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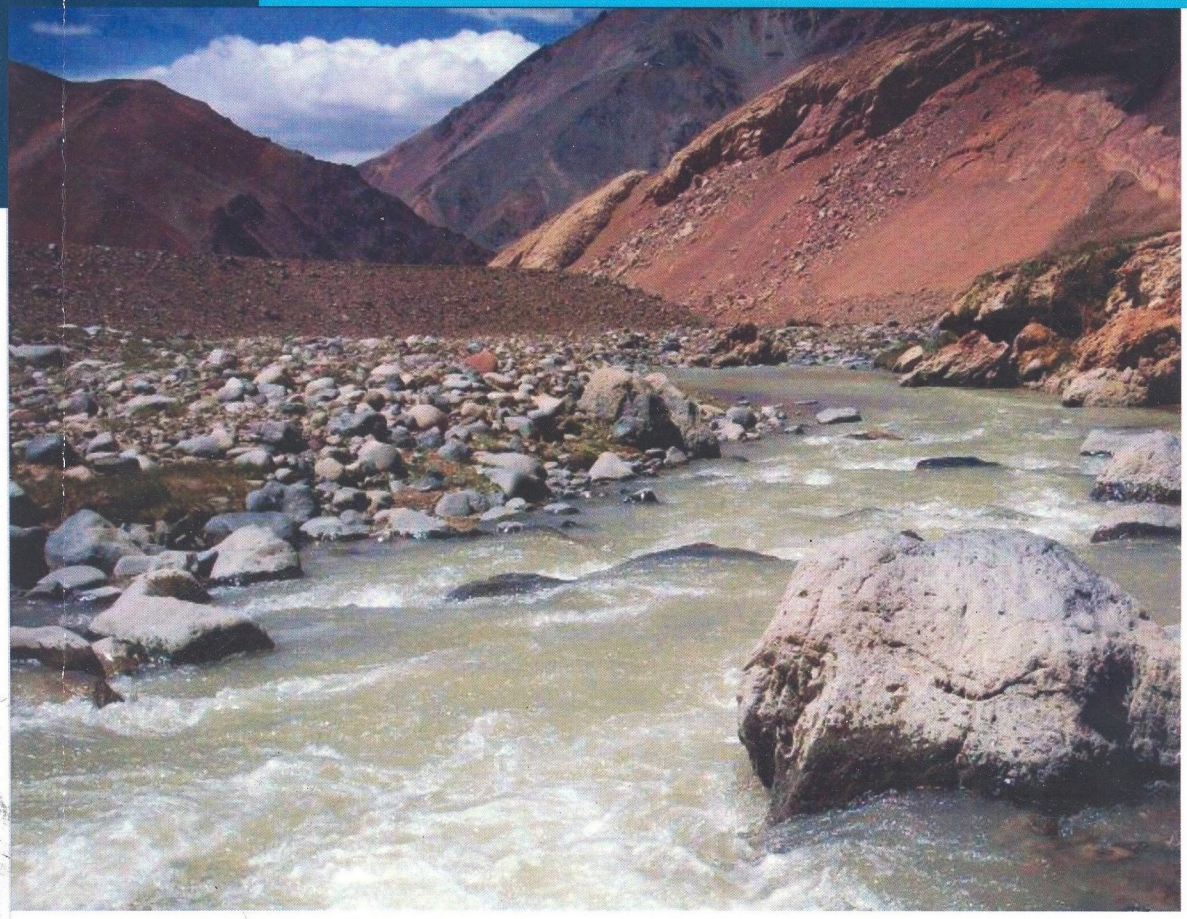

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THESEUS: INNOVATIVE TECHNOLOGIES FOR SAFER EUROPEAN COASTS IN A CHANGING CLIMATE.

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Resumen
Las áreas costeras son zonas muy importantes de asentamiento y juegan un papel vital para la mayoría de los países europeos. Particularmente vulnerable a los efectos del cambio climático, la zona costera requiere de un enfoque integrado para la gestión de los riesgos de inundación y erosión, y para preservar los hábitats costeros sanos, todo ello en una economía Europea en crecimiento. Por lo tanto, THESEUS, asume el reto de proporcionar un enfoque aplicable en todo el mundo para hacer frente a los riesgos costeros, con el objetivo de proporcionar una costa de bajo riesgo para su desarrollo y uso humano, en condiciones climáticas cambiantes.

THESEUS proporcionará una metodología integral e innovadora para la planificación de estrategias de defensa sustentables, que permitan la evaluación, regulación y gestión del riesgo de inundación y erosión costera, integrando aspectos técnicos, socio-económicos y ambientales. Las estrategias de evaluación de riesgo, generación de políticas, gestión y planificación se han elaborado, ilustrado y validado a través de su aplicación en ocho sitios de estudio representativos de diferentes condiciones ambientales, sociales y económicas.

Los productos principales serán: SIG para la planificación de estrategias de mitigación en las zonas costeras; criterios que describan las mejores y más innovadoras prácticas de protección costera; y una estrategia eficiente de comunicación del riesgo al público general y apoyo a la implementación de las directivas de la Unión Europea sobre inundaciones.

THESEUS reúne a una amplia gama de conocimientos y expertos de 31 institutos, distribuidos en 26 países, de los de los cuales 14 son de la Unión Europea y 5 de otras regiones.

Fecha de Inicio: 01 de diciembre de 2009 - Fecha de finalización: 30 de noviembre de 2013. (http://www.theseusproject.eu)

Abstract
Coastal areas are very important zones of settlement and play a vital role in the economics of most European countries. Particularly vulnerable to climate change effects, the coastal zone needs an integrated approach to manage erosion and flood risks and at the same time preserve healthy coastal habitats. Therefore, the THESEUS project has taken up the challenge to provide an approach to deal with coastal risk, which is applicable worldwide with the aim of delivering safer coasts for human use and development under changing climate conditions (Zanuttigh, 2011).

THESEUS provides an innovative integrated methodology for planning sustainable defence strategies for risk assessment, policy and management of coastal erosion and flooding, addressing technical, socio-economic and environmental aspects. Risk assessment, policy, management and planning strategies are being worked out, illustrated and validated through implementation at eight study sites representative of different environmental, social and economic conditions.

The main products under development are: a GIS software for planning mitigation strategies in coas-

tal areas; guidelines describing best practices and innovative solutions for coastal defence; and a strategy for communications relating risks to the public at large and support for the implementation of the EU Floods directive (2007).

THESEUS brings together a wide range of expertise from 31 participant institutions, spread across 26 countries, from which 14 are EU members, and 5 are from outside the EU.

Start Date: December 1, 2009 - End Date: November 30, 2013. (http://www.theseusproject.eu)

Introduction

THESEUS is funded by the European Commission under FP7 Environment and involves many research institutions from several countries, among which are Italy, Spain, England, France, Denmark, Bulgaria, Ukraine, Russia, USA, China, Netherlands, Germany, Poland, Greece, Latvia, Belgium and Mexico. The project is coordinated by Barbara Zanuttigh of the University of Bologna (Italy).

The Mexican participation is led by the UNAM Institute of Engineering, with the collaboration of the Laboratory of Coastal Processes CINVESTAV-IPN, Mérida, and EPOMEX of the Autonomous University of Campeche. Through this collaboration, the Mexican group brings together specialists with extensive experience in field measurements, numerical modelling and laboratory studies to investigate coastal processes.

The framework of the project stems from four major premises:
1. The occupation of the coastal strip is increasing and a large part of it is already threatened by coastal erosion events and flooding.
2. The frequency and intensity of flood and erosion events is expected to increase due to climate change and the predicted sea level rise, of 0.2 to 0.8 m/century (SRES scenarios, IPCC 2007).
3. Coastal risk management has often damaged natural environments, as coastal protection has been implemented at the expense of coastal habitats in the majority of occasions.
4. Europe (and the world) does not have a comprehensive strategy for the evaluation and management of the increased risk of coastal flooding and erosion, which takes into account the multiple challenges of balancing human and environmental interests.

Objectives

The main objective of THESEUS was to provide an integral approach to sustainable defence strategies in the management of coastal erosion and flooding considering technical, social, economic and environmental aspects. To this end, the project has focused its efforts on the following three main aspects.

1. Risk assessment. To develop tools for estimating probabilistic scenarios of flooding and coastal erosion related to climate variability and change. Through this work we have advanced the understanding of the vulnerability and resilience of coastal infrastructures and ecosystems.
2. Response strategies. To analyse measures which mitigate erosion and flooding risk as well as the latest developments in coastal defence structures and coastline stabilisation technologies (such as reefs, resilient dikes, over-washed structures). In addition, proposals for and analysis of innovative solutions are discussed, such as the use of wave energy converters close to the shoreline for attenuating wave attack. The group examine and set up adaptation strategies such as the promotion of social resilience, insurance programs, spatial planning, evacuation plans, post-crisis responses and managed realignment.
3. Implementation of measures. To establish "best practices" and prepare guidelines for the integrated design and application of efficient, equitable and sustainable coastal defence technologies. To set up a portfolio of mitigation options and to develop an integrated approach for the selection of a sustainable defence strategy to face coastal erosion and flooding in a given coastal area which addresses technical, social, economic and environmental factors. Study sites, representative of different environmental, social and economic conditions, are discussed. A Geographic Information System (GIS) based Decision Support System (DSS) is being developed and is based on the approach developed for promoting coastal flooding resilience and disaster preparedness through education, training, development of best practices for organising post-crisis assistance and dissemination of project results.

Participation of the Mexican team
The participation of the Mexican team in the project focuses on performing the following activities.

The study of erosion and flooding scenarios for selected sites. The scenarios have been analysed in the short, medium and long term, including the estimation of the effects of wave overtopping on coastal structures and dune breaching.

Laboratory tests in the wave flume of the Institute of Engineering of UNAM for the development of innovative techniques and technologies for coastal defence and harnessing wave energy, as well as to provide computational numerical models to estimate the potential effects of mitigation infrastructure.

The development of methods and tools calibrated under conditions of uncertainty, which can be used by stakeholders and end users in the planning and evaluation of risk mitigation measures on the coast. The evaluation of the efficiency, equity and sustainability of the effects of erosion mitigation options and flood risk will be verified. These, in turn, provide guidelines for the design of defensive strategies.

Applications
Isla del Carmen: The coastal zone of Isla del Carmen, on the Gulf of Mexico, is enclosed in an area affected annually by very strong winds of polar origin (locally known as "Nortes") as well as by extreme events, such as hurricanes formed in the Atlantic Ocean (Figure 1).

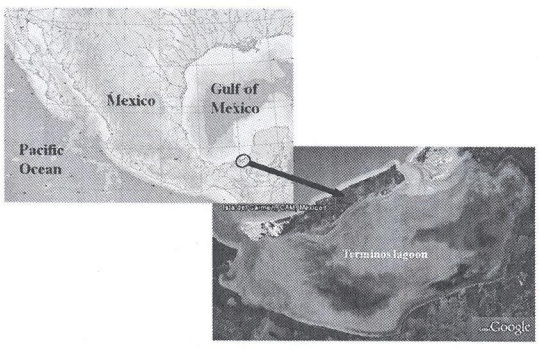


Figure 1. Location of Isla del Carmen study site.

These hydro-meteorological phenomena cause problems of beach erosion as well as the processes of overtopping and/or breaching of the dunes, which extend longitudinally along the almost forty kilometres of beach, leading ultimately to the flooding of settlements and of the natural ecosystems next to the beach (figure 2).

(a) (b)

Figure 2. (a) Mangrove area located next to the beach (CONABIO, 2009). (b) Dune in Isla del Carmen beach.

The risk assessment carried out at Isla del Carmen will assist in preserving the existing natural ecosystem, which is considered a "Protected Natural Area of Flora and Fauna", an area of mangroves with biological relevance (CONABIO 2009), a UNESCO world heritage site since 2008, and an area of sea turtle spawning. It will also prevent or reduce the economic and social damage caused by extreme meteorological events on tourists and the local population.

The methodology used for risk assessment is based on the source-pathway-receptor approach (Burzel et al. 2010; Jha 2011; Narayan et al., 2011; Escudero et al. 2012); where risk is defined as the combination of probability of occurrence of a harmful event (P) and the consequences or damages expected on all physical entities exposed to the threat (D), R=P*D

This model is applied, to analyse the risks produced by the storm surge, wave and wind hazards on the dune ecosystem considering the dune as a receptor element (figure 3a). It is also applied again to analyse the risks produced by the storm surge, wave and wind hazards on the population, infrastructure and natural habitat of the area protected by the dune considering the dune as a pathway element (Figure 3b).

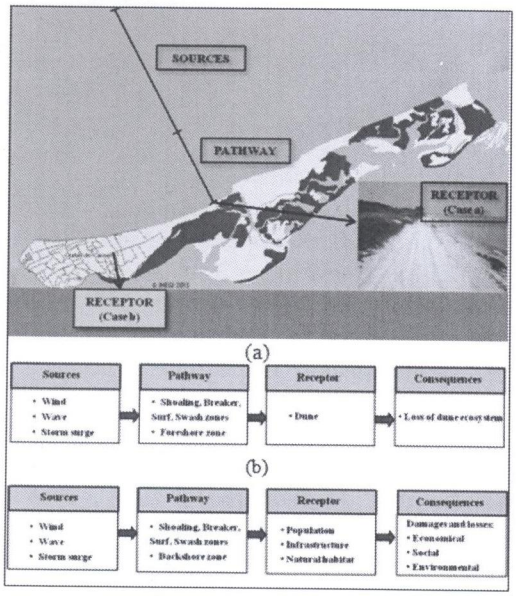
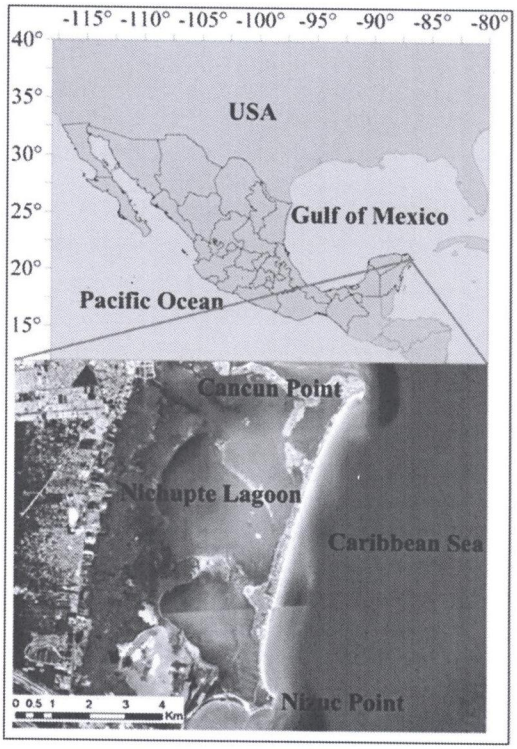


Figure 3. Sketch of the source-pathway-receptor model application at the study sites

Cancun: The SPRC model was also applied to investigate erosion risks and possible mitigation strategies at Cancun, an important beach resort located on the Mexican Caribbean, on the north-eastern coast of the Yucatan Peninsula, (see Fig. 1). This resort town was built on a lagoon-barrier system formed by Nichupte Lagoon, Punta Cancun, Punta Nizuc, and a dynamic barrier island that separates the lagoon from the Caribbean Sea. Its on-going development started in the 1970's, on the northern part of the lagoon-barrier system (Cancun Point), and has now covered the entire length of the barrier island. Erosion problems in the region were first noticed after hurricane Gilbert, 1988, when, for the first time, the un-regulated character of the resort's development was discussed.

The fragility of the coastal zone of the Yucatan Peninsula is strongly conditioned by meteorological and geological characteristics of the area. Due to its extreme karst nature, there are no rivers in the central and northern parts of the peninsula, resulting in a lack of supply of terrigenous sediment to the coast. This means that most sand found on this coast is of marine origin (fragments of shells and corals) (Ruiz Martinez, 2009) and thus the recovery possibilities of the coast after an extreme event are very limited.

Like Isla del Carmen, Cancun is also affected by hurricanes and northerly winds and storms; however, in this case the beach/dune system has already been severely affected by human activities, and is therefore considered as the pathway of risk, while the receptors are the population, infrastructure and natural habitat (see Case b, in Fig. 3b).



It was found that the destruction of the dune system, caused by the constructon of permanent infrastructure over it, severely limits the ability of the beach to recover after storm events, while the permanent closure of seasonal inlets affects the flushing cycles of the lagoon, particularly during storm events. There have been various attempts to re-establish the original beach volumes through renourishment activities, construction of illegal groynes and breakwaters, and more recently the building of a terminal groyne at Punta Cancun. As yet, no comprehensive risk management and mitigation strategies have been put in place.

Conclusions

The THESEUS project has allowed the Mexican team to develop and reproduce new coastal methologies for two study sites in Mexico. On the other hand, through this collaboration several academics, students and professionals from Mexico have been interchanging knowledge and experience with other countries around the world.

In particular, for Cancun Beach and Isla del Carmen, the ability to predict the morphological response to the sources of risk is crucial to generating an efficient management strategy, and therefore, of great use to stake holders and policy makers.

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Photo: Determinación de parámetros de campo sobre el río Santa Cruz, entre los ríos Pachón y de la Carnicería – Proyecto Pachón. Fechas: Verano de 2013.
Autor: Ingeniera Zulma Estela Menna. Directora de los trabajos para el "Proyecto Pachón"

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