



Photo: Boris Bašić

## Assessment of climate variability and change impacts and evaluation of response options (a case study of Croatia)

### AT A GLANCE

The “*Integration of climatic variability and change into national strategies to implement the ICZM Protocol in the Mediterranean*” project (“*ClimVar & ICZM*”) is a collective effort to promote the use of Integrated Coastal Zone Management (ICZM) in countries sharing the Mediterranean as an effective tool to deal with the impacts of climate variability and change in coastal zones, by mainstreaming them into the ICZM process. It was adopted in January 2012 and will be completed late in 2015.

The project is led by UNEP/MAP, within the framework of the MedPartnership project. Its executing partners are PAP/RAC, Plan Bleu/RAC and GWP-Med.

**Participating countries:** Albania, Algeria, Bosnia and Herzegovina, Croatia, Egypt, Libya, Morocco, Montenegro, Palestine, Syria and Tunisia.

Total budget: 9.2 million USD.

2.2 million, USD: Global Environment Facility  
7 million USD: Participating countries, executing agencies, and donors.

### ABSTRACT

The aim of this activity was to provide the tools to influence the current practice of unsustainable coastal development around the Mediterranean. Croatia is one of the Mediterranean countries with highest ratio of coastal length per inhabitant. Driven by tourism, this resulted in high coastal urbanisation, often of the ribbon type. The estimated costs that future generations will have to bear is expected to assist in developing the needed political will to change unsustainable coastal development patterns.

For this assessment the Dynamic Integrated Vulnerability Assessment (DIVA) method was selected. It focused on increased coastal flood risk in terms of the expected annual damage from extreme sea level events and dry land loss due to sea-level rise.

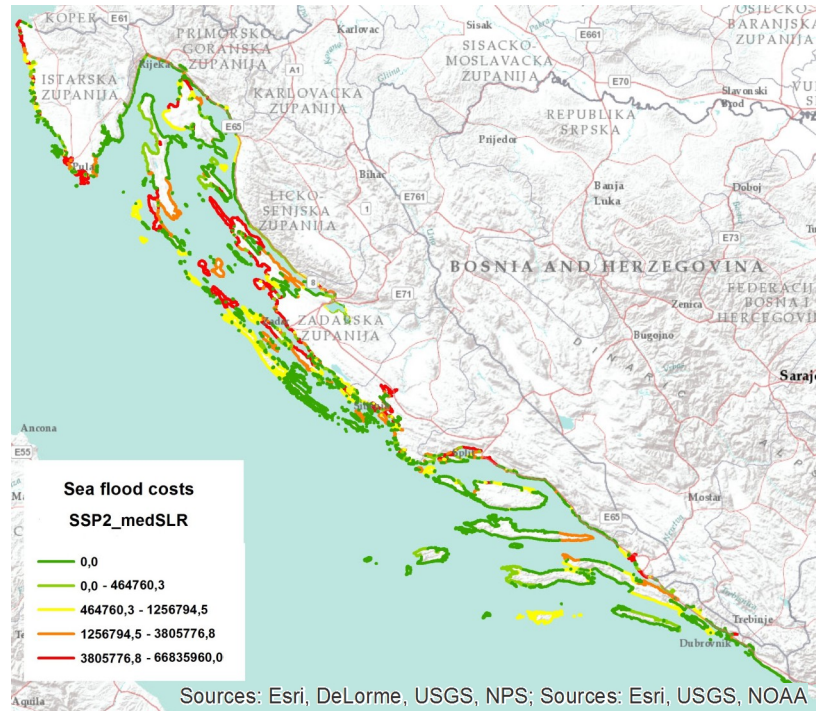
The assessment showed that the impacts of sea-level rise will be substantial in the 21<sup>st</sup> century for Croatia if no adaptation measures are implemented. Hard adaptation measures are still less costly than the possible damage.

## ACTIVITY DESCRIPTION

This activity used the most promising methodology to estimate the economic costs of climate variability and change (CVC), and applied it in two countries. All project countries were invited to apply if they could guarantee the necessary input data. From the countries that applied, Croatia and Tunisia were selected. The assessment for Croatia was completed in September 2015 and published as a report.

## THE EXPERIENCE

The DIVA model provided estimates of potential damage and adaptation costs for the Croatian coastal zone. Because of Croatia's ribbon-type coastal development and its low share of residential population, the key question for the future of Croatia, as well as for other Mediterranean touristic countries is – who will bear these costs?



## Addressing the Issue/Methodology

DIVA is an integrated, global research framework for assessing the biophysical and socio-economic consequences of sea-level rise and associated extreme water levels under different physical and socio-economic scenarios that considers various adaptation strategies. For the assessment on Croatia the application of DIVA focused on:

- increased coastal flood risk in terms of the expected annual damages of extreme sea level events (storm surges), in terms of monetary damages to assets and number of people affected, and
- dry land loss due to increased coastal erosion from sea-level rise and resulting damages

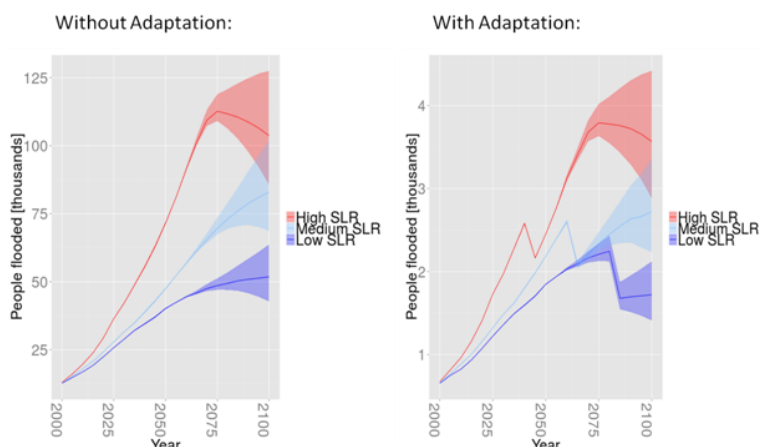
The assessment was based on three sea-level rise scenarios (a 21st century sea-level rise of 0.28m, 0.49m and 1.08m) and three socio-economic development scenarios based on the shared socio-economic pathways (SSPs). Impacts were assessed with adaptation and without adaptation in the form of upgrading dikes to protect against flooding and nourishing beaches and shores to protect against erosion.

For this project DIVA has been downscaled to the national level. Many Croatian institutions provided the required data. Some of the data were used as-is, while some were used to validate the data from global datasets. Particular attention was paid to estimating the value of coastal housing and tourism facilities, the data for which were obtained from the Tax Office of Croatia. DIVA method, as well as the results, together with the outputs from local vulnerability assessment, were discussed at Climagine workshops and Final ClimVar & ICZM workshop. The results serve as an input for the Marine and Coastal Strategy for Croatia.

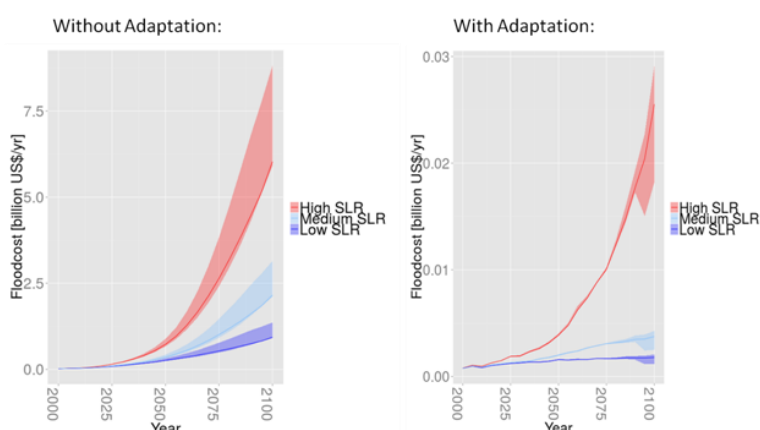
## RESULTS

The assessment showed that the impacts of sea-level rise in Croatia will be substantial in the 21<sup>st</sup> century if no adaptation measures are taken. The area of Croatian coastal zone exposed to the 1-in-100 year coastal extreme water level will increase from the current 240 km<sup>2</sup> to 320-360 km<sup>2</sup> in the late 21<sup>st</sup> century. The expected number of people flooded annually will increase from 17,000 in 2010 to 43,000-128,000 in 2100, and the expected annual damages from USD 40 million in 2010 to 0.9 to 8.9 billion per year in 2100.

The analysis also showed that impacts would be significantly reduced by applying the appropriate adaptation measures. Adaptation investment depends on the population density thresholds above which dike construction should take place. In case that segments with more than 30 inhabitants/km<sup>2</sup> are protected, this would result in protecting 84% of Croatia's coastline, costing USD 11.2 billion. In case that segments with more than 200 inhabitants/km<sup>2</sup> are protected the share of coastline to protect would be 49.6%, costing USD 6.5 billion. While these costs are substantial, they are at least one order of magnitude lower than the avoided damage costs. Compared to the impacts of sea-level rise on coastal flooding, coastal erosion was found to be a minor issue for Croatia.



Average number of people flooded until 2100 for the Croatian coast



Average annual flood costs until 2100 for the Croatian coast

## LESSONS LEARNED

By applying the DIVA method to the Croatian coast, the discrepancy between population projections and the intense coastal urbanization came into focus. Although the projections for Croatia indicate a population decrease, spatial plans allow for a 10-fold increase in the urbanized coast compared to before the 1960s. The highly seasonal character of tourism focused on “sun, sea and beach” encourages the construction of tourism facilities in the zone with the greatest danger from sea-level rise and related events. The expected increase in temperatures in July and August may result in a more favourable tourist distribution in the shoulder season making many of the existing capacities in the Mediterranean redundant in those months.

The outputs of the DIVA assessment summarize the potential costs of increasing the exposure of this high-density construction to sea-level rise and extreme water levels. The results identified hotspots of coastal vulnerability for which future assessments of specific adaptation options is needed, such as floodplain areas of Zadar and Šibenik. It should be highlighted that DIVA assesses dikes as the only adaptation option, even though there are many more options available, including the adjustment of already-established setback zones, green adaptation, or other visionary options, such as strategic retreat.

An interesting finding is that in Croatia the areas with high asset exposure to coastal flooding are not necessarily ones with high population exposure, and vice versa. For example, Vodice municipality has the fourth biggest value of assets in the floodplain, but at the same time it is not even among top ten areas regarding population in the floodplain.

## IMPACTS

The results of this assessment will be included in the Marine and Coastal Strategy for Croatia, and also in the National Strategy for Adaptation to Climate Change. This study was presented to the Inter-Ministerial Committee (IMC), established to prepare the Marine and Coastal Strategy for Croatia. The IMC is supported by the Med-Partnership Project, while the coastal part of the Strategy is a Med-Partnership replication project.

DIVA's results downscaled to the county level and the results of the local vulnerability assessment have been introduced into the coastal plan for Šibenik-Knin, which will in turn serve as a base for the county's spatial plan.

It is important to stress that neither coastal flood nor coastal erosion risks have been assessed before for Croatia. These new insights should be considered in future development and land-use plans, and accounted for in adapting the widths of setback zones to changing sea levels.

## REFERENCES

Priority Actions Programme/Regional Activity Centre (PAP/RAC)  
<http://www.pap-thecoastcentre.org/>  
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## KEYWORDS

climate change; sea level rise; coastal flooding; coastal management; adaptation

## EXECUTING PARTNER

PAP/RAC is established in 1977 in Split, Croatia, as a part of the Mediterranean Action Plan (MAP) of the United Nations Environment Programme (UNEP). PAP/RAC's mandate is to provide support to Mediterranean countries in the implementation of the Barcelona Convention and its Protocols, and in particular of the Protocol on Integrated Coastal Zone Management. PAP/RAC is oriented towards carrying out of the activities contributing to sustainable development of coastal zones and strengthening capacities for their implementation. Thereby, it co-operates with the national, regional and local authorities, as well as with a large number of international organisations and institutions.



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Strategic Partnership for the Mediterranean Sea Large Marine Ecosystem

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# MedPartnership



**Executing partners:** FAO, UNESCO/IHP, UNIDO, GWP-Med, MIO-ECSDE, WWF MedPO, UNEP/MAP's MEDPOL programme and regional activity centres (CP/RAC, SPA/RAC and PAP/RAC).

**Participating countries:** Albania, Algeria, Bosnia and Herzegovina, Croatia, Egypt, Lebanon, Libya, Morocco, Montenegro, Palestine, Syria, Tunisia and Turkey.

**Partner countries:** Albania, Algeria, Bosnia and Herzegovina, Croatia, Egypt, Lebanon, Libya, Morocco, Montenegro, Palestine, Syria, Tunisia and Turkey.



Photo: Nino Strmotić/PIXSELL