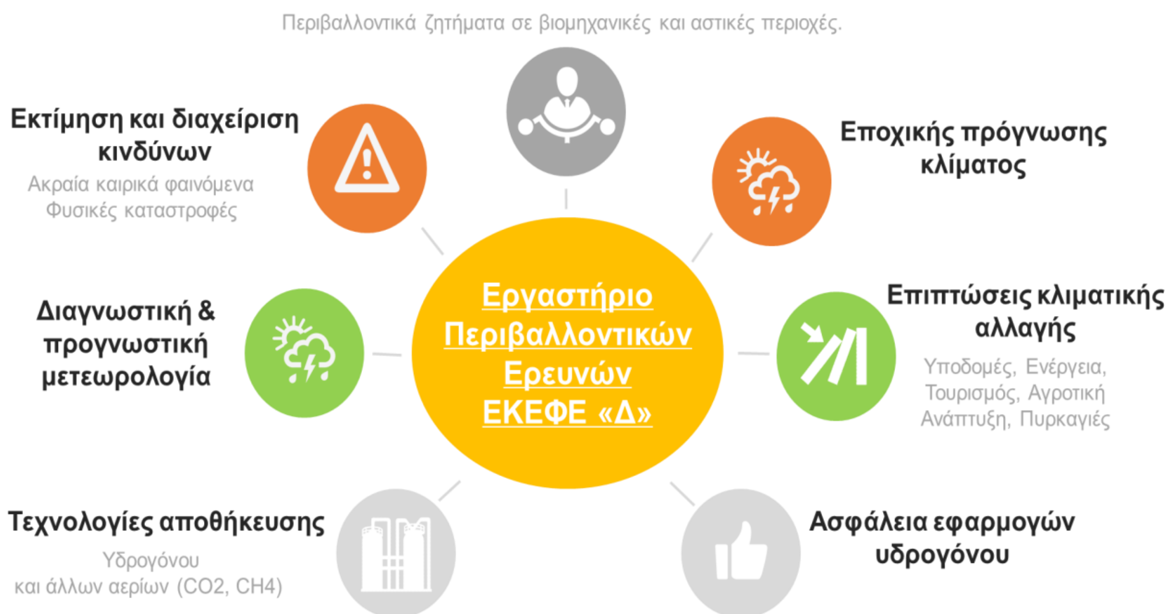
Climate Resilient Infrastructures:
from disaster management to sustainable adaptation



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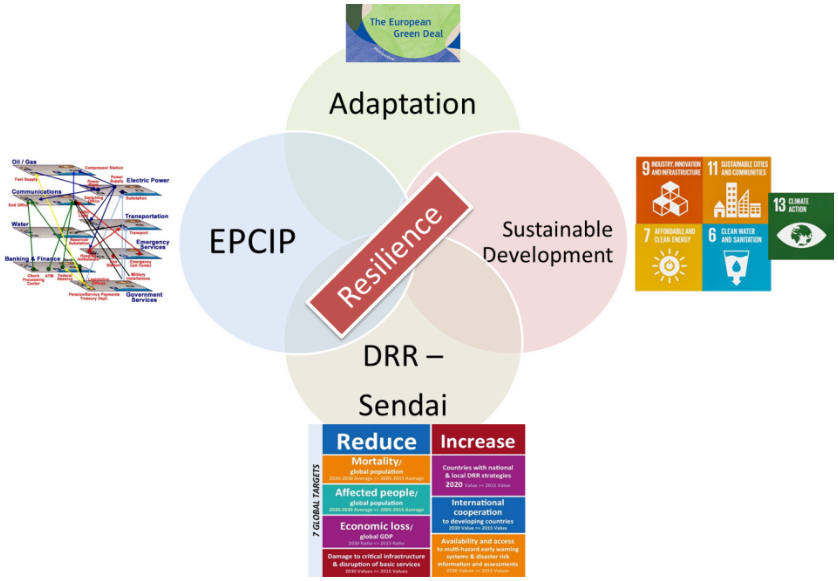
ΕΘΝΙΚΟ ΚΕΝΤΡΟ ΕΡΕΥΝΑΣ
ΦΥΣΙΚΩΝ ΕΠΙΣΤΗΜΩΝ «ΔΗΜΟΚΡΙΤΟΣ»

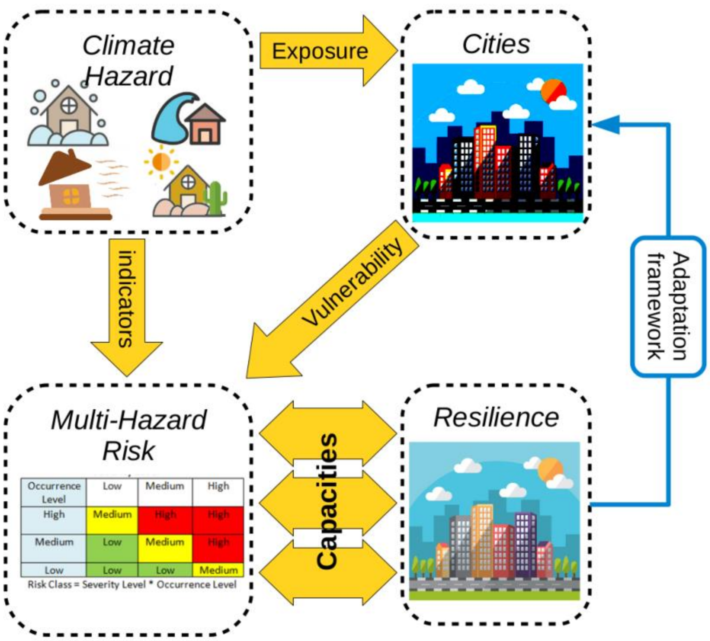
Contents

1. Overall concept

Unique connection between research and EU/National Policies to industrial applications

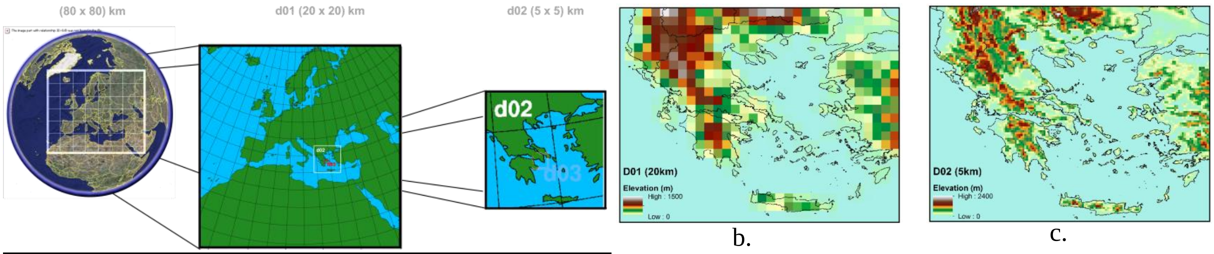


From Climate Risk to Climate Resilience through participatory process

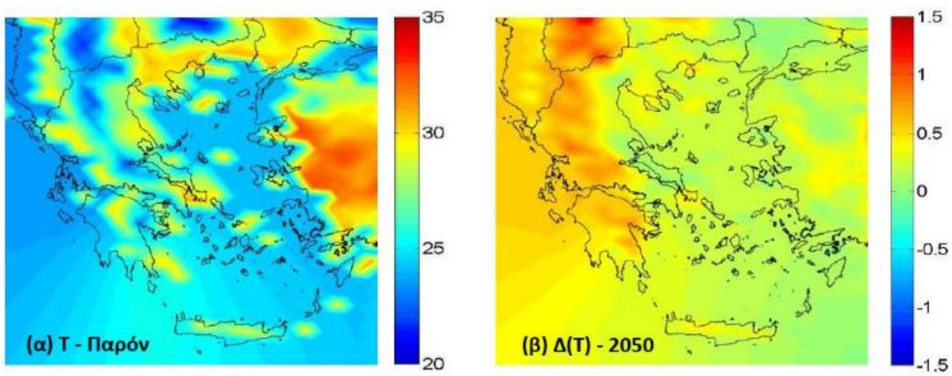


2. Climate projections

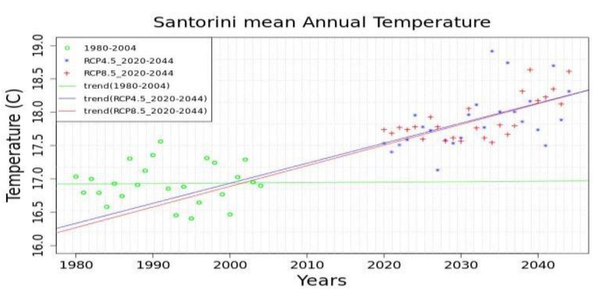
2.1 Climate predictions over Greece at 5km spatial resolution

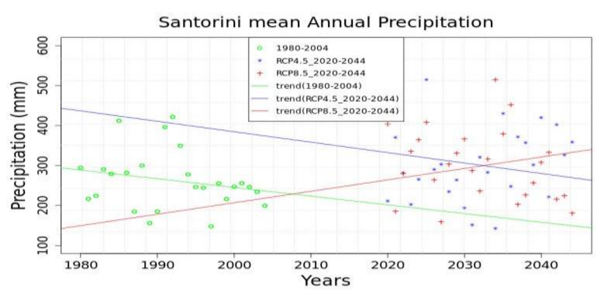


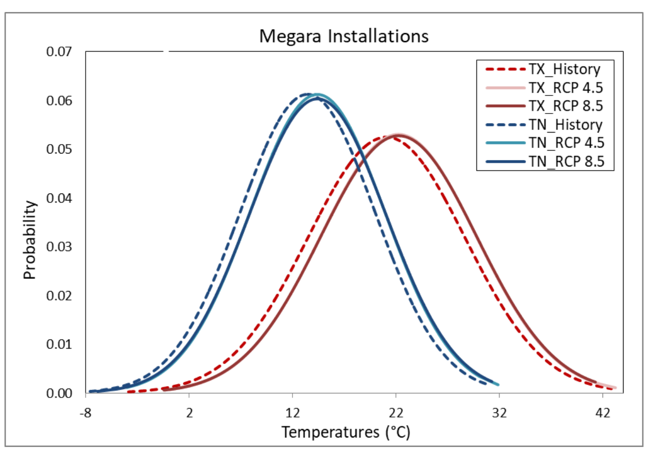
<u>Αλλαγή στη Μέση Θερμοκρασία</u>



<u>Παράδειγμα για την Σαντορίνη</u>

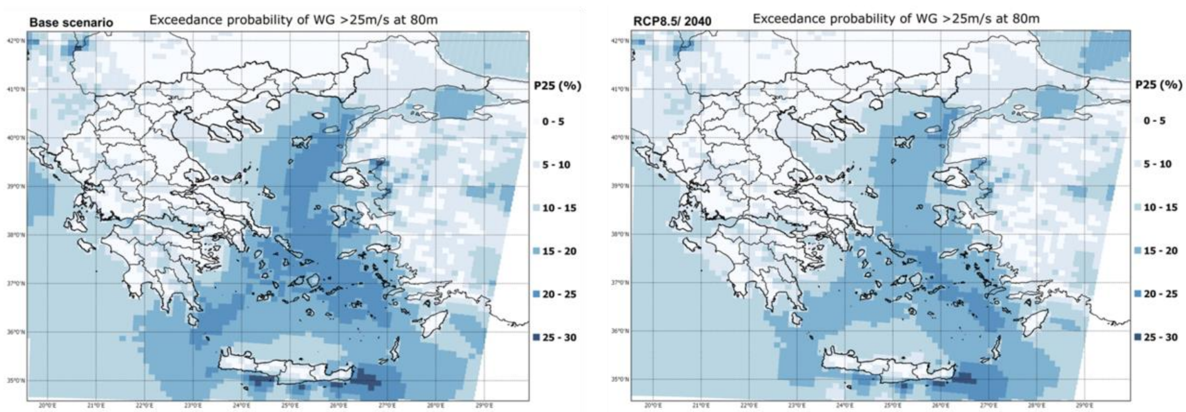






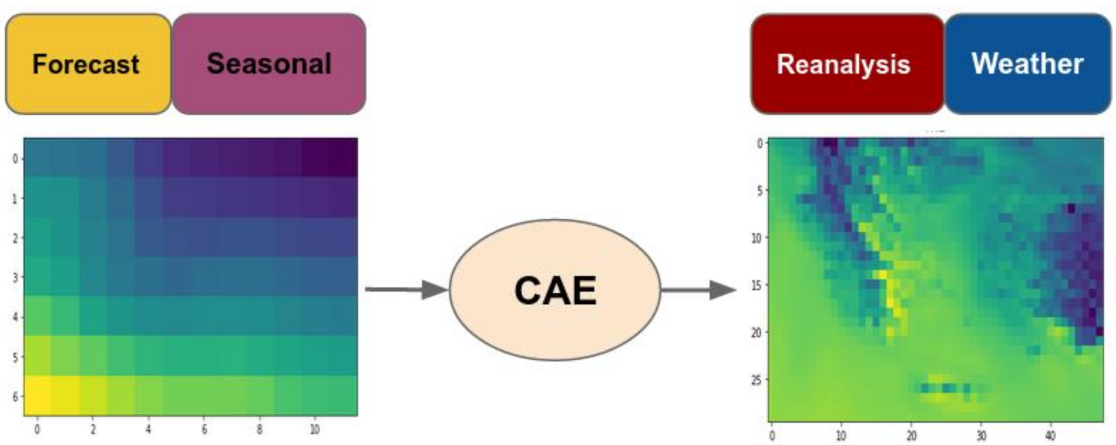
2.2 Seasonal Forecasting

6 months ahead forecast at 5km over Greece



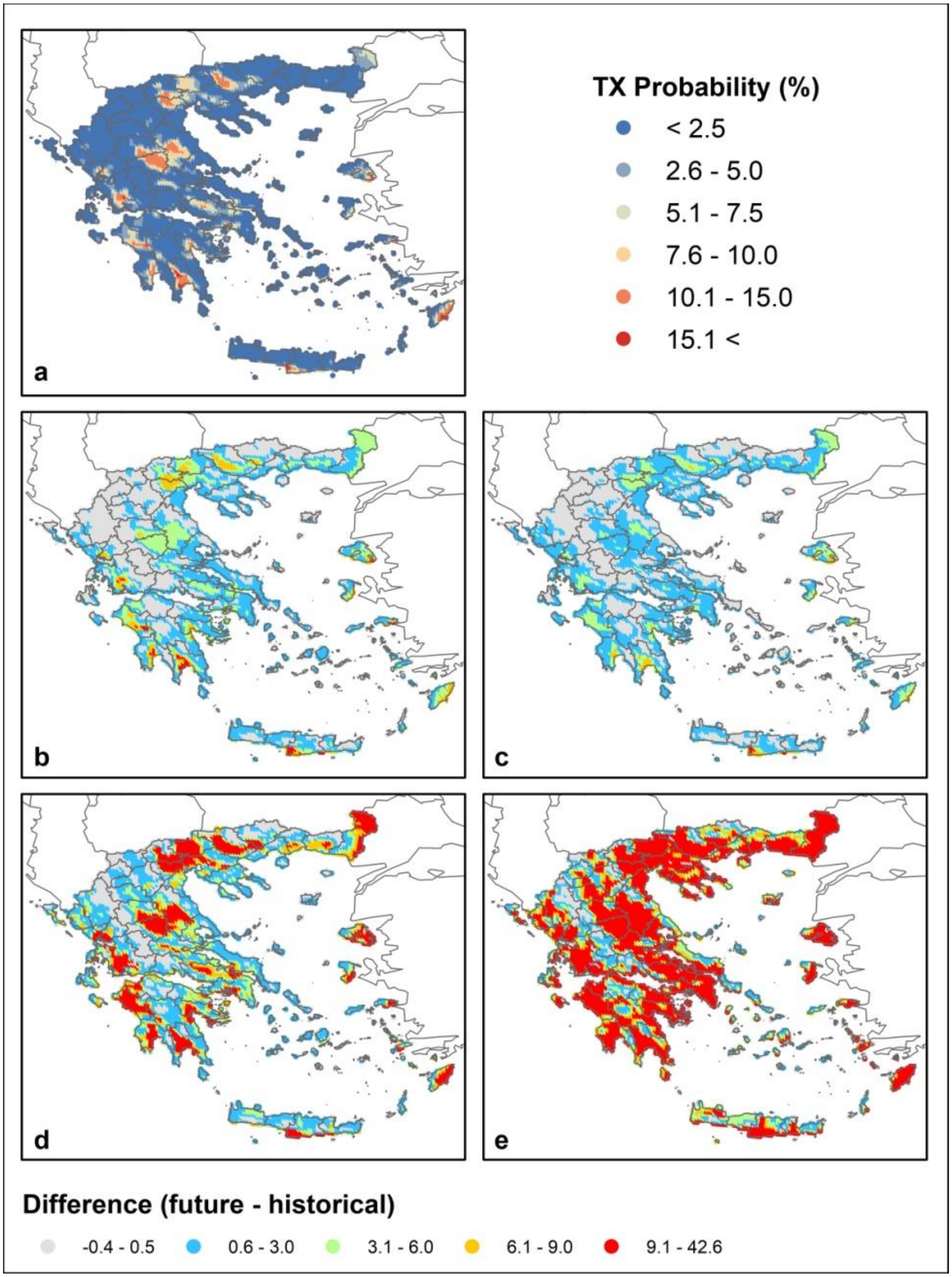
Πιθανότητα εμφάνιση ριπών αέρα (ταχύτητα αέρα > 25 m/s στα 80m)

Artificial Intelligence for improving Seasonal predictions



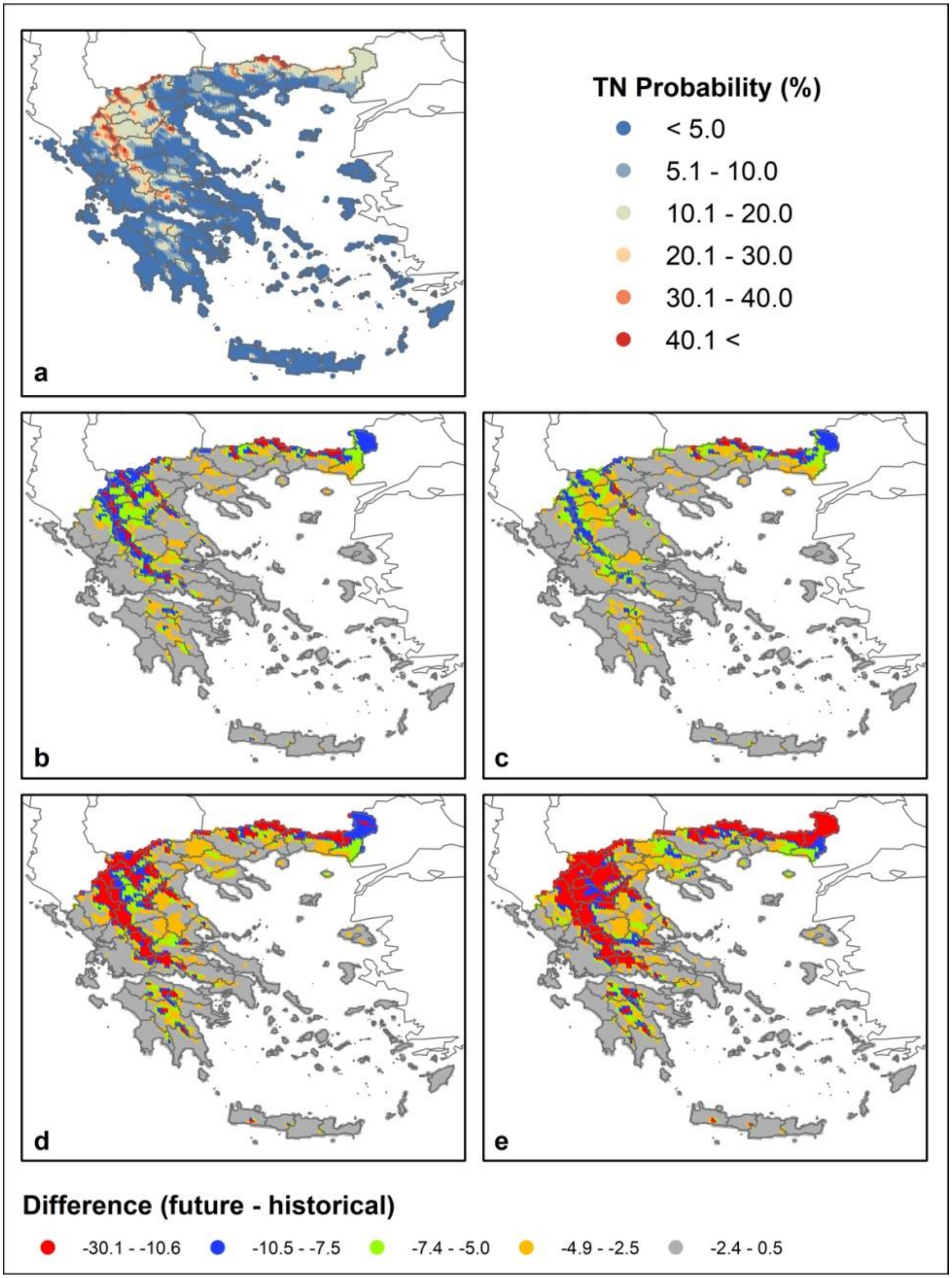
2.3 Determination of Hazard Evolution due to Climate Change

Max Temperature > 35 C



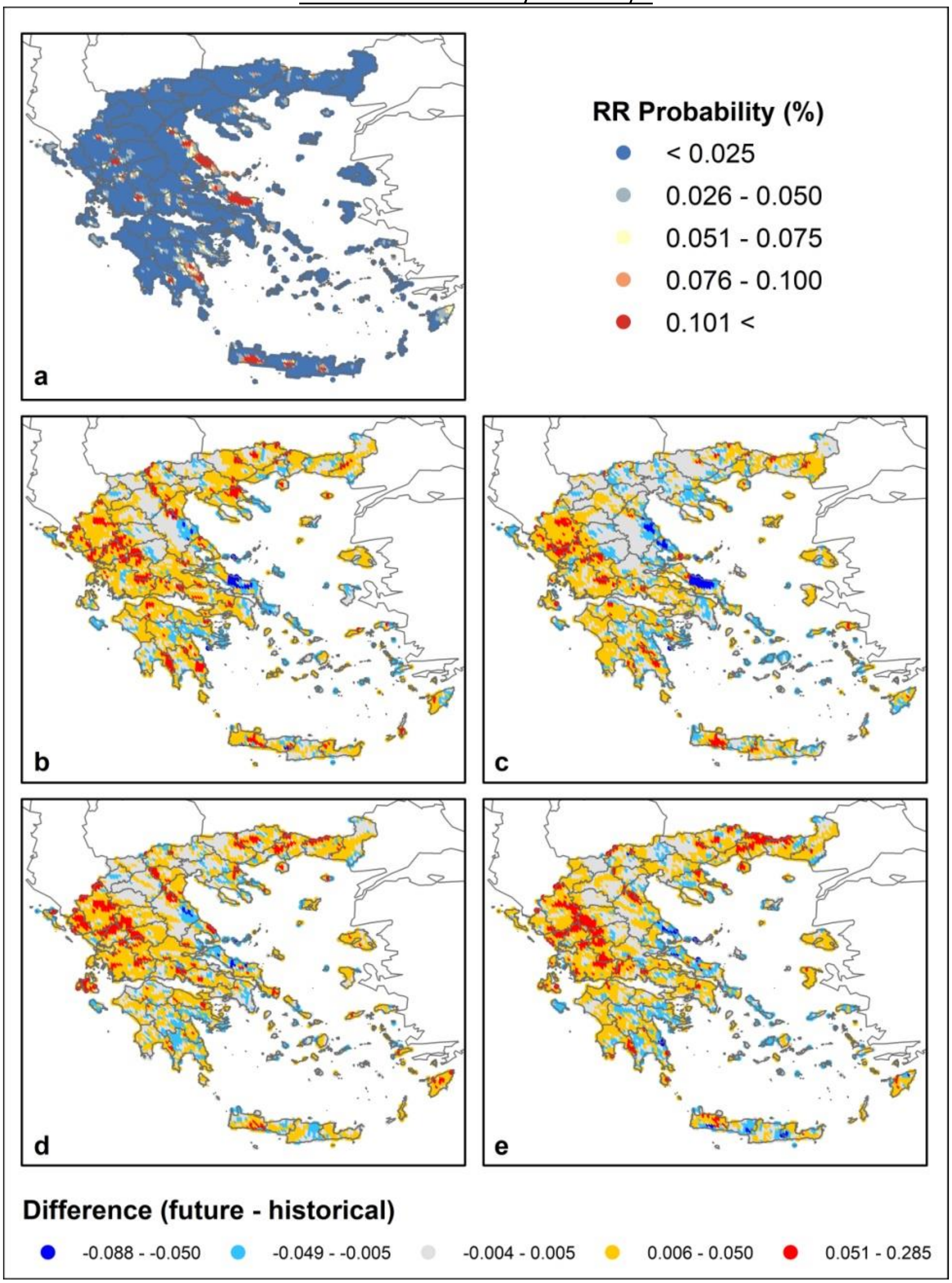
a) Spatial distribution of probability of TX exceedance above 35°C calculated using EC-EARTH_WRF downscaled data for the historical summer period 1980-2004. Differences (future – historical) in the probability of TX exceedance for: b) RCP4.5 in near future (2025-2049), c) RCP8.5 in near future (2025-2049), d) RCP4.5 in far future (2075-2099) and e) RCP8.5 in far future (2075-2099).

Min Temperature < -5 C



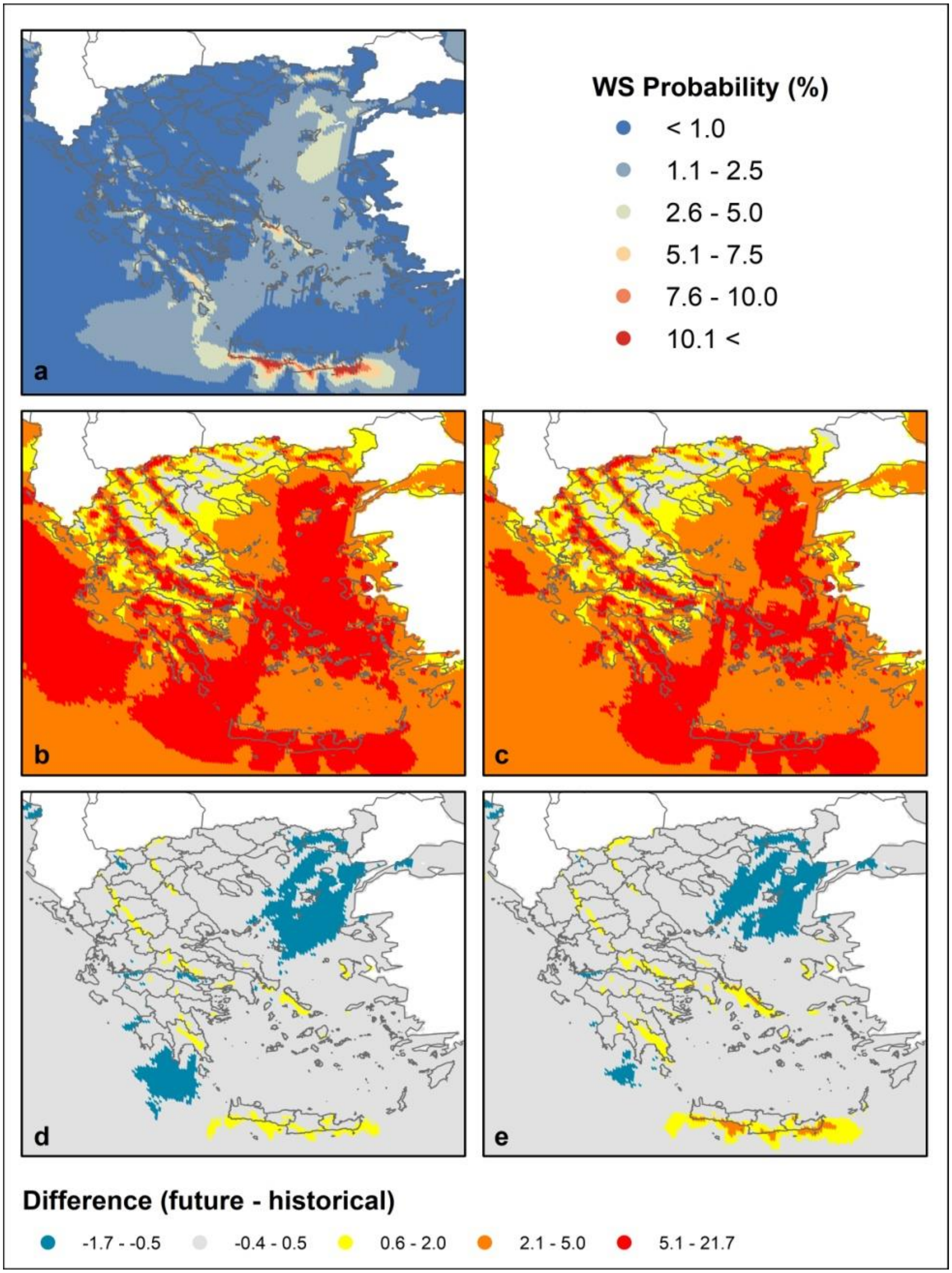
a) Spatial distribution of probability of TN exceedance below -5°C calculated using EC-EARTH_WRF downscaled data for the historical winter period 1980-2004. Differences (future – historical) in the probability of TN exceedance for: b) RCP4.5 in near future (2025-2049), c) RCP8.5 in near future (2025-2049), d) RCP4.5 in far future (2075-2099) and e) RCP8.5 in far future (2075-2099).

Rain Rate within a day > 10 mm/h



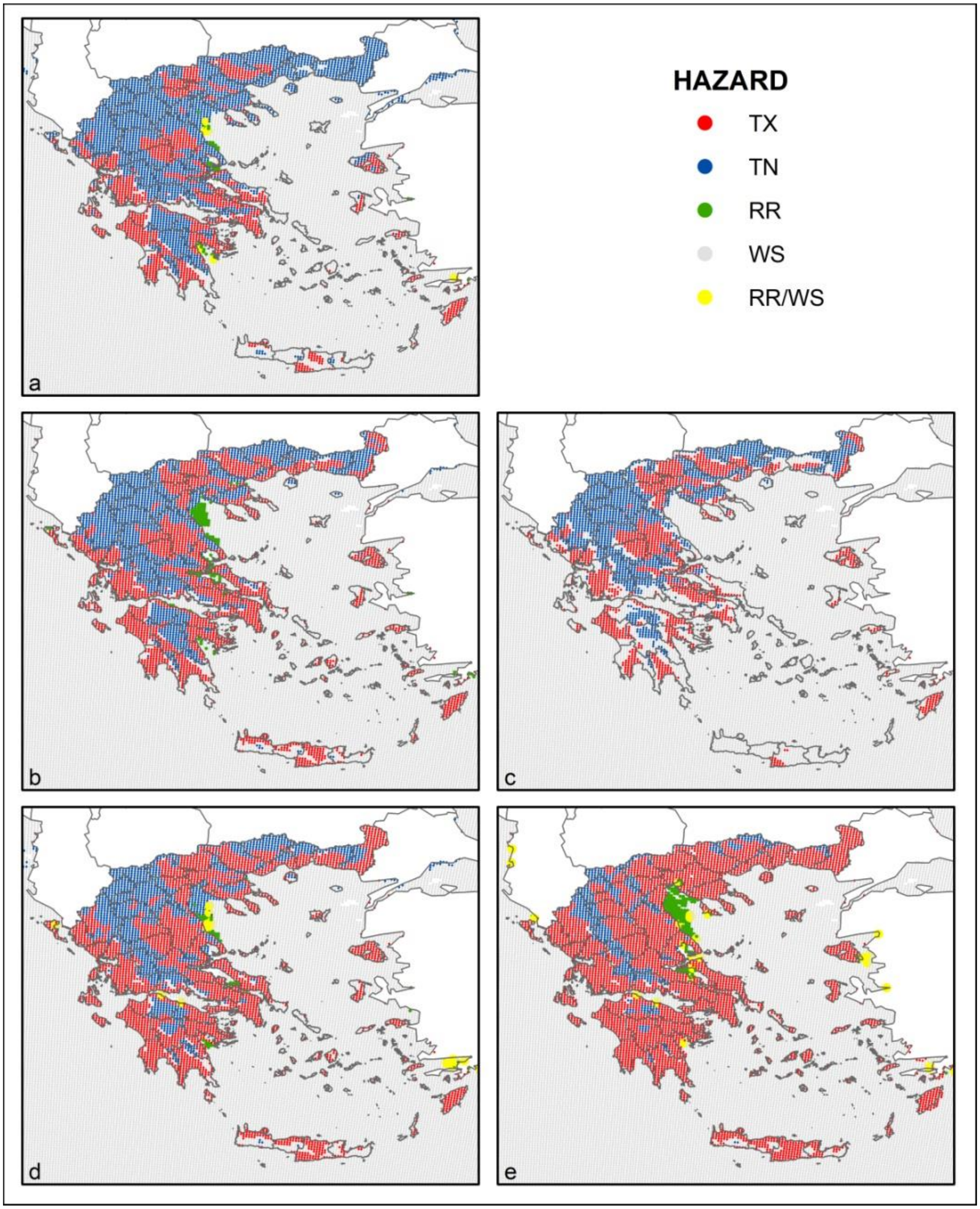
a) Spatial distribution of probability of RR exceedance above 10 mm/h calculated using EC-EARTH_WRF downscaled data for the historical period 1980-2004. Differences (future – historical) in the probability of RR exceedance for: b) RCP4.5 in near future (2025-2049), c) RCP8.5 in near future (2025-2049), d) RCP4.5 in far future (2075-2099) and e) RCP8.5 in far future (2075-2099).

Daily Average Wind Speed > 15m/s



a) Spatial distribution of probability of wind speed exceedance over the threshold (15 m/s) calculated using EC-EARTH_WRF downscaled data for the historical period 1980-2004. Differences (future – historical) in the probability of wind speed exceedance for: b) RCP4.5 in near future (2025-2049), c) RCP8.5 in near future (2025-2049), d) RCP4.5 in far future (2075-2099) and e) RCP8.5 in far future (2075-2099).

Maximum Hazard and its evolution under climate change

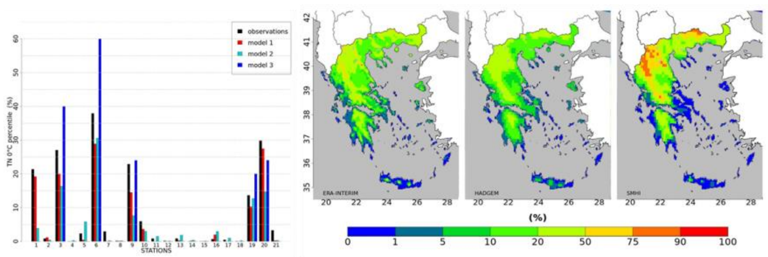


Multi-hazard maps using EC-EARTH_WRF downscaled data for: a) the historical period 1980-2004, b) RCP4.5 in near future (2025-2049), c) RCP8.5 in near future (2025-2049), d) RCP4.5 in far future (2075-2099) and e) RCP8.5 in far future (2075-2099).

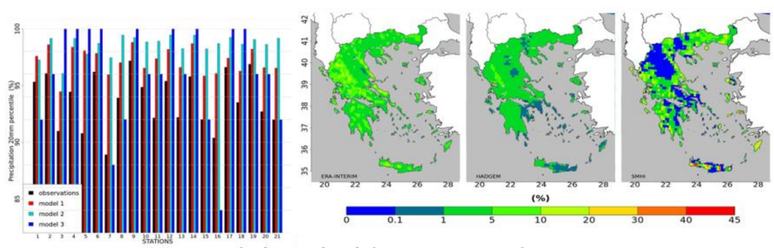
3. Extremes & Compound Event Analysis

Cold – Wet compounds over Greece

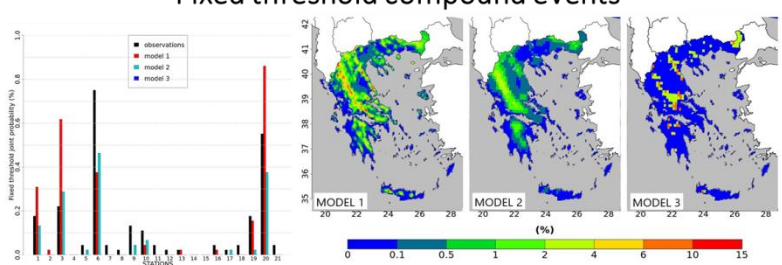
TN 0 °c probability (%)



RR (20 mm/day) probability (%)

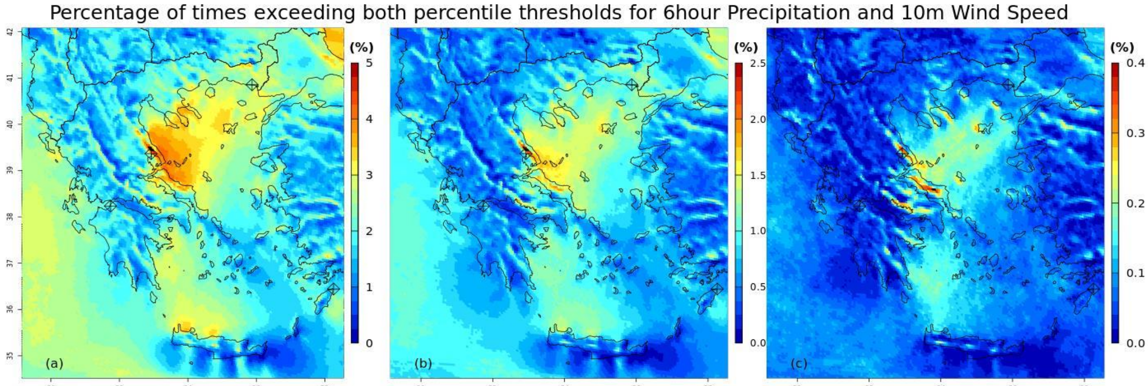


Fixed threshold compound events



Rain – Wind compounds over Greece

Percentage of times exceeding both percentile thresholds for 6hour Precipitation and 10m Wind Speed



4. Hazard Simulation

4.1 Wildfires

Analysis of future evolution of fire weather patterns and fire spreading simulation models

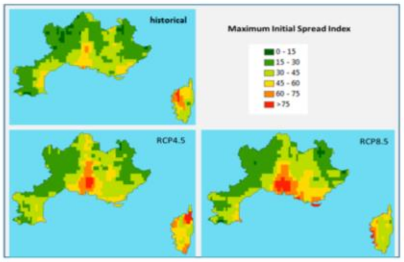
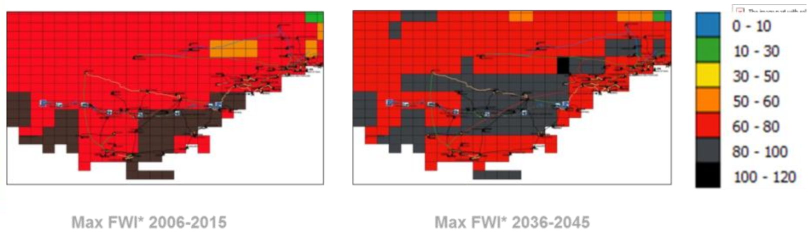


Figure 5. Maps of the historic (2006–2015) and near future (2036–2045) maximum values of Initial Spread Index for fire season.



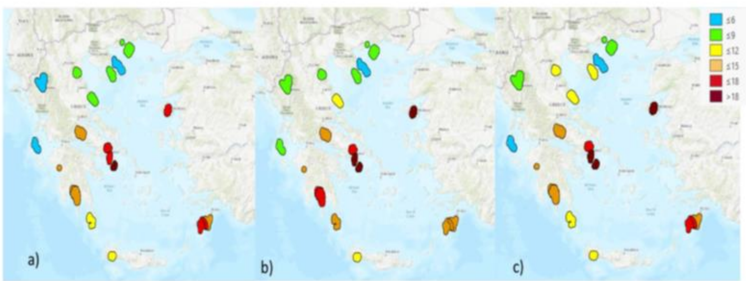


Figure 7. Maps of coloured Areas of Interest (AoI) depicting classified Seasonal Severity Rating (SSR) Mean values, for: (**a**) the historic period, (**b**) RCP 4.5 2036–2045, (**c**) RCP 8.5 2036–2045.

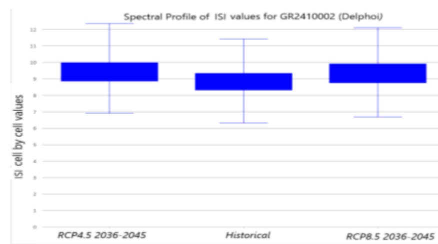
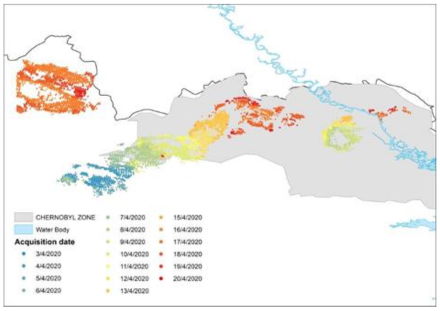
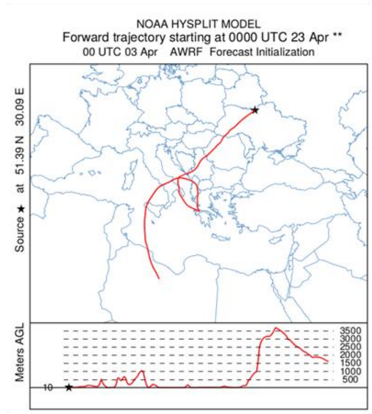


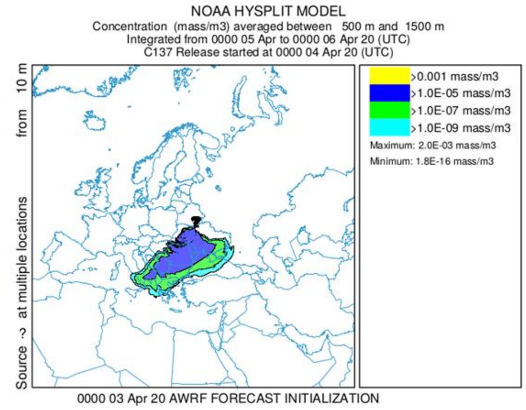
Figure 10. Spectral Profile of Initial Spread Index (ISI) values for GR2410002 (Delphoi), for RCP 4.5 2036–2045 (**left**), historic period (**centre**), and RCP 8.5 2036–2045 (**right**).

Fire Spreading Models – Examples at NCSRD

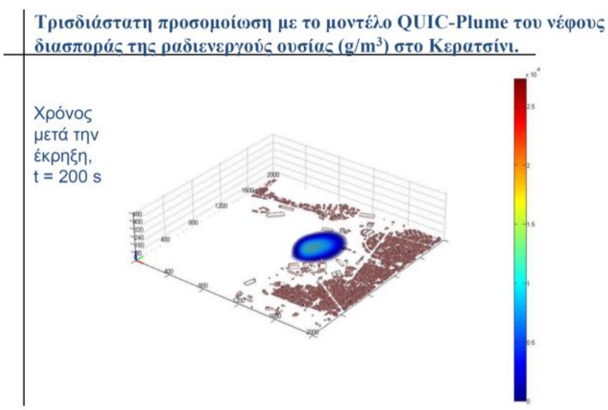
4.2 Smoke Dispersion

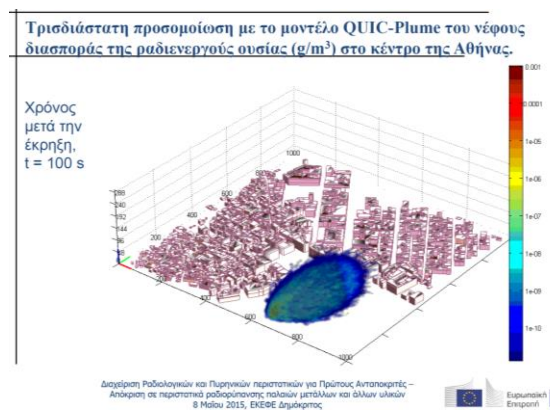




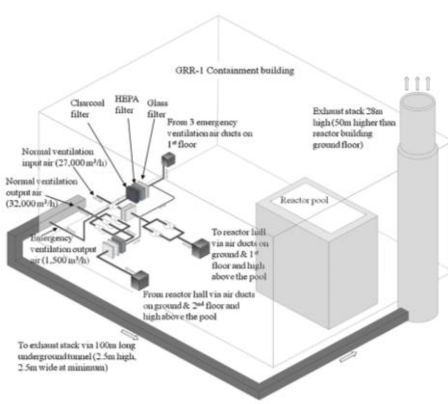


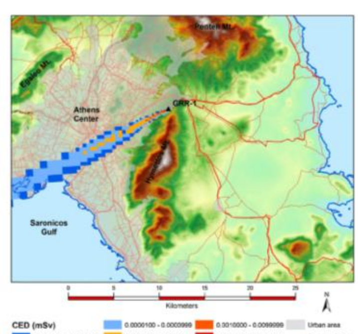
4.3 Dirty Bombs in City Centers





4.4 Dispersion from Nuclear Accidents





5. Impact Assessment

- ✓ Changing nature of hazards (faster, more frequent, extended, higher magnitude)
- ✓ Change of design thresholds (EUROCODES, return periods)
- ✓ Faster degradation (due to multiple factors)-> requirements for predictive maintenance
- ✓ Change in supply and demand profiles
- ✓ Increased vulnerability to
  - Structural damages due to extreme events
  - Human capital (e.g. heatwaves)
  - Operational / response element
- ✓ Change of damage profiling (time dynamic damage) and restoration properties

<u>Muti-scale impact assessment model</u>

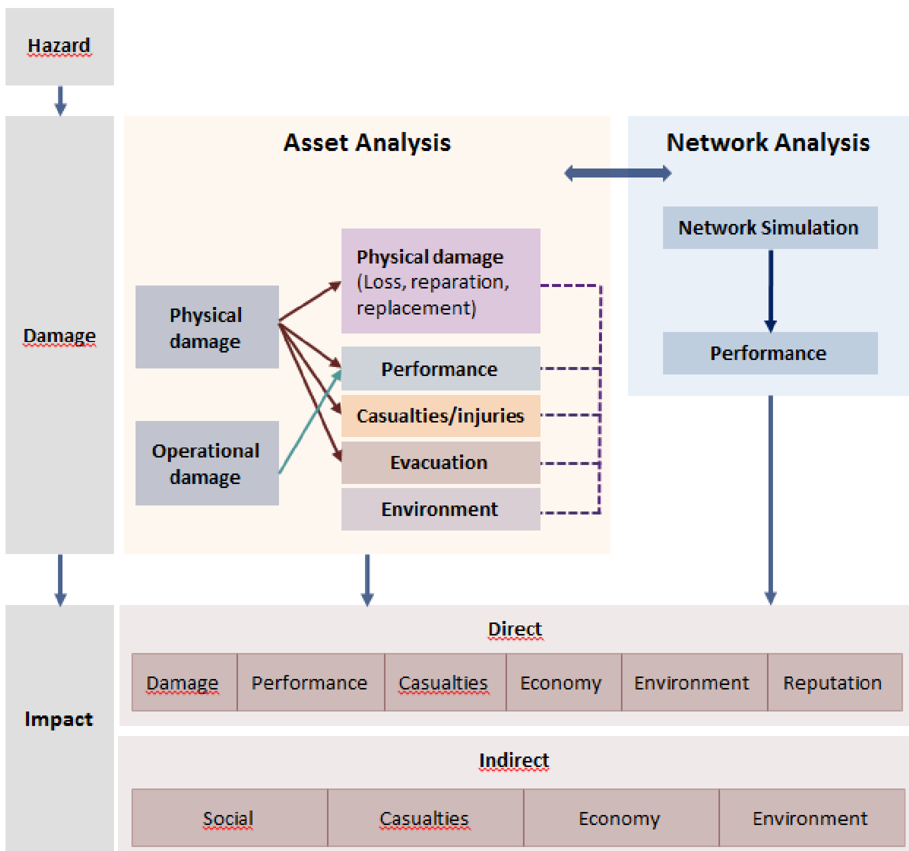
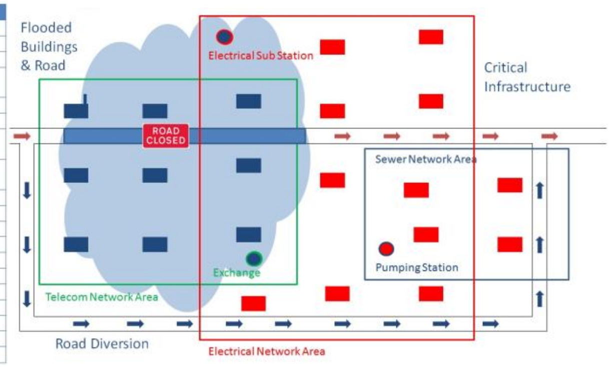


Figure 4: Workflow of EU-CIRCLE holistic impact analysis

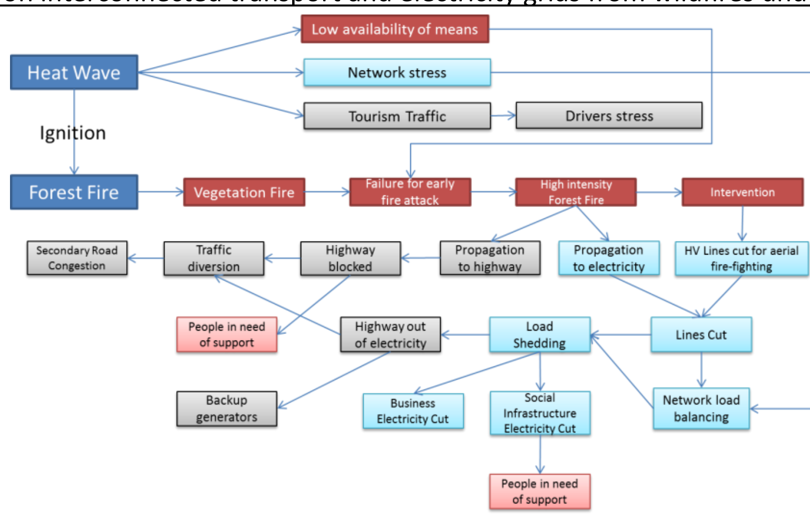
<u>Flooding impact on interconnected infrastructures</u>

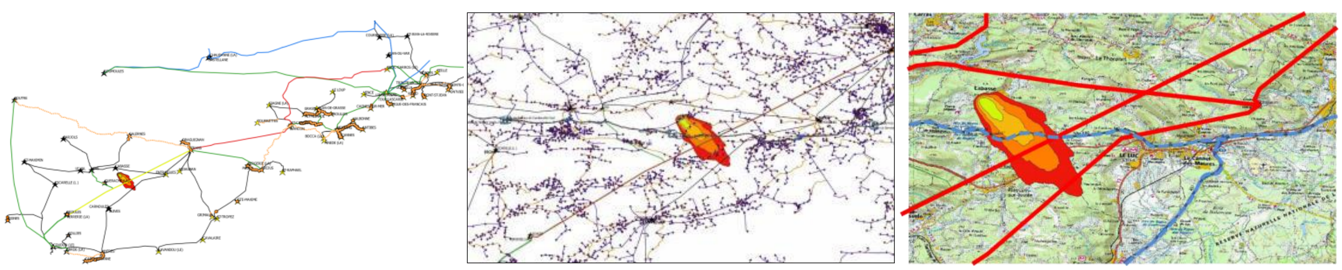
Critical Infrastructure	Effects of flooding
Electricity	Service disruption, Infrastructure damage
Gas	Service disruption, Infrastructure damage
Telecommunications	Service disruption, Infrastructure damage
Sea Defence	Overtopping, Infrastructure damage
Water	Service disruption, Infrastructure damage
Sewer	Service disruption, Infrastructure damage
Highways	Road network disruption, Road damage, diversions, Pressure on other routes, manpower issues
Rail	Rail network disruption, damage, diversions, pressure on other routes, manpower issues
Emergency Services	
Fire Service	Ability to attend flooding incidents and other emergency incidents
Police	Ability to attend flooding incidents and other emergency incidents
Ambulance	Ability to attend flooding incidents and other emergency incidents
Local Community	
Residents	Safety, damage to property/possessions, evacuation
Tourism	Depends on time of year, events, safety, evacuation
Businesses	Damage, disruption, evacuation
Hospital/Care homes	Service disruption, Infrastructure damage, evacuation
Schools	Service disruption, Infrastructure damage, evacuation
Environment	Damage, pollution



Present Day   50 Years Climate Change

- <u>Example in South France</u>
- <u>Impacts on interconnected transport and electricity grids from wildfires under climate change</u>

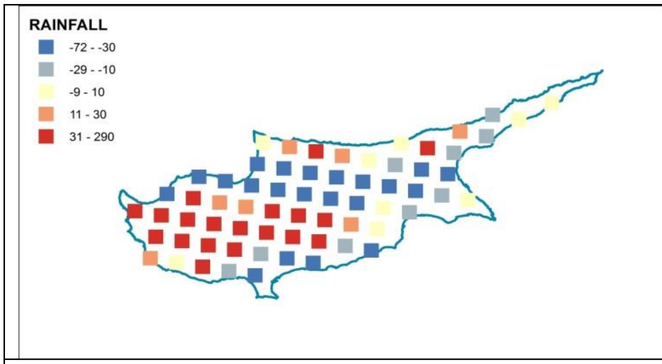




6. Climate Risk Assessment

6.1 National Risk Assessments

Water Scarcity in Cyprus



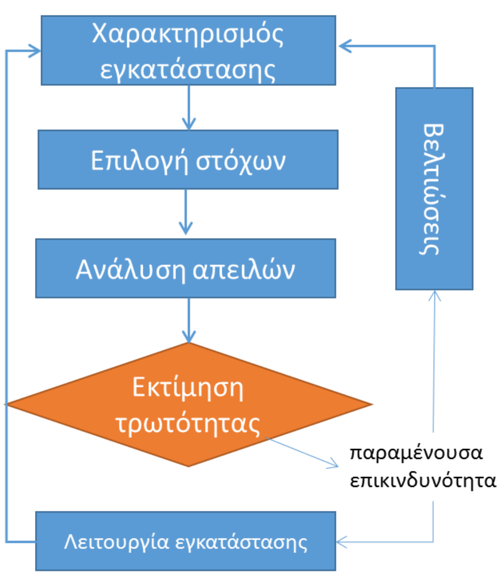
Spatial deviation of annual rainfall from national average, future years based on CORDEX EC-EARTH/RCA4

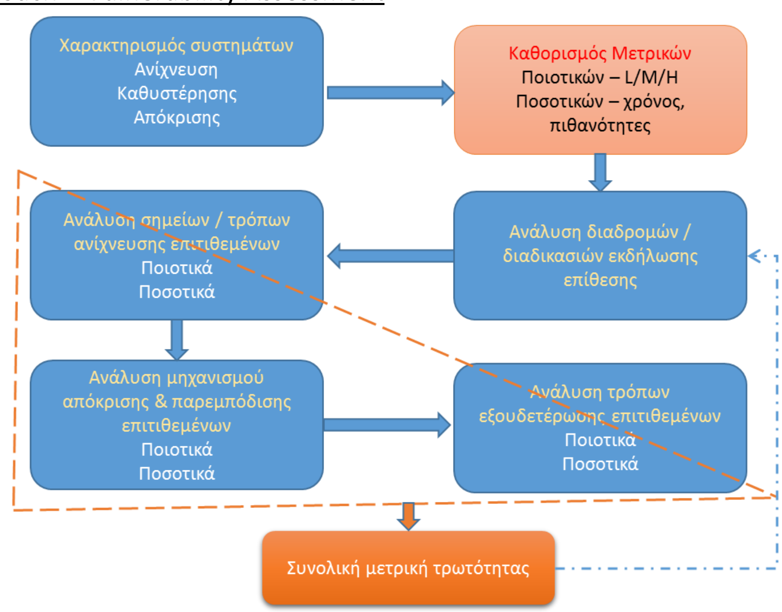
Impact category	Criterion	A	B	C	D	E
HUMAN→numbers	**H1**: Fatalities and injuries	X				
	H2: People Relocation/evacuation	X				
ECONOMY→ **EC1**: Assets costs (€) for the following indicators:	→ **EC1**: Assets costs (€) Indicators:			x		
	a)Property damage: repairs/restoration for buildings/coast/environment etc; materials	x				
	b)Cultural heritage					
	c)Infrastructure: roads, bridges, energy/technology plants etc.		x			
	d)Disruption of economic activity: tourism & agriculture			x		
	e)Other specific cost (secondary cost to economy)		x			

Impact category	Criterion	A	B	C	D	E
ENVIRONMENTAL →polluted area (sq km) and event duration, for each	**EN1**: Environmental damage					x
SOCIAL-POLITICAL→number and duration (use 2-entry matrix), when possible, eg. For infrastructures and functions	**SP1**:damage (interruption/shutdown) of critical infrastructures	x				
	SP2: everyday life/needs disruption-societal functionality: traffic flow; normal activities (school, work)			x		
	SP3: social impact= public order and safety; psychological implications; anxiety				x	

CI Risk and Vulnerability Assessment Reference plans

<u>All hazard approach – Vulnerability Assessment</u>





6.2 Critical Infrastructure Climate Risk

Hellenic Petroleum

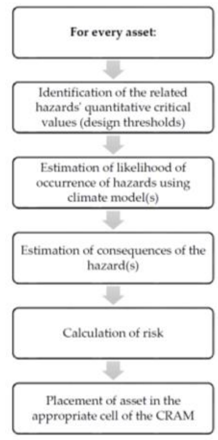


Figure 1. The overall climate risk-assessment process.

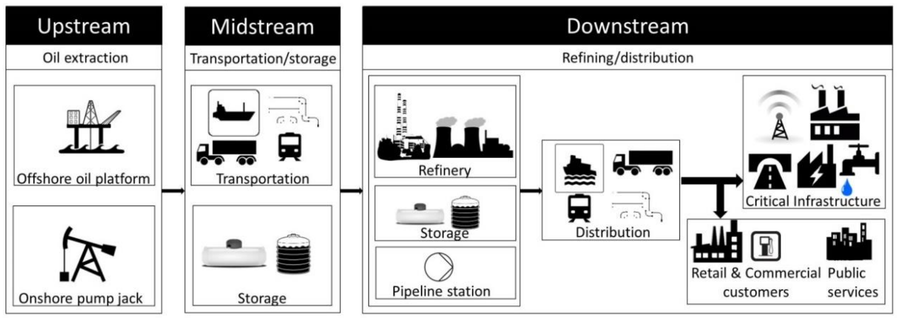
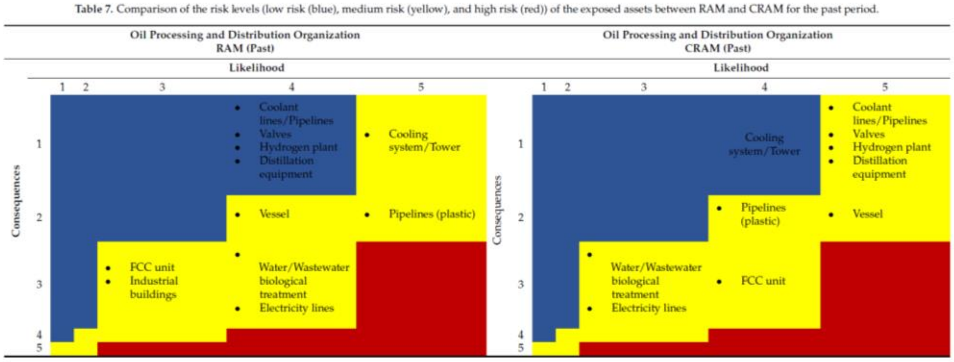


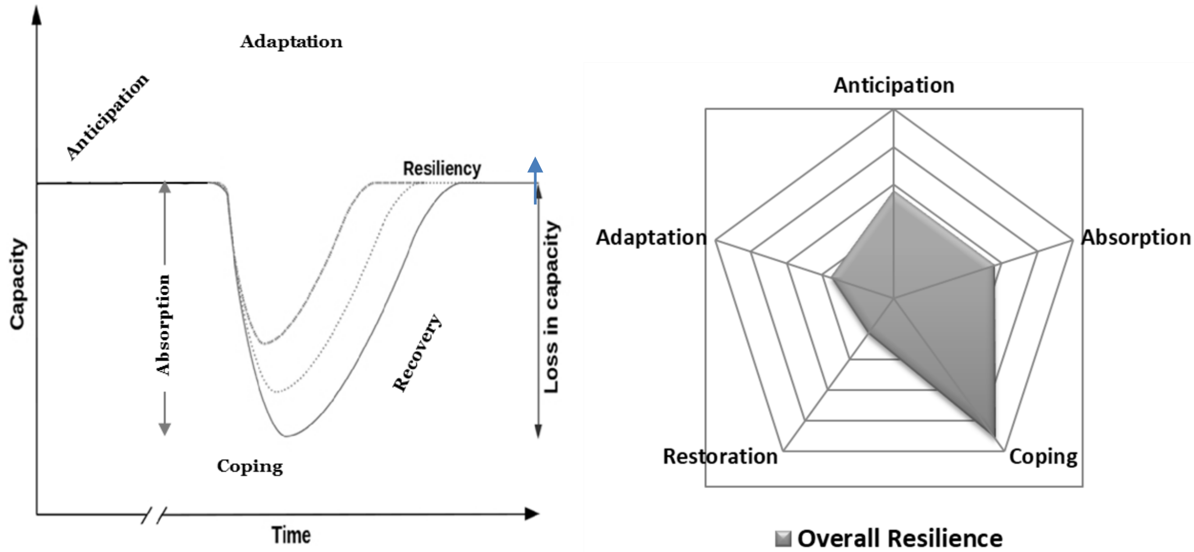
Table 7. Comparison of the risk levels (low risk (blue), medium risk (yellow), and high risk (red)) of the exposed assets between RAM and CRAM for the past period.



Cyprus Energy Hub

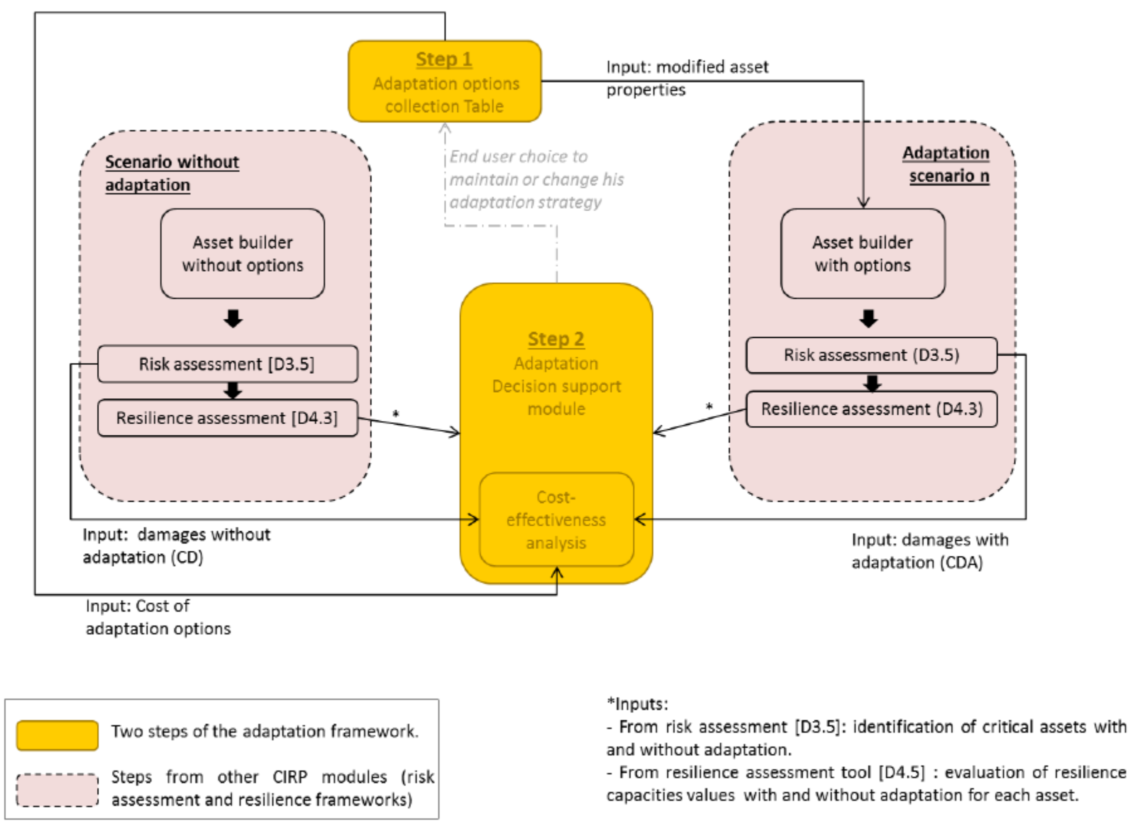
CI operator	asset	hazard	Value (unit)	LIKE Class	IMP Class	Risk Class
VTTV	storage tanks	Max T (RCP 8.5)	41	HIGH	NEGLIGIBLE	VERY LOW
VTTV	storage tanks	Max T (RCP 8.5)	45	MEDIUM	NEGLIGIBLE	VERY LOW
VTTV	storage tanks	Max T (RCP 8.5)	48	LOW	NEGLIGIBLE	VERY LOW
VVTV	storage tanks	wind (RCP 4.5)	36m/s	MEDIUM	MEDIUM	MEDIUM
VTTV	storage tanks	wind (RCP 8.5)	36 m/s	MEDIUM	MEDIUM	MEDIUM

7. Climate Resilience



Conceptual resilience curve, adapted for EU-CIRCLE project (left); Overall Resilience Index from Resilience Assessment Tool (right)

Resilience based adaptation



8. Climate Adaptation through Nature Based Solutions

LIFE RESYSTAL - Climate change REsilience framework for health SYStems and hospiTALs

Project Timeline: September 2021 - August 2025

The current COVID-19 crisis throws into sharp focus the importance of resilient societies and of their health sectors. We must complement our efforts to reduce the effects of climate change with those which enable us to adapt to it. Climate change strikes at the very core of health systems whose mission is to keep people healthy. They are also affected financially and structurally by the rising frequency of extreme weather events. Even distant climate events can impact them. For health systems, climate change directly impacts the health of patients and communities. We are only as healthy as the environment in which we live, and as climate change worsens, more and more people face the health consequences of wildfires, hurricanes, floods, and forced migration globally from failed crops, droughts, and resulting political unrest.

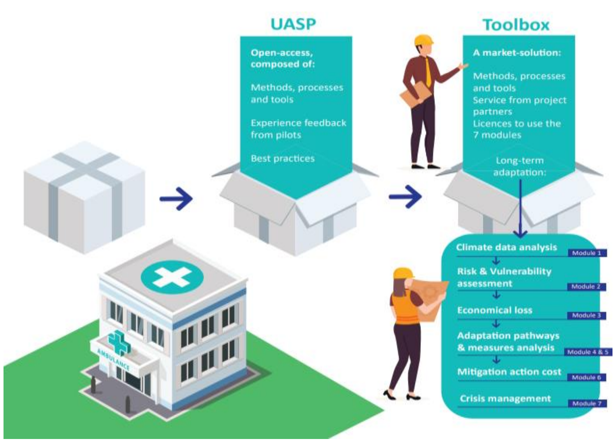
The Objectives

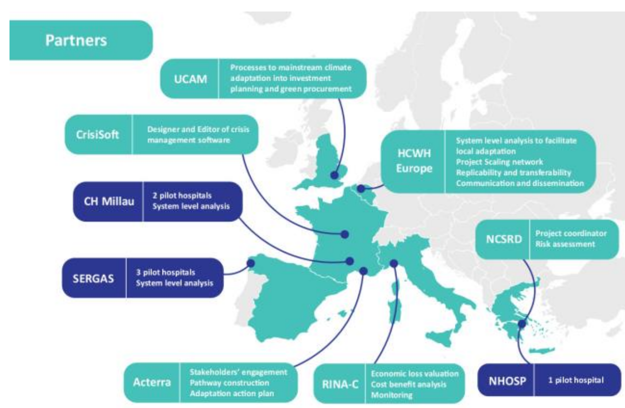
The LIFE RESYSTAL project's main objective is to **increase climate adaptation capacities and resilience of the European Health Infrastructure (EHI) and systems** and related dependant critical infrastructures.

To achieve this, the project will

1. set the basis of a **European Network for the climate adaptation of the European health sector**;
2. provide **science based support for implementing Climate Change Adaptation measures** applicable to any EHI;
3. demonstrate EHI **adaptation in diverse climate conditions**; and
4. **facilitate and promote EHI resilience**.

This 4-year project will develop, demonstrate, evaluate and disseminate a **framework for climate-resilient health systems** with seven pilot hospitals (site-level) and two pilot regional health systems (system-level).

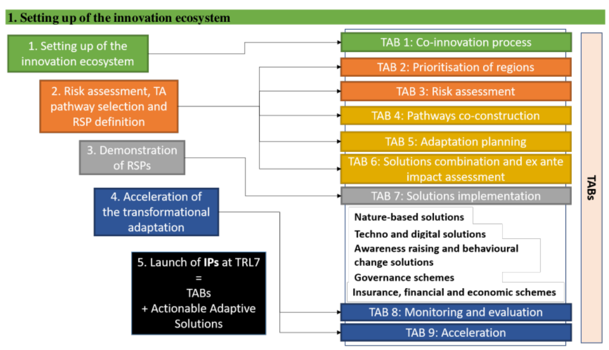




TransfomAr - Accelerating and upscaling transformational adaptation in Europe: demonstration of water-related innovation packages

Project Timeline: October 2021 - September 2025

TransformAr aims to develop and demonstrate solutions and pathways to achieve rapid and far-reaching transformational adaptation (TA) across the EU. Cross-sectoral and multi-scale innovation packages, as the combination of solutions and pathways, will support regions and communities in their societal transformation towards climate change resilience. Region-specific portfolios (RSPs) including Nature-Based Solutions, innovative technologies, financing, insurance and governance models, awareness and behavioural change are o-developed and demonstrated. Transformational adaptation will be triggered by a co-innovation process that will co-create transformational adaptation pathways for six demonstrator regions and communities in Europe. The pathway co-creation process is supported by user-friendly, accessible, and comprehensive multi-sector dynamics data services. The data services fit to the needs of public and private investors, including citizens in TA. To accelerate investment in climate change adaptation (CCA), and to enable that plans are brought into practice, TransformAr also demonstrates the potential of business models and alternative finance mechanisms for transformation adaptation. A European Community of Practice will furthermore be organised and institutionalised to facilitate the exchange of knowledge and other resources that may help to overcome barriers, implement, and accelerate opportunities. Common processes to reach TA are gathered 9 in Transformational Adaptive Blocks (TABs).

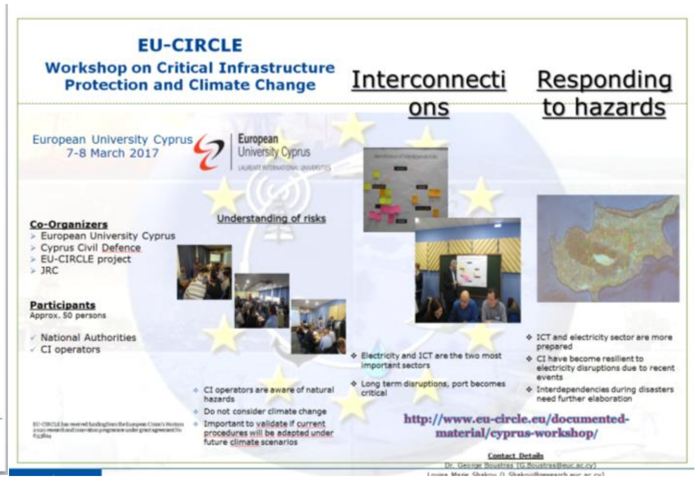


Overall concept

TransformAr will develop an adaptive process based on open innovation, user-friendly and accessible climate data services, actionable solutions and large-scale experimentation. It will be supported by the implementation of IPs built to increase communities' social and climate resilience. These IPs seek to reverse and/or adapt to the increasing anthropogenic pressures on the landscape that are exacerbated by climate change (CC) extremes such as increasing drought, flood or pollution. The replicability and sustainability of IPs will be ensured through genuine community engagement and adoption, use of stakeholder knowledge and bottom-up approaches. Clearly demonstrating both public and private benefits as a way of securing future investment will add to that. The COVID-19 impacts on society, public health and the economy are fully integrated into all stages of the project, from socio-economic modelling and risk assessment to local community engagement, business models and innovative financing schemes. A particular focus will be placed on assessing the potential for TA as part of the Recovery and Resilience plan in EU countries and mainstreaming transformational adaptation investment in the context of the EU Green Deal.

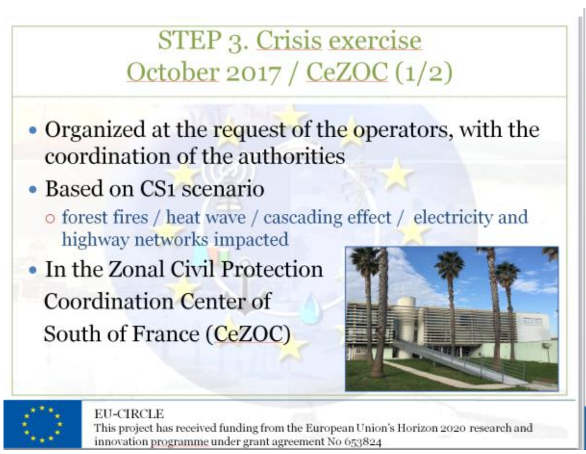
9. Exercises

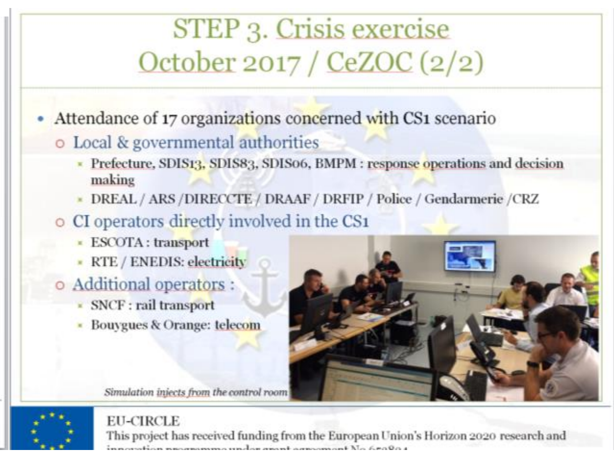
9.1Table Top – Cyprus

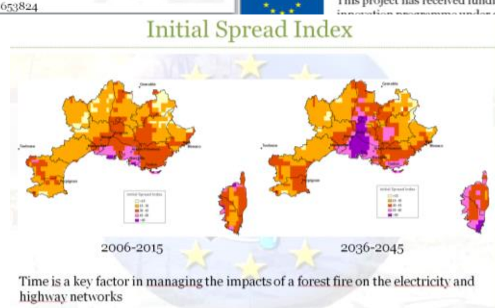


9.2 Command Post France

<u>1st command post exercise that considered a scenario under climate change</u>







9.3 Community Based Exercises

- ✓ **Main Goa**l : Enhancement of public's preparedness / resilience (at individual, household, and community level).
- ✓ The exercise participants are (predominantly) citizens (members of the local community), local administration personnel and local stakeholders (who are not part of the Civil Protection system proper).
- ✓ a tool to promote integration of efforts of all stakeholders, applicable to all phases of DRR