSITE (2009): www.floodsite.net

THESEUS: Innovative technologies for safer European coasts in a changing climate

SCIENCE POLICY BRIEF 2

EC Flood Directive 2007/60/EC
Flood hazard maps and flood risk maps (Article 6; Article 14)

Project THESEUS

Promotion of "healthy" coasts for both development and the natural environment by taking into consideration governance structures, natural responses to coastal processes and perceptions of flood risk.

Development of an integrated methodology for risk assessment of coastal flooding and erosion, by taking into account the changing climate and integrating the best technical and adaptive capacity in coastal management in a strategic framework; including response strategies and application.

Policy focus

Contribution to consolidated methodologies for risk assessment with analysis of drivers and impacts of changing flood risk and uncertainties in coastal processes.

Purpose of this policy brief

Floods should be mapped in terms of extent, depth/level and if relevant velocity, and indicate the impact by adverse consequences such as population, economic activity, irreversible ecological damage, release of pollutants, and other relevant factors.
The maps should consider different scenarios characterised by:

1. Low probability, i.e. extreme event scenarios;
2. Medium probability (likely return period ≥100 years);
3. High probability, where appropriate.

THESEUS project contributes to advance the methodology –at European scale- for coastal flood mapping by means of:

- Development and harmonisation of probabilistic tools for estimating hazard scenarios related to climate variability and change;
- Improvement of the knowledge of vulnerability and resilience;
- Improved assessment of the damages to infrastructure, environment and human activities; impacts on society, including change of social cohesion, livelihoods, and opportunities.

Key policy milestones requiring technical / scientific support:

Flood hazard and risk maps are due by 22 December 2013 (FD Article 6.8), updated by 22 December 2019 and every 6 years after (FD Article 14.2).

Relevant THESEUS outputs and key findings

THESEUS key findings are based on the activities carried out in 8 representative case study sites around Europe: Varna spit (Bulgaria), Vistula delta plain (Poland), Elbe estuary (Germany), Scheldt estuary (Belgium/Netherlands), South Devon (UK), Gironde estuary (France), Santander spit (Spain) and Po Delta coastal plain (Italy).

- Flood hazard and risk maps provide essential information for the planning and preparation of response to the occurrence of extreme sea levels. They are also an important part of communicating the potential effects of climate change and the uncertainties associated with these estimations.
  - Extreme sea levels causing flooding usually correspond to a joint event of storm surge and a high astronomical tide. These events also allow large waves to propagate onshore. Rising sea levels will raise these extreme water levels and often increase extreme near-shore wave heights.
  - Land subsidence can be an important contributor to relative sea-level rise. This is generally a slow but certain process. In areas with (deep) groundwater and/or methane abstraction and/or extensive land drainage it warrants detailed attention. Next to the consequences for flood vulnerability, problems with salt (ground)water intrusion may increase in the coastal areas.
  - The size of the area vulnerable to flooding for a given event can be estimated by a variety of methods, ranging from bath-tub analyses which just consider contours, to a range of hydrodynamic models that consider the defence failure and water flow. Hydrodynamic models are more computational expensive but the results are more realistic. The bath-tub models are simple, however less accurate, and might underestimate the growing problems due to sea-level rise and climate change around Europe’s coasts.
- Linking flood area to consequences in terms of population, economic activity, etc. is greatly facilitated by modern spatial analysis tools and the often used chain ‘map of flooded area – map of flooded people/habitats/facilities, etc. – estimate of consequences’ appears straightforward. However, this may lead to inconsistent results, especially when dealing with highly dynamic and long-term conditions, and may also not capture the more intangible social and environmental consequences of flooding.
- Mapping social, economic, environmental vulnerability and resilience requires the identification of a set of indicators which fully represent the physical flood system and important consequences.
- Habitat mapping should always be included in flood risk assessments. Determining existing species, abundance, communities and botanical associations provides a baseline to establish habitat extents and conservation status. These parameters can then be used to identify habitat resilience, especially in relation to flood duration, and therefore their potential role in flood risk management.
- How to calculate the habitat value is actually a conditional concept, especially when discussing rare or threatened species. In certain cases, for example commercial species, this value may be calculated using the species market prices. For non-commercial species it is far more difficult to reach an acceptable value setting. In this regard, the value that habitats, ecosystems and ecosystem services represent can being assessed using the concept of natural capital.

A synthesis of THESEUS analysis of coastal risk assessment and mitigation solutions is published in the special issue on Coastal Engineering: “Coasts@Risks: THESEUS, a new wave in coastal protection”, Elsevier, Volume 87, May 2014.

Limitations

- Determination of parameters which are relevant for social and economic consequences in flood risk assessment is problematic. These are often inter-dependent or may not be able to capture universal impacts due to a variety of reasons
- Analyses of present and future climate conditions for specific sites are best achieved by a set of common (Europe-wide) analysis complemented by site specific analyses accounting for the specific conditions and needs at the various study site.
- In the short term (2020s and 2050s), mean sea levels to be used at local (i.e. high resolution) spatial scale can be extrapolated from historical data. Over longer time periods (2080s and longer) use of the IPCC scenarios is more applicable.
- Hydrodynamic models can be applied at local scale, providing detailed and accurate information about flooding depth and velocities; at regional/national scale, simplified models are needed. These large scale models generally map floods based on storm surge level only, without considering finite overtopping volumes, run-up and beach reshaping during storms.

Experiences gained/ Recommendations to policy makers – Next steps

The results from this project indicate that the following steps should be followed in order to obtain flood hazard and risk maps:

1. The inclusion of social and ecological aspects into flood mapping and the determination of consequences is essential in the understanding of flood risk including the options for mitigation. It is particularly relevant where development activities are proposed in flood prone areas where laws, spatial plans and building regulations can all help reducing the impacts.
2. Addressing and explaining the uncertainties associated with flood mapping is important, particularly among those making, and those affected by, any decisions. This includes explaining the:
   a. probabilities of flood events: errors may occur e.g. through the extrapolation of short time series flood discharges;
   b. inundation area and depth: imprecision e.g. due to generalised digital terrain models or because of difficulties in estimating failure probabilities of flood defences;
   c. type and location of elements at risk: inaccuracies e.g. because of generalisations in spatial resolution and categorisation of land use data;
   d. value of elements at risk: values are often approximations or have to be disaggregated or have to cope with non-marketable elements such as valuable habitats or life;
   e. susceptibility of elements at risk: damage functions are often derived from poor empirical data.
3. Probabilistic approaches are a good method for presenting hazard/risk in an understandable way. Considering a full range of future scenarios also allows uncertainty in both the projection of climate conditions and modelling techniques to be addressed.

4. Flood risk strategies need to be developed over the long term to include factors such as climate change, especially sea-level rise and rising coastal development; financial and management commitment to selected strategies is required beyond typical decision timescales e.g. political.

Related projects

- Programme PROVIA / Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (joint initiative of UNEP, WMO and UNESCO)
- CLIMSAVE, www.climsave.eu/
- PREPARED Enabling Change, www.prepared-fp7.eu
- CIRCE www.circeproject.eu
- MICORE (2011) www.micore.eu
- FLOODsite (2009) www.floodsite.net.
- RESPONSE (2009) www.coastalwight.gov.uk/response

THESEUS: Innovative technologies for safer European coasts in a changing climate

SCIENCE POLICY BRIEF 3

EC Flood Directive 2007/60/EC
Flood risk management plans-preparedness (Article 7; Article 14)

Project THESEUS

Promotion of "healthy" coasts for both development and the protection of natural environment, taking into consideration governance structures, natural responses to coastal processes and perceptions of flood risk.
Development of an integrated methodology for risk assessment of coastal flooding and erosion, taking into account the changing climate and integrating the best technical and adaptive capacities in coastal management in a strategic framework, including response strategies and applications.

Policy focus

This policy focus is on setting up and assessing flood risk management plans for preparedness.

Background to this policy brief

EC communication COM(2004) 472 defines *preparedness* as 'Informing the population about flood risks and what to do in the event of a Flood while UNISDR defines it as 'The knowledge and capacities developed by governments, professional response and recovery organizations, communities and individuals to effectively anticipate, respond to, and recover from, the impacts of likely, imminent or current hazard events or conditions. (UNISDR 2009 TERMINOLOGY (http://www.unisdr.org/we/inform/terminology))
Preparedness action is carried out within the context of disaster risk management and aims to build the capacities needed to efficiently manage all types of emergencies and achieve orderly transitions from response through to sustained recovery. Preparedness is based on a sound analysis of disaster risks and good linkages with early warning systems, and includes such activities as contingency planning, stockpiling of equipment and supplies, the development of arrangements for coordination, evacuation and public information, and associated training and field exercises. These must be supported by formal institutional, legal and budgetary capacities. The related term "readiness" describes the ability to quickly and appropriately respond when required.

Key policy milestones requiring technical / scientific support:

Flood risk management plans are due by 22 December 2015 (FD Article 7(5)), updated by 22 December 2021 and every 6 years after (FD Article 14(3)).

Directive 2007/60/EC on the assessment and management of flood risks applies to inland waters as well as all coastal waters across the whole territory of the EU.
This policy brief is a contribution related to Chapter 4, Article 7 of the Directive which requires Member States to establish for coastal areas at risk of flooding a flood risk management plans

by 2015.

Flood risk management plans "shall address all aspects of flood risk management focusing on prevention, protection, preparedness, including flood forecasts and early warning systems and taking into account the characteristics of the particular river basin or sub-basin. Flood risk management plans may also include the promotion of sustainable land use practices, improvement of water retention as well as the controlled flooding of certain areas in the case of a flood event" (Art.7 (3)).

Flood risk management plans must be coordinated with the Water Framework Directive 2000/60/EC, particularly as regards the characterisation of river basins, river basin management plans, public consultation and information procedures.

Relevant THESEUS outputs and key findings

THESEUS activities are carried out in 8 representative case study sites around Europe: Santander spit (Atlantic Ocean, Santander, ES); Gironde estuary (Bordeaux, FR); Plymouth Sound to Exe Estuary, (English channel, Plymouth - Teignmouth - Exeter,UK); Scheldt estuary (Antwerp, NL-BE); Elbe estuary (North Sea, Hamburg, DE); Po delta plain and adjoining coast (Ravenna, Mediterranean Sea, IT); Vistula flood plain (Baltic Sea, Gdànsk, PL); Varna spit (Black Sea, BG).

The different study sites are characterized by a variety of environments (estuary, delta, coastal lagoon, protected or unprotected beach), by different wave climate conditions and sea level rise expectations (Atlantic Ocean, North Sea, English channel, Baltic Sea, Mediterranean Sea, Black Sea) and by different social and economic conditions (urbanised and industrial areas). In this way stakeholders can use for coastal management the results obtained in the study sites with similar characteristics to their coastal areas.

THESEUS contributes in PREPARDNESS aspects by looking at

- Hazard scenarios
- Forecast
- Early Warning system
- Evacuation plans

It will never be possible neither to totally avoid the expansion of human activities on territories under risk nor to prevent a risk event from occurring. Thus the only remaining option is to help human societies and economic systems to be better prepared for the event. In this project, an evacuation is defined as the "organisation of the movements of a large part of the population to a safe place prior to the occurrence of a natural disaster, with the aim of bringing the highest proportion of it to a safe location in a constraint time frame".

THESEUS propose a methodology that can be applied to prepare an evacuation plan, a book that can be used by decision makers at local levels who are responsible for ensuring the safety of their district, city or region. In this project the focus is given to flood events on coastal zone but the methodology is as generic as possible so it can be applied to other kinds of natural events and in different countries:

- one first has to make sure a certain amount of data regarding the description of the territory and its inhabitants is available
- the authorities should be able to esimate the probability of occurrence of a disaster in the near future based on forecasts of physical parameters.
- when forecast parameters have been identified, one can establish hazard scenarios
- from the sets of discrete parameters established for each hazard scenario, one then has to produce hazard maps describing how the disaster will occur in the city.

- by intersecting the hazard maps with the buildings usage maps, one should then get a map of the priority evacuation sectors.
- for each transportation network that may be used by evacuation vehicles and every hazard scenarios, the evacuation planner should draw a map of the exposed part by crossing the map of the network with the hazard map for the given scenario. At this stage, we identify areas to evacuate and places where people will seek shelters.
- describe the potential resources that can be summoned to facilitate the evacuation process: human resources, material resources, shelters, transportation means, actions levers that will speed up one of the stages of the process.
- from all data gathered in the previous parts, the planner defines the overall strategy of evacuation

A synthesis of THESEUS analysis of coastal risk assessment mitigation solutions is published in the special issue on Coastal Engineering: "Coasts@Risks: THESEUS, a new wave in coastal protection", Elsevier, Volume 87, May 2014.

Recommendations to policy makers

1. Information, education and involvement are the basic elements for the adoption of any non--structural mitigation measures: without them warning will lose their effectiveness.
2. Public food risk communication has to give an opportunity for non formal learning.
3. Many ways of disseminating alerts exist and are currently used but to reach as many people as possible an integration of traditional dissemination methods and new technologies is recommended.
4. It is important to adopt a careful and responsible way of transmitting messages specifying the character of risk, locations and time of the impact.

THESEUS: Innovative technologies for safer European coasts in a changing climate

SCIENCE POLICY BRIEF 4

EC Flood Directive 2007/60/EC
Flood risk management plans-prevention (Article 7; Article 14)

Project THESEUS

Promotion of "healthy" coasts for both development and the protection of natural environment, taking into consideration governance structures, natural responses to coastal processes and perceptions of flood risk.

Policy focus

Set up and assessment of flood risk management plans for prevention.

Purpose of this policy brief

EC communication COM(2004) 472 final defines *prevention* as 'preventing damage caused by floods by avoiding construction of houses and industries in present and future flood-prone areas; by adapting future developments to the risk of flooding; and by promoting appropriate land-use, agricultural and forestry practices' while UNISDR defines it as 'the outright avoidance of adverse impacts of hazards and related disaster' .
Disaster prevention expresses the concept and intention to completely avoid potential adverse impacts through action taken in advance. Examples include dams or embankments that eliminate flood risks, land-use regulations that do not permit any settlement in high risk zones. Very often the complete avoidance of losses is not feasible and the task transforms to that of mitigation. Partly for this reason, the terms prevention and mitigation are sometimes used interchangeably in casual use.

The related term *resilience* refers to the 'ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions.'
Resilience means the ability to "resile from" or "spring back from" a shock. The resilience of a community in respect to potential hazard events is determined by the degree to which the community has the necessary resources and is capable of organizing itself both prior to and during times of need.

This brief describes how the THESEUS project has addressed these issues to develop and integrate new measures for a more comprehensive management of the coastal flood system.

Key policy milestones requiring technical / scientific support:

Flood risk management plans are due by 22 December 2015 (FD Article 7(5)), updated by 22 December 2021 and every 6 years after (FD Article 14(3)).

Directive 2007/60/EC on the assessment and management of flood risks applies to inland waters as well as all coastal waters across the whole territory of the EU.
This policy brief is a contribution related to Chapter 4, Article 7 of the Directive which requires Member States to establish for coastal areas at risk of flooding a flood risk management plans (FRMP) by 2015.
Flood risk management plans "shall address all aspects of flood risk management focusing on prevention, protection, preparedness, including flood forecasts and early warning systems and taking into account the characteristics of the particular river basin or sub-basin. Flood risk management plans may also include the promotion of sustainable land use practices, improvement of water retention as well as the controlled flooding of certain areas in the case of a flood event" (Art.7 (3)).
Flood risk management plans must be coordinated with the Water Framework Directive 2000/60/EC, particularly as regards the characterisation of river basins, river basin management plans, public consultation and information procedures.

Relevant THESEUS outputs and key findings

THESEUS activities are carried out in 8 representative case study sites around Europe: Santander spit (Atlantic Ocean, Santander, ES); Gironde estuary (Bordeaux, FR); Plymouth Sound to Exe Estuary, (English channel, Plymouth - Teignmouth - Exeter,UK); Scheldt estuary (Antwerp, NL-BE); Elbe estuary (North Sea, Hamburg, DE); Po delta plain and adjoining coast (Ravenna, Mediterranean Sea, IT); Vistula flood plain (Baltic Sea, Gdànsk, PL); Varna spit (Black Sea, BG).
The different study sites are characterized by a variety of environments (estuary, delta, coastal lagoon, protected or unprotected beach), by different wave climate conditions and sea level rise expectations (Atlantic Ocean, North Sea, English channel, Baltic Sea, Mediterranean Sea, Black Sea) and by different social and economic conditions (urbanised and industrial areas). In this way stakeholders can use for coastal management the results obtained in the study sites with similar characteristics to their coastal areas.

THESEUS contributes in PREVENTION and RESILIENCE aspects:

- Development of a participatory approach for coastal management
- Advancement of engineering solutions for coastal protection
- Preservation and enhancement of coastal ecosystems
- Analysis of risk perception for people centred based management and risk communication
- Spatial planning and better governance.

Existing Coastal Management and policies: The current coastal defence policy, management and planning strategy and durability of strategies has been assessed in every study site by means of a questionnaire proposed to national and local decision makers and managerial authorities. An inventory of coastal policies and an estimate of their sustainability have been realized.

In all sites, various institutions at different administration levels (state, regional, local) play a role in the management of the coastal zone. Their responsibility could be both in setting new rules, preparing new plans or enforcing existing rules.
The survey showed the importance of building relationships between all those individuals and organisations involved in managing the coastal zone; where these relationships are well

established responsibilities are clearly assigned; for other sites the overlapping of responsibility of many institutions leads to some confusion of roles and an “integrated management”, in line with the Flood Directive, seems more difficult to achieve.

Technical and ecological innovation: THESEUS has advanced the knowledge and proposed innovative technologies to protect and reduce the impact of hazards: wave energy converters, artificial reefs, floating breakwaters, overtopping resistant dikes and levees, rubble mound breakwater, beach and foreshore nourishments, sand dunes, mud flats and mud banks. THESEUS has also explored and embraced ecological mitigation option such as use of sea-grasses, salt marshes and biogenic reefs (http://www.theseusproject.eu/resources/documents/Deliverables/).

Risk perception: Defining “risk” may be a quite controversial issue. THESEUS developed not only a common language on risk, but also a deeper understanding of the perception of risk that may be different between flood managers and those who might be affected by floods. This difference is important and may influence future management decisions and has the potential to raise questions about their legitimacy and effectiveness among the wider public. We assumed the general definition *Risk=probability x consequences*: therefore, it is of paramount importance to convey the probabilistic nature of flooding to those potentially affected.
For Gironde, Santander and Adriatic coast interviews and focus group where conducted and results have been compared to two more corpuses, collected in Varna and Gdansk and thereafter validated.
Key results indicate that:

- Quite coherently across interviews participants associate risk with the modified state of the receptor or the consequences of flooding and erosion.
- For a flood manager, risk means expected annual damage.
- Very seldom do participant mention the probabilistic nature of flooding and erosion risk.
- In all study sites, respondents clearly state that priorities should be given first to risk of human losses, second to losses in dwellings, and third to losses in economic activity.
- Normatively it was clearly expressed that the only acceptable option is an option were the cost is born collectively even if the asset protected benefit to a minority.
- Stakeholders in order to perceive risk, rely on their personal heuristics that lead them to a mistrust on science based approaches.

Risk communication is a key feature in risk mitigation and crosses all phases of risk governance from pre-assessment over decision making to implementation and management.
A range of signals and communication media, modern alongside low tech ones, can and should be used in order to reach all. A participatory approach involving all is needed for effectiveness. Communication is crucial for survival in case of disaster.

Spatial planning acts at the receptor and consequences end rather than at the source. Spatial planning has the potential to reduce future impacts by controlling the value of potentially flooded areas and can be used to influence where critical services such as water, electricity, evacuation routes, hospital and other emergency services are to be located.

A synthesis of THESEUS analysis of coastal risk assessment and mitigation solutions is published in the special issue on Coastal Engineering: "Coasts@Risks: THESEUS, a new wave in coastal protection", Elsevier, Volume 87, May 2014.

Recommendations to policy makers - Next steps

1. Technical innovation for coastal flood risk management also depends on **social innovation**:
   a. Coordination: good coordination and linking between institutions, organisations, or communities involved in managing the coastal zone is fundamental.
   b. Participation: Involve stakeholders, land use planners and policy makers) to set specific and common goals of risk reduction. A participatory processes
   c. Appreciation: Establish links also with those potentially affected by flooding and keep them engaged /aware of the process in decision-making. This has the advantage of appreciating what is important to those 'on the ground' and building an appreciation of the flood system and the steps required to manage it.
   d. Legitimacy: to successfully implement risk management strategies that are good collectively but can harm individual interests, a high level of legitimacy is needed.

2. **Science** is important
   a. Promote knowledge generation and new technologies as a process that is integral to the communities' individual and collective experience.
   b. Involve scientific institutions (Universities, research centers) located in the territory actively in the construction, and monitoring stage of the Flood Risk Management Plan.

3. **Risk perception** should not be underestimated
   a. Study and understand flooding and erosion risk are conceived.
   b. Understand how local perception of risks is fed by sound knowledge.
   c. Use results of risk perception studies to manage risk in technological, governance and political terms.
   d. Promote convergence between stakeholders' perception and the scientific basis.

4. **Risk communication** is important:
   a. Use knowledge, innovation and education to **build and promote a culture of safety and resilience** at all levels.
   b. Promote the use of new technologies and mechanisms to share information among scientific communities, practitioners, experts, managers, planners and the public at large.
   c. Dare to rethink, redesign and adapt existing coastal systems, including their governance frameworks, to make them more resilient to coastal crises.
   d. Extend resilience ideas beyond the limits of recovering from shock.

4. **Spatial planning** has great potential:
   a. reduce future impacts through controlling the type and extent of property built in flood or erosion risk areas.
   b. Increase resilience by innovative spatial planning

THESEUS: Innovative technologies for safer European coasts in a changing climate

SCIENCE POLICY BRIEF 5

EC Flood Directive 2007/60/EC
Flood risk management plans-protection (Article 7; Article 14)

Project THESEUS

Development of an integrated methodology for risk assessment of coastal flooding and erosion, taking into account the changing climate and integrating the best technical and adaptive capacities in coastal management in a strategic framework, including response strategies and applications.

Policy focus

Set up and assessment of flood risk management plans for protection.

Purpose of this policy brief

Sustainable development is defined as a pattern of resource use that aims to meet human needs while preserving the environment so that these needs can be met not only in the present, but also for future generations. The concept implies the consideration of spatial and temporal dimensions, system components (i.e. economic, social and environmental aspects), and the interactions between these components. Development is a dynamic process and a function of its dimensions and components, while sustainability is complex and adaptive and can be achieved via innumerable paths, yielding contrasting results for system components.

Decision making is also a dynamic process and is carried out at different levels of society, considering cultural, social, economic, institutional, political, and environmental differences. This process requires the design of a strategy, the definition of policies, and the implementation of actions.

Thus, key to successful coastal flood management is to use mitigation techniques that are appropriate for the local circumstances. This is best achieved if all alternatives are reviewed to identify the most efficient individual or suite of options for consideration by stakeholders and decision makers.

Key policy milestones requiring technical / scientific support:

Flood risk management plans are due by 22 December 2015 (FD Article 7(5)), updated by 22 December 2021 and every 6 years after (FD Article 14(3)).

Directive 2007/60/EC on the assessment and management of flood risks applies to inland waters as well as all coastal waters across the whole territory of the EU.

This policy brief is a contribution related to Chapter 4, Article 7 of the Directive which requires Member States to establish flood risk management plans for coastal areas at risk of flooding, by 2015.

Flood risk management plans *"shall address all aspects of flood risk management focusing on prevention,* ***protection****, preparedness, including flood forecasts and early warning systems and*

taking into account the characteristics of the particular river basin or sub-basin. Flood risk management plans may also include the promotion of sustainable land use practices, improvement of water retention as well as the controlled flooding of certain areas in the case of a flood event" (Art.7 (3)).
Flood risk management plans must be coordinated with the Water Framework Directive 2000/60/EC, particularly as regards the characterisation of river basins, river basin management plans, public consultation and information procedures.

Relevant THESEUS outputs and key findings

THESEUS activities are carried out in 8 representative case study sites around Europe: Santander spit (Atlantic Ocean, Santander, ES); Gironde estuary (Bordeaux, FR); Plymouth Sound to Exe Estuary, (English channel, Plymouth - Teignmouth - Exeter,UK); Scheldt estuary (Antwerp, NL-BE); Elbe estuary (North Sea, Hamburg, DE); Po delta plain and adjoining coast (Ravenna, Mediterranean Sea, IT); Vistula flood plain (Baltic Sea, Gdànsk, PL); Varna spit (Black Sea, BG).
The different study sites are characterized by a variety of environments (estuary, delta, coastal lagoon, protected or unprotected beach), by different wave climate conditions and sea level rise expectations (Atlantic Ocean, North Sea, English channel, Baltic Sea, Mediterranean Sea, Black Sea) and by different social and economic conditions (urbanised and industrial areas). In this way stakeholders can use for coastal management the results obtained in the study sites with similar characteristics to their coastal areas.

THESEUS proposes innovative methods for *protection* against and *mitigation* of erosion and sea-flood hazard and examines the application of innovative technologies that integrate the best techniques for coastal engineering, environmental and socio-economic aspects. THESEUS contributes through technical and social innovation and has developed a software tool and guidelines, to be used by stakeholders and decision makers, for the setting up of Flood Risk Management Plans in coastal zones. Eco-system services and effects of climate change are explicitly incorporated. Examples taken from the project's case studies illustrate the applicability.

Procedure and guidelines for planning coastal management strategies: THESEUS provides a verified procedure for coastal risk assessment and mitigation by means of engineering, ecological and socio-economic mitigation options.
Once mitigation options have been identified based on the site specificity and its constraints, their efficiency, equity and sustainability must be assessed. If and how these options could or should be incorporated in new long term policy and planning should also be assessed. This procedure requires relevant stakeholders and end users to be involved in the identification and assessment process.

THESEUS guidelines explain how to apply the procedure to real cases. The guidelines identify and describe coastal risk assessment, measures for risk mitigation and the methods for assessing their effectiveness. The developed methodologies and the portfolio of mitigation options are applied to case studies and overall conclusions and recommendations are drawn to allow the reader exportability of the results.
While a detailed report is open access available through the project website the guidelines are presently under publication by Elsevier and will be available by end of 2014.

Decision Support System (DSS) software tool: THESEUS also developed a software tool designed for application over tens of kilometers of coast using a GIS platform and provided of a Graphical User Interface (GUI).

- The software tool guides the user through the Risk Assessment process. The user can choose between different build in or incorporate his own climate scenario's, technological or ecological mitigation options and societal adaptations strategies and obtain an evaluation of impacts and consequences.
- THESEUS-DSS has been defined as a scoping tool to assess risk conditions and consequences of mitigation options against flooding and erosion at a given coastal site.
- The DSS supports decision-making to resolve ambiguity regarding the choice of the combination of intervention measures from an available portfolio. The exploratory tool allows the users to perform an integrated coastal risk assessment, to analyse the effects of different combinations of engineering, social, economic and ecologically based mitigation options, across short (2020s), medium (2050s) and long term (2080s) scenarios, taking into account physical and non-physical drivers, such as climate change, subsidence, population and economic growth.
- The software fundamentals aim at exportability in different sites but include a site-dependent component since the software should be based on high spatial resolution information on wave climate, habitats, society and mitigation options which will vary depending on the site.
- The main foundation of this DSS is that it has to be "Open and Parametric", not only in terms of source code and technology but, first of all, in terms of usability. It is also an "Interactive" tool so that users can verify a lot of combination of scenarios and while testing the scenarios be trained to a fully interdisciplinary risk assessment in the area and to the selection of the best solution or combination of solutions for risk mitigation. In the DSS actually the term "best" solution means "sustainable", i.e. protecting the coast while preserving its socio-economic development and the integrity of the ecosystem services.
- The DSS was calibrated in Cesenatico, in the Gironde Estuary, in the Teign estuary and in Santander Bay, therefore in 4 of the 8 sites examined within THESEUS.
- An English manual detailing the software architecture, functions and methodology was also prepared. Software and manual (OD5.6) are available through THESEUS website (http://www.theseusproject.eu/dss).

A synthesis of THESEUS analysis of coastal risk assessment and mitigation solutions is published in the special issue on Coastal Engineering: "Coasts@Risks: THESEUS, a new wave in coastal protection", Elsevier, Volume 87, May 2014.

Experiences gained/ Recommendations to policy makers – Next steps

- Consider environmental, social and economic issues when addressing coastal flooding problems. Technical solutions alone are not the answer to coastal flooding problems.
- Non-structural mitigation options reduce the risk by decreasing the consequences of flooding.
- Integrate a combination of the best technical measures and non-structural mitigation actions in a strategic policy context. Together they have the potential to transcend the sum of their individual contributions.
- Use a verified procedure to draft flood risk management plans.

- GIS based Decision Support System facilitates the discussion between stakeholders and is of great value in the risk assessment process.

THESEUS: Innovative technologies for safer European coasts in a changing climate

SCIENCE POLICY BRIEF 6

EC Habitats Directive 92/43/EEC
Improving ecological coherence in land use planning & development strategies (Article 10)
with relevance to the Convention on Biological Diversity (CBD) and the Marine Strategy Framework Directive (MSFD)

Project THESEUS

Promotion of "healthy" coasts for both development and the protection of natural environment, taking into consideration governance structures, natural responses to coastal processes and perceptions of flood risk.

Development of an integrated methodology for risk assessment of coastal flooding and erosion, taking into account the changing climate and integrating the best technical and adaptive capacities in coastal management in a strategic framework, including response strategies and applications.

Policy focus

Contribution to novel engineering technologies for ecological enhancement to the artificial environment and conservation of local biodiversity.

Purpose of this policy brief

Promotion of enhancement and conservation of local biodiversity on artificial coastal defence structures.

It supports EC Habitats Directive 92/43/EEC (Article 10) where '*Member states shall endeavour, where they consider it necessary, in their land-use planning and development policies and, in particular, with a view to improving the ecological coherence of the Natura 2000 network, to encourage the management of features of the landscape which are of major importance for wild fauna and flora.*'

Relevant THESEUS outputs and key findings

THESEUS activities were carried out in 8 representative case study sites around Europe: Santander spit (Atlantic Ocean, Santander, ES); Gironde estuary (Bordeaux, FR); Plymouth Sound to Exe Estuary, (English channel, Plymouth - Teignmouth - Exeter,UK); Scheldt estuary (Antwerp, NL-BE); Elbe estuary (North Sea, Hamburg, DE); Po delta plain and adjoining coast (Ravenna, Mediterranean Sea, IT); Vistula flood plain (Baltic Sea, Gdànsk, PL); Varna spit (Black Sea, BG).

The different study sites are characterized by a variety of environments (estuary, delta, coastal lagoon, protected or unprotected beach), by different wave climate and tidal range conditions and sea level rise expectations (Atlantic Ocean, North Sea, English channel, Baltic Sea, Mediterranean Sea, Black Sea) and by different social and economic conditions (urbanised and industrial areas). In this way stakeholders can use the results obtained for coastal management in the study sites with similar characteristics to their own local coastal areas.
In response to rising and stormier seas, artificial coastal defence structures are proliferating at the expense of natural habitats. Ecological engineering is a relatively new concept which integrates ecological, economic and social needs into the design of man-made ecosystems. The creation of novel habitats can have a positive effect on biodiversity on artificial coastal defence structures.
The THESEUS project contributes to advance the field of ecological engineering by:

- Assessing the importance of increasing habitat heterogeneity (water retaining features, pits & crevices) on biodiversity in both natural and artificial habitats
- Testing the effect of the addition of water retaining features (“rockpools”) to coastal defences on local biodiversity at the design and post built stages
- Enhancing collaboration between engineers, ecologists and coastal managers to implement novel engineering techniques for habitat enhancement on coastal defence structures. This led to the design a generic precast habitat enhancement unit that can be fitted to any rock armour coastal defence structure, either during the construction phase or retrospectively. A prototype precast habitat enhancement unit that has been deployed in a coastal defence scheme in North Wales, UK
- Working with nature by managing natural habitats such as saltmarches and sand dunes to stabilize and protect coasts.
- Reducing the positive role shallow water habitats can play in reducing wave and flood impacts

A synthesis of THESEUS analysis of coastal risk assessment mitigation solutions is published in the special issue on Coastal Engineering: “Coasts@Risks: THESEUS, a new wave in coastal protection”, Elsevier, Volume 87, May 2014.

Recommendations to policy makers

- Ecosystem services are an important economic good and should be incorporated in the risk analysis.
- Natural coastal defence systems like biogenic reefs, sea-grasses meadows, saltmarshes and sand dunes can recover after storm damage. Resilience is an inherent property and should be valued appropriately.
- Sustainable management of coastal ecosystems is needed to preserve its potential as defence system.
- Natural coastal defence systems often have the ability to keep pace with sea level rise by trapping and stabilizing sediment.
- Ecological considerations translated into relatively small changes and low coast in the engineering design of hard coastal defence structures can give a substantial boost for biodiversity. Such interventions do not compromise the efficacy of the defences.
- Establish the dialogue between all parties involved: ecologists, engineers and the stakeholders. The combination of the best technical and ecological measures and non-structural mitigation actions in a strategic policy context, has the potential to transcend the sum of their individual contributions.

References

Project Open Archive: http://www.theseusproject.eu/resources/open-archive

Borsje, B.W., van Wesenbeeck, B.K., Dekker, F., Paalvast, P., Bouma, T.J., van Katwijk, M.M. & de Vries, M.B. (2011). How ecological engineering can serve in coastal protection. Ecological Engineering 37, 113-122.

de Vries, W.S.; Zanuttigh, B.; Steendam, G.J.; Kloosterboer, H.; van der Nat, A.; Graaff, H. (2011). Integrating science and policy for creating tools for safer European coasts in a changing climate. Paper presentation at the 25th ICID European Regional Conference, May 16-20, 2011, Groningen, the Netherlands. INFRAM: Marknesse. 9 pp., details

Firth, L.B.; Thompson, R.C.; White, F.J.; Schofield, M.; Skov, M.W.; Hoggart, S.P.G.; Jackson, J.; Knights, A.M.; Hawkins, S.J. (2013). The importance of water-retaining features for biodiversity on artificial intertidal coastal defence structures. Diversity Distrib. Online First.

Firth, B.; Hawkins, S.J. (2011). Introductory comments - Global change in marine ecosystems: Patterns, processes and interactions with regional and local scale impacts J. Exp. Mar. Biol. Ecol. 400(1-2): 1-6, details

Koundouri, P.; Rulleau, B.; Stithou, M. (2011). Can coastal Europe insure against climate change: A review of experiences on floods and soil erosion Geophys. Res. Abstr. 13(12548), details

Le Cozannet, G.; Lecacheux, S.; Delvallee, E.; Desramaut, N.; Oliveros, C.; Pedreros, R. (2011). Teleconnection pattern influence on sea-wave climate in the Bay of Biscay J. Clim. 24(3): 641 -652

Martins, G.M., Thompson, R.C., Neto, A.I., Hawkins, S.J. & Jenkins, S.R. (2010). Enhancing stocks of the exploited limpet Patella candei d'Orbigny via modifications in coastal engineering. Biological Conservation 143, 203-211.

Mendez, F.J.; Losada, I.J.; Castanedo, S.; Minguez, R.; Medina, R.; Reguero, B.G.; Izaguirre, C. (2011). Present and future coastal risk assessment Geophys. Res. Abstr. 13(13680), European Geosciences Union General Assembly 2011 Vienna, Austria

Menendez, M.; Mendez, F.J.; Losada, I.J. (2011). Short-term extrapolation of extreme sea level statistical distributions Geophys. Res. Abstr. 13(13683), European Geosciences Union General Assembly 2011 Vienna, Austria

Narayan, S.; Hanson, S.; Nicholls, R.; Clarke, D. (2011). Use of the Source - Pathway - Receptor - Consequence Model in coastal flood risk assessment Geophys. Res. Abstr. 13(10394), European Geosciences Union General Assembly 2011 Vienna, Austria

Ntegeka, V.; Willems, P.; Monbaliu, J. (2011). Incorporating the correlation between upstream inland, downstream coastal and surface boundary conditions into climate scenarios for flood impact analysis along the river Scheldt Geophys. Res. Abstr. 13(6554), European Geosciences Union General Assembly 2011 Vienna, Austria

Witt, M.J., Sheehan, E.V., Bearhop, S., Broderick, A.C., Conley, D.C., Cotterell, S.P., Crow, E., Grecian, W.J., Halsband, C., Hodgson, D.J., Hosegood, P., Inger, R., Miller, P.I., Sims, D.W., Thompson, R.C., Vanstaen, K., Votier, S.C., Attrill, M.J. & Godley, B.J. (2012). Assessing wave energy effects on biodiversity: the Wave Hub experience. Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences 370, 502-529.

Zanuttigh, B.; Perini, L.; Mazzoli, P. (2011). Scenarios of combined river and sea water inundation along the Adriatic Coast. Geophys. Res. Abstr. 13(1694), European Geosciences Union General Assembly 2011 Vienna, Austria

Zanuttigh, B. (2011). Coastal flood protection: What perspective in a changing climate? The THESEUS approach Environ. Sci. Policy 14(7): 845-863.

Project Repository: http://www.theseusproject.eu/resources/documents

OD1.7: Report on consolidated methodologies for the assessment of coastal vulnerability and resilience to erosion and floods

OD1.10: Report on quantified scenarios analysis of drivers and impacts of changing flood risk

OD1.15: Integrated report on risk assessment in study sites: present and future scenarios; analysis of drivers and impacts of changing flood risk; uncertainties in coastal processes through monitoring systems; early warning tools

OD2.1: Integrated inventory of data and prototype experience on coastal defences and technologies

OD3.10: Integrated report on contrasting ecological outcomes of alternative management strategies. In particular this will consider i) management of natural habitats that offer coastal protection, ii) ecological design of hard coastal defences and iii) managed retreat.

OD4.1: General framing document for the development of a coherent portfolio of risk management approaches.

OD4.8: Structured portfolio of tested operational innovative tools and protocols for policy and management purposes of coastal flooding risks.

OD5.5: Identification, impact and selection of mitigation options in study sites with implication for policies and regulations

OD5.6: THESEUS Decision Support System User Manual