Assessing land use scenarios and climate change related risks in the Italian coast: an integrated approach supporting climate change adaptation

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Scientific conference on Coastal Risks: risks for societies' facing environmental changes versus risks for nature under human pressure

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SAVEMEDCOASTS
sea level rise scenarios along the mediterranean coasts

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Centro Euro-Mediterraneo per i Cambiamenti Climatici

Euro-Mediterranean Centre on Climate Change

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Focal Point IPCC in Italy:
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CMCC SCIENTIFIC DIVISIONS:

- **OPA – Ocean Predictions and Applications (Lecce):** models and methods for marine operational forecasting.
- **ODA - Ocean modelling and Data Assimilation (Bologna):** numerical models for global marine forecasts and the study of the interactions between the physical and biogeochemical processes of oceans.
- **CSP – Climate Simulations and Predictions (Bologna):** models of the Earth system, climate predictions and projections of climate change from seasonal to decadal scales.
- **ASC - Advanced Scientific Computing (Lecce):** optimization of models on emerging computational structures and advanced analysis of large volumes of data.
- **IAFES - Impacts on Agriculture, Forests and Ecosystem Services (Viterbo, Sassari):** diagnosis and prediction of the impacts on agriculture and terrestrial ecosystems, natural and semi-natural.
- **REMHI - REgional Models and Hydrogeological Impacts (Capua):** hydrological impacts related to climate change and dynamic/statistical downscaling techniques.
- **RAAS - Risk Assessment and Adaptation Strategies (Venice):** methods for the analysis of environmental impacts and risks related to climate change and natural hazards, and development of strategies and plans for adaptation to climate change.
- **ECIP - Economic analysis of Impacts and Policy (Venice):** translate into economic values climate scenarios, for designing the most appropriate policies to mitigate emissions and for adaptation to climate change.

1. Objectives

SAVEMEDCOASTS

sea level rise scenarios along the mediterranean coasts

Aims to respond to the need of people and assets prevention from natural disasters and sea level rise in Mediterranean coasts

http://www.savemedcoasts.eu

DG-ECHO (European Civil Protection and Humanitarian Aid Operations)

Provide guidance and criteria for risk and vulnerability assessment

Development of GIS-based maps and indicators ranking the coastal areas at higher risks

Improve risk governance and raise community awareness towards the impacts of climate change and sea level rise

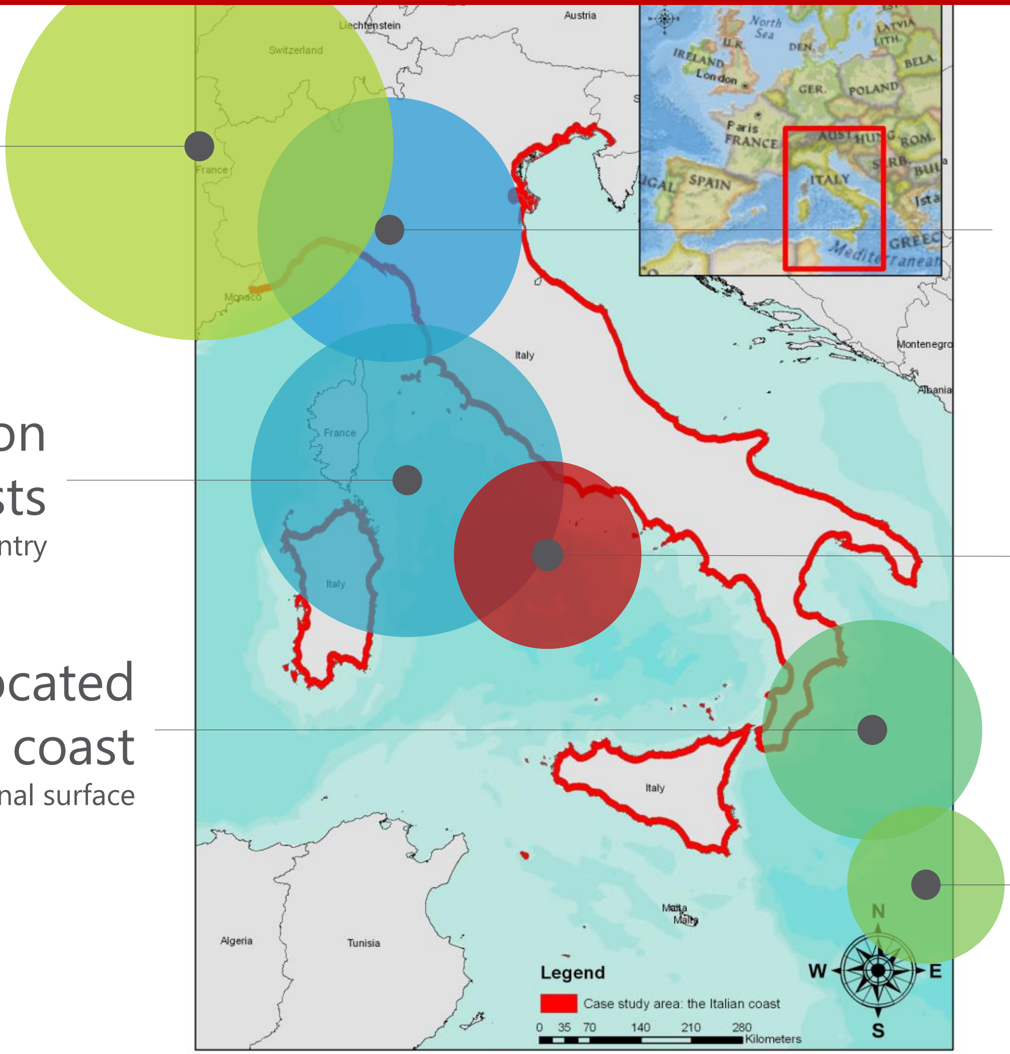
2. Case study area

How is Italian coastal vulnerability going to evolve as a consequence of climate and socio-economic changes?

A coastline of 8.970 km
Including the islands

28,4 % of the population living along the coasts
Most densely populated areas of the country

63 out of 107 provinces located along the coast
14.3 % of the national surface



Natura2000 sites cover 10.353,75 km^2

(23,3% of the coastal area)

Main issues:

- Biodiversity loss
- Flooding
- Erosion
- Saltwater intrusion
- Land take
- Pollution

Unique ecosystems and habitats
2314 ZSC

3. Methodology and data

Multiple methodologies and tools to evaluate coastal vulnerability :

CVI

- **One of the most commonly used method** to assess coastal vulnerability to SLR
- **Easy to use** for a scoping or "first look" assessment
- Simplified approach useful for communication purposes
- **Applicable** to different geographic contexts
- **Flexible** for multi-scale vulnerability appraisal
- **Expandable** to include a variety of heterogeneous indicators

DSS

Risk assessment

Models

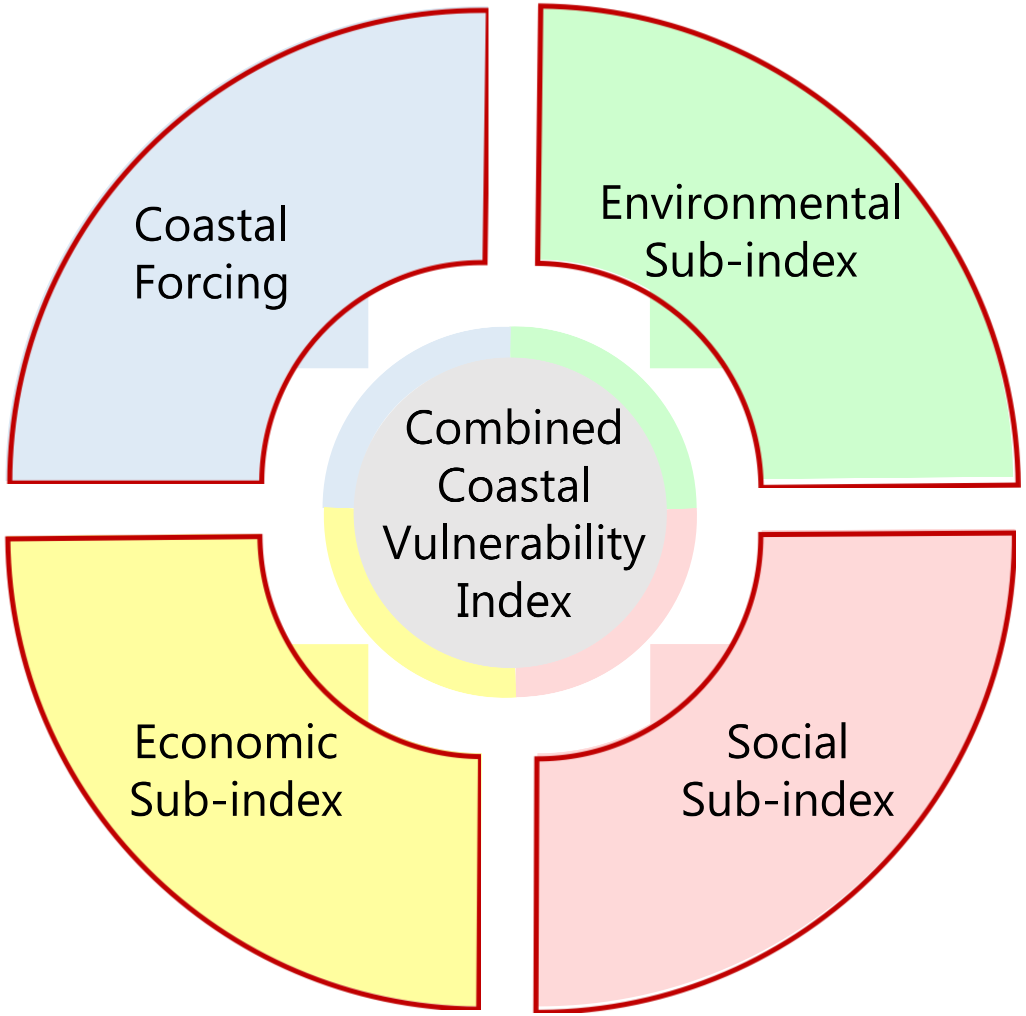
GIS

Indicators

Ramieri et al. (2011); Zanuttigh et al. (2013); Torresan et al. (2016)

3. Methodology and data

- Extreme Sea Level



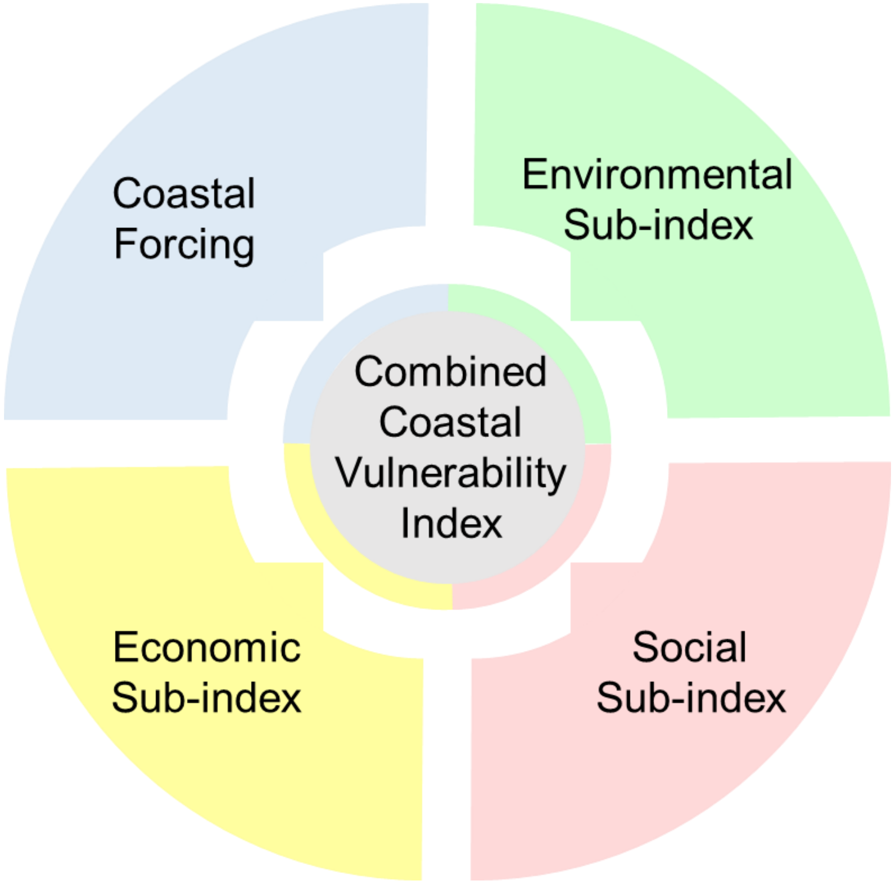
- Shoreline evolution trend
- Distance from shoreline
- Coastal slope
- Elevation
- Geological coastal types
- Land roughness
- Conservation designation
- Coastal protection structures

- Land use patterns
- GDP per capita

- People younger than 5 years
- People older than 65 years

Adapted from the multi-scale CVI by McLaughling & Cooper (2010)

3. Methodology and data



Baseline and future scenario for ESL, land use, population and GDP based indicators

	Baseline	Future scenario 2050
Combined -CVI	Extreme Sea Level 1969 - 2004	Extreme Sea Level 2039 - 2049 under RCP8.5
	Corine Land Cover 2000	LULC – CMCC - 2050 under RCP8.5
	ISTAT – Population census 2001	ISTAT - Population projections 2007 - 2051
	GDP - 2010	GDP - 2050 under SSP3

RCP 8.5: "Worst case scenario"; high demographic growth, low innovation, absence of mitigation policies ☹

SSP 3: high challenges for mitigation and adaptation; little progress in reducing resource consumption and fossil fuel dependency, in addressing local environmental issues; strong environmental degradation in some region. Low population growth in industrialized countries and higher in developing ones

Climate Forcing: Extreme Sea Level scenarios (ESL)

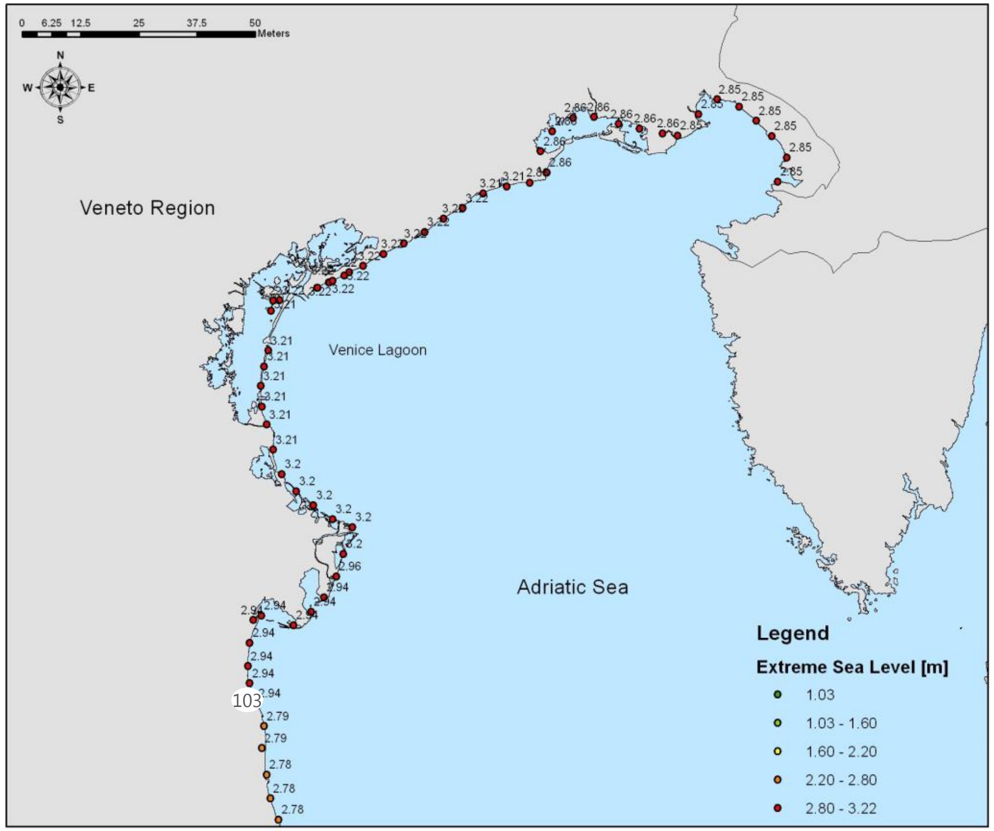
Joint Research Centre JRC

ESL = RSLR + (tide) + (ss-w)

Scenarios:	Historical RCP 4.5 RCP 8.5
Grid resolution:	0.2° (~ 11 km)
Temporal coverage:	Baseline: 1969-2004 Future: decades among 2039-2049 timeframe

Mean ESL [m]			RP 5	RP 10	RP 20	RP 50	RP 100	RP 200	RP 500	RP 1000
BASELINE		MIN	0.82	0.89	0.95	1.00	1.03	1.06	1.10	1.12
		MEAN	1.17	1.26	1.33	1.43	1.51	1.58	1.67	1.74
		MAX	2.10	2.34	2.59	2.94	3.22	3.52	3.93	4.27
2039 - 2049	RCP 4.5	MIN	1.03	1.10	1.16	1.20	1.24	1.27	1.30	1.33
		MEAN	1.37	1.46	1.53	1.63	1.71	1.78	1.87	1.95
		MAX	2.35	2.59	2.84	3.18	3.46	3.75	4.16	4.49
	RCP 8.5	MIN	1.03	1.13	1.19	1.24	1.27	1.31	1.34	1.37
		MEAN	1.37	1.49	1.57	1.67	1.75	1.82	1.92	1.99
		MAX	2.35	2.66	2.91	3.27	3.55	3.85	4.26	4.60

Baseline - 100 years Return Period

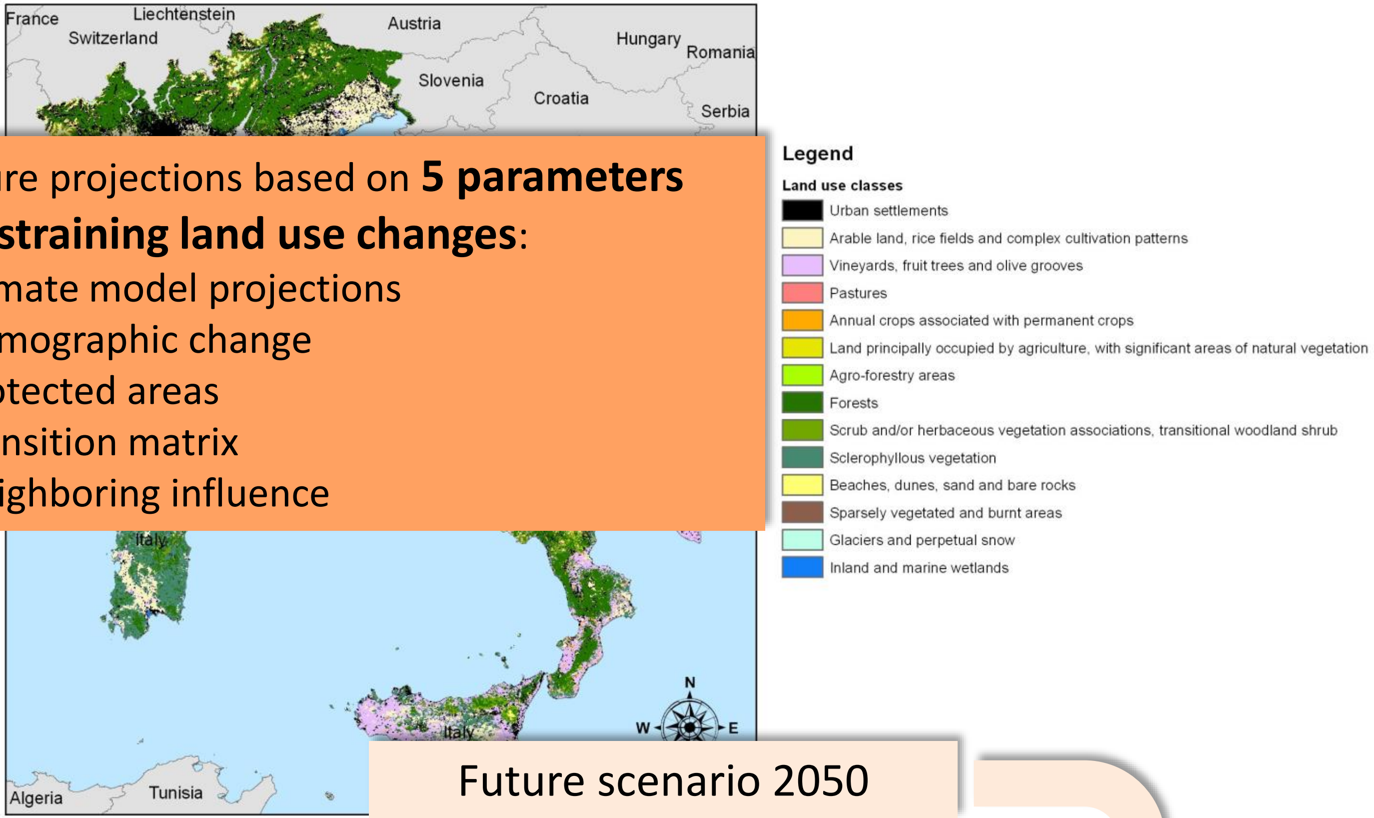


(Vousdoukas et al., 2017)

3. Methodology and data

Land-use related indicators (i.e. land roughness and land use pattern) are based on the recent LULC maps developed by using the **LULC-CMCC model** (Santini and Valentini, 2011)

Future projections based on **5 parameters constraining land use changes**:
- Climate model projections
- Demographic change
- Protected areas
- Transition matrix
- Neighboring influence



Future scenario 2050

<u>Temporal coverage:</u>

Baseline scenario **2000**

Future scenario **2050**

Emission scenario: **RCP8.5**

Resolution: **500 m**

<u>Two scenario selected for the combined-CVI:</u>
- **Baseline** (based on the Corine Land Cover map 2000)
- **Future scenario 2050**, considering climate model projections, high demographic change, presence of protected areas, transition matrix and neighboring influence between land use classes

3. Methodology and data

Economic indicators are based on GDP projections developed by Murakami & Yamagata, (2016)

<u>Temporal coverage:</u>

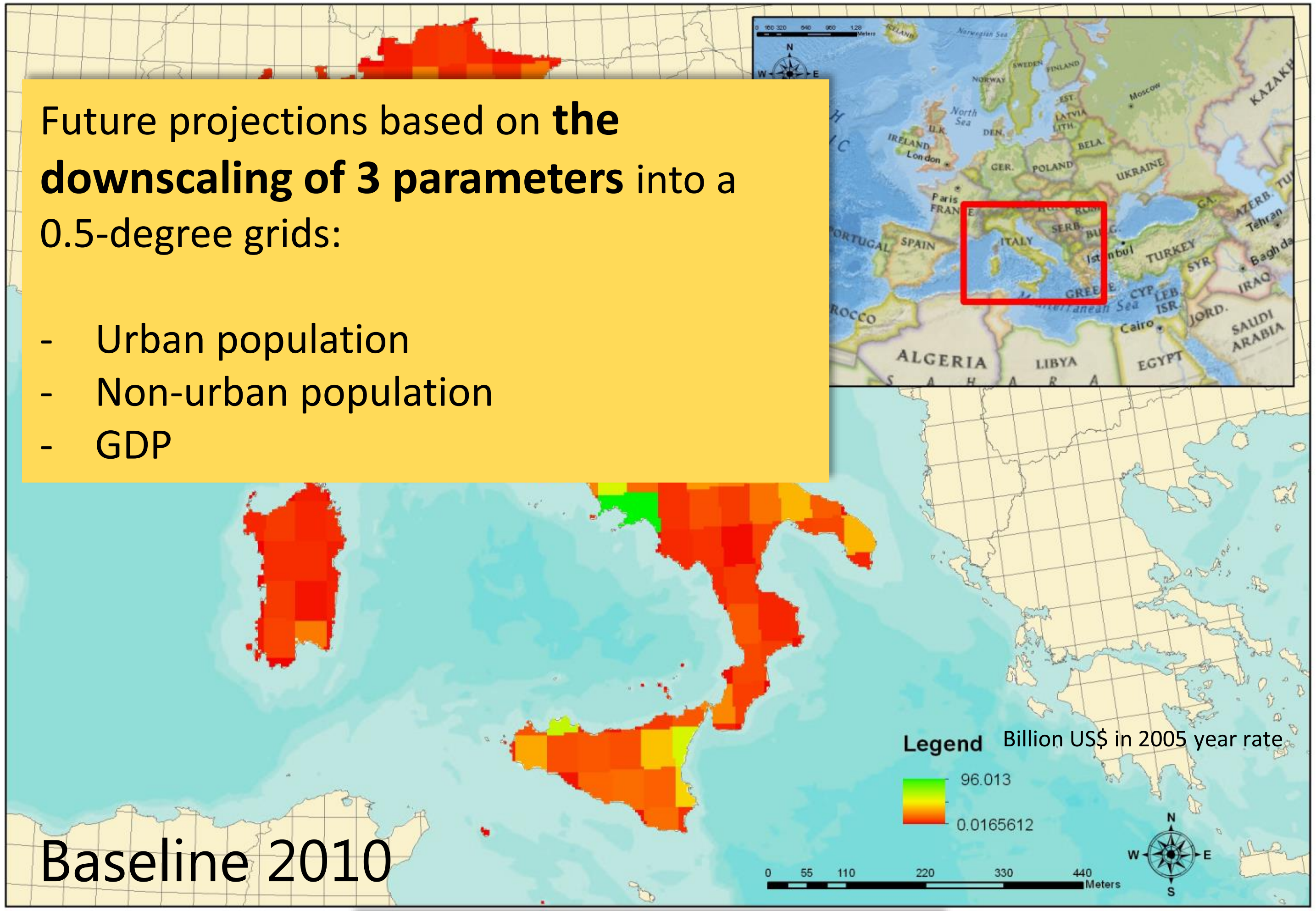
Baseline scenario **2010**

Future scenario **2050**

Selected socio-economic pathways: **SSP3**

Future projections based on **the downscaling of 3 parameters** into a 0.5-degree grids:

- Urban population
- Non-urban population
- GDP



GDP tot 2010: 1641 billion US$

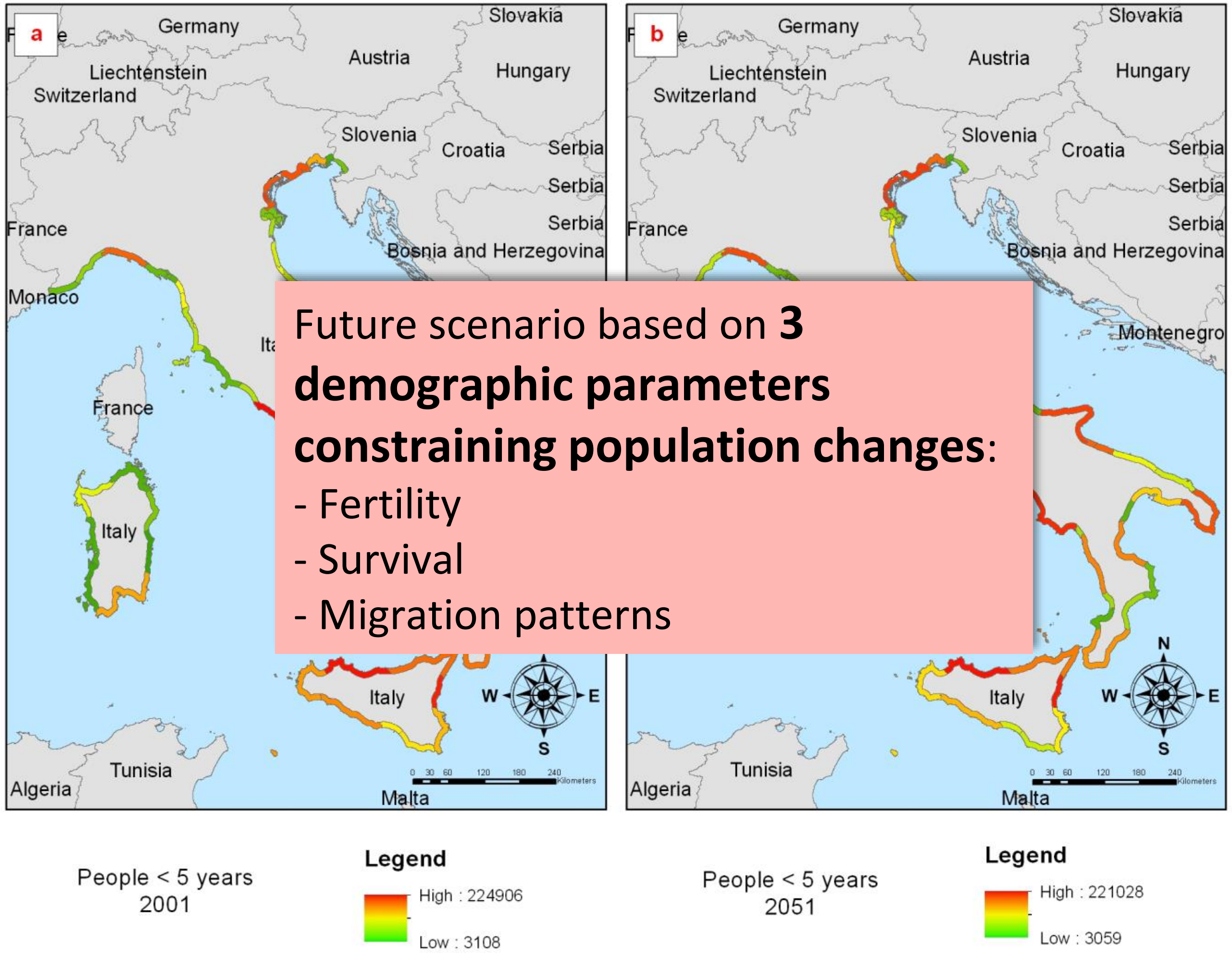
3. Methodology and data

Social indicators developed based on data collected and modelled by ISTAT, 2001 and 2008

<u>Temporal coverage:</u>

Baseline scenario **2001** (census data)

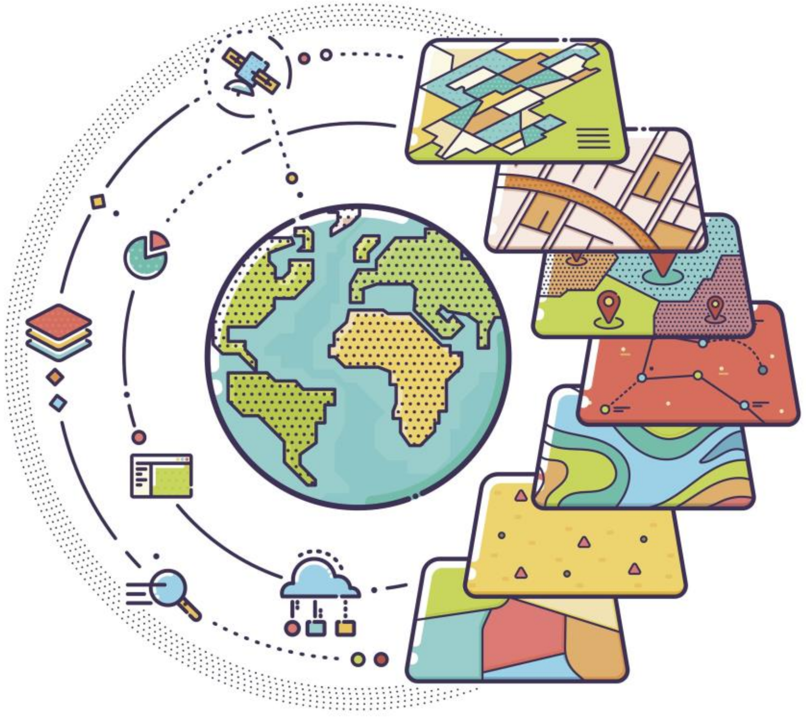
Future scenario **2051**



Future scenario based on **3 demographic parameters constraining population changes**:
- Fertility
- Survival
- Migration patterns

Istat
Istituto Nazionale di Statistica

3. Methodology and data



GIS-based physical, environmental and socio-economic indicators spatially evaluated by:

Aggregating information at the **provincial scale** (nuts3 level) based on:

- **Percentage**
- **Mean values**

Reclassification of variables according to their capacity to determine detrimental changes to coastlines (1 – 5)

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3. Methodology and data

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Variable	Unit	Score				
		Very low	Low	Moderate	High	Very high
		1	2	3	4	5
[illegible] indicators						
Extreme Sea Levels (ESL)	m	[illegible]	[illegible]	1.6 – 2.2	2.2 – 2.8	> 2.8
[illegible] indicators						
Shoreline evolution trend	%	Less than 20% of the shoreline is in erosion or in accretion (per region)	/	Between 20% and 60% of the shoreline is in erosion or in accretion (per region)	/	More than 60% of the shoreline is in erosion or in accretion (per region)
Distance from shoreline	m	> 4500	4500 - 2100	2099 - 900	899 - 300	< 300
Coastal slope	%	> 1/10	1/10 - 1/20	1/20 - 1/30	1/30 - 1/50	1/50 - 1/100
Elevation	m	> 30	20 to < 30	10 to < 20	5 to < 10	< 5
Geological coastal type	%	> 70% of "likely non-erodible segments"	/	"likely non-erodible segments" between 40% and 70%	/	< 40% of "likely non-erodible segments"
Land roughness	/	Urban areas	Forest and water bodies	Shrub land, grassland, sparse vegetation	Agriculture	Bare areas
Conservation designation	/	Absent		European international		National
Coastal protection structures	%	> 50% of protected coast	31-50% of protected coast	21-30% of protected coast	5-20% of protected coast	< 5% of protected coast
[illegible]						
Population < 5 years	/	[illegible]	[illegible]	[illegible] - 21644	21645 - 35733	> 35734
Population > 65 years	/	< 41[illegible]	[illegible]	[illegible] - 76078	76079 - 106784	> 106785
Economic indicators						
Gross domestic product - GDP	$	> 31000	31000 - 25000	24000 - 1700[illegible]	[illegible]	[illegible]
Land use pattern	/	Water bodies, marsh/bog and moor, sparsely vegetated areas, bare rocks	Natural grasslands, coastal areas	Forest	Agriculture	Urban and industrial infrastructure

Based on scenarios developed by Vousdoukas et al., 2017

Based on scenarios developed by ISTAT, 2008

Based on scenarios developed by Santini & Valentini, 2011

Based on scenarios developed by Murakami & Yamagata, 2016

3. Methodology and data

National - Coastal Vulnerability Index
Adapted from the multi-scale CVI by McLaughling & Cooper (2010)

Sum of the values of the relative variables → Normalization of the resulting output elaborating it as percentage of the range of scores possible (maximum and minimum) → Standardization in the range 0-100

Coastal Forcing (CF) sub-index = {[(sum of CF indicators) – 1]/4}x 100

Environmental (Env) sub-index = {[(sum of Env indicators) – 9]/36} x 100

Social (S) sub-index = {[(sum of S indicators) – 1]/4}x 100

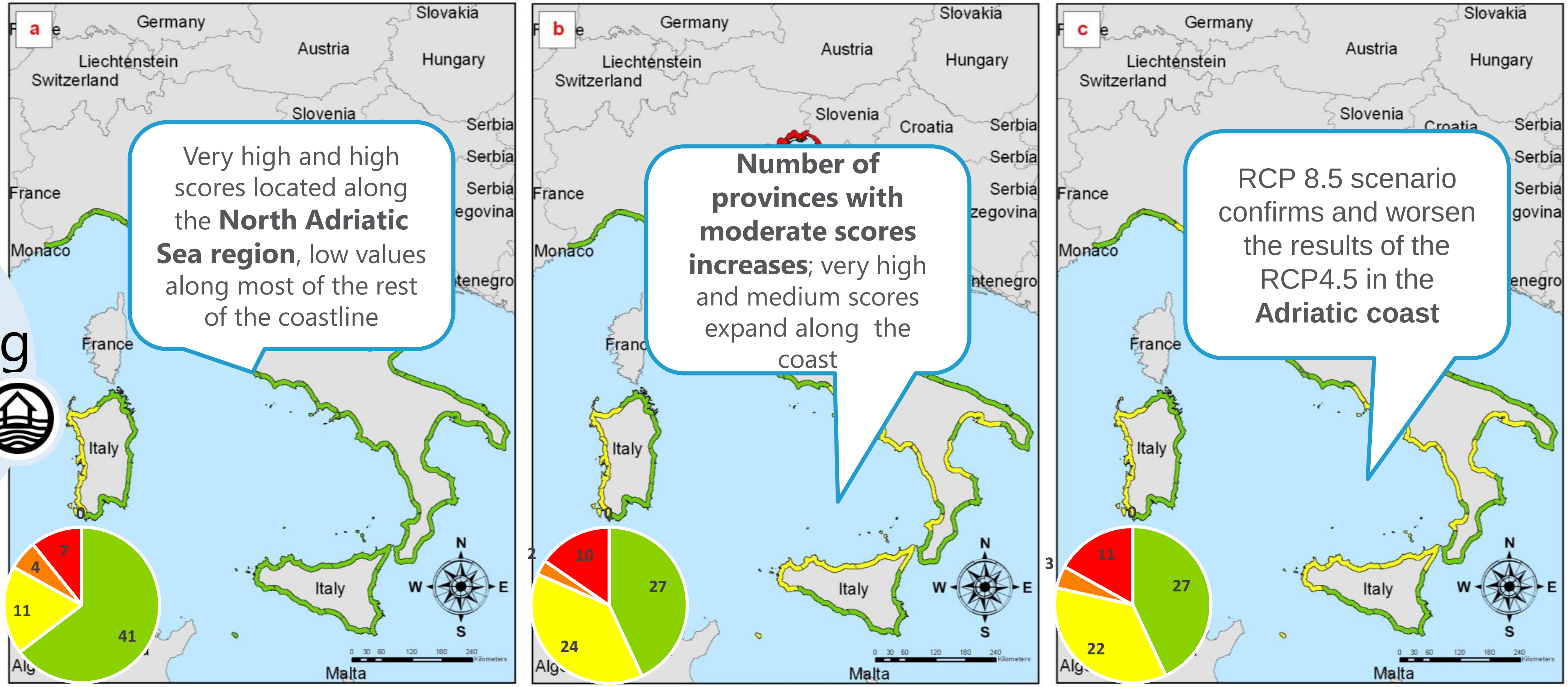
Economic (Econ) sub-index = {[(sum of Econ indicators) – 2]/8}x 100

Average of the four sub-indices values

CVI = (Env sub-index + CF sub-index + S sub-index + Econ sub-index) / 4

4. Results and discussion

Coastal forcing sub-index



Very high and high scores located along the **North Adriatic Sea region**, low values along most of the rest of the coastline

Number of provinces with moderate scores increases; very high and medium scores expand along the coast

RCP 8.5 scenario confirms and worsen the results of the RCP4.5 in the **Adriatic coast**

Baseline

Future 2050 scenario RCP4.5

Future 2050 scenario RCP8.5

Vulnerability classes 0 - 20 | 20 - 40 | 40 - 60 | 60 - 80 | 80 - 100

4. Results and discussion

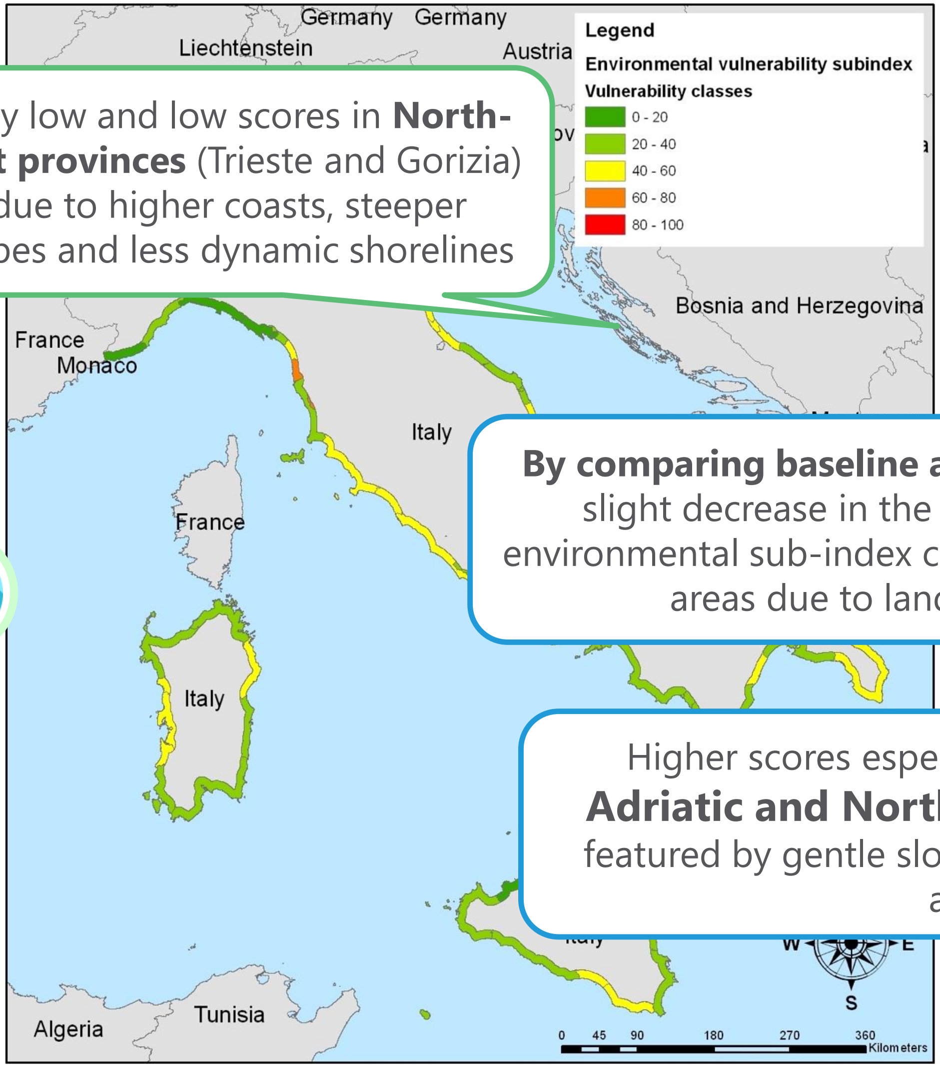
Environmental sub-index

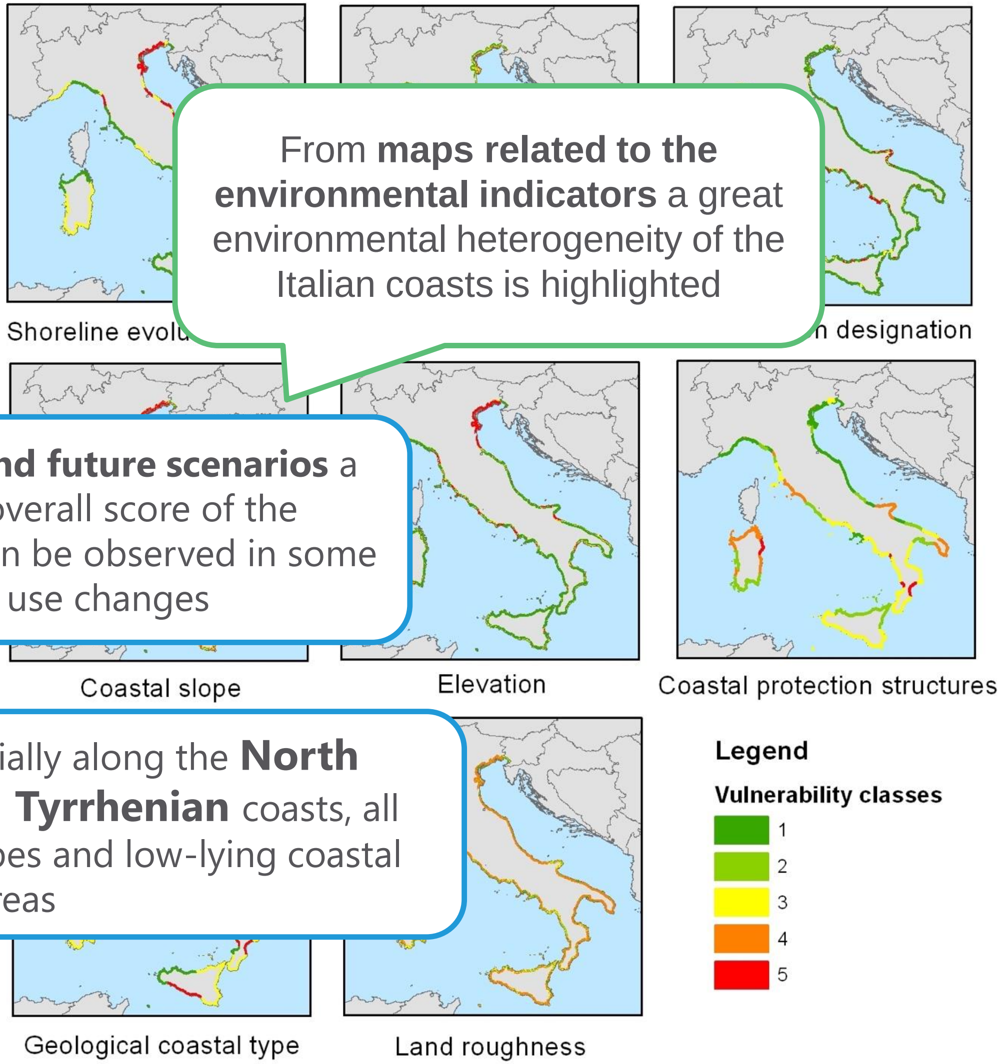
Very low and low scores in **North-East provinces** (Trieste and Gorizia) due to higher coasts, steeper slopes and less dynamic shorelines

From **maps related to the environmental indicators** a great environmental heterogeneity of the Italian coasts is highlighted

By comparing baseline and future scenarios a slight decrease in the overall score of the environmental sub-index can be observed in some areas due to land use changes

Higher scores especially along the **North Adriatic and North Tyrrhenian** coasts, all featured by gentle slopes and low-lying coastal areas

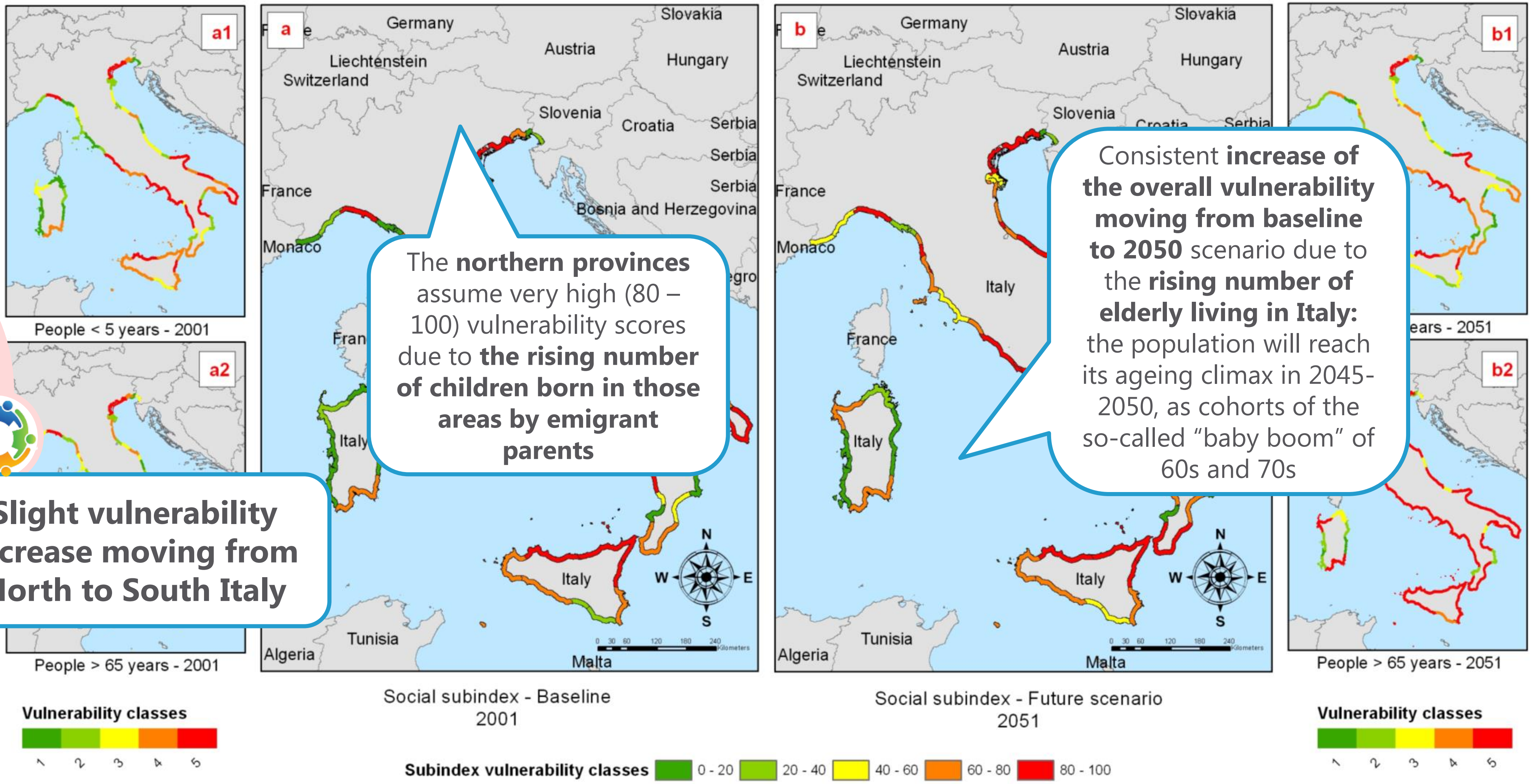




Baseline

4. Results and discussion

Social sub-index



Slight vulnerability increase moving from North to South Italy

The **northern provinces** assume very high (80 – 100) vulnerability scores due to **the rising number of children born in those areas by emigrant parents**

Consistent **increase of the overall vulnerability moving from baseline to 2050** scenario due to the **rising number of elderly living in Italy:** the population will reach its ageing climax in 2045-2050, as cohorts of the so-called "baby boom" of 60s and 70s

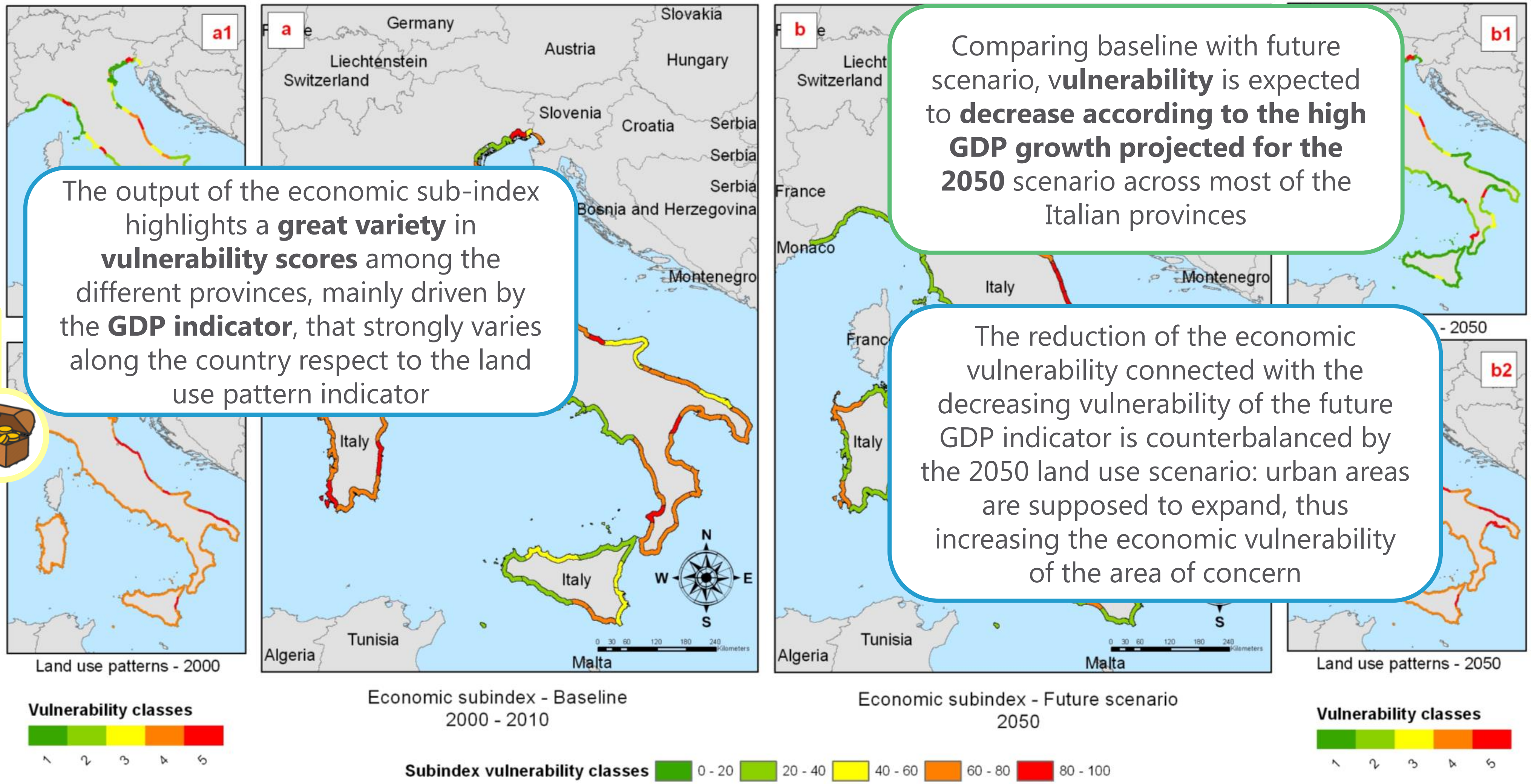
4. Results and discussion

Economic sub-index

The output of the economic sub-index highlights a **great variety** in **vulnerability scores** among the different provinces, mainly driven by the **GDP indicator**, that strongly varies along the country respect to the land use pattern indicator

Comparing baseline with future scenario, v**ulnerability** is expected to **decrease according to the high GDP growth projected for the 2050** scenario across most of the Italian provinces

The reduction of the economic vulnerability connected with the decreasing vulnerability of the future GDP indicator is counterbalanced by the 2050 land use scenario: urban areas are supposed to expand, thus increasing the economic vulnerability of the area of concern

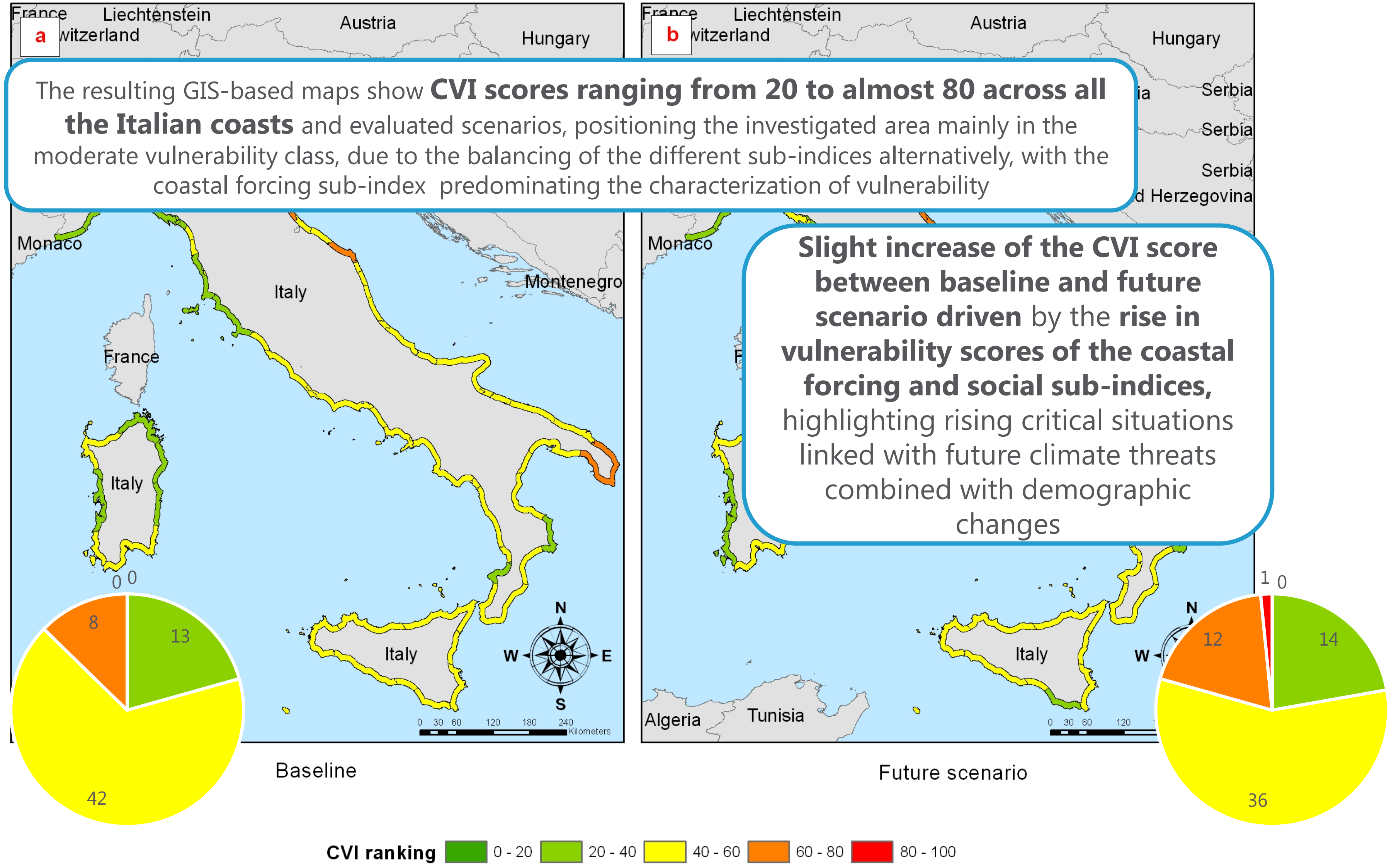


4. Results and discussion

Combined CVI

The resulting GIS-based maps show **CVI scores ranging from 20 to almost 80 across all the Italian coasts** and evaluated scenarios, positioning the investigated area mainly in the moderate vulnerability class, due to the balancing of the different sub-indices alternatively, with the coastal forcing sub-index predominating the characterization of vulnerability

Slight increase of the CVI score between baseline and future scenario driven by the **rise in vulnerability scores of the coastal forcing and social sub-indices,** highlighting rising critical situations linked with future climate threats combined with demographic changes



Baseline

Future scenario

5. Conclusions

- Implementation of social and economic projections to better investigate the **interconnections of climatic hazards with changes in social and economic systems**, as well as their relationship with the surrounding environment.

- **Adaptable to different spatial scales of analysis and geographic context**, integrating different data at higher resolutions

- Useful to easily **communicate and translate knowledge** between the science and practitioners interfaces and to be implemented for national adaptation policies

- **Evaluation of uncertainty** by integrating climate, land use and economic social scenarios from different assumptions/models

- Lack of **temporal coherence** among the different scenarios for all the indicators

- **Low spatial resolution of economic data** not supporting the evaluation of economic dynamics of coastal areas

Thanks for your attention !

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