



# COASTAL FLOODING

ARE WE  
AT RISK?



# THESEUS

## INNOVATIVE TECHNOLOGIES FOR SAFER EUROPEAN COASTS IN A CHANGING CLIMATE

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<http://www.theseusproject.eu>



▼ Cap Blanc Nez. Photo: Karl Van Ginderdeuren

▼ Storm surges in France Nice, 4 May 2010. Photo: AFP



# INTRODUCING THESEUS

Our coasts are increasingly being put at risk of flooding and erosion due to trends in sea level rise caused by climate change. One of the key challenges facing us is to find a means with which to protect our coastal environments and safeguard their various assets.

Until recently, coastal defence against flooding and the related protection against erosion was carried out on a local scale. There is now a changing attitude to this both globally and particularly in parts of Europe. Whilst it is impractical to achieve complete protection, appropriate measures can be taken to minimize adverse impacts on human health, economic activity, environment and cultural heritage.

With this aim, the European Commission has launched the THESEUS research project to enable scientists and engineers to assess innovative measures for coastal protection.



# THE EUROPEAN FLOODS DIRECTIVE

> The storm Xynthia hit the French Atlantic coast in February 2010. It claimed 47 lives and over 2,5 billion Euros of material damage. One million citizens were cut off from electricity. Waves in the flooded area reached up to 1,5m height and strong winds caused widespread damage.  
Photo: DDTM17 - B. Landreau



Specific flood prevention policies already exist for many European coastlines. Coastal management take place at many levels: local, national, regional and even at European and global levels. After all, natural coastlines do not respect the political borders of Member States.

At European level, the Floods Directive was adopted by the European Commission on 26 November 2007 (EC, 2007b). This is the most important concerted action covering coastal flood management. The European Directive requires Member States: to assess which water courses and coastlines are at risk from 2011; to map the flood extent, assets and populations at risk in these areas by 2013; to take adequate and coordinated measures to reduce and manage these flood risks by 2015.

This Directive also reinforces the rights of the public to access this information and to have a say in the planning process.





# A RISK AFFECTING US ALL

Are we truly aware and alert to the catastrophic events that can come our way? We all hear about the floods occurring throughout the world. It mostly happens in faraway places and perception is that it does not affect us directly.

In fact, between 1998 and 2009, Europe suffered over 213 major floods causing 1126 deaths and at least €50.000 billion in insured economic losses (EEA, 2010). These data help us to realize the social and economic importance of flooding.

# THE EUROPEAN FLOODS DIRECTIVE

Most flood events are associated with rivers but recent storms have demonstrated the significant impact of coastal flooding on coast-lines of Europe. In November 2010 storm Becky caused considerable damage in some twenty ports along the Galician coast of Northern Spain. Previously, at the end of February of the same year storm Xynthia had claimed 47 lives along the Atlantic coast of France. Only afterwards, it became clear that the severe storm warnings had not been picked up properly.

These two examples demonstrate that flood risk awareness concerns us all. The consequences of coastal flooding are not only a matter for the engineers responsible for the design of a dike and the authorities responsible for the issuing of warnings and drafting of legislation. They must also be the concern of all stakeholders and residents in coastal environments who must work together to balance the physical, economic, environmental and safety issues with social concerns.

► Autumn 2010: Storm Becky reached Santander Bay in Northern Spain.

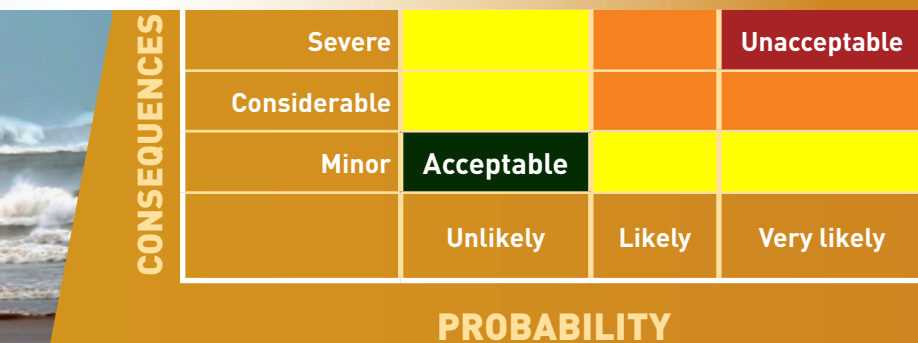


# ASSESSING THE RISK OF FLOODING

The first step is to qualify and quantify risk in an objective way. Risk is defined as the probability of an event or hazard, multiplied by its consequences.

**Risk = probability of occurrence x consequence**

We need to assess the probability and the consequences of a flood event. Quantification of these risks can be achieved through the creation of a risk matrix. This provides categories expressing the likelihood of an event occurring and others expressing the consequence. Once completed, risks can be prioritised according to their magnitude. Events with low probability and low consequences can be ignored, whilst events that are very likely to occur with severe consequences will be considered unacceptable.



CONSEQUENCES	Severe			Unacceptable
	Considerable			
	Minor	Acceptable		
		Unlikely	Likely	Very likely
PROBABILITY				



# ASSESSING THE RISK

This is usually based on a combination of modelling and statistical analysis which takes into account uncertainty. Tools exist to estimate the probability of occurrence of a storm for example 1/100, 1/1000, 1/4000 years,... and the associated uncertainty of a physical quantity such as a water level, a wave height, a wind speed, a rainfall depth.

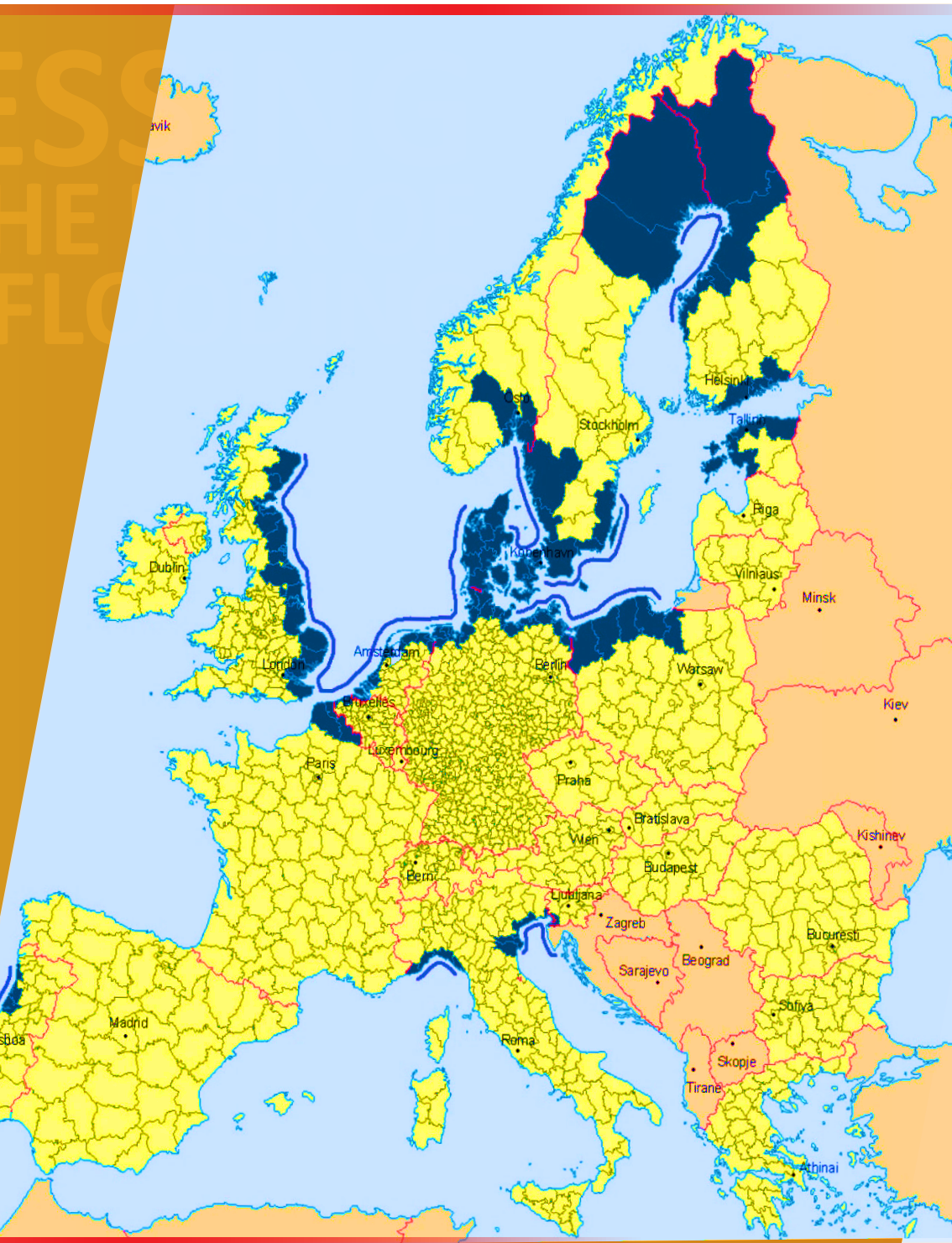
Other tools will help in determining the probability of failure of a coastal defence structure or river dike given a certain load.

The consequences of flooding or erosion can then be assessed by calculating the damage to private and public properties, the natural environment and to people on the basis of topographic, socio-economic, land-use and demographic data.

Loss of economic value, as a consequence, can be readily quantified, and hence so can the economic risk. However less tangible values related to, for instance, habitat loss or quality of life, require informed judgements to be made.

- These coastal areas in blue have a high probability of storm surge hazard. These areas can be particularly threatened by coastal flooding.  
Source: ESPON.

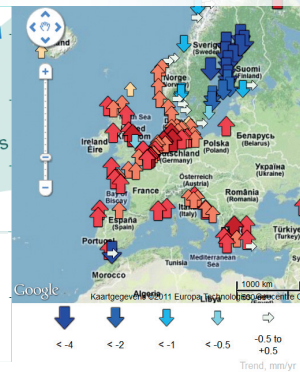
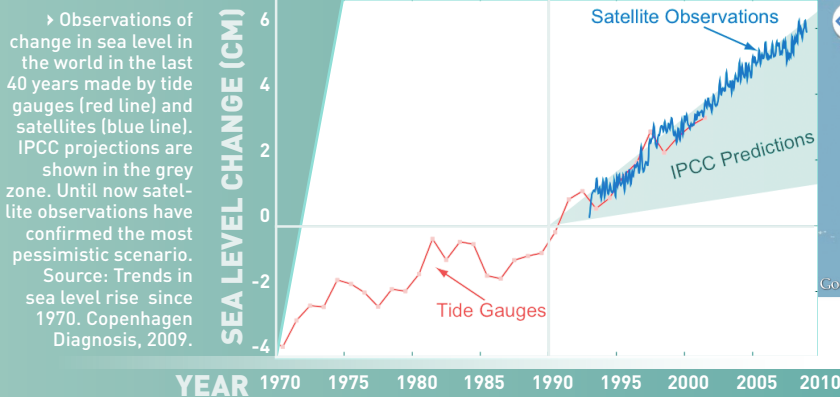




# SEA LEVEL RISE

Sea level rise due to climate change is one of the key parameters influencing the probability that flooding will occur. Sea level rise can cause flooding, coastal erosion and the loss of flat and low-lying coastal regions. It increases the likelihood of storm surges, enforces landward intrusion of salt water and endangers coastal ecosystems and wetlands. An additional 1.6 million people living in Europe's coastal zones could experience coastal flooding by 2080.

~ Trends in sea level rise since 1980 for Europe.  
Source: Permanent Service for Mean Sea Level Rise  
<http://www.psmsl.org/products/trends>



Global average sea level rose by around 1.7 mm/year during the 20th century. Recent results from satellites and tide gauges in Europe indicate a higher average rate of global sea level rise in the past 15 years of about 3.1 mm/year. Projections by the Intergovernmental Panel on Climate Change (IPCC) for the end of the 21st century suggest a sea level rise between 18-59 cm above the average 1980-2000 level, with indications it might be even higher. What will happen to our coasts if sea level rises by approximately 0.5m is therefore a very relevant issue. Source: EEA, 2010



# ASSESSING THE RISK OF FLOODING

## A DYNAMIC RISK



Risk however is not a static feature. Many factors can contribute to changes in a risk assessment: time deterioration of defence structures, renovation or heightening of a dike; the effect of climate change on rising sea levels; ecosystem evolution due to global warming; growing social and economic pressure on coastal areas; coastal zone management decisions.

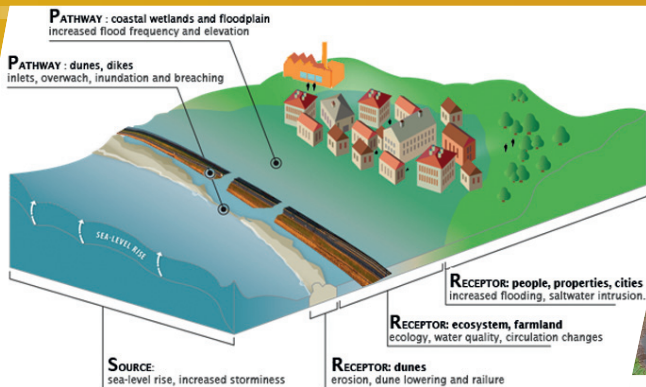
Risk is therefore a dynamic concept that changes with time. Different scenarios will lead to different associated risk values. To compare scenario's the area of interest should be analysed in detail. First of all we need to understand the sources of the hazard: for example a high rainfall, large tide, strong waves or land subsidence.

# SEA LEVEL RISE

Then it is important to examine the pathways through which flooding occurs. For example these might include the failure of barriers, overtopping of dikes or erosion of dunes. Finally we need to understand, who and what is affected by a flood event, the receptors and what are the consequences in terms of harm to people, properties and ecosystem.

This approach is called the Source-Pathway-Receptor-Consequences Model. In order to reduce flood risk, we can intervene by changing pathways or reducing the vulnerability of receptors. This basic model can be an important tool for evaluating innovative technologies and measures for coastal protection.

► Source-Pathway-Receptor Model  
source: North Carolina Sea Level Rise Study, North Carolina Division of Emergency Management, Geospatial and Technology Management Office (adapted by VLIZ).



~ Importance of saltmarshes to attenuate waves.

# MANAGING THE RISK

We have many options for managing flood risk in the near future: heightening or strengthening a dike section, nourishing a beach, building a storm surge barrier, installing an innovative wave absorbing system, opting for managed realignment of the coastline, attenuating waves through saltmarshes, restoring dunes, setting up insurances, evacuation planning or changing the designation or land use of a coastal zone.

For each management option, for each proven or innovative design, the current risks and future risk can be estimated and compared.



◀ Agucadoura Wave Farm of Pelamis wave energy converters. This mitigation measure is under analysis in the Theseus project.

However irrespective of risk assessment, good design and good management should not be inflexible, i.e. the aim should be to ensure continuity and resilience of everyday life before, during and after a flood. It is therefore important to involve all stakeholders (residents, fishermen, tourism operators, policy makers,...) and to have a common willingness to minimize the adverse consequences and maximize the potential benefits for ourselves and following generations.



# A CASE STUDY

## Challenges Facing the South Devon Coastline

The 100km of coast between Plymouth Sound and the Exe Estuary is one of the most diverse coastal settings in Europe. It comprises a spectrum of environments that range from exposed rocky shingle and sandy coasts, cliffs and dunes to sheltered mudflats and saltmarsh, barrier beaches, estuaries protected by spits, and drowned river mouths or 'rias'. These exist adjacent to both productive agricultural land and the densely populated, urbanised and industrial zones of Plymouth, Torbay and Exeter.

In the South West UK, isostatic rebound following the last ice age, exacerbates the anticipated global rise in sea level to yield estimates of 1m rise over the next century.

Such predictions pose serious challenges for the resilience of populations living in close proximity to the coast. This includes communities living under the protection of coastal features such as the those along the Exe estuary which is protected by the spit at Dawlish Warren. The spit itself is pinned in position by a groyne field to prevent the natural tendency to realign and breach under extreme conditions. Erosion of dunes along the Warren is mitigated by wire-cage

» Entrance to the Exe Estuary between Exmouth and Dawlish Spit (courtesy of Teignbridge District Council)

» Dune erosion, Dawlish Warren (courtesy TDC)



gabions and other measures. Sea level rise and predictions of increased storminess under climate change also increase the threat of coastal flooding and erosion to the sustainability of key infrastructure. Of particular concern is the main railway link to Plymouth and Cornwall from Exeter. This runs along the S. Devon coastline between a sea wall designed the early 19th century by Isambard Kingdom Brunel, and below soft cliffs prone to slumping.

Teignmouth is an historic port at the mouth of the Teign estuary lying along a stretch of red sandstone coast and now has a population of about 15,000. It has all the attractions of a sea-side town, including a Victorian pier. Teignmouth also has a working harbour, with many vessels, large ships, fishing boats and pleasure craft, entering and leaving the port. The low-lying seafront, shops and houses will be increasingly under threat of flooding from the sea over the next century as the extensive seawall becomes less effective. Over the estuary, at Shaldon, a recent flood defence scheme has been constructed after detailed consultation with the local community to provide medium term protection that can be uprated as the effects of climate change become clearer.

Slapton Ley is a lagoon separated from the sea by a shingle beach, known as Slapton Sands. It is the largest natural freshwater lake in South West England. It is 1.5 miles long and is made up of two parts, the Lower Ley and the Higher Ley. The ridge itself is a fragile shingle beach constantly being re-shaped by the sea. A main road (A379) Slapton and Torcross runs along the shingle ridge. This link is prone to storm damage and recently a realignment of the route was forced by storm activity.

It is clear that continuous efforts are to be expected. Public authorities, stakeholders and citizens must be fully aware and work effectively together to reduce risk of coastal flooding today and in the future.







## MORE INFORMATION

Theseus Project:

<http://www.theseusproject.eu>

European directive

[http://ec.europa.eu/environment/water/flood\\_risk/index.htm](http://ec.europa.eu/environment/water/flood_risk/index.htm)

Permanent Service for Mean Sea Level

<http://www.psmsl.org/>

Sea Level Station Monitoring Facility

<http://www.ioc-sealevelmonitoring.org/>

Sea level rise maps for the world

<http://www.cresis.ku.edu/data/sea-level-rise-maps>

Information on coastal flooding in the UK

<http://www.environment-agency.gov.uk>

<http://www.defra.gov.uk/environment/flooding/>