LIFE SEC ADAPT PROJECT

Upgrading Sustainable Energy Communities in Mayor Adapt initiative by planning Climate Change Adaptation strategies

METHODOLOGY FOR VULNERABILITY AND RISK ASSESSMENT IN REGIONS MARCHE AND ISTRIA

LIFE SEC ADAPT
LIFE14 CCA/IT/000316

Life SEC Adapt Project - Sustainable Energy Communities promoting Climate adaptation strategies in Mayor Adapt Initiative
LIFE 14 CCA/IT/000316

http://www.lifesecadapt.eu/

Life SEC Adapt Project

With the contribution of the LIFE financial instrument of European Union

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Partners:

Istrian Development Agency - IDA
Municipal enterprise for planning and development of Patras S.A.

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SOMMARIO

1 Introduction

"The European Commission, adopting a EU Strategy on adaptation to climate change in April 2013, set out a framework and mechanisms for taking the EU's preparedness for current and future climate impacts to a new level. The EU Adaptation Strategy aims to make Europe more climate-resilient and has three key objectives, which are complementary to countries activities:
• Promoting action by Member State: the Commission encourages all Member States to adopt comprehensive adaptation strategies and will provide guidance and funding to help them build up their adaptation capacities and take action. The Commission will also support adaptation in cities by launching a voluntary commitment based on the Covenant of Mayors initiative;
• Promoting better informed decision-making by addressing gaps in knowledge about adaptation and further developing the European Climate Adaptation Platform (Climate-ADAPT) as the 'one-stop shop' for adaptation information in Europe.
• Promoting adaptation in key vulnerable sectors through agriculture, fisheries and cohesion policy, ensuring that Europe's infrastructure is made more resilient, and encouraging the use of insurance against natural and man-made disasters.
The EU also addresses knowledge gaps through research and the European climate adaptation platform. This platform, launched in March 2012, provides several useful resources to support adaptation policy and decision making, such as: a toolset for adaptation planning; a projects and case studies' database; and information on adaptation action at all levels, from the EU through regional and national to the local level.[1]

Climate change manifests itself on different temporal and spatial scales. In general, a significant increase in the intensity of its effects is expected in the Mediterranean region in the 21st century. Climate change is felt in almost all natural systems and sectors of human activities, some of which are deemed particularly sensitive. In order to reduce the impacts of potential adverse change on the urban regions of towns and settlements, their infrastructure and surroundings, as well as on the people and other living world associated with such regions and systems, the establishment of long-term climate mitigation and adaptation policies on the local (municipal) level is becoming more and more frequent. This is based on appropriate analyses of sensitivity of an area to potential change in accordance with the potential intensities

1 Climate-ADAPT: http://climate-adapt.eea.europa.eu/about

of climate impacts and assessment of risks of negative change compared to the baseline. Many international, national, and even regional projects dealing precisely with sensitivity analyses and risk assessment have already been implemented or are in implementation. In that process, very strong heterogeneity of methodological approaches to their quantification or qualitative evaluations has been observed.
The purpose of this methodology, i.e. of the presented guidelines, is to provide – based on available information about the characteristics of both natural and developed urban or infrastructural systems of towns, as well as based on estimates about potential climate change to be quantified within climatological analyses in this project – an appropriate methodological framework to carry out analyses of vulnerability and risks of negative consequences of climate change in the analysed area covered by the project – towns in Marche region in Italy and Istria County in Croatia.
Considering the number of municipalities and the different region that participate to the project, a wide range of potential impacts referred to natural and territorial features will be described by this methodology. A general and detailed work chain will be defined as a guideline that each municipalities may follow to select his main sectors to analyse. According with local board meating, municipalities and stakeholders needs and data available the analysis of particular aspects could be further developed.

1.1 Definitions and conceptual approaches

As the starting point for the presented guidelines, it is important to clarify several key terms as taken over from the Glossary of different EU projects, reported as annex at the end of this document.

- Risk analysis is a comparative analysis of the nature and extent of risks linked to different kinds of hazards and vulnerable conditions that could harm people, assets, livelihoods, infrastructure and services in a given locality (UNICEF, 2013). The result of risk assessment is an evaluation of the likelihood and magnitude of potential losses as well as an understanding of why these losses occur and what impact they have.
- Climate change vulnerability helps us to better comprehend the cause/effect relationships behind climate change and its impact on people, economic sectors and socio-ecological systems. Vulnerability is a main concept that can assume different significance according to the reference topic:

•Disaster Risk Management: in this case vulnerability is a component of risk and interacts with the hazard and exposure to the hazard to indicate the level of risk. Vulnerability is defined as 'the characteristics and circumstances

of a community, system or asset that make it susceptible to the damaging effects of a hazard' (UNISDR, 2009);
•**Critical Infrastructure Protection:** is normally approached with a hazard-centric view; that is by considering when and where critical infrastructure comes into contact with a specific hazard, in this case vulnerability is defined as 'intrinsic properties of something resulting in susceptibility to a risk source that can lead to an event with a consequence'.
•**Climate Change Studies:** the notion of vulnerability, as adopted by the IPCC up to the Fourth Assessment Report (AR4), defines vulnerability as: 'the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity' (IPCC, 2001, p. 995; Parry et al. 2007)

Vulnerability may be expressed as a function:

Vulnerability = f (Exposure, Sensitivity, Adaptive Capacity)

where:

• **Exposure:** *is 'the nature and degree to which a system is exposed to significant climatic variations' where the exposure unit is 'an activity, group, region, or resource that is subjected to climatic stimuli' (IPCC, 2001) ;*[2]
•**Sensitivity:** *is 'the degree to which a system or species is affected, either adversely or beneficially, by climate variability or change' (IPCC, 2014) ;*[3]

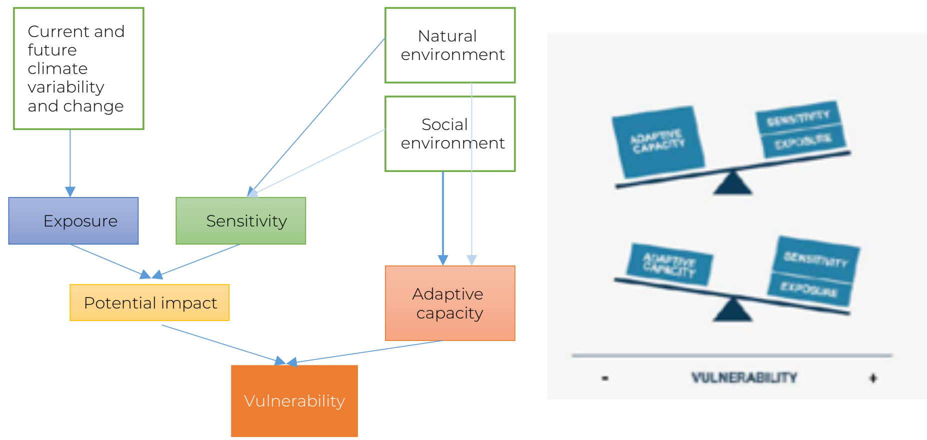
<u>Exposure + Sensitivity = Potential Impact</u>

"Exposure and sensitivity in combination determine the Potential Impact of climate change. For instance, heavy rain events (exposure) in combination with steep slopes and soils with high susceptibility to erosion (sensitivity) will result in erosion (potential impact). Climate change impacts can form a chain from more direct impact (e.g. erosion) to indirect impact (e.g. reduction in yield, loss of income) which stretches from the biophysical sphere to the societal sphere." (GIZ, 2014)

2 Exposure can be also defined ,as set "of all the components which contribute to vulnerability, is the only one directly linked to climate parameters, that is, the character, magnitude, and rate of change and variation in the climate. Typical exposure factors include temperature, precipitation, evapotranspiration and climatic water balance, as well as extreme events such as heavy rain and meteorological drought. Changes in these parameters can exert major additional stress on systems (e.g. heavy rain events, increase in temperature, shift of peak rain from June to May)" (GIZ, 2014).
3 Sensitivity can also "determine the degree to which a system is adversely or beneficially affected by a given climate change exposure. Sensitivity is typically shaped by natural and/or physical attributes of the system including topography, the capacity of different soil types to resist erosion, land cover type. But it also refers to human activities which affect the physical constitution of a system, such as tillage systems, water management, resource depletion and population pressure. As most systems have been adapted to the current climate (e.g. construction of dams and dikes, irrigation systems), sensitivity already includes historic and recent adaptation. Societal factors such as population density should only be regarded as sensitivities if they contribute directly to a specific climate (change) impact" (GIZ, 2014).

• **Adaptive Capacity:** is the 'ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences' (IPCC, 2001).

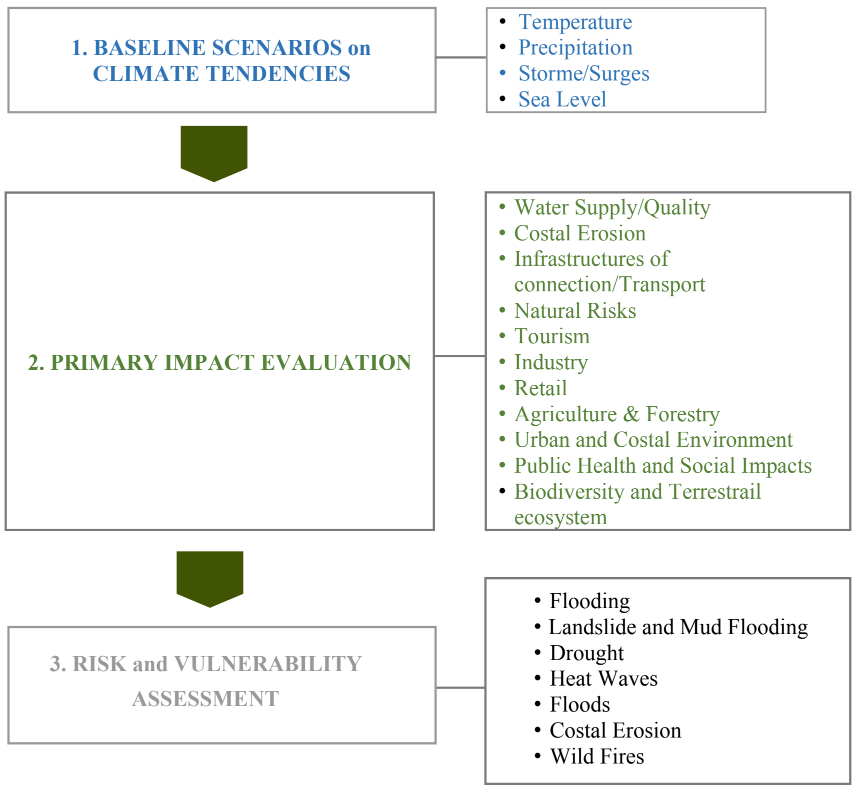
Climate change exposure, and a system's sensitivity to it, determine the potential impact. However vulnerability to that impact also depends on the system's adaptive capacity.
Following picture shows the most common impact chain to achive Vulnerability.



Picture 1 Vulnerability analysis impact chain (on the left), and (on the right) balance between the components of Vunerability: if Exposure + Sensitivity have more weight respect the Adaptive Capacity, Vulnerability is higher, and vice-versa (GIZ, 2014)

2 Work chain framework

The work chain could be summarized in 3 main steps clearly explained in the following graph:



2.1 Baseline Scenarios on Climate Tendencies

2.1.1 Climate Change effects on Mediterranean areas

According to the EEA repot 2017 the Mediterranean region is facing decreasing precipitation and increasing temperatures, in particular in summer. The main impacts are decreases in water availability and crop yields, increasing risks of droughts and forest fires, biodiversity loss and adverse impacts on human health and well-being and on livestock. Environmental water flows, which are important for aquatic ecosystems, are threatened by climate change and by socio-economic developments. Overall, the competition between different water users is expected to increase. The observed invasion and survival of alien species in the Mediterranean Sea is partly due to the warming trend in sea surface temperature. The energy sector will be affected by decreasing water availability and increasing energy demand for heating, in particular in summer. The suitability for tourism will decline markedly during the key summer months, but will improve in other seasons. The Mediterranean region is a hotspot of climate change impacts, having the highest number of economic sectors severely affected. It is also particularly vulnerable to the spill-over effects of climate change impacts in neighbouring regions, in particular related to disruptions in agricultural trade and to migration flows (EEA, 2017).

For these reasons the EEA Report No.1/2017, defines that for the key observed and projected climate change and impacts for the Mediterranean region are:

- Large increase in heat extremes
- Decrease in precipitation and river flow
- Increasing risk of droughts
- Increasing risk of biodiversity loss
- Increasing risk of forest fires
- Increased competition between different water users
- Increasing water demand for agriculture
- Decrease in crop yields
- Increasing risks for livestock production
- Increase in mortality from heat waves
- Expansion of habitats for southern disease vectors
- Decreasing potential for energy production
- Increase in energy demand for cooling
- Decrease in summer tourism and potential increase in other seasons
- Increase in multiple climatic hazards
- Most economic sectors negatively affected
- High vulnerability to spillover effects of climate change from outside Europe

While coastal zones across Europe are facing an increasing risk of flooding from rising sea levels and a possible increase in storm surges. Climate change is leading to major changes in marine ecosystems as a result of warming and ocean acidification. It can also exacerbate oxygen depletion from eutrophication, leading to dead zones. Impacts on fisheries can be both adverse and beneficial, with the highest risks faced by coastal fisheries with limited adaptation potential. Increasing sea surface temperatures can also adversely affect water quality (e.g. through algal blooms) and facilitate the spread of water-borne diseases, such as vibriosis. For these areas the main impacts are:

- Sea level rise
- Increase in sea surface temperatures
- Increase in ocean acidity
- Northward migration of marine species
- Risks and some opportunities for fisheries
- Changes in phytoplankton communities
- Increasing number of marine dead zones
- Increasing risk of water-borne diseases

2.1.2 Climate variability and change on the studied areas

This table summarizes the observed and projected variability and change on climate conditions resulted from the local and regional climate assessment analysis, performed in the Action A1.

Table 2-1 Observed and projected trend of the climate and variability change in the studied areas

Climate variability and change			Observed trend	Projections
TEMPERATURE	Mean Temperature		*Istria and Marche Regions: in the study timespan, the mean annual increase an average 1,3°C with largest increases in summer – 2°C up to 4°C*	*Istria and Marche Regions: The average temperature increase is estimated between 1.7 and 3.1 °C until 2099. Positive temperature changes are expected in all seasons. The strongest variation of mean temperature is projected in summer, ranging from 2.3 to 3.6 °C*
	Extreme Temperature	HEAT WAVE	During the timespan period the increase of heat vawes is extandes between 200 and 300% -but the number of annual cases don't'exceed 8.	a strong positive change in the number of heat waves is estimated -- range from 23 to 90 days This signal seems to be able to be more intense inland of the Istrian peninsula
		COLD NIGHT AND DAYS	A strong decrease of phenomena is pobserved, in particolar along the Marche coast and hilly hinterland	The average variation of the nights and cold days in the thirty years 2061-2090 are included, respectively, between -6.4 and -9.4% (TN10P) and between -6.0 and -9.0% (TX10P).

PRECIPITATION		Mean Precipitation	Istria Region: observed slight tendency to increase the annual precipitation Marche Region: annual total precipitation do not highlights a clear signal of increase or reduction. The tendency to a precipitation increase in spring and a decrease is shown in summer.	Istria Region: increase of medium daily rainfall Marche Region: probably weak reduction of annual precipitation in a century, and seasonal precipitation results indicate a weak reduction in spring, summer and autumn
PRECIPITATION	Extreme Events	EXTREME PRECIPITATION EVENTS	Istria Region: slight increase in maximum daily precipitation and mild increase in dry periods Marche Region: Light increasing trends of SDII index (daily precipitation intensity) and CDD (maximum number of consecutive dry days)	Istria Region: an increase of extreme rainfall index (maximum daily precipitation) Marche Region: general tendency to less frequent but more intensive precipitation events (generally weak or moderate.)
PRECIPITATION	Extreme Events	DROUGHT	An increase of about 5 days in the length of the dry period (CDD) has been observed in both the studied areas	likely increase in the duration of dry periods - up to 15-20 days in a century, particularly in Istria during the summer
STORM/SURGES			During the last 15 years, in the northern and medium Adriatic basin, significant changes in relative trend of frequency of storm surges don't' observed	The signal relatively at MEDICANE origin has not yet been quantified as it depends considerably from some tropospheric patterns as NAO, SCAND, and EUH EUL and secondarily behavior of the Asian monsoon
Sea Level			During the last 15 years, in the northern and medium Adriatic basin , an increases in the average sea level rise of about 6 mm / year were observed. This signal is, however, a slight tendency in the last five years	level rise about 3 mm/year until the end of the century for the Northern Adriatic Sea

2.2 Primary Impact Evaluation

The following table is obtained matching information from previous chapter related to possible impacts derived from the regional analysis on observed and projected climate conditions with the typical local context of Marche and Istria territories.
The matrix offers a check list to develop the analysis of the sector potential affected by the climate change effects.

*Table 2-2 – Potential Impacts (*long period variations)*

Sectors	Heat wave Mean Temperature*	Drought	Heavy precipitation	Storms Surges Sea Level*
Public health / vulnerable groups (elderly, child)	- Deaths, mainly due to cardiovascular diseases/Increase of hospital admission - Spread of vector-born and infectious diseases - Altered allergic pattern - Heat stress - Respiratory illnesses - Incidence of allergic population	-Effects on the air-hygienic situation -Leads to an accumulation of trace elements	-Injured and deaths -Spread of diseases due to contaminated water, mainly infections - Increase of deaths/injuries due to car accidents	- Injured and deaths
Transport and Infrastructures	-Damages -Changes in behaviour pattern / demand -Air quality problems -Higher maintenance costs -Emergency management needed	-Difficult transport of bulk material	-Damages due to floods -Damages due to landslides -Emergency management needed	-Damages
Water supply and sanitation services and Water quality	-Higher water demand -Water quality problems -Lower water flows -Lower groundwater recharge -Higher maintenance	-Water scarcity -Water quality problems -Higher maintenance costs -Lower water flows / lower groundwater recharge -Salinisation	-Damages due floods -Higher maintenance costs -Water quality problems	- Water quality problems Saltwater intrusion into acquifers and surface waters

Sectors	Heat wave Mean Temperature*	Drought	Heavy precipitation	Storms Surges Sea Level*
	costs -Higher evaporation / higher water uptake by ecosystem / lower water flows -Spread of algae, bacteria -Altered fauna -Lower groundwater recharge	-Dikes may collapse		
Tourism	- Change in touristic flow -Image changes -Increasing costs, e.g. for cooling	- Change in touristic flow -Image changes -Increasing costs, e.g. for water supply -Higher water demand	-Damages on touristic infrastructure -Higher costs for maintenance and repair -Damages due to floods -Damages due to landslides	-Damages on touristic infrastructure -Higher costs for maintenance and repair - Loss of beach surface*
Industry	-Lower efficiency -Cooling problems and higher costs -Shortfall of workers	-Water scarcity / cooling problems -Supply problems due to limited bulk transport	-Damages / failures -Damages due to floods -Damages due to landslides	-Damages / failures
Retail	-Changes in buying behaviour -Sales boost / shortfall	-Changes in buying behaviour -Sales boost / shortfall	-Damages / failures -Sales shortfall	
Agriculture and Foresty	-Changes in growth cycle -Thrive / decline of species - Loss on quality of the harvest - Saltwater intrusion due to intese water pumping - Altered flora and fauna, new invasive species* -Forest fires	-Damages / loss of harvest - Desertification - Loss on quality harvest - Saltwater intrusion due to intese water pumping - Loss of UAA (Usable Agricultural Area) - Changes in growth cycle - Altered flora and fauna, new invasive species*	- Soil Erosion -Damages due to floods -Damages due to landslides Loss on quality harvest . Damages in agricultural infrastructures and crop - Changes in growth cycle	- Loss of UAA (Usable Agricultural Area) . Damages in agricultural infrastructures - Loss in agricultural crop - Saltwater intrusion into acquifers and surface waters - Loss in agricultural crop

Sectors	Heat wave Mean Temperature*	Drought	Heavy precipitation	Storms Surges Sea Level*
Urban environment	- Damages, e.g. on asphalt - Higher cooling demand - Higher maintenance costs - Heat island increase - Alteration of growth of urban plants - Altered behaviour pattern / demands - Higher maintenance costs due to extensive use / water use etc. - Altered flora and fauna, new invasive species* - Damages to cultural heritage - Spread of diseases - Smog / higher concentration of air pollutants and allergens	- Higher water demand - Dying of plants - Higher maintenance costs, mainly watering - Risk of fires - Smog / higher concentration of air pollutants and allergens	-Damages due to floods -Damages due to landslides - Surface runoff - Altered drainage system - Damages on infrastructure and plants - Damages to cultural heritage	- Damages on infrastructure - Surface runoff -Damages due to landslides - Damages to cultural heritage - Damages on infrastructure and plants
Marine and Coastal environment	- introduction of non-indigenous species*		- Reduction of bathing water quality - Damage to costal infrastructure -Damages due to landslides	- Damages to costal infrastructured - Coastal erosion - Saltwater intrusion - Changes in surface runoff - Damages in drainage systems
Parks and protected areas Biodiversity Terrestrial ecosystems	-Altered behaviour pattern / demands -Higher maintenance costs due to extensive use / water use etc. - New flora and fauna invasive species* - Change and loss on species and habitats	- Change and loss on species and habitats - Higher maintenance costs, mainly watering - New flora and fauna invasive species* - Increase of fires	- Damages on infrastructure and plants - Change and loss on species and habitats	- Damages on infrastructure and plants - Change and loss on species and habitats

To better understand local sensitivity of potential impacts in partners territories, the Municipalities involved by the project have preliminarly provided information regarding most important potential impacts for certain sectors, based on the local knowledge and experiences. The different selecting sector and their key climate impacts are displayed in the following table. Numbers are the times of selection. in parenthesis expreses preferences of partners.

Table 2-3 – Potential impacts result from municipalities screening

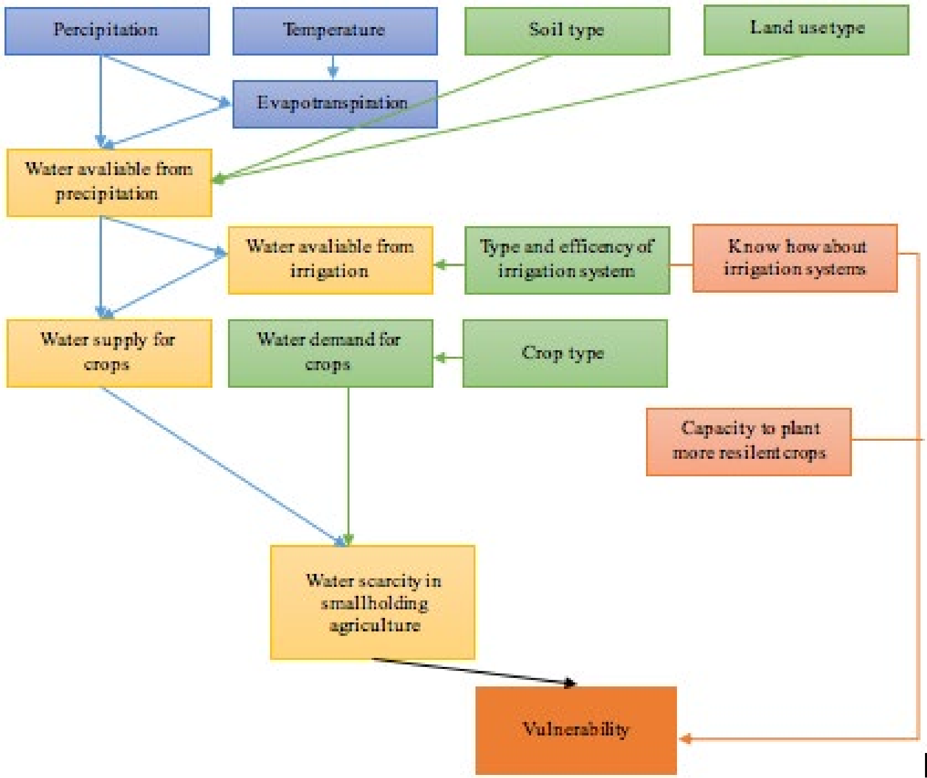
Sectors	Key climate impacts related to past and present climate trends	Key climate impacts related to climate future scenario
Health	- Weather related mortality (3) -Spread of vector-born and infectious diseases (1) -Altered allergic pattern (3) -Heat stress (12) -Respiratory illnesses (3) - Incidence of allergic population (2)	-Weather related mortality (3) -Spread of vector-born and infectious diseases (2) -Altered allergic pattern (3) -Heat stress (12) -Respiratory illnesses (3) - Incidence of allergic population (2)
Transport	Damages (5) -Higher maintenance costs (4)	Damages (5) -Higher maintenance costs (4)
Tourism	-Altered high / low seasons (7) -Image changes (3) -Increasing costs (cooling, water suply, repair…) (6) -Costal erosion (2) -Damages on touristic infrastructure (4) - Damage on cultural heritage (2)	-Altered high / low seasons (7) -Image changes (4) -Increasing costs (cooling, water suply, repair…) (5) -Costal erosion (2) -Damages on touristic infrastructure (6) - Damage on cultural heritage (2)
Industry	-Damages/failures (1) -Increasing costs (2) - Shortfall of worker (1) - Air quality problem (1)	-Damages/failures (3) -Increasing costs (2) -Changes in buying behaviour (1) Shortfall of worker (1) - Air quality problem (1)
Environmental protection/ biodiversity	-Dying of plants and wildlife (2) -Spread of algae, bacteria (1) -Increased forrest fires (10) -Altered flora and fauna, new and invasive species (7) -Loss of species (3) Mortality/damages of trees (7) -Landslides (7) - Pollution of natural resources (1)	-Dying of plants and wildlife (2) -Spread of algae, bacteria (2) -Increased forrest fires (10) -Altered flora and fauna, new and invasive species (7) Loss of species (3) Mortality/damages of trees (6) - Landslides (7) - Pollution of natural resources (1)

Sectors	Key climate impacts related to past and	Key climate impacts related to climate future
Agriculture	-Loss of livestock (1) -Damages / loss of harvest (4) -Water scarsity for crop irrigation (9) -Changes in growth cycle (5) -Soil water erosion (3) - Soli moisture (1)	-Loss of livestock (1) -Damages / loss of harvest (5) -Water scarsity for crop irrigation (9) -Changes in growth cycle (5) -Soil water erosion (3) - Soil moisture (1)
Coastal environment	- Increased storm damage to coastal infrastructure (2) - More rapid coastal erosion (2) - Shoreline change including the possibility for total loss of protective natural barriers (2) - Saltwater intrusion into aquifers and surface waters (1)	- Increased storm damage to coastal infrastructure (2) - More rapid coastal erosion (2) - Shoreline change including the possibility for total loss of protective natural barriers (3) - Saltwater intrusion into aquifers and surface waters (1) - Rising water tables (2)
Social infrastructure	- Altered demands, e.g. for cooling (1) - More patiants in hospital (1) - Higther maintenance costs for pubblic spaces (1)	- Changes in behaviuor pattern (1) - Altered demands, e.g. for cooling (1) - More patiants in hospital (1) - Higther maintenance costs for pubblic spaces (1) - Emergency management needed (1)

3 VULNERABILITY ASSESSMENT

Vulnerability is not a measurable characteristic of a system, such as temperature, precipitation or agricultural production. It is a concept that expresses the complex interaction of different factors that determine system's susceptibility to the impacts of climate change. Many experiences have been developed in the last years in Europe on how assess Vulnerability, each suitable to deal specifc sectors or territories. This methodology offers a possible framework to guide SEC ADAPT partners to assess vulnerability at regional and local level. Following pictures shows the most common impact chain to achieve Vulnerability.

Picture 2 Vulnerability analysis impact chain with example for the impact "Water scarcity in agriculture"[1]



4 *The Vulnerability Sourcebook, GIZ, august 2014, page 66*

3.1 – Logical framework for vulnerability assessment

The procedure suggested to develop the vulnerability assessment at local level, recall the general definition V = E + S - A, and according the following procedure.

Picture 3 Four critical elements of the vulnerability assessment

For each potential impacts, obtained from the application of the application of the work chain described in the previous chapter using the matrix of the Table 2-2.

TASK 1: sectors Exposed to climate change and variability

For each potential impact and related sector detected for the local context, the first task consist to detect if the local territory is Exposed by the potential impact respect to specifc sector.
It is important to make a review of information available at local level (and also ar regional, national) about:
- oberved phenomena (list of events already occoursed) regulation, normative and (if available) actions applied to tackle the specific problem (possible adaptive measures already provided);
- quantitative/qualitative data (frequency of phenomena, intensity, damages etc);
- possible future scenarios;
- regulation plans and (if available) actions applied to tackle the specific problem (possible adaptive measures already provided could emerge during this research)

If the sector result exposed, it is necessary to define an EXPOSURE Indicator that could be quantitative or qualitative (in this case is possible to define categorical values - See Chapters 3.2, 3.3, 3.4 and 3.5).

For example:
- Potential impact 1 (es. DAMAGES DUE TO FLOODING)
  - o Is sector A (eg Urban Environment) exposed?
    - Yes → DEFINE EXPOSURE INDICATOR → go to TASK 2
    - NO → stop

o Is Sector B (eg Agriculture) exposed ?
- Yes → DEFINE EXPOSURE INDICATOR → go to TASK 2
- NO → stop

• Potential impact 2 (es. HEAT WAVES)
o Is Sector A (eg Urban Environment) exposed ?
- Yes → DEFINE EXPOSURE INDICATOR → go to TASK 2
- NO → stop

o Is Sector B (eg Agriculture) exposed ?
- Yes → DEFINE EXPOSURE INDICATOR → go to TASK 2
- NO → stop

The result of TASK 1 is a matrix of observed EFFECTS at local level:

	Sector A	**Sector B**	**...**	**Sector Z**
Impact 1	Exposure Indicator A1	(no exposure)	...	Exposure Indicator Z1
Impact 2	(no exposure)	Exposure Indicator B2	...	Exposure Indicator Z2
...	...	...	...	...
Impact N	(no exposure)	Exposure Indicator BN	...	(no exposure)

Some type of Impacts could be detailed at spatialitation level, eg Floods, landslide susceptibility areas etc , in order to detect maps of exposure.

A possible way is to classify the local territory on the base of land uses. For European territories is available the Corine Land Cover data, as result on the EU Copernicus initiative (http://land.copernicus.eu/pan-european/corine-land-cover). The GIS data, constantly updated and with a spatial resolution of 100 meters, are free available under open license.
The portal land.copernicus.eu offers other dataset with several level of resolution, starting from 10 meters. The section “high resolution layers” provide information on specific land cover characteristics (eg Imperviousness, Forest etc), and are complementary to land cover / land use mapping such as in the CORINE land cover (CLC) datasets. The HRLs are

produced from 20 m resolution satellite imagery through a combination of automatic processing and interactive rule based classification.

Each territory could also refer to more detailed spatial data if available at local level.

TASK 2: Define local Sensitivity

For each Sector exposed define the level sensitivity. The approach could be quantitative or qualitative in this case is possible to define categorical values (See Chapter 3.3, sub,section “applying ranking evaluation scheme”).

• Sector A
o Level of Senitivity for
- Impact 1
- Impact 2
• Sector B
o Level of Senitivity for
- Impact 2
- Impact n

The result of TASK 2 is a matrix of observed EFFECTS at local level:

	Indicator A1		
Impact 2	(no exposure)	Sensitivity Indicator B2	...
...	...	...	...
Impact N	(no exposure)	Sensitivity Indicator BN	...

With Regard to spatialitation, different maps could be used (Copernicus database, regional maps etc) or local indicators could be determineted following the guidelines of the chapter 3.2.
Once Exposure and Sensitivity are defined, these have to be combined to determine the Potential impact value for each Sector.

PI 1A = EI A1 + SI A1 [(Potential Impact 1 on sector A) = (Exposure Indicator A1) + Sensitivity Indicator A1]

TASK 3: define local adaptation

Next step is to move on to the identification of **adaptive capacities** of Marche and Istria regions for each calculated impact. Adaptive capacities are resources that will allow to address climate change impacts and for the purpose of this methodology they are divided in categories:

- Economy
- Technology
- Institutions
- Human resources
- Communication
- Institutions

Indicator could be used to quantify the adaptive capacity following the procedure described in the chapter 3.2.

TASK 4: define local vulnerability

The local vulnerability will be determined for each sector following the general principle:
V A = PI A – AC A [Vulnerability Sector A = Potential Impact sector A – Adaptative Capacity sector A].
The procedure to define and assess the needed indicators is described in the next chapters.

3.2 Selecting indicators

In this step, the goal is to select three types of indicators: for exposure, sensitivity and adaptive capacity.
It is important that indicators are formulated regarding for specific details, such as spatial and temporal coverage.
A good indicator has the following characteristics:
It is **valid and relevant**, i.e., it represents well the factor you want to assess
It is **reliable** and credible and also allows for data acquisition in the future
It has a **precise meaning**, i.e. stakeholders agree on what the indicator is measuring in the context of the vulnerability assessment
It is **clear in its direction**, i.e. an increase in value is unambiguously positive or negative with relation to the factor and vulnerability component
It is **practical and affordable**, i.e., it comes from an accessible data source

It is **appropriate**, i.e., the temporal and spatial resolution of the indicator is right for the vulnerability assessment

Below a possible list of indicators for exposure, sensitivity and adaptive capacity, that according with local board meeting, municipalities and stakeholders needs and data available may be amended. The list of indicators cover the 5 key sectors most voted as priority by all partners (see Table 2-3). For specific local needs other sectors, and relative indicators, could be considered.

Table 3 1 Example of possible indicators

Potential impacts	Exposure factor	Indicator
Increased forest fires	Temperature	Medium daily air temperature
	Precipitation	Total average precipitation
	Extreme weather events	- Number of hot days (TX ≥ 30°C, TX > 25°C) - Duration of dry periods (CDD Consecutive Dry Days, Maximum number of consecutive days with daily PRCP < 1mm)
Water scarcity	Temperature	Medium daily air temperature
	Precipitation	Total average precipitation
	Extreme weather events	- Duration of dry periods - Simple Daily Intensity Index (SDII, Annual total precipitation divided by the number of wet days (defined as daily PRCP ≥ 1.0 mm) in the year)
Heat stress	Temperature	Medium daily air temperature
		Maximum daily air temperature
	Extreme weather events	- Number of hot days (Annual count when TX ≥ 30°C) - WSDI (Warm Spell Duration Index, Annual count of days with at least 6 consecutive days when TX > 90th percentile of the base period)
	Scaling	- Degree of soil sealing - Lack of green urban areas
Water scarcity for crop irrigation	Temperature	Medium daily air temperature
	Precipitation	Total medium precipitation
	Extreme weather events	- Duration of dry periods (CDD, Maximum number of consecutive days with daily PRCP < 1mm) - Simple Daily Intensity Index (Annual total precipitation divided by the number of wet days (defined as daily PRCP ≥ 1.0 mm) in the year)
Change in touristic flow	Temperature	Medium daily air temperature

Potential impacts	Exposure factor	Indicator
	Extreme weather events Extreme weather events	Duration of warm periods (WSDI, Annual count of days with at least 6 consecutive days when TX > 90th percentile of the base period)
		- Number of tropical nights (Annual count of days when TN (daily minimum) > 20°C) - Number of Summer Days (annual count of days when TX (daily maximum) > 25°C)
Potential impacts	**Sensitivity factor**	**Indicator**
Increased forest fires	Biodiversity	- Land use and vegetation typology (eg Broadleaved and Conifer)
	Urban Areas	Proximity to forests and high number of vegetated areas at the edge of cities
	Population	High density of population in high-risk zones
Water scarcity	Civil demands	Amount of water that is needed for civil uses
	Agriculture demands	Amount of water that is needed for agriculture
	Industry demands	Amount of water that is needed for industry
Heat stress	Population	Population density High share of elderly/very young/chronically ill people
	Urban context	Scarcity of green areas
		Building density
Water scarcity for crop irrigation	Efficiency of irrigation system	% of area equipped with irrigation
	Land use	% of UAA (Utilized Agriculture Area)
	Type of crop	Average demands for water irrigation (for crop per square km)
	Economy	% of agricultural import
Change in touristic flow	Income structure	% of income (per region) that comes from tourism
	Turistic flow compostion	Sahre of arrivals visiting for leisure, recreation and holiday porposes
	Geomorphology	Geomorphological costal type
Potential impacts	**Adaptive capacity**	**Indicator**
Increased forest fires	Economy	% of public funds available to combat forest fires
	Technology	Number of firefighting vehicles
	Human resources	Number of fire fighters (professional and amateur)
Water scarcity	Economy	% of income available to combat water scarcity
	Technology	Number of households educated in house water management
	Institutions	Regulations limiting water use (eg in summer – dry periods) or adoption of provision to promote water saving
	Communication	n. of participants to awareness campaigns on heat stress effect
	Institutions	- Average time to the nearest health facility - Number of hospital beds (per 1000 people)

Potential impacts	Exposure factor	Indicator
Water scarcity for crop irrigation	Economy	% of income available for investment into new crop types
	Communication	n. of participants to awareness campaigns on sustainable water use
	Technology	Presence of storage and recycle water systems
Change in touristic flow	Economy	Public spending on marketing in tourism
	Economy	Development of new tourist programs
	Economy	Finalncial opportunities for costal defense

Here a list of possible resources to find ispiration to define possible vulnerability indicators:

Repository of Adaptation Indicators, GIZ, 2015	The repository of adaptation indicators (PDF and spreadsheet documents) is intended to illustrate possible adaptation indicators and their application context. For each indicator, its adaptation relevance, limitations, data needs, sources and territorial relevance are described.	http://www.adaptationcommunity.net/knowledge/monitoring-evaluation-2/project-level-adaptation-me-2/
Local Vulnerability Indicators and Adaptation to Climate Change IDD, 2015	The paper evaluates interdisciplinary research on vulnerability indexes to climate change. The paper presents a systematized analysis of recent literature on agriculture, coastal areas, water resources, forests and health sectors	http://www.unccelearn.org/sites/default/files/inventory/idb01062016_local_vulnerability_indicators_and_adaptation_to_climate_change_a_survey.pdf
VULNERABILITY INDICATORS ClimWatAdapt project	Indicators for water sector (water scarcity, droughts, floodings)	http://climwatadapt.eu/vulnerabilityindicators
Covenant of Mayors for Climate & Energy Reporting Guidelines - SECAP Template	The ANNEX IV of the guidelines proposes a list of example of indicators for adaptation	http://www.covenantofmayors.eu/Covenant-technical-materials.html
Urban vulnerability to climate change in Europe – an interactive map book	An Europe-wide overview Map of the potential vulnerability. It present single indicators or variables that indicate certain vulnerabilities specifically to the climatic threats of heatwaves, water scarcity and droughts, floods and forest fires	http://climate-adapt.eea.europa.eu/knowledge/tools/urban-adaptation details on indicators methodology and additional maps: http://climate-adapt.eea.europa.eu/knowledge/tools/urban-adaptation/my-adaptation

Once indicators are selected and data has been collected they should be stored in a common database to avoid the risk of redundancy and data loss.

3.3 Normalization of indicator data

For the creation of composite indicators there is a wide scale of normalisation, weighting and aggregation methods as showed in OECD (2008). About normalization the two most common types: min-max method and z-scores. The first, according to original direction of variable is used min-max formula. Weighting methods in two main groups: statistical approaches (Factor analysis, Benefit of the doubt, Regression) and participatory approaches (Budget allocation, Public opinion, Analytic hierarchy process). One of the participatory methods, called budget allocation process, is based on a simple idea, to bring together a wide spectrum of experts.
About aggregation, the main approaches are linear aggregation, Geometric mean, Multi-criteria analysis. More details are available on the "Handbook on constructing composite indicators: methodology and user guide (http://www.oecd.org/els/soc/handbookonconstructingcompositeindicatorsmethodologyanduserguide.htm)
Once you collect and store data you have to transfer (normalize) your different indicator data sets into unit-less values with a common scale from 0 to 1.

3.3.1 Determine scale of measurement

In order to normalize your datasets, you first have to determine the scale of measurement for each indicator. The scale of measurement is determined by the phenomenon you observe and how you intend to describe it (temperature, % of area equipped with irrigation, field size). It determines which mathematical operations can be applied to analyze a dataset – the higher the scale level, the more operations are possible. This is important for normalization where you will apply different methods for indicators with categorical and metric scales.

Table 3 2 Scale of measurement for each indicator example

Indicator	Measurement unit
Amount of precipitation	mm
Temperature	° C
% of area equipped with irrigation	%
Number of firefighting vehicles	No measurement unit
Development of new tourist programs	Ranking in 5 classes (very low, low, medium, high, very high)

3.3.2 Normalize your indicator values

Indicators measured using a metric scale are normalized by applying the min-max method. This method transforms all values to scores ranging from 0 to 1 by subtracting the minimum score and dividing it by the range of the indicator values. The following formula is used to apply min-max:

$$\frac{X_i - X_{min}}{X_{max} - X_{min}} = X_{i,1\ to\ 0}$$

X_i represents the individual data point to be transformed
X_{min} the lowest value for that indicator
X_{max} the highest value for that indicator
$X_{i,1\ to\ 0}$ the new value you wish to calculate, i.e. the normalized data point within the range of 0 to 1.

As an example, the calculation for value no. 3 in the following table according to the formula used for min-max normalization is:

$$\frac{780 - 400}{1150 - 400} = 0{,}5066$$

Table 3-3 Normalisation of values

Number	Household income (€ per month)	Normalized value
1	1.150,00	1,00
2	1.009,00	0,81
3	780,00	0,51
4	620,00	0,29
5	490,00	0,12
6	400,00	0,00

3.3.3 Direction of the values

Lower values should reflect positive conditions in terms of vulnerability and risks and higher values more negative conditions (GIZ, 2014). For example, the indicator 'household income' is selected for the vulnerability assessment component 'adaptive capacity' to indicate whether there are sufficient financial resources to carry out adaptation measures. A higher household income represents a higher adaptive capacity and consequently lowers vulnerability. Therefore, the direction of the indicator's value range is negative: vulnerability increases as the indicator value decreases, and vice versa. So here the value range of the indicator, should be inverted so that the lowest value is represented by the standardized value of 1 and the highest by the standardized value 0. To achieve this, simply subtract your value from 1 to determine the final standardized value (e.g. for a value of 0.29, apply calculation of 1-0.29, which returns a final standardized value of 0.71).

Table 3-4 Inversion of values

Number	Household income (€ per month)	Normalized value	Value for the VA after inversion
1	1.150,00	1,00	0,00
2	1.009,00	0,81	0,19
3	780,00	0,51	0,49
4	620,00	0,29	0,71
5	490,00	0,12	0,88
6	400,00	0,00	1,00

3.3.4 Applying ranking evaluation scheme

The min-max method applied to metric indicator values cannot be applied to categorical values, eg for qualitative indicators. Instead, you will need to use a rating scale to normalize your data. For example indicator in this evaluation scheme would be "development of new tourist programs". By defining classes in negative or positive terms, you also give the indicator values a meaning applicable to the vulnerability assessment.

Table 3-5 Ranking evaluation scheme

Class no.	Description
1	optimal
2	positive
3	neutral
4	negative
5	critical

3.3.5 Transformation from five-class scheme into 0 to 1 scheme

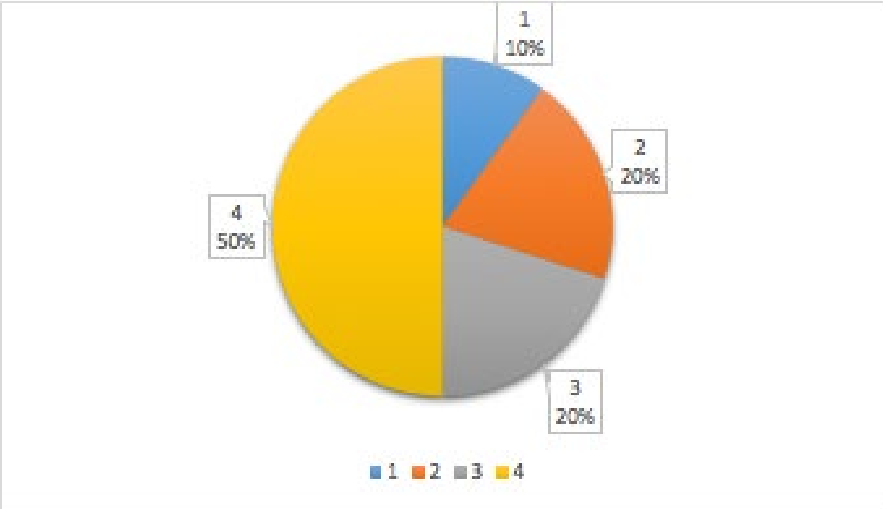
In preparation for the aggregation of indicator values in Step 4 you will need to ensure that all indicator values are transformed into the value range of 0 to 1. Next table describes the procedure.

Table 3-6 Transformation of five-class scheme

Class no.	Class value	Description	Indicator value 0 to 1
1	0-0,2	optimal	0,1
2	0,2-0,4	positive	0,3
3	0,4-0,6	neutral	0,5
4	0,6-0,8	negative	0,7
5	0,8-1	critical	0,9

3.4 Weighting and aggregating of indicators

This step explains how you should way indicators of exposure, sensitivity and adaptive capacity. Weighting is not applied always but only in cases when some of the indicators are considered to have a greater influence on a vulnerability and risks than others.
Weighting cannot be compulsory because certain indicators cannot have the same significance for two different regions.
When you have more than two indicators weights should be added following the "budget procedure" . "Budget procedure" works in the matter in which you set yourself a budget (recommending 100) and give each indicator a certain value. In the chart below, 4 indicators have been used. Indicator 1 has been given 10% of the budget, indicators 2 and 3 20% each, and indicator 4 50% of the budget. In this case weight (w1) for indicator 1 is the base (because it is smallest) and it is 1. Weights 2 and 3 should be calculated by dividing their own percentages of the budget with the smallest given percentage (20%/10%=2) and then multiplied with the base (1*2=2). Following the same procedure weight for indicator 4 is 5 (50%/10%=5, 5*1=5).
It must be mentioned that "budget procedure" is not the only way of weighting indicators but the one mostly used.



Once the different indicators of a vulnerability component have been evaluated and weighted, they are aggregated into three vulnerability components: exposure, sensitivity and adaptive capacity. These discrete (normalized) indicators must be aggregated into a composite indicator representing the sensitivity of the system in question.

IMPORTANT!

Special care must be taken that individual indicators do not mix within composite indicators (exposure, sensitivity or adaptive capacity factor) or sectors (environmental protection/ biodiversity, water resources and quality, health, agriculture and tourism). Individual indicator must be collected and stored so it is clear in which sector and to which composite indicator it belongs.

3.4.1 Aggregation method

Once the different indicators of a vulnerability component have been evaluated and weighted, they are aggregated with following formula.

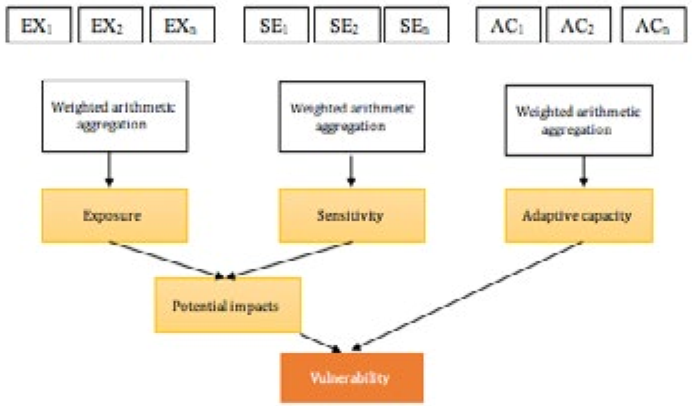
$$CI = \frac{(I_1 * w_1 + I_2 * w_2 \ldots + I_n * w_n)}{\sum_1^n w}$$

...where CI is the composite indicator (exposure, sensitivity or adaptive capacity factor) I is an individual indicator of a vulnerability component, e.g. land use, and w is the weight assigned to the indicator.
If equal weighting applies, indicators are simply summed and divided by the number of indicators. Assigning a weight of 2 (or 3) to one or more indicators implies that these indicators are twice (or three times) more important than indicators which retain a weighting of 1.
To enable meaningful aggregation of individual indicators, remember that all indicators of the three vulnerability components must be aligned in the same way. This means that a low or high score represents a 'low' or 'high' value in terms of vulnerability.

3.5 Aggregating vulnerability components to vulnerability

This step shows you how to aggregate the vulnerability components exposure and sensitivity to a potential impact. It also explains how to combine the potential impacts of different sectors and how to combine adaptive capacity into a composite vulnerability indicator.

Picture 4 Approach to aggregating indicators for vulnerability



Aggregation of exposure and sensitivity to potential impact

Once you derived a composite indicator for the two vulnerability components exposure and sensitivity, these two components must be combined to form the vulnerability component potential impact. Because we have five sectors: environmental protection/biodiversity, water resources and quality, health, agriculture and tourism, potential impact for each sector must be calculated separately and then aggregated in to one. Weighted arithmetic aggregation is once more applied to calculate the potential impact composite indicator, using the following formula for health sector:

$$PI_{(health)} = \frac{EX_{(health)} * w_{ex(health)} + SE_{(health)} * w_{se(health)}}{w_{ex(health)} + w_{se(health)}}$$

...where PI is the potential impact composite indicator, EX is the vulnerability component exposure, SE is the vulnerability component sensitivity and w is the weight assigned to the vulnerability components.

Weighting in this case is simple because it uses two vulnerability components. You have to determine significance of one component compared to other. For example, if you determine that exposure has 65% significance of the potential impact, wex would be 0,65 and wse would be 0,35. If you determine that they are equal than they would be both 0,5.

Aggregation of potential impact and adaptive capacity to vulnerability

Potential impact composite indicator is aggregated with adaptive capacity in order to arrive at a composite vulnerability indicator for the system under review. Here, again, weighted arithmetic aggregation is applied:

$$V_{(health)} = \frac{PI_{(health)} * w_{PI(health)} + AC_{health} * w_{AC(health)}}{w_{PI(health)} + w_{AC(health)}}$$

...where V is the vulnerability indicator, PI is the potential impact indicator, AC is the vulnerability component adaptive capacity, and w is the weight assigned to the vulnerability components.

4 RISK ASSESSMENT

Risk analysis is a comparative analysis of the nature and extent of risks linked to different kinds of hazards and vulnerable conditions that could harm people, assets, livelihoods, infrastructure and services in a given locality (UNICEF, 2013). The result of risk assessment is an evaluation of the likelihood and magnitude of potential losses as well as an understanding of why these losses occur and what impact they have.

4.1 Identifying hazards

First step in risk assessment is hazard identification.. To evaluate if an hazard is significant we should think about the following questions: is this a dominant hazard in the pilot area or in the region causing regular disasters? Do the meteorological, hydrological and geographical circumstances justify that this hazard type causes problems regularly?

Hazards (He) that are selected for Istria and Marche region are connected to the main results of the Climate Baseline Analysis (A1) developed in the previous phase. The three most criticial phenomenon are related to the increase of summer heat waves, the average reduction of precipitations, with long periods of drought and the concentration of heavy precipitations in very short time periods, causing indirectly floods and other hydrogeological impacts.

- Heat waves: according to the World Meteorological Organization definition, a heatwave is "when the daily maximum temperature of more than five consecutive days exceeds the average maximum temperature by 5 °C, the normal period being 1961-1990". In this methodology we can calculate the heat waves on the basis of the CLINO 1971-2000, as defined in the previous phase.
- Droughts: the beginning of drought is usually defined by comparing the current situation to the historical average, often based on a 30-year period of record (CLINO 1971-2000). The threshold identified as the beginning of a drought is usually established somewhat arbitrarily. (IPCC, 2012) defines a drought as "the phenomenon that exists when precipitation has been significantly below normal recorded levels, causing serious hydrological imbalances that adversely affect land resource production systems".
- Floods: according to the Flood Directive (EC, 2007), "flood means the temporary covering by water of land not normally covered by water. This shall include floods from rivers, mountain torrents, Mediterranean ephemeral water courses and floods from the sea in coastal areas, and may

exclude floods from sewerage systems".
- Wild fires: any non-structure fire, other than prescribed fire, that occurs in the wildland (Firewise, 1998).
- Landslides: a mass of material that has moved downhill by gravity, often assisted by water when the material is saturated. The movement of soil, rock, or debris down a slope can occur rapidly, or may involve slow, gradual failure (IPCC, 2012).

4.2 Calculate the intensity of hazard events

The intensity of the event describes the magnitude of the hazard expressed in a qualitative or quantitative format. The intensity is definend by a minimum threshold which had been defined to identify the hazard; for example, we suppose that for the definition of an heat wave we should register at least "a daily maximum temperature for more than five consecutive days exceeding the average maximum temperature of the normal period (CLINO) by 5 °C". The minimum threshold defines if a phenomenon can be considered as an hazard or not.
The intensity of the hazard can be also calculated defining different intensity bands, over the minimum thresholds. For example, the heat waves can be differentiated in degree bands exceeding the threshold, or, in the case of floods, the measurements regarding the water level can be used.
The identification of the minimum intensity level is crucial to highlight the hazard events occurred in the past and eventually to estimate their probability of occurrence in the next decades.

4.3 Classifying likelihood of hazard events

The likelihood of a specific hazard has to be based on factual, historical data. The likelihood can be also supported by a textual description. There are three different approaches to classify the likelihood of an hazard event:
a) Use of historic data: which are normally registered by some local and regional stakeholders, to be involved through regional boards set-up. Some hazards (heat waves and droughts) can be based on the meteorological data, collected by the partners for the climate baseline definition.
b) Probability forecasts: strongly related to the meteorological analysis developed in the previous phase (A1) and to the scenarios defined at regional level for the next century (just as tendency trends).
c) Expert opinion: which can be provided by key experts working in the hazard monitoring at regional level, with a strong background in the specific field.

The likelihood evalution must be realized for each selected hazard. For the purpose of this risk assessment hazards will be collected just from the latest 20 years, depending on the availability of data. The probability forecasts will be considered only as tendency trends, with a qualitative approach.

Table 4-1 Likelihood

Likelihood level	Frequency (in 10 yr. period per region)[6]
5: Almost certain	More than 25
4	Between 10 and 24
3	Between 5 and 9
2	Between 1 and 4
1: Almost incredible	Never

Table 3-2 provides an example of likelihood evaluation in a period of 10 years.

Table 4-2 Hazard valuation example

Hazard element (He)	Frequency	Likelihood level
Heat waves	3	2
Droughts	6	3
Floods	2	2
Wild fires	1	1
Landslides	10	4

<u>The results of table 3-1 will be one of the two entries in the risk matrix final evaluation: "hazard". This entry considers the hazard level, which is determined by the multiplication of the hazard intensity (the minimum threshold which help us to understand if the phenomenon can be considered as an hazard) and the hazard likelihood (which tells us if a phenomenon occur with a certain frequency).</u>

6 Derived from Disaster Risk Analysis, Guidance for Local Governments, UNICEF, december 2013., page 16

4.4 Defining the elements at risks

To evaluate the element at risks due to an hazard, it is crucial to cross some features of the phenomenon.

- The size of the affected area: defines the geographical location and the territory being affected by the natural hazard. For example, if a flood hazard map does exist then it can be directly used as a basis for risk mapping. If not, a flood hazard map has to be developed based on historical data or exploiting the expert opinion.

Picture 5 Example of affected areas (flooden areas)

- The duration of the event: it should answer to the following question, when it normally happens and how long does the event last? It could be described using the historic data or the expert opinion. This parameter tells us if the hazard can be problematic for certain elements or not (for example, regarding the droughts, if the hazard occurs exactly during the agriculture growth period for specific crops).

The features should be sufficient detailed to identify the element at risk (sectors and subsectors), located within the hazard zones. In the vulnerability step analysis (chapter 4) these elements have been already evaluate in terms of exposure, sensitivity and adaptive capacity. The elements at risk should be described in depth, mainly regarding the impacts they could face (physical impacts, economic impacts, ecological impacts, social and physiological impacts). For each element at risk the global vulnerability index should be considered.

4.5 Analyzing risks

The analysis of risks has to be performed for the specific pilot area, for each element at risk and type of hazard considered. The concepts of hazard, vulnerability and disaster risk are dynamically related i.e. hazards and vulnerability have to be both present in the same location to create risk (UNICEF, 2013). The relationship of these elements can be expressed as a simple formula that illustrates the concept that the greater the potential occurrence of a destructive hazard and the more vulnerable an exposed population, then the greater the risk. It is also important to note that human vulnerability to disaster is inversely related to human capacity to withstand the effects of disasters i.e. the more capacities a community has the less vulnerable it is (that is why valuation of adaptive capacities are important).

Risk = Hazard x Vulnerability
or
R= H*V

This is not the only formula in use but certainly the most widely spread. It is relatively straightforward to apply (subsuming exposure and capacity under vulnerability) and at the core of risk matrices produced in many European countries.

4.6 Weighting and aggregating hazards

Weighting and aggregating hazards is done identically as with of indicators of vulnerability (2.4 Step 4) with the formula:

$$H_{(87/96)} = \frac{(He_{1(87/96)} * w_1 + He_{2(87/96)} * w_2 \ldots + He_{n(87/96)} * w_n)}{\sum_1^n w}$$

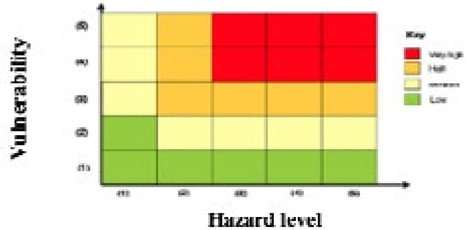
...where H(87/96) is hazard for period 1987-1996, He1(87/96) is an individual hazard element for same period, w is assigned weight and $\sum_1^n w$ is number of weights/hazard elements.
After calculating all hazards for six selected periods, next step is to calculate summarized hazard.

$$H = \frac{(H_{(87/96)} + H_{(97/06)} \cdots + He_{(37/46)} * w_{(37/46)})}{6}$$

...where H is hazard, H(87/96) is hazard for period 1987-1996 and 6 is number of selected periods.

4.7 Selecting risks

At this stage, the decision-makers have to identify which risks they are going to accept and which ones they are going to treat. Decisions related to risk evaluation (e.g. acceptable risk criteria) have to be set right at the beginning of the procedure. At this stage the results of the risk analysis and the risk criteria have to be compared.



A risk matrix could be used to identify the risks which we do accept (within the low and medium cells) or those which we should face in the adaptation plan (high and very high cells).

4.8 Risks mapping

Risk mapping is an essential tool for local authorities and decision-makers and it should accompany the risk assessment. Maps provide information regarding the spatial distribution of risk and they can support decision making and risk management. The risk mapping can be produced at regional level (and with specific focuses on the Municipalities members of the project), for each selected risk. The risk maps can be finally overlapped to select the most critical areas.

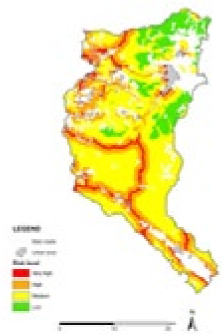


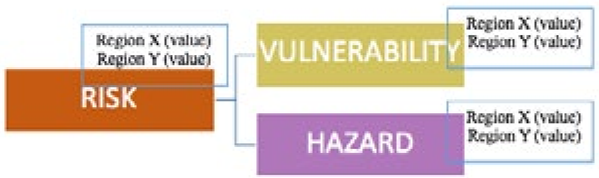
Figure 6 Wildfire risk map of Velingrad, Bulgaria (University of Vienna, 2013- SEERISK project)

5 PRESENTING RESULTS

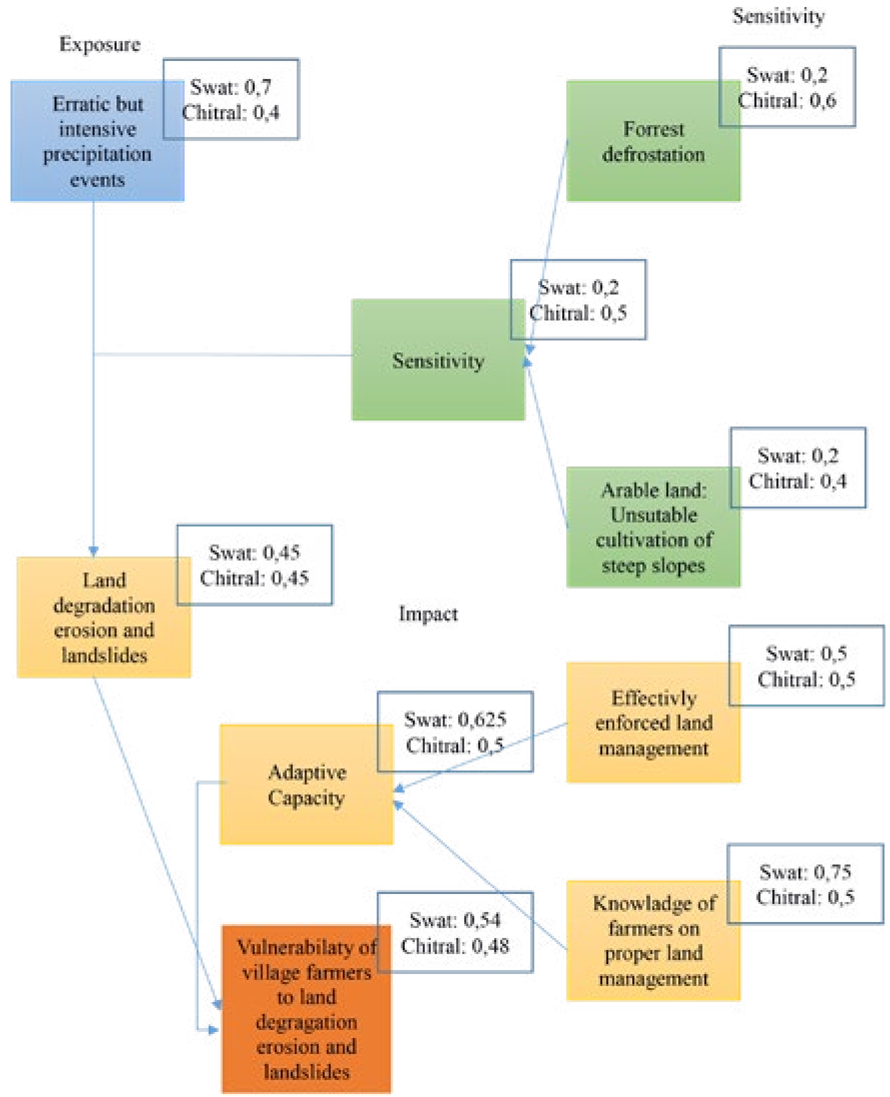
Maps, diagrams and graphs are valuable and compelling tools for illustrating assessment findings. These elements represent high-level views of data, and while there is a danger of misinterpretation, when used with a sufficient description and/or legend in the context of a detailed report, they can aid understanding of outcomes.
Two methods of presentation are represented in the following examples.

Summarized vulnerability can be presented in the same manner as *Picture 5 1 Summarization of vulnerability.* Chart, of course, has to have values like pictures 4-1 and 4-2.

Picture 7 Example of risk presentation for two fictive regions

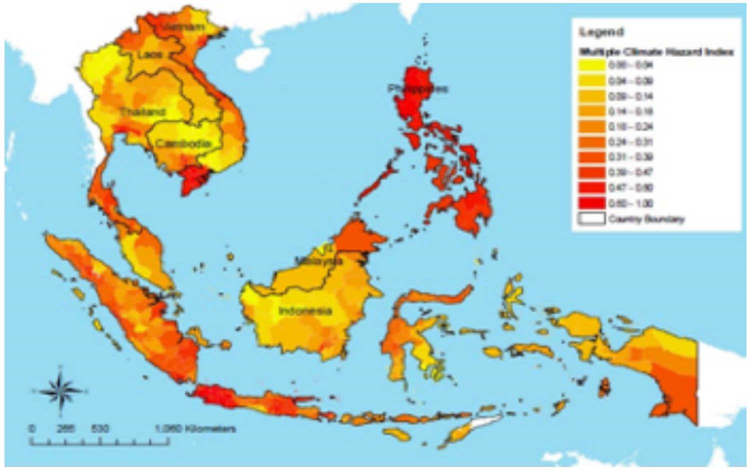


Picture 8: Example of vulnerability presentation of two regions



Other method of presentation could be map display. Following picture shows climate hazard index in south-east Asia.

Picture 9 Climate hazard index in south-east Asia (GIS mapping technology)



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- Local Vulnerability Indicators and Adaptation to Climate Change IDB, 2015 (http://www.uncclearn.org/sites/default/files/inventory/idb01062016_local_vulnerability_indicators_and_adaptation_to_climate_change_a_survey.pdf)
- VULNERABILITY INDICATORS ClimWatAdapt project (http://climwatadapt.eu/vulnerabilityindicators)
- Covenant of Mayors for Climate & Energy Reporting Guidelines - SECAP Template (http://www.covenantofmayors.eu/Covenant-technical-materials.html)
- Urban vulnerability to climate change in Europe – an interactive map book – (http://climate-adapt.eea.europa.eu/knowledge/tools/urban-adaptation)

7 GLOSSARY

- Adaptation (to climate change): The process of adjustment to actual or expected climate, and its effects. See also Autonomous Adaptation, Evolutionary Adaptation, Incremental Adaptation and Transformative Adaptation (IPCC, 2014).
- Adaptation Strategies: Adaptation Strategies include a mix of policies and measures with the overarching objective of reducing vulnerability. Depending on the circumstances, the strategy can be set at a national level, addressing adaptation across sectors, regions and vulnerable populations, or it can be more limited, focusing on just one or two sectors or regions (IPCC, 2014).
- Adaptive Capacity: is the ‘ability of systems, institutions, humans, and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences’ (IPCC, 2014).
- Baseline: ‘the baseline (or reference) is the state against which change is measured. It might be a ‘current baseline’, in which case it represents observable, present-day conditions. It might also be a ‘future baseline’, which is a projected future set of conditions excluding the driving factor of interest. Alternative interpretations of the reference conditions can give rise to multiple baselines’ (IPCC, 2007b).
- Climate: Climate in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization (IPPC, 2013).
- Climate change: climate change refers to a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer (IPPC, 2013).
- Climate Change Studies: the degree to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity’ (IPCC, 2001, p. 995; Parry et al. 2007).
- Composite indicator: a composite indicator (also called index) is a complex indicator, composed by combining several (weighted) individual indicators. Composite Indicators are able to measure multi-dimensional concepts (vulnerability against climate change effects) which cannot be captured by a single indicator. The methodology of its composition

should entail the details of the theoretic framework or definition upon whereas indicators have been selected, weighted and combined to reflect the structure or dimension of the phenomena being measured (OECD, 2007).

- Consequence: The outcome of an event affecting objectives (ISO/IEC 27000: 2014 and ISO 310000: 2009).
- Critical Infrastructure: An asset, system or part thereof located in Member States which is essential for the maintenance of vital societal functions, health, safety, security, economic or social well-being of people, and the disruption or destruction of which would have a significant impact in a Member State as a result of the failure to maintain those functions (European Commission: Council Directive 2008/114/EC).
- Critical Infrastructure Protection: All activities aimed at ensuring the functionality, continuity and integrity of critical infrastructures in order to deter, mitigate and neutralise a threat, risk or vulnerability (Council Directive 2008/114/EC).
- Damage: Damage classification is the evaluation and recording of damage to structures, facilities, or objects according to three (or more) categories (UN Department of Humanitarian Affairs, 1992).
- Efficiency: The good use of time and energy in a way that does not waste any (http://dictionary.cambridge.org/dictionary/english/efficiency).
- Event: Occurrence or change of a particular set of circumstances. - An event can be one or more occurrences, and can have several causes. - An event can consist of something not happening. - An event can sometimes be referred to as an “incident” or “accident”. (CIPedia® 2015 based on ISO/PAS 22399:2007 and ISO/IEC 27000:2014).
- Exposure: is ‘the nature and degree to which a system is exposed to significant climatic variations‘ where the exposure unit is ‘an activity, group, region, or resource that is subjected to climatic stimuli’ (IPCC, 2001).
- Extreme weather event: An extreme weather event is an event that is rare at a particular place and time of year (IPPC, 2013.
- Hazard: The potential occurrence of a natural or human-induced physical event or trend, or physical impact, that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, and environmental resources (IPPC, 2014).
- Impact: Effects on natural and human systems (...) the term impact is used primarily to refer to the effects on natural and human systems of extreme weather and events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure due to the interaction of climate

changes of hazardous climate events occurring within a specific time period and the vulnerability of an exposed society or system (Adapted from IPCC 2014).

- Indicator: Measurable characteristic or variable which helps to describe a situation that exists and to track changes or trends – i.e. progress – over a period of time (GIZ, 2013).
- Intergovernmental Panel on Climate Change (IPCC): is perceived as the leading international body for the assessment of climate change. In the 23 years since its founding, it has become a key framework for the exchange of scientific dialogue on climate change within the scientific community as well as across the science and policy arenas (Edenhofer and Seyboth 2013).
- Resilience: The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions (UNISDR, 2009).
- Risk: The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values. Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard (IPPC, 2014).
- Scenario: A plausible description of how the future may develop based on a coherent and internally consistent set of assumptions about key driving forces (e.g. rate of technological change, prices) and relationships (IPPC, 2013).
- Sensitivity: is ‘the degree to which a system or species is affected, either adversely or beneficially, by climate variability or change’ (IPCC, 2014).
- Stakeholder: Person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity (Adapted from: ISO 31000:2009).
- United Nations Framework Convention on Climate Change (UNFCCC): ‘the Convention was adopted on 9 May 1992 in New York and signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European Community. Its ultimate objective is the ‘stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system’. It contains commitments for all Parties. Under the Convention, Parties included in Annex 1 (all OECD countries and countries with economies in transition) aim to return greenhouse gas emissions not controlled by the Montreal Protocol to 1990 levels by the year 2000. The convention ente-

red in force in March 1994' (IPCC 2007c).

- Vulnerability: the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity' (IPCC, 2007b).
- Vulnerability Index: A metric characterizing the vulnerability of a system. A climate vulnerability index is typically derived by combining, with or without weighting, several indicators assumed to represent vulnerability (IPPC, 2014).