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HERMES

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## Contents

## Executive Summary

HERMES is an ambitious project which is expected to:

a) aid coastal stakeholders to harmonize and adapt to the most relevant EU policies on coastal zones,

b) upgrade the current level of research and innovation in the field of coastal sustainable development, protection and adaptation,

c) enhance responses to challenges driven by climate change, and

d) sustainably use strategic coastal resources to achieve Blue Coastal Growth.

This deliverable describes the Common Methodological Framework adopted, to be followed during the implementation of the project and applied at all four pilot study sites. The herein presented methodological framework could be expanded to any Mediterranean/Black Sea shoreline to assess the historic level of coastal erosion, to evaluate the vulnerability of coastal areas in erosion and climate change, to monitor and model the open sea to nearshore processes dynamically shaping geomorphology and morphometry of shorelines in these enclosed basins, to develop scenarios of intervention focusing on “soft”, environmental-friendly technologies for prevention and restoration, as beach nourishment, and to report inefficiencies in relevant legislation and enforcement at all four partner countries and propose harmonized policies and legal measures in line to International and EU ICZM legal framework.

## 1. The General Framework

The coastline is the active and dynamic boundary between land and ocean.

Coastlines change in time at varying rates due to coastal processes. Abrupt changes occur during highly energetic phenomena as storm-surges, earthquakes and volcanic eruptions, while more gradual changes occur during lower energetic periods, as sea level changes, waves and nearshore longshore and cross-shore currents. Human intervention also affects and changes coastlines through developments in the adjacent watershed (urbanization, land reclamation, damming) and coastal infrastructures (harbors, marinas, touristic developments) (Figure 1).

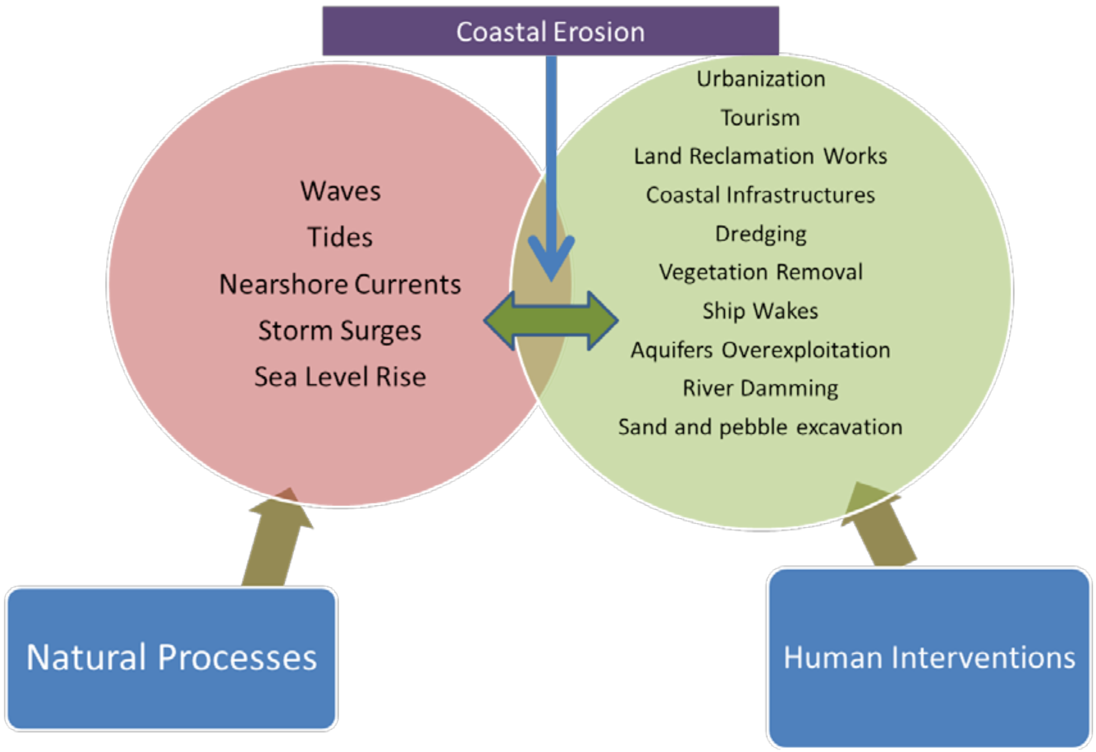


*Figure 1. Processes natural and anthropogenic affecting coastline changes.*

Coastline changes result into coastal retrieval, reported as coastal erosion, or coastal advancement, reported as coastal deposition. A coastline advances where the deposition of sediment exceeds the rate of erosion, or where there is emergence due to uplift of the land or a fall in sea level, and retreats as the result of erosion exceeding deposition, or where there is submergence due to land subsidence or a sea level rise.

Coastal evolution understanding, prediction and protection ultimately leads to the sustainable coastal zone management.

This is particularly important, as coastal erosion is one of the highly growing environmental concerns faced by coastal communities. Over the past 100 years about 70% of the world's sandy shorelines have been retreating due to coastal erosion, while currently around 20% of EU coastline is eroding. Coastal erosion is aggravated by the prospect of accelerated sea level rise due to climate change and the accumulated negative effects of mismanagement practices.

Coastal erosion is directly linked to economic losses due to coastal retreat and loss of land, ecological damage (especially of valuable coastal habitats) and societal problems. Especially, as coastlines and beaches represent valuable buffer zones protecting backshore from marine flooding while shaping the socio-economic environment. Globally coastal tourism and seashore recreational activities contribute by 5% to Global GDP and by 6-7% to global employment (Hall et al., 2013).

## 2. The Legislative Tools

Presently, coastal authorities are faced with the increasingly complex tasks of balancing between development (urbanization, tourism) and managing coastal risks. Coastal zones are areas hosting dynamic economies into sensitive and vulnerable ecological frames, making coastal planning and resource management particularly challenging.

The Integrated Coastal Zone Management (ICZM) provides the scientific framework to resolve conflicts, mitigate impacts of short- / long-term uses and support strategies for sustainable coastal management. More specifically, the Barcelona convention and its protocols, the ecosystem management approach and the most relevant EU policies on coastal zones recognize the dual role of coastal resources as ecological functions and productive socio-economical assets.

In parallel, the Marine Strategy Framework Directive (2008/56/EC, European Commission 2008) (MSFD) is the main legal instrument that have been adopted to protect more effectively the marine environment. MSFD establishes a set of descriptors capable to assess the Good Ecosystem Status (GES) following the ecosystem-based approach (Table 1).

Although MSFD is not directly referring to coastal erosion prevention and restoration, it indirectly states that Member States should undergo any action to diminish the permanent alteration of hydrographical conditions, including the changes in freshwater fluxes, reduction of sediment fluxes from rivers and changes in nearshore circulation due to human constructions. The construction of ports and other infrastructure may represent a significant pressure all around the Mediterranean and Black Seas and therefore associated impacts might include sandy beach erosion and need for beach nourishment.

Additionally, the physical damage and loss of habitats affects sea-floor integrity and disintegrates coastal ecosystems enhancing coastal erosion and climate change vulnerability. Sea meadow destruction and changes in the food webs have been also usually observed and related to dredging, bottom trawling, anchoring, discharges of wastewaters, and littering. Desertification due to harvesting and destructive fisheries poses a critical risk, and it has already been described in the Naples area, the southeast Adriatic, the Burgas Bay and the northwestern Black Sea.

In the Mediterranean basin, coastal erosion threatens 1/5 of coastlines exhibiting a retrieval rate of 0.5-2.0 m/y. Human encroachment on the coast and climate change impacts through storms intensity and frequency intensification are expected to amplify coastal erosion, leading to the degradation of coastal ecosystems, threatening economic activities (as tourism and recreation), damaging coastal infrastructures and posing a risk to social welfare.

*Table 1. MSFD Descriptors.*

| Number | Nickname | Descriptor |
|---|---|---|
| 1 | Biological diversity | Biological diversity is maintained. The quality and occurrence of habitats and the distribution and abundance of species are in line with prevailing physiographic, geographic and climatic conditions |
| 2 | Non-indigenous species | Non-indigenous species introduced by human activities are at levels that do not adversely alter the ecosystem |
| 3 | Commercially exploited fish and shellfish | Populations of all commercially exploited fish and shellfish are within safe biological limits, exhibiting a population age and size distribution that is indicative of a healthy stock |
| 4 | Marine food webs | All elements of the marine food webs, to the extent that they are known, occur at normal abundance and diversity and levels capable of ensuring the long-term abundance of the species and the retention of their full reproductive capacity |
| 5 | Eutrophication | Human-induced eutrophication is minimised, especially adverse effects thereof, such as losses in biodiversity, ecosystem degradation, harmful algal blooms and oxygen deficiency in bottom waters |
| 6 | Sea-floor integrity | Sea-floor integrity is at a level that ensures that the structure and functions of the ecosystems are safeguarded and benthic ecosystems, in particular, are not adversely affected |
| 7 | Hydrographical conditions | Permanent alteration of hydrographical conditions does not adversely affect marine ecosystems |
| 8 | Contaminants | Concentrations of contaminants are at levels not giving rise to pollution effects |
| 9 | Contaminants in fish and other seafood | Contaminants in fish and other seafood for human consumption do not exceed levels established by Community legislation or other relevant standards |
| 10 | Marine litter | Properties and quantities of marine litter do not cause harm to the coastal and marine environment |
| 11 | Underwater noise and other forms of energy | Introduction of energy, including underwater noise, is at levels that do not adversely affect the marine environment |

In this context, scientific recommendations involve management decentralization to the lowest appropriate level (bottom-up approach), upgrading in parallel managers' adaptation capacity to enhance coastal resilience and strengthen multi-level and territorial cooperation among Mediterranean rims to promote joint actions.

However, the implementation of such recommendation requires a harmonized methodological framework to coastal erosion mitigation.

## 3. The HERMES Project

The HERMES project - *A HarmonizEd fRamework to Mitigate coastal EroSion promoting ICZM protocol implementation* - is a project funded by the **Interreg V-B BalkanMed 2014-2020 Program**, submitted in compliance to the Priority Axis 2 on *Environment*, the Specific Objective 2.2 on *Sustainable territories*, the Thematic Objective 6 on *Preserving and protecting the environment and promoting resource efficiency* and the Investment Priority 6f on *Promoting innovative technologies to improve environmental protection and resource efficiency in the waste sector, water sector and with regard to soil, or to reduce air pollution*.

HERMES aims to develop a unified and harmonized framework for coastal erosion and sea-level rise mitigation and beach restoration, covering the four partner countries: Albania, Cyprus, Greece and Bulgaria. Indeed, in these countries coastal erosion and sea level rise significantly threaten coastal zones, as:

- In Greece almost 30% of coasts are eroding or appear as vulnerable to erosion;
- In Cyprus this percentage reaches 38%;
- In Bulgaria almost 71% of Black Sea beaches are eroding; and
- In Albania, a country with 420 km coastline coastal erosion is a significant issue for the northern and central parts.

HERMES is expected to achieve its scopes through the implementation of a coherent ensemble of studies, the sharing of already developed technical tools and the design of joint policy instruments at each study site (one per partner country). HERMES will apply at local/regional scale existing sophisticated tools (monitoring systems and models), enhancing the close collaboration between scientists and managers, bridging the gap in the science-policy interface, and the continuous public and private stakeholders' involvement. The project will transfer the knowledge and experience gained through previously EU-funded projects (e.g., BeachMED, CoastGAP, FaceCoast, Coastance, Mare Nostrum) and the 'Bologna Charter 2012', aiming to build and implement a joint coastal erosion framework, adapted to the specific conditions of the four study sites (one per partner country).

The conceptual framework of HERMES will follow the well-known ICZM principles within the DPSIR context (Drivers, Pressures, States, Impacts and Responses) as adopted by the European Environmental Agency. The four pillars of HERMES integrated approach are (Figure 2):

1. Data Accessibility, as all data collected during HERMES will be open and freely accessible to the broad public. Real-time data recorded from all four oceanographic monitoring stations will be readily available to relevant networks as monGOOS (the **Mediterranean Operational Network for the Global Ocean Observing System**), EuroGOOS (the **European Global Ocean Observing System**) and CMEMS (the **Copernicus Marine Environmental Monitoring System**).
2. Stakeholders' Collaboration, as all relevant stakeholders and marine users will be informed and invited to participate and collaborate.

3. Compliance & enforcement with EU and national/regional/municipal relevant policies, strategies and legislation.
4. Public Participation, the broad public should be directly informed and actively participating in all actions related to coastal zone protection and management.

HERMES will undertake actions targeting to the following authorities, agencies and groups: local/regional authorities; coastal management authorities; national cadaster; local/regional development agencies; members of technical chambers; environmental protection agencies; management bodies of protected areas; public undertakers; researchers, professors and students on coastal management and environmental protection; environmental NGOs; SMEs in tourism and recreation and the wider audience.

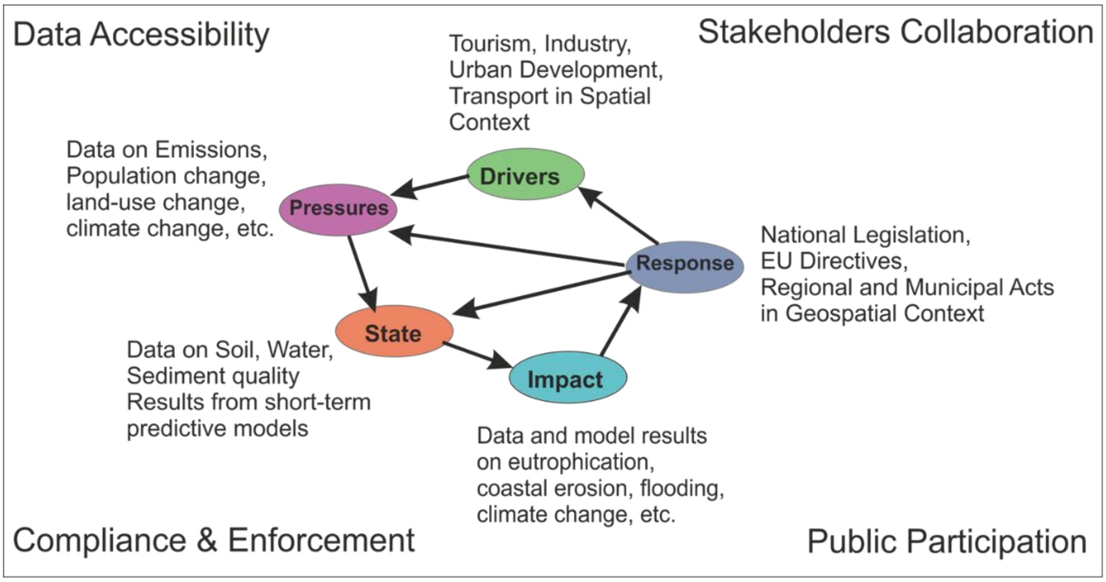


*Figure 2. HERMES pillars of Conceptual Framework.*

## 4. The HERMES Action Plan

HERMES involves actions at four pilot study sites, one per partner country:

a) **the coastline of Paggaio Municipality**, Northeastern Greece, a coastline of 45 km length where erosion is very crucial for tourism and coastal infrastructures, damaged under extreme waves and storm surges;

b) **the coastline of Larnaka-Zygi**, located along the south coast of Cyprus, particularly impacted by anthropogenic interventions (development, tourism, fisheries, industry) exhibiting strong erosion signs;

c) **the coastline from Cape Galata to Cape Emine**, representing a single coastal cell at the central part of the Bulgarian Black Sea coastline. Along this coastal strip there exist both large stable beaches and smaller heavily eroded beaches; and,

d) **the coastline from the northern border of Albania to near the Mat River delta**, where coastal erosion had the harshest effects, with the sea advancing up to 500 meters inland in the last 15 years, affecting beaches, forests and land, increasing salt water intrusion, damaging touristic investments on the seashore, and destroying wetlands and lagoons.

At each study site HERMES partners will share common methodological standards to study coastal and marine dynamics and erosion phenomena; adopt common strategies in coastal monitoring and surveying; device common indicators for coastal management and preservation actions; apply common tools for erosion-protection scenario building; promote environmental-friendly technologies ('soft' techniques) to tackle coastal erosion.

More specifically, for each study site the following actions will be undertaken by all partners:

a) assessment of historic and future coastline retreat, using satellite and Google Earth images, by applying existing practices and tools;

b) evaluation of coastal erosion and climate change vulnerability indicators, as reported by previous projects;

c) understanding of the relative influence on coastal erosion of human interventions (river damming, illegal sand mining, uncontrolled urbanization, port/coastal protection structures, dredging works, etc.);

d) analysis of existing environmental and socio-economic data at local/regional scale;

e) integration of data into a coastal web-based PPGIS, serving as a prototype platform to support networking, policy implementation, best practices and stakeholders' involvement;

f) development and application of a novel modeling toolkit coupling meteorological, hydrodynamic, wave and morphodynamical models;

g) deployment of a real-time monitoring station at each study site reporting coastal waves and currents, serving as a network of observing structures on erosion, storms impact and climate change influence;

h) evaluation and testing of intervention scenarios for mitigation works using the long-term morphodynamic model results. HERMES will place emphasis to promote the environmental-friendly technical works for coastal restoration (e.g., beach and dune stabilization, beach nourishment); and

i) develop and promote the HERMES project training pack, in which workshops and seminars will train national, regional and local managers on the use of the HERMES system.

Coastal authorities, local, regional and national are the organizations responsible to receive HERMES-produced tools and outputs and raise coastal risk awareness, promote stakeholders and citizen participatory processes, introduce environmental awareness on coastal works design, devise new integrated coastal management plans and formulate climate change adaptation strategies.

HERMES will provide a link to previous and currently-implemented projects on coastal erosion and climate change resilience and will proceed with a follow up of outputs and results to complete the mainstreaming processes within the respective Administrations, to demonstrate its transferability and to enhance the territorial cooperation on coastal protection, management and adaptation to climate change in the Mediterranean context.


*Figure 3. The HERMES pilot study sites.*

## 5. The HERMES Work Plan

HERMES is a network joint action supporting the planning of the most appropriate coastal erosion and climate change resilience management strategy for the coastal communities of the partner-countries involved. It links scientific expertise with developing agencies, coastal zone managers and decision-makers on issues related to ICZM, coastal erosion, beach stabilization and restoration, coastal environmental rehabilitation and climate change resilience and adaptation.

HERMES is a research collaborative project comprised of six well-defined work-packages as follows:

- WP1 on management and coordination (led by the Municipality of Paggaio);
- WP2 on Project communication and dissemination (led by the Union of Bulgarian Black Sea Local Authorities);
- WP3 on current status analysis and assessment (led by ORION-Joint Research and Development Centre);
- WP4 on the production of common methodologies and tools (led by TEULEDA, Local Economic Development Agency);
- WP5 on pilot implementation of methodology at four sites, one per partner (led by Democritus University of Thrace); and
- WP6 on the joint policy recommendations and guidelines (led byIGEWE).

The workplan of HERMES project per work-package is shown in Figure 4.

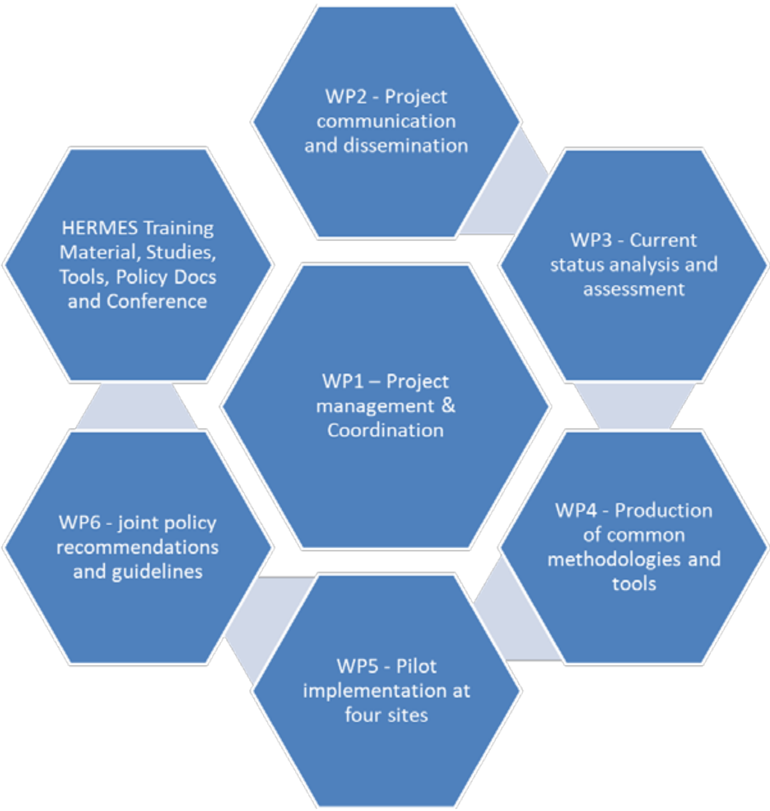


*Figure 4. HERMES workplan.*

## 6. The methodology for Coastline Classification

To understand the processes relevant to coastal erosion at the nearshore environment, we need to follow existing standardized coastal classification systems, identifying areas, beaches, coasts with similar characteristics and potentially propose/impose similar mitigation measures.

Geomorphology classifies coastlines into the following five distinct features:

- Sandy beaches, dominated by loose sediments (mostly sands) transported along the shoreline by littoral transport. Occurrence of sandy beaches is determined by hydrology, hydrography and geology of the broader areas.
- Muddy beaches, dominated by fine material represent wave/tide calm conditions.
- Rocky coasts, mostly cliffs, normally steep usually more than 40◦, but often vertical and sometimes overhanging.
- Arctic coasts, shores exposed to freezing for more than six months annually.
- Barrier islands, parallel to the shore, separated from mainland by a lagoon.

*During HERMES, classification of each study site into the above types will take place, based on local/regional maps and satellite and Google Earth images.*

Further, coastlines may be categorized into:

- Nearly straight coastlines, subdivided according to the angle of wave incidence into:
    - Perpendicular wave approach coastlines, with near zero angle of wave incidence,
    - Nearly perpendicular wave approach coastlines, with angle of incidence ranging from 1-10$^o$, favoring small to moderate longshore transport,
    - Moderate oblique wave approach coastlines, with angle of incidence ranging from 10-50$^o$, favoring large net longshore transport,
    - Very oblique wave approach coastlines, with angle of incidence ranging from 50-85$^o$, favoring large net longshore transport,
    - Nearly-parallel wave approach coastlines, with angle of incidence > 85$^o$ favoring very large net longshore transport.
- Delta coastlines, formed by river sediments supply, and
- Sand spits, morphologically active formations when exposed to extreme waves under storm surges.

*In HERMES CMEMS mean inter-annual wave model data will be used to classify the coasts based on their angle of wave incidence.*

Based on wave exposure, the above divisions may be characterized as:

- P: Protected, the "once per year event" having $H_{s,12h/y} < 1$ m
- M: Moderately exposed, the "once per year event" having 1 m < $H_{s,12h/y}$ <3m
- E: Exposed, the "once per year event" having $H_{s,12h/y} > 3$ m

where $H_{s,\ 12h/y}$ is the significant wave height occurring under storm conditions with 12 hr duration.

*In HERMES CMEMS mean inter-annual wave model data will be used to classify the coasts based on their storm significant wave height.*

*During HERMES, classification of all study sites in the above types and sub-types will be based on data collected by the oceanographic monitoring system (deployed one per location) and the results of the applied wave numerical models. The recommended shore protection and sea defense measures will be based on this classification.*

## 7. Assessment of historic and future coastline retreat

Understanding the primary controls on coastal behavior over timescales relevant to management remains extremely challenging despite the continuing extension of multi-year monitoring programs and datasets. The combined use of in situ measurements and remote sensing methods can provide a realistic assessment of high erosion-risk zones. The assessment of coastline changes in the past was mainly based on the use of bathymetric and topographic maps, over which the shoreline position was specified at different time periods, providing an assessment on the annual erosion or deposition rates (Golik and Rosen, 1999). Over the last decades, aerial photography and maps are replaced by medium and high-resolution satellite images (Frihy et al., 1994; Süzen and Őzhan, 2000; Berriolo et al., 2001; Fatallah and Gueddari, 2001; Maktav et al., 2010).

*In HERMES project, series of satellite images will be used to assess the coastline change along all four pilot study sites at all partner countries (Greece, Cyprus, Bulgaria and Albania). Based on these images, the annual deposition −erosion rates will be calculated for the time-period covered between them.*

Satellite images in Geotiff format, originated from the satellite images of the Landsat system and supplied by the U.S. Geological Survey (USGS), will be used. Images will cover a time period adequate to assess coastline changes. Images will be pre-processed following all geometric and radiometric corrections as recommended by USGS. It is apparent that older images will have a relatively low resolution (average order of pixel size at 28.5m). Newer images will have higher resolution (the half pixel size of 14.25m). Enhancement techniques such as the linear extension of the histogram and linear contrast stretching will be applied to all images. The 3 × 3 median Kernel filter (mobile window) and edge detection techniques will be applied on the older images to increase spatial resolution and to reduce the background noise.

After pre-processing, images will be inserted into the GIS MapInfo software (WGS84, NUTM35 North) and further geometric corrections will be made based on the digitized hydrographic map of all study areas. The geometric corrections, rectification and verification will be based on the 'image to image registration' technique. The satellite images will be rectified with the use of Ground Control Points (GCPs) taken at permanent features such as road intersection, building corners, bridge corners, rail-road intersection, etc. Image registration will involve the alignment process, by which the obtained shorelines will be geographically positioned in the appropriate manner that images are coincident to each other.

After image registration, the coastline will be separated by a series of transects into different sectors, based on the coastal morphological characteristics (coastline types and sub-types). The points each transect intersect the shoreline, as shown by the various satellite images, may be used for the assessment of coastal erosion in the area (single transect method).

Different shoreline erosion/deposition assessment methodologies have been developed over the years (Dolan et al., 1991):

1. The End Point Rate (EPR) method uses only two data points to delineate the change rate: the earliest and most recent shoreline positions. Given that only the end data points are used, the information contained in the other data points is entirely omitted, preventing the observation of variations in rate through time. The main disadvantage of this method is that if one or both end points are erroneous, the calculated erosion rate will be inaccurate (Crowell et al., 1997; Crowell et al., 1999; Dolan et al., 1991). Also, the method considers a linear trend in erosion/accretion rates.

2. The Average of Rates (AOR) method considers the mean long-term change, excluding changes due to measurement errors. To do this a minimum time criterion that filters out any changes due to short time spans or measurement errors was introduced. EPRs are determined between all data point pairs and are removed if the time interval is less than a specified minimum. All EPRs that pass the criterion are averaged to determine the shoreline change rate (Dolan et al., 1991; Foster and Savage, 1989). The main drawback is that the minimum time criterion can be affected by large errors or small EPRs, resulting in potentially misleading results (Dolan et al., 1991).

3. The Minimum Description Length (MDL) method assumes Gaussian error component and a complexity penalty to select the best model fit, whether it is a constant, line, quadratic, etc. In case the resulting model is quadratic or higher, two lines are produced: the zero-weight line (MDL ZERO), which uses only recent data, and the low-weight line (MDL LOW), which assigns weights to older data. MDL rates based on nonlinear models tend to result in variable or highly inaccurate forecasts, though the MDL criterion can help identify physical changes within a beach.

4. The Ordinary Least Squares (OLS) method assumes a least squares regression in shoreline change trends and minimizes the sum of the squared residuals between the data and line. The method estimates the parameters of liner a regression ($b_0$, or intercept; $b_1$, or slope). The method assumes a Gaussian distribution in the errors introduced by analysis, and is usually valid, since the sum of many sources of error in these studies tends toward a Gaussian distribution. A number of statistical tests have been developed (e.g., analysis of variance [ANOVA]) to determine the goodness of the fit and to calculate confidence intervals around the line, future position, and shoreline change rate. These tests require near Gaussian statistics, which are derived from data scatter rather than independent sources.

5. The Jackknifing (JK) method uses multiple OLS fits to determine the shoreline change rate. A different point for each line is omitted, resulting in a different slope for each line. The jackknifing method uses multiple OLS fits to determine the shoreline change rate. A different point for each line is omitted, resulting in a different slope for each line. Jackknifing has the advantage of decreasing the influence of clustered data and extreme data points. However, computing all possible linear trends is not efficient.

6. The Reweighted Least Squares (RLS) method identifies the true trend of shoreline change data, by removing statistical outliers in the data. It is a two-step procedure: step one identifies outliers at a cutoff value ($\hat{\sigma}$) using the least median of squares (LMS) regression. Points identified as statistical outliers are given a weight of 0, and all other points are assigned a weight of 1. An OLS fit then finds the trend with all data points of weights equal to 1. Unlike OLS, RLS is more robust and not as sensitive to outliers. The method probably works best with a large amount of data or if data from adjacent transects are binned so that true outliers are more evident.

7. The Weighted Least Squares (WLS) method assumes heteroscedastic uncertainties to accommodate larger uncertainties associated with early shoreline data in comparison to those of recent shorelines. The resulting trend line incorporates the uncertainty at each position as well as the uncertainty of the model. Application of this method implies that all errors and uncertainties have been estimated. The method assumes a Gaussian distribution of errors, but in case this is a false estimate the method may lead to over- or under-estimation of true rates.

8. The Reweighted Weighted Least Squares (RWLS) method is similar to the RLS method, except that it takes into account the uncertainties of each shoreline position. After identifying and removing outliers using LMS, a WLS line may fit to the data.

9. The Least Absolute Deviation (LAD) method attempts to minimize the sum of the absolute value residuals in LAD. To obtain a range of slopes at a certain percentile, an estimator of standard deviation (analogous to the root mean square error in least squares) should be computed and used to compute the likelihood function, which in this case is the joint probability density function (PDF) of both the slope and intercept.

Five different errors may be identified for calculating the rate of shoreline change. These are both positional and measurement related errors. Positional uncertainties are related to the features and phenomena that reduce the precision and accuracy of defining a shoreline position from a given data set such as:

a) seasonal error $E_s$, and
b) tidal fluctuation $E_{td}$ (tide range from nearest station).

Measurement uncertainties are related to the skill and approach such as;

c) digitizing error $E_d$,
d) rectification error $E_r$ and
e) pixel error $E_p$.

Finally, total uncertainty value $E_T$ will be estimated for each shoreline by accounting both positional and measurement uncertainties asthe square root of the sum of squares (Hapke et al., 2010) of the relevant uncertainty terms, as:

$$E_T = \pm\sqrt{E_S^2 + E_{td}^2 + E_d^2 + E_P^2 + E_r^2}$$

The uncertainty of the shoreline change, $U_E$ applied by any of the above methods is found as the quadrature addition of the uncertainties for each year's shoreline position, divided by the number of years between the shoreline surveys, as:

$$U_E = \frac{\sqrt{U_1^2 + U_2^2}}{year_2 - year_1}$$

where $U_1$ and $U_2$ are the errors associated with each shoreline position.

*The above presented methods of shoreline change assessment and uncertainties evaluation will be followed at all pilot study areas of HERMES project.*

## 8. Evaluation of coastal erosion and climate change vulnerability indicators

In science an indicator is considered as an inherent characteristic that quantitatively estimates the condition of a system offering people a sense of the “bigger representation”.

In terms of environmental systems, it appears that all systems are in hazard, but their **vulnerability reflects the possible damages that can be expected in the case of an event**. Therefore, vulnerability is considered as the extent of harm, which can be expected under certain conditions of exposure, susceptibility and resilience (Balica et al. 2009; Hufschmidt 2011; Scheuer et al. 2010; Willroth et al. 2010; Fuchs et al. 2011).

However, the concept of vulnerability is closely related to other concepts, such as hazard, risk and resilience. Hazards may be divided into technological hazards and into hazards associated with natural extreme events (like storm surges, tsunamis, etc.). Risk introduces a quantitative or qualitative estimate of probability of possible events and the likely impacts related to these events. Finally, resilience is the maximum possible disturbance that a system may receive to remain at the same state or to maintain its functions. Therefore, resilience is directly related to the capacity of the system to re-organize, renew and re-build itself, thus its adaptive capacity.

In the coastal zone, and in view of the ICZM approach, several coastal vulnerability indicators have been developed. The simplest assess the physical vulnerability of the system, e.g., the Coastal Vulnerability Index (CVI) initially proposed by Gornitz et al., (1991) and modified by Thieler (2000), and the Beach Vulnerability Index (BVI) introduced by Alexandrakis and Poulos (2014).

Other more complex indicators were gradually introduced to include the social dimension of the coastal system, as the Social Vulnerability Index (SVI) by Boruff et al., (2005), socio-economic indices as the Risk Matrix (Hughes and Brundrit, 1992) and the Sustainable Capacity Index by Yamada et al., (1995).

The CVI is the mostly used vulnerability index to assess the impact of coastal erosion and climate change. It provides a simple numerical basis for ranking sections of coastline in terms of their potential for change. This information may later be used by coastal managers to identify regions where risks may be relatively high. The CVI results can be displayed on maps to highlight regions where the factors that contribute to shoreline changes may have the greatest potential to contribute to changes to shoreline retreat (Gutierrez et al., 2009).

The first methodological step deals with the identification of key variables and their respective significant driving processes affecting coastal vulnerability. In general, CVI formulation includes the 6 to 7 main variables that shape the physical environment of the studied area. The second step deals with the quantification of these variables. Quantification is based on the definition of semi-quantitative scores according to a 1-5 scale (Gornitz, 1990; Hammer-Klose and Thieler, 2001), where score 1 indicates a low contribution to coastal vulnerability of a specific key variable for the studied area or sub-areas, while 5 indicates a high contribution. Finally (third step), all key variables are integrated into a single index.

The physical parameters used widely in CVI estimation are:

1. Geomorphology;
2. Historic Shoreline Change Rates;
3. Coastal Slope;
4. Relative Sea Level Change Rate;
5. Mean Significant Wave Height;
6. Mean Tidal Range.

CVI is calculated as

$$CVI = \sqrt{\frac{1 \times 2 \times 3 \times 4 \times 5 \times 6}{6}}$$

Based on CVI results, the studied coastal area may be classified as:

- Low Vulnerability Area: 2.23 < CVI < 6.32;
- Medium Vulnerability Area: 6.32 < CVI < 10.00;
- High Vulnerability Area: 10.00 <CVI < 14.14); and
- Very High Vulnerability Area: 14.14 < 35.35.

*In HERMES the above-described version of CVI will be followed. This CVI has been proposed by EEA (2011) and by numerous USGS reports. The following table will be used for each key parameter estimation.*

*Data for key parameter 1 (geomorphology) will be based on experts' opinion, for parameter 2 (relative shoreline change rate) on the assessment of coastal erosion based on satellite images, for parameter 3 (coastal slope) on topographic and bathymetric maps, for parameter 4 (relative sea level change) on data recorded by the oceanographic station, for parameter 5 (significant wave height) on data recorded by the oceanographic station and for parameter 6 (mean tidal range) on data recorded from the oceanographic station.*

*Table 2. Key parameters and their respective scores for CVI estimation along all pilot study sites of HERMES project.*

| Key Variables | 1, Very Low | 2, Low | 3, Moderate | 4, High | 5, Very High |
|---|---|---|---|---|---|
| Geomorphology | Rocky, cliffed coasts | Medium Cliffs, indented coasts | Low cliffs, alluvian plains | Cobble beaches, estuary, lagoon | Barrier beaches, sand beaches, deltas |
| Historic Shoreline | > 2.0 m, accretion | 1.1 to 2.0 m, accretion | -1.0 to +1.0 | -1.0 to -2.0, erosion | > 2.0 m, erosion |

| | | | | | |
|---|---|---|---|---|---|
| Change (m/yr) | | | | | |
| Coastal Slope | > 1/10 | 1/10 to 1/20 | 1/20 to 1/30 | 1/30 to 1/50 | 1/50 to 1/100 |
| Relative Sea Level Change (mm/yr) | <1.0 | 1.0 to 2.0 | 2.0 to 5.0 | 5.0 to 7.0 | >7.0 |
| Mean Significant Wave Height (m) | < 0.5 | 0.5 to 3.0 | 3.0 to 6.0 | 6.0 to 8.0 | > 8.0 |
| Mean Tidal Range (m) | > 6.0 | 4.0 to 6.0 | 2.0 to 4.0 | 0.5 to 2.0 | < 0.5 |

## 9. Understanding of the relative influence on coastal erosion of human interventions

To assess the relative influence of human interventions in the studied coastal zone, the methodology proposed by Özyurt (2007) will be followed. A CVI index for Human Pressure is developed based on the following parameters, as described in Table 2:

- Sediment supply reduction, estimated as the ratio of present sediment supply to the natural state sediment supply. It mostly includes the sediments trapped in dams or reservoirs at the upstream of rivers and the sediment excavated by the coastal zone.
- River flow regulation, estimated as the amount of impact of any regulative structure on rivers at the down drift in terms of the flow rate. There are three ranges considered, as the strongly affected, moderately affected and not affected. Nilson et al. (2005) estimated the river flow regulation as the percentage of river volumetric annual discharge that can be contained in reservoirs constructed in the watershed. In case no data is available, then 50% of the river gross capacity may be used. Fragmentation is also important for river flow regulation, describing the longest portion of the main channel left without dams in relation to the total channel length (not affected, up to 75%; moderately affected, from 75 to 30%, and strongly affected > 30%).
- Engineered frontage, estimated as the percentage of the shoreline occupied and affected by coastal structures. In this category the following structures are included: harbors, marinas, jetties, navigation channels, as well as any coastal protection structures.
- Groundwater consumption, estimated as the ratio of annual groundwater usage to the total annually available groundwater.

- Land use pattern, indicating again the pressure to groundwater. The area is more vulnerable in case the watershed is more agricultural or industrial and less vulnerable if protected.
- Natural protection degradation, describing the status of natural protection of the coastal zone. In case the area in terms of natural protection is healthy then resilience to sea level rise is high.
- Coastal protection structures, is expressed as the percentage of coastline occupied by these structures as groins, seawalls, barriers, etc. If properly designed, coastal protection structures increase the resilience of the area.

*Table 2. Parameters of human influence and the corresponding ranges.*

| Human Parameters | 1, Very Low | 2, Low | 3, Moderate | 4, High | 5, Very High |
|---|---|---|---|---|---|
| Reduction of sediment supply | >80% | 60-80% | 40-60% | 20-40% | <20% |
| River flow regulation | Not affected | | Moderately affected | | Strongly affected |
| Engineered frontage | <5% | 5-20% | 20-30% | 30-50% | >50% |
| Ground water consumption | <20% | 20-30% | 30-40% | 40-40% | >50% |
| Land use pattern | Protected area | Unclaimed | Settlement | Industrial | Agricultural |
| Natural protection degradation | >80% | 60-80% | 40-60% | 20-40% | <20% |
| Coastal protection structures | >50% | 30-50% | 20-30% | 5-20% | <5% |

Then, the value of CVI for human impact assessment can be derived by:

$$CVI_{HP} = \frac{\sum_{i=1}^{5} Total\,\mathrm{Im}\,pact}{\sum_{i=1}^{5} Least\,Vu\,\mathrm{ln}\,erable\,Case}$$

The vulnerability on human pressure is classified as:

- Very low vulnerability: $1 \leq CVI_{HP} < 1.5$;
- Low vulnerability: $1.5 \leq CVI_{HP} < 2.5$;
- Moderate vulnerability: $2.5 \leq CVI_{HP} < 3.5$;
- High vulnerability: $3.5 \leq CVI_{HP} < 4.5$;
- Very high vulnerability: $4.5 \leq CVI_{HP} \leq 5.0$.

## 10. Analysis of environmental and socio-economic databases at local/regional scale

The following factors will be considered to assess the Social Vulnerability Index (SVI):

- Demographic factors
    a) Population within 100 km from coastline, to indicate population at risk of any climate change impact;
    b) Population density, to indicate population at risk;
    c) Female to male ratio, to indicate population at risk;
    d) Population over 50 and below 10, to indicate population at risk
- Employment factors
    a) Agricultural employees, to indicate dependence on agriculture;
    b) Rural population, to indicate dependence on agriculture;
    c) Agricultural area, to indicate dependence on agriculture.
- Economic factors
    a) GDP per capita of the area in comparison to national, to assess the wealth of the area;
    b) GINI coefficient of the region, to indicate the inequality in wealth in the region;
    c) Seasonal unemployment rate, to indicate the weather sensitivity of the economy of the region;
    d) Urban, industrial and touristic living in the region, to indicate the stage of development in the region.

- Natural resources and education factors
    a) Protected land area, to indicate the environmental stress;
    b) Unpopulated land, to indicate the environmental stress;
    c) Water resources per capita, to indicate the water sustainability;
    d) Groundwater use per capita, to indicate the groundwater sustainability and salt water intrusion resilience.

## 11. Coastal web-based PPGIS development

PPGIS is a Public Participatory Geographic Information System. It is a visualization tool that taps local knowledge; a facilitator that encourages people to think spatially. Encourages people to think about how they would like their coastal zone to look. An opportunity to share local knowledge and discuss prevalent issues.

The HERMES PPGIS system is expected to serve key coastal local actors, as:

a) local authorities and services, faced with intense coastal development pressures and concerned about the increasing risks for natural hazards;

b) other government and elected bodies (horizontal, vertical and cross-national) relevant to ICZM in general and to spatial planning in particular;

c) Civil-society bodies (NGOs) with special interest on the built coastal environment; and

d) all coastal stakeholders and residents seeking to benefit from public access and sustainable use of coastal resources for navigation (ports), fishing, environmental quality, tourism, conservation, improved built environment and economic development.

Presently all these groups are insufficiently aware of coastal planning and management issues and face difficulties in accessing information.

The HERMES PPGIS is expected to formulate a functional unit embedded within the operational framework of users' day-to-day operation, aiming to collect, analyze, process and ultimately expose historic, present and forecasted ICZM datasets from satellite images, on-line instruments and numerical models.

All data collected during all processes and tasks of HERMES project will be imported in the PPGIS system. These will be the 'key' data layers needed to be incorporated into the PPGIS of all pilot study sites. The PPGIS user will be able to receive all the appropriate background data required for coastal zone management, with special emphasis on erosion and climate change. In this way, it is ensured that the PPGIS user can formulate a complete view of the current management status of the coastal zone and has available all the relevant information to recognize problems and indicate alternatives.

All data will be available in standard editable GIS standard formats, like shape file (ArcGis) or tab (Mapinfo) format. Keyhole Markup Language (KML) data format has become one of the most common and widely applied geographical data format, as it can be easily created and formatted and it is supported by several conventional GIS systems, while it takes advantage of the fact that it can be produced, modified and viewed in the very popular Google Earth application. KML is supported by a wide variety of web-based map servers.

Considering the above, the GIS datasets collected will be properly processed and KML files will be produced for each dataset. Then, the produced KML files will be further organized and finally, a KMZ file including all KMLs for each pilot study site will be created.

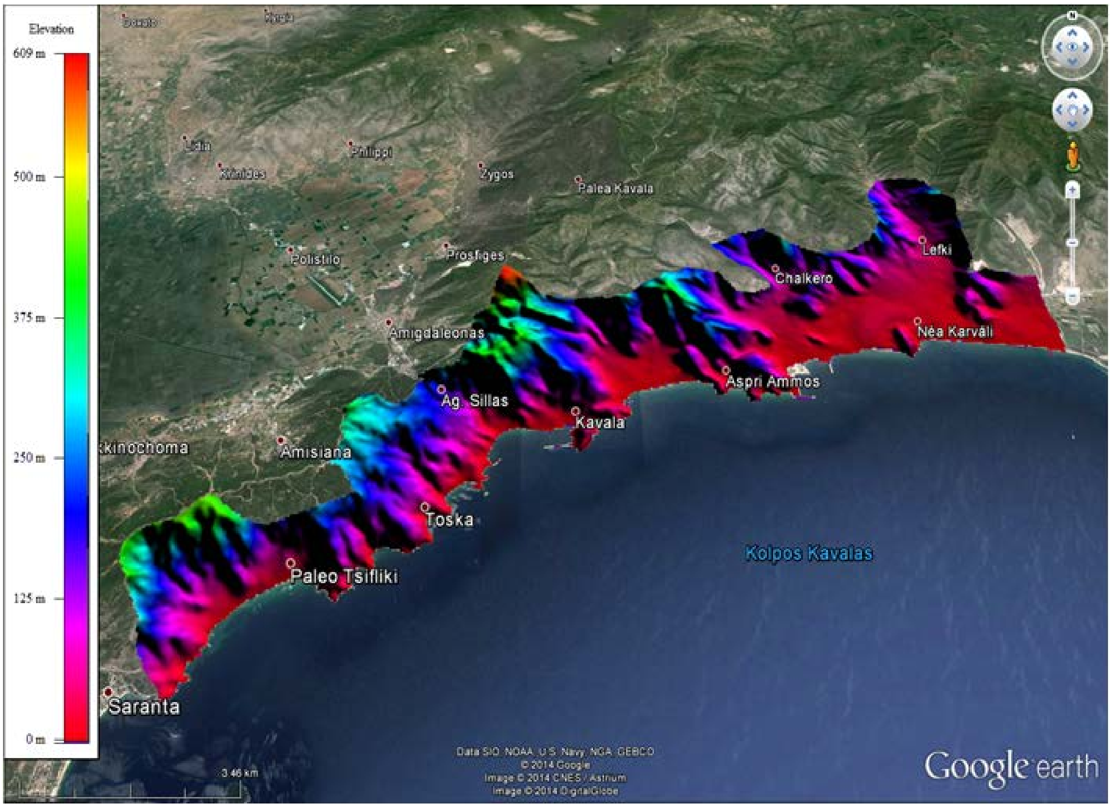


*Figure 5. A PPGIS example - Screenshot of a Digital Elevation Model of Kavala Municipality, as presented by the Google Earth software.*

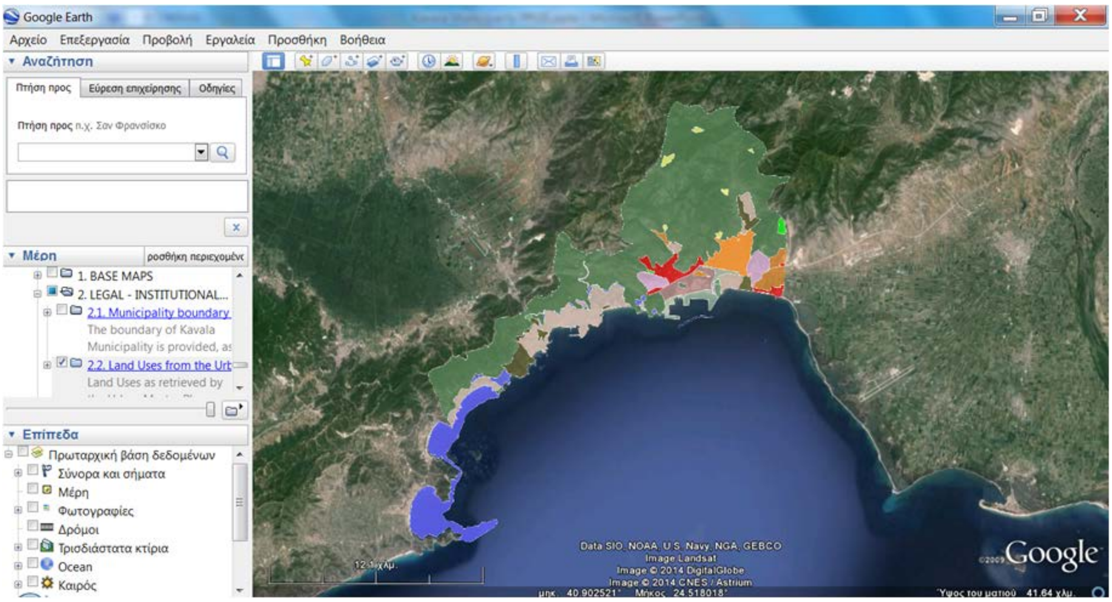


*Figure 6. A PPGIS example - Land uses based on Corine 2000, as presented in the Google Earth PPGIS.*

## 12. Development and application of a novel modeling toolkit

Numerical models are commonly used in the DPSIR framework, as they allow the generation of predictions on potential levels of selected impacts, giving the opportunity to policy and decision-makers to proceed to pro-active management actions. The ICZM Observatory of Kavala Municipality is equipped with a series of coupled and nested numerical models, aiming to provide short-term prognostic results on various environmental parameters.

The model 'chain' (Figure 7) starts with the 'state of the art' meteorological models Weather Research and Forecasting (WRF) model, version 3.5.1 (Skamarock et al. 2008) and The Air Pollution Model (TAPM) (Hurley et al. 2005). Both models are initiated and forced utilizing information for initial and boundary conditions downloaded from NOAA/GFS. These meteorological models offer regional/local short-term predictions at a grid scale of 500 m on several meteorological parameters for the next five days. Model results are daily evaluated based on a series of local meteorological stations covering the study areas of interest. Rainfall depths predicted by the meteorological model are further utilized by the hydrological model SWAT 2009 (Neitsch et al. 2011), to predict the level of discharge, and potentially the risk of flooding, at local streams and torrents. Freshwater outflux among with winds, tides and meteorological variability are imported as boundary conditions to the coastal three-dimensional hydrodynamic model ELCOM (Hodges and Dallimore 2001), to reproduce the predicted flow field, with a high grid resolution. ELCOM model is forced from the open ocean boundary using the daily updated myOcean model datasets, thus utilizing operational Copernicus Program products. Further, the water column flow field, the stratification-mixing patterns and the primary production, expressed as chlorophyll-a concentration, is locally forecasted using the 1-D model PHYTO (Sharples 1999). Finally, wind speeds and directions produced by the meteorological model as short-term forecasts are imported on SWAN wave model (Booij et al. 1999), implemented at three gradually increased in resolution nested grids, to produce the wave characteristics (significant wave height, wave period and propagation direction) predicted at all beaches of Kavala Municipality (Anastasiou and Sylaios 2013).

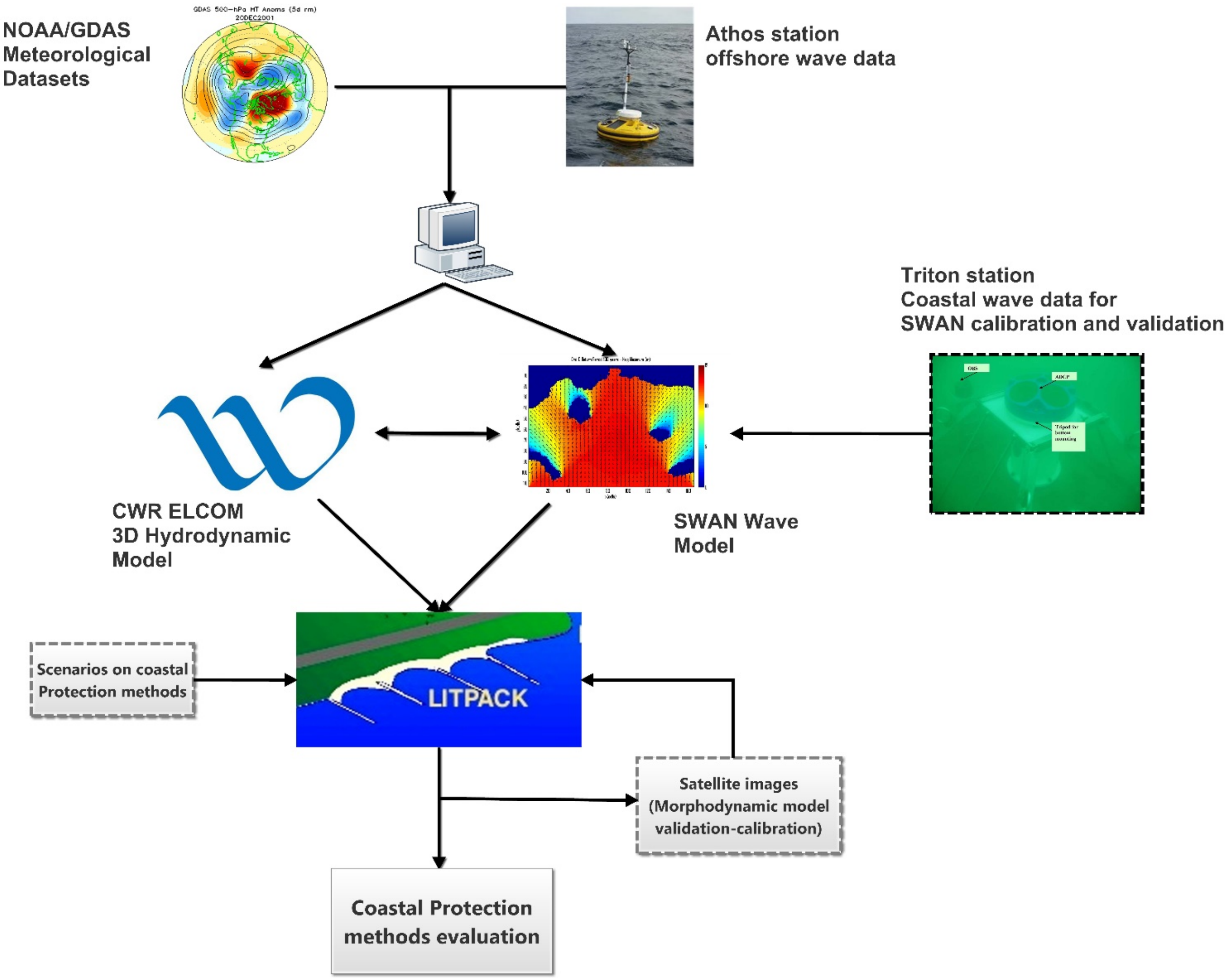


*Figure 7. An indicative model chain to be developed and applied at all HERMES study sites.*

## 13. Deployment of real-time monitoring station at each study site

Within the framework of HERMES project, a bottom-mounted upward facing Acoustic Doppler Current Profiler (ADCP) will be deployed at each pilot study site to comprise a real-time oceanographic monitoring station. The station will have the capacity to record the full profile of water column currents, the sea level change, the wave parameters (significant wave height, wave period and propagation direction) and the estimate of suspended particulate matter (SPM) concentrations. Data will be collected, stored at internal memory and transferred to a land station at real-time operational mode. The station (hardware) will be equipped with an advanced software to communicate with the oceanographic station, retrieve data, and eventually store, process, analyze and visualize the current, wave and SPM data.

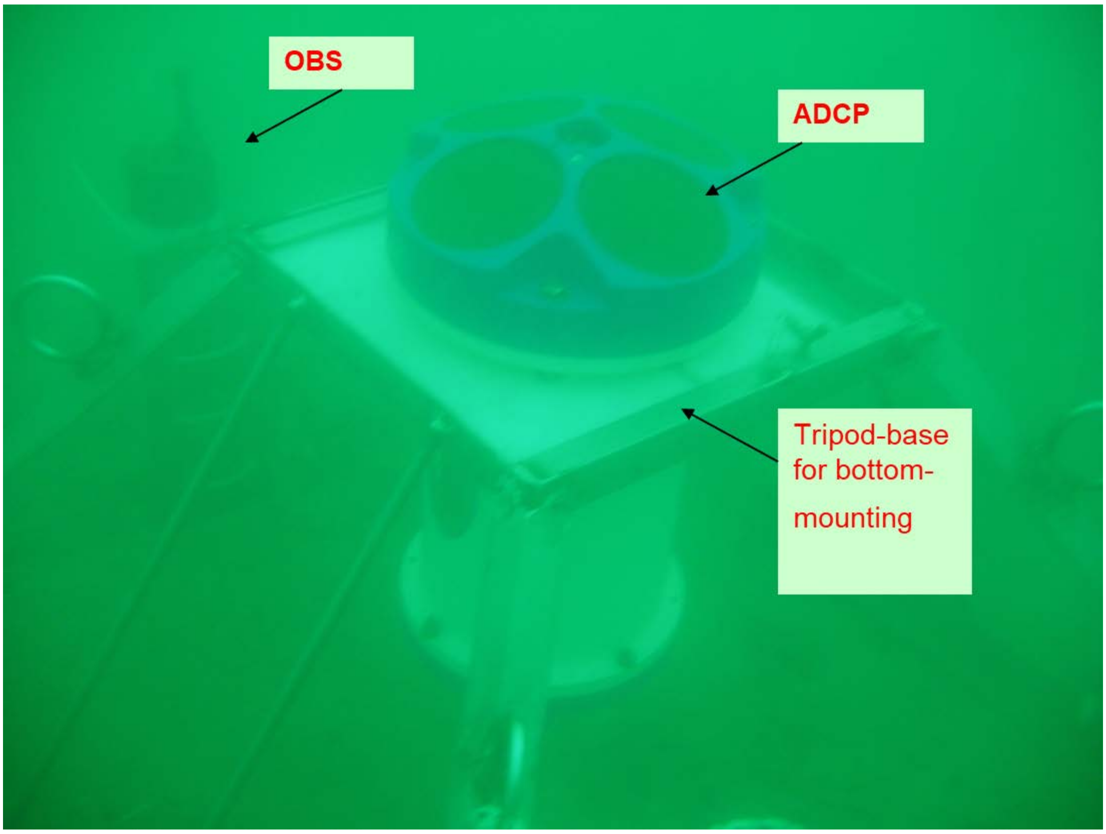


*Figure 7. Bottom-mounted upward-facing ADCP.*

The following technical specifications should be met:

1. The oceanographic station should be able to record the sea level change (due to tide and storm surge), the waves, the currents, and estimate the concentrations of suspended particulate matter at specific cells throughout the water column. The system should be able to transfer collected data at **real time mode** and will be comprised by the following elements:

   a) an echosounder with four acoustic beams emitting/receiving sound in the range between 500 KHz and 1 MHz, bottom-mounted upward-facing at a depth of 15-20 m at the pilot study site (the exact location will be indicated by the respective HERMES partner), for the monitoring of:

      - three-dimensional current profiles (u, v and w-velocity components) at distinctive layers (cells) with thickness from 0.25 to 4 m, throughout the whole water column above the oceanographic station,
      - the wave characteristics (significant wave height, wave period, wave direction of propagation) at the sea surface,
      - the change in sea level due to tides and storm surges,
      - the estimate of suspended particulate matter concentration (in mg/l) at distinctive layers (cells) with thickness from 0.25 to 4 m, throughout the whole water column above the oceanographic station,

b) a tripod serving as the base to mount the instrument at sea bottom,

c) safe anchoring at sea bottom for the instrument,

d) a surface buoy of at least 1 m diameter, equipped with solar panels for the appropriate energy supply of the system,

e) safe anchoring at sea bottom for the surface buoy,

f) a high strength cable of appropriate length to ensure data transfer from the bottom-mounted instrument to the surface data-logger positioned in the surface buoy, and

g) a datalogger for data storage equipped with a telecommunication data transfer system (GPRS modem) for the real-time data transfer to a land-based PC.

Additional technical specifications involve:

- The echosounder system should have an internal battery to ensure as much as possible energy autonomy of the monitoring system,
- The echosounder should have at least 2 analogue input channels allowing the future additional sensor installation,
- The echosounder should be equipped with an internal memory of at least 4GB, to ensure data storage in case of standalone use,
- The echosounder should be equipped with an internal compass and pitch and roll sensors to report deviations from horizontality,
- The estimate of SPM concentration (in mg/l) should be derived from processing the acoustic backscatter intensity (ABI) data recorded by the echosounder,
- The cable for data transfer should be appropriate for long-underwater operations,
- The echosounder should comply with all international standards (EN 61000-6-4) as declared by relevant accompanying documents and have a guarantee for at least one year of full operational use by the manufacturer.
- The supplied hardware and software should be able to compute internally at real time mode the typical directional wave parameters, as $H_{max}$, $H_{1/10}$, $T_{mean}$, and wave propagation direction.
- The system should be also able to operate as bottom-mounted at higher depths recording the typical directional wave parameters, as $H_{max}$, $H_{1/10}$, $T_{mean}$, and wave propagation direction.
- The telecommunication system (modem) for data transfer should ensure the safe and easy transfer of data using the GPRS technology, or any other appropriate for the study area technology, allowing the real-time processing and visualization of data at the land system.
- The surface buoy should have a height of at least 1.5 m above sea surface and weight over 100 kg. The system should be visible by nearby vessels. The system should be

equipped by all navigation safety systems. The buoy should be made by high resistivity to solar radiation plastic.

- The surface buoy should have the appropriate safe and waterproof space to accommodate any electrical/electronic devices, batteries, dataloggers and telecommunication modems.
- The datalogger should comply to international standards as IEC61326:2002, should have an internal memory of at least 4MB, should have low energy requirements (e.g., operation at sleep mode up to 0.7 mA), and protection from transitional hyper-voltages, electrostatic incidents and electromagnetic interventions.
- The recording and storage system should allow a min sampling rate of 60 Hz, should have serial ports and capacity to communicate with protocols HTML, POP3, SMTP, Telnet, NTCIP, NTP, HTTP, FTP.
- It should be ensured that all communication protocols between the echosounder and the datalogger and any other element of the system are compatible and operational.
- The datalogger system and the energy supply system should have a guarantee of good operation for at least two years,
- The contractor should undertake all expenses related to the transfer of the system and its elements at the location of installation, costs related to customs clearance, and all administrative costs and procedures until its final deployment, operation of the system and the real-time transfer of data at the premises of the respective HERMES partner.

The requested oceanographic parameters will have to be recorded according to the following specifications and standards:

| | | |
|---|---|---|
| 1. Horizontal Velocity (u, v) | Measurement Range | ±10 m/s |
| | Measurement Accuracy | ±0.5 cm/s |
| 2. Vertical Velocity (w) | Measurement Range | ±5 m/s |
| | Measurement Accuracy | ±0.005 cm/s |
| 3. Sea Level | Measurement Range | 0 – 50 m |
| | Measurement Accuracy | ~ 0.5% of full scale |
| 4. Wave | Sampling rate | 2 Hz with capacity to record up to 2048 data per sampling |
| 5. Wave Height | Measurement Range | Up to 15 m |

| | | |
|---|---|---|
| | Measurement Accuracy | ~ 1 cm |
| 6. Wave Period | Measurement Range | 0.5 to 50 s |
| 7. Direction of wave propagation | Measurement Range | 0-360º |
| | Measurement Accuracy | 2º |
| | Measurement Resolution | Per 0.1º |

The licensed software accompanying the above described system should be able to collect, process and analyze data transferred from the oceanographic station (waves, sea level, currents and SPM concentration profiles) at real time mode.

The software will be installed at a PC or laptop determined by the respective HERMES partner and will allow:

a) To perform data quality and reliability tests, data transformation tasks and the synchronization of all initially collected measurements,

b) To analyze and process data the collected and cleaned datasets of waves, sea level, currents and SPM concentrations,

c) To produce the energy and directional wave spectrum per data ensemble.

In addition, a web-based version of this software should allow the management and visualization of data from any remote computer through the internet. This web-software should allow:

a) The creation of diagrams and comparative diagrams between one or more sets of data (sea level, significant wave height, wave period, direction of wave propagation, u, v, w-currents),

b) The creation and maintenance of database containing all recorded and cleaned datasets,

c) The direct receipt and storage of measurements as recorded by the oceanographic system through the GPRS cell phone network,

d) The capacity to receive and process data from more than one oceanographic station (system expansion in future),

e) The presentation and visualization of historic data recorded from the oceanographic station(s),

f) The management and visualization of data by authorized users,

g) The transformation of data to any other data format (as CSV, Ascii data files),

h) The capacity to alert the administrator in the case of extreme values, errors and misfunctions of the system, through SMS and e-mails,

i) The visualization of alerts and alarms of each parameter in a graphical form.

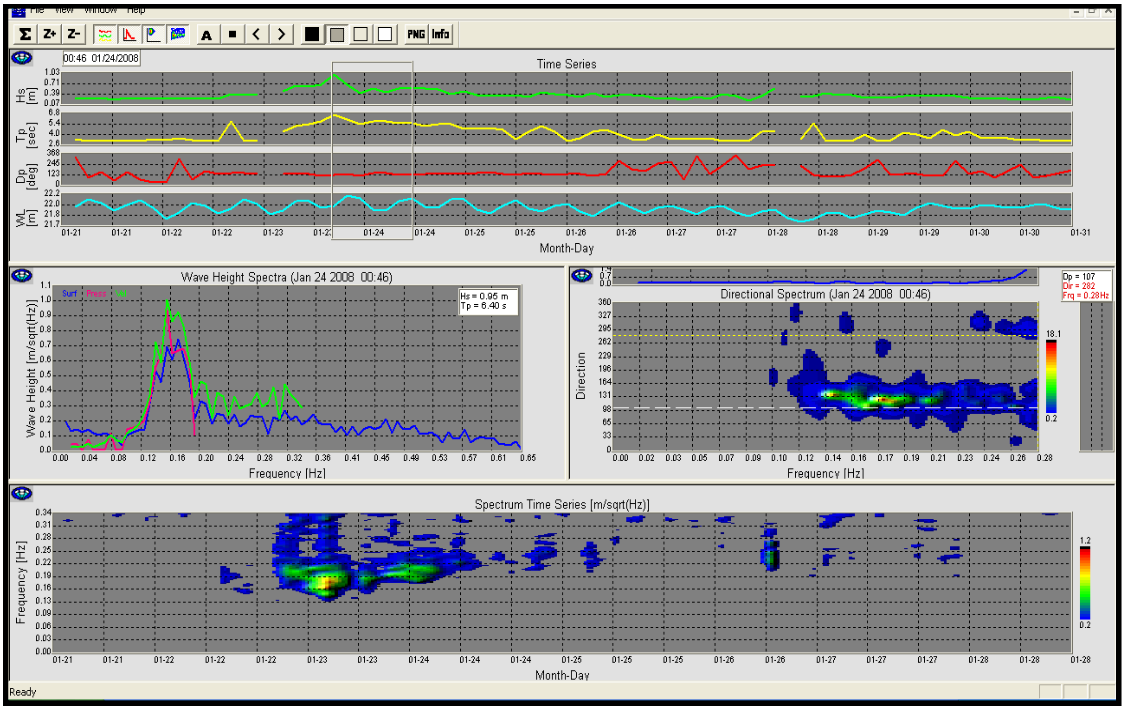


*Figure 8. Indicative software for sea level and waves visualization and analysis.*

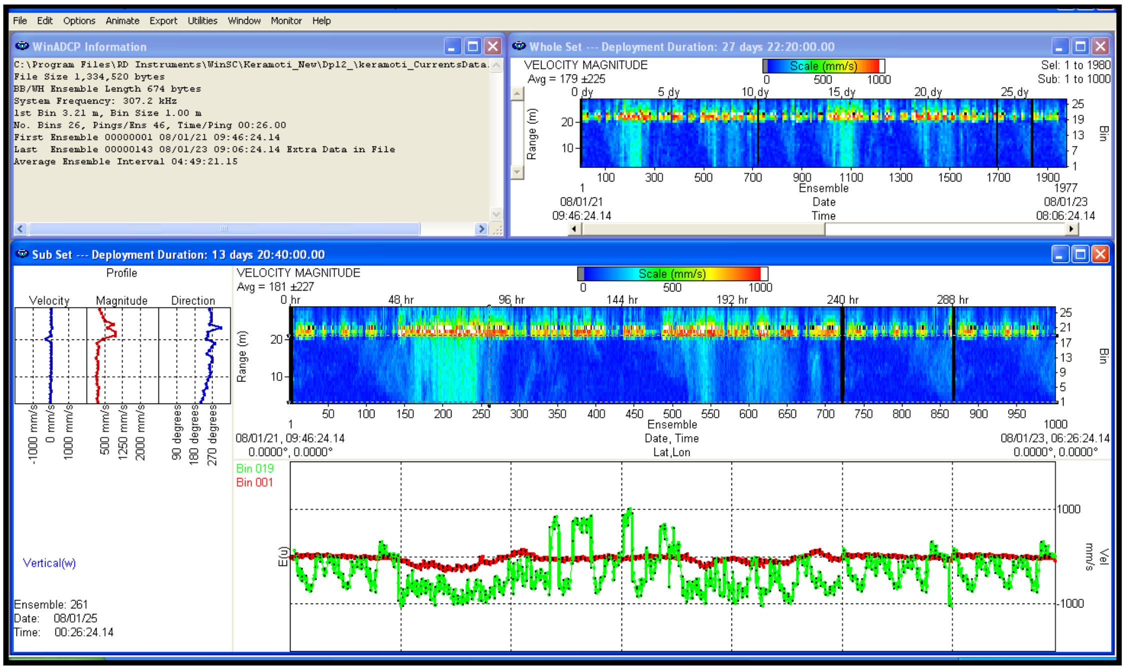


*Figure 9. Indicative software for the visualization and analysis of currents as profiles and as time-series.*

## 14. Evaluation and testing of intervention scenarios for mitigation works

Operational model results from the hydrodynamic and wave models at all four study areas will be validated based on observations collected by the monitoring stations.

Several validation criteria will be used for this assessment, as:

a) The Root Mean Square Error (RMSE) and the Scatter Index (SI) of the modelled and observed values of significant wave height, $H_S$, and zero-up-crossing period, $T_{02}$. RMSE is defined as:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{N}\left(y_i - \hat{y}_i\right)^2}{N}}$$

where $y_i$ represent the observed time-series of $H_S$ and $T_{02}$; $\hat{y}_i$ are the corresponding model values; and N is the total number of dataset. The parameter RMSE should be as close to 0.0 as possible for good prediction. The Scatter Index is defined as the ratio of the RMSE normalised by the mean of the observed values, expressed as:

$$SI = \frac{RMSE}{average\,observed\;value}$$

SI has to be as close to 0.0 as possible, but a value less than 1.0 is generally accepted.

The validity of these models could also be tested through scattergrams, which are graphs of the predicted versus measured $H_S$ and $T_{02}$ values. Best match occurs when all points fall on a 1:1 slope line. Deviation from that line is measured by fitting through the points a straight regression line of the following equation:

$$y_i = \gamma\,\hat{y}_i$$

If this slope $\gamma$ is less than 1.0, the model underestimates the observed data. If the slope $\gamma$ is greater than 1.0, the model overestimates the observed values. Another parameter that evaluates the accuracy of the agreement is the squared correlation coefficient $R^2$, which shows whether data scatter are around the best fit line. The closer $R^2$ is to 1.0 the less the points are scattered around the straight line. $R^2$ is defined as:

$$R^2 = \frac{ssr}{sst}$$

where $ssr = \sum_{i=1}^{N}(\hat{y}_i - \bar{y})^2$ and $sst = \sum_{i=1}^{N}(y_i - \bar{y})^2$ where $\bar{y}$ is the mean observed value.

c) Finally, model's performance under extreme wave height conditions could be tested using the detection rate (DR) and the false alarm rate (FAR) parameters. DR is defined as the ratio between the number of modeled episodes in which $H_S$ exceeded the threshold value of 3.5 m, and the number of the observed extreme wave episodes, while FAR as the ratio of false alarms predicted by the model to the total number of observed episodes.

In terms of shoreline morphodynamics model validation will be implemented utilizing the reconstructed coastlines derived from the collected and analyzed satellite images. Validation will be carried out by comparing the average annual shoreline regression/accretion rate, as calculated by the results of each model application, with the results of the satellite images, in order to determine whether the main erosion/accretion areas coincide in both cases.

The morphodynamic model will then be applied to select the most appropriate protection method, focusing on the certain sectors of the study areas where coastal erosion appears eminent. The assessment study of different protection methods will be performed on the shoreline evolved by the model throughout the reconstruction period. Scenarios may involve a) multiple rubble-mound groynes, having variable lengths and distances between them; b) multiple low-crested rubble-mound breakwaters; c) beach restoration through beach nourishment.

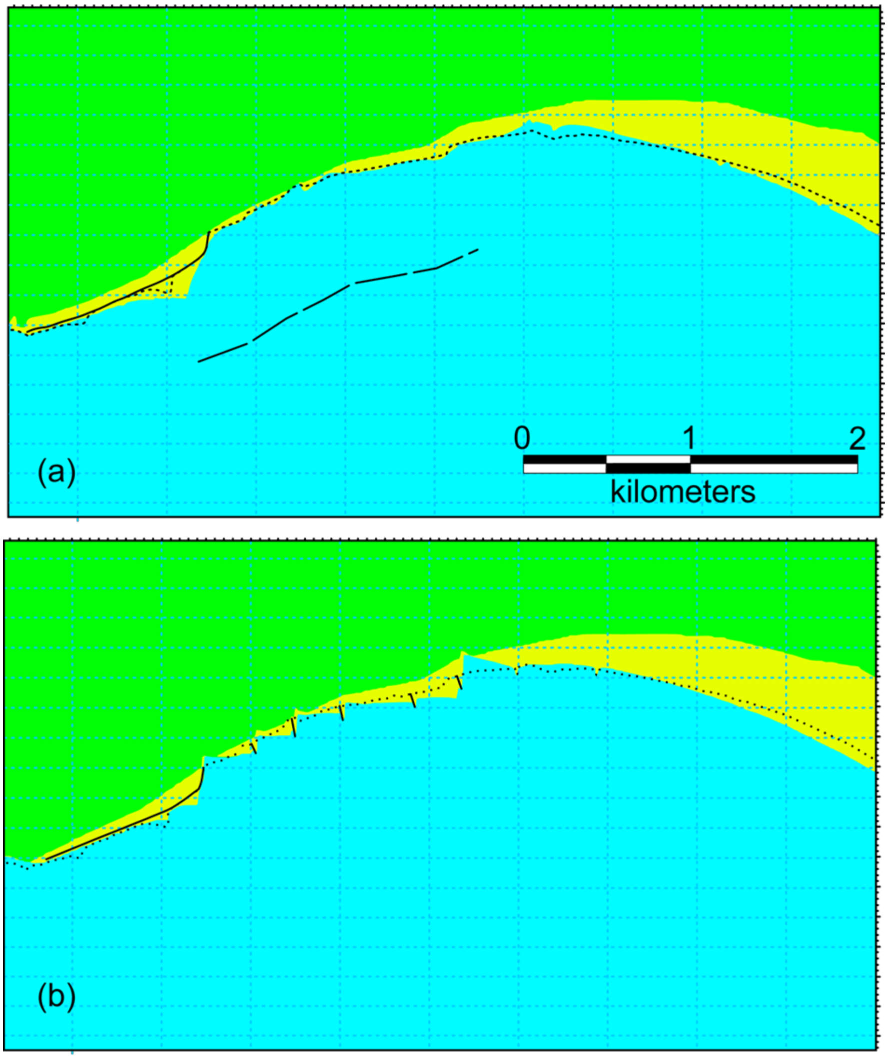


*Figure 9. Morphodynamic scenario analysis along the Nestos River shoreline (after Anastasiou & Sylaios, 2016).*

A statistical process of the model's results will be carried out for the entire shoreline regarding the regression or accretion rates from the original position throughout its length, as well as the computed sediment transport, expressed at mean annual values. Box-Whisker plots will be produced to illustrate the spatial variability produced by the morphodynamic model results under the various coastal protection scenarios.

## 15. Legislation and Policy recommendations

The methodological framework of this Task will be described by PP5.

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