Guidelines for climate analysis and vulnerability assessment at local level
The Master Adapt perspective and the focus on North Salento

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Abstract

The LIFE Master Adapt project aims to implement the mainstreaming of climate change adaptation within Italian local authorities. The project brings together eight partners (local administrations, universities and research institutions) and focuses on seven local areas (regions, metropolitan areas and groups of municipalities). For more information on the project see the website http://www.masteradapt.eu. One of its main deliverables is the document that outlines the *guidelines for climate analysis and vulnerability assessment at a regional and local level* [1], which should help local authorities prepare their own analyses and assessments, in keeping with the project's main aim of mainstreaming climate change adaptation. This paper seeks first to describe these guidelines and secondly to focus on the analysis carried out in North Salento, which is one of the target areas of the project.

The guidelines

The guidelines' document builds on the climate analysis produced for the previous deliverable of the project, the *report on climate analysis and vulnerability assessment results in the pilot region (Sardinia Region) and in the areas targeted in Action C3* [2].

These guidelines are addressed to local administrators who may not have a background on climate science, therefore they must be clear and easy to understand. For instance, when the main text touches a concept that needs to be analysed in depth, a text box containing further information on that topic follows the paragraph. Moreover, at the end of every chapter and each major paragraph there is a short text that sums up the main concepts.

The first chapter focuses on the analysis of past climate trends and future climate projections. The analysis of climate trends allows researchers to study previous climate data and assess whether it is possible to acknowledge climate signals in the area. It is particularly important to focus on climate extremes which can have a relevant impact on the environment. While studying climate trends, retrieving homogeneous and high quality data on temperature and precipitation is key to an accurate analysis. It is also important to calculate extreme indexes and regional series on both average values and extreme indexes. With regard to this, the guidelines provide an example list of temperature and precipitation indexes and an explanation of the different categories of indexes. Finally one has to assess the trends of the regional series.

In terms of climate projections, the focus is on multiple climate models from which medium values and indexes for 30-year periods must be calculated. The most up-to-date source of climate projections in Italy is the Med-CORDEX initiative. The projections it offers are based on the RCP4.5 and RCP8.5 emission scenarios. A report by ISPRA [3] studied climate projections in the 21st century, providing climate forecasts up to 2100 in the RCP4.5 and RCP8.5 emission scenarios. The mean values of temperature and precipitation, as well as extreme indexes, are calculated for three 30-year timeframes (2021-2050, 2041-2060, 2061-2090) compared to the mean value of the 1971-2000 period, as figure 1 shows.

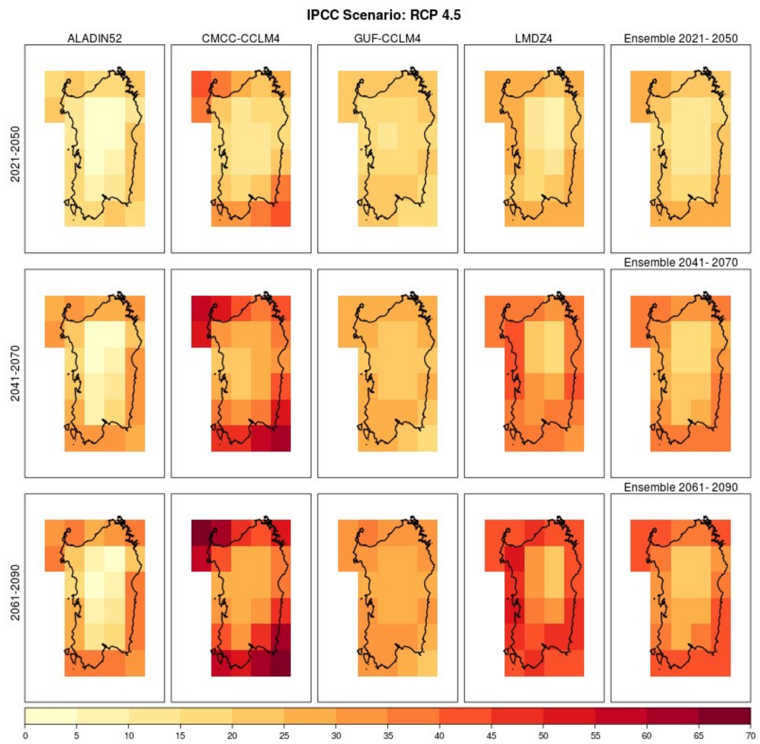


Figure 1 – Tropical nights (days), RCP4.5 scenario. Maps of variation forecasted by models and by the ensemble mean at the three time horizons 2021-2050 (first row), 2041-2070 (second row), 2061-2090 (third row), with respect to the 1971-2000 mean values.

Vulnerability assessment is the core part of the guidelines. The first paragraph focuses on the Intergovernmental Panel on Climate Change (IPCC) definitions and theoretical frameworks on vulnerability assessments over the past few years: using the right terms and definitions a key topic. Between 2007 [4] and 2014 [5] there has been a shift in the key components of climate vulnerability and risk. As the scheme below shows what was defined as vulnerability in 2007 is now described as risk.

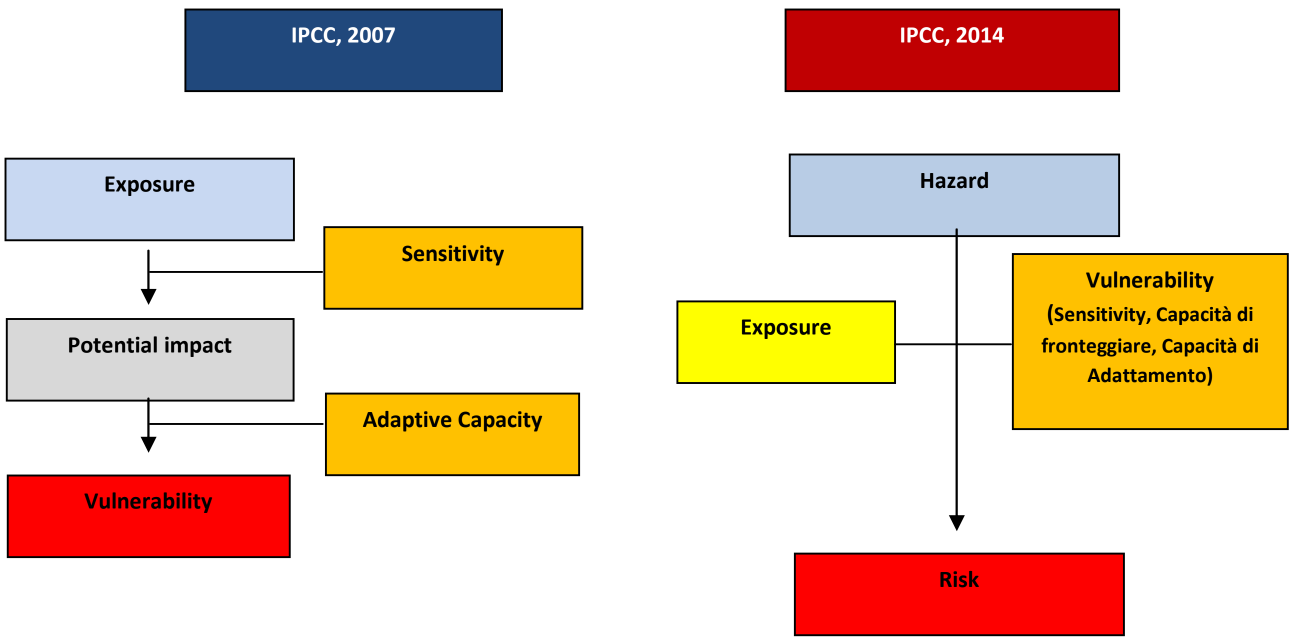


*Figure 2 – Comparison between factors contributing to climate change vulnerability [4] and risk [5]. Note: same colors were used for similar concepts (*e.g. *2007 vulnerability corresponds to 2014 risk IPCC 2014) [6].*

These guidelines are based on the most recent framework and definitions [4]. Table 1 below provides an useful example of the different key concepts meaning compared between 2007 and 2014.

Table 1 – Comparison between the key concepts' meanings in the 2007 and 2014 IPCC reports

EXAMPLE		**IPCC 2007**	**IPCC 2014**
External climate signal	Precipitation scarcity	Exposure	Hazard
Direct physical impact	Drought	Potential impact	Hazard
Sensitivity	Type of crop	Sensitivity	Vulnerability (Sensitivity)
Capacity	Knowledge on water management	Adaptive capacity	Vulnerability (Capacity)
Presence and relevance of exposed elements	Relevance of small farms	Implicitly included in Sensitivity	Exposure
Final result	Water scarcity in agriculture	Vulnerability	Risk

The paragraph also focuses on the normalization and weighing of indicators and the calculation of global indicators. The normalization of quantitative indicators is carried out using the Min-Max method, while qualitative indicators are divided in five classes which correspond to the 0-1 interval in order to be comparable to quantitative indicators. The indicators are then weighted according to the Analytic Hierarchy Process (AHP) method. The guidelines then propose two methods for calculating the four global indexes: the weighted arithmetic aggregation and the weighted geometric aggregation.

The guidelines' seven steps are:

- characterising the environmental and socio-economic context;
- identifying climate hazard sources;
- identifying potential impacts;
- identifying exposed elements;
- assessing sensitivity;
- assessing adaptive capacity;
- assessing climate change vulnerability.

For each of the steps the guidelines explain how to retrieve data, choose indicators, and how to assess vulnerability as a combination of sensitivity and adaptive capacity. This is carefully described through the help of examples (mostly from the analysis carried out in [2]) and by providing example lists of indicators.

The *first step* regards the analysis of the environmental and socio-economic context. It is important to select an adequate set of indicators that can both provide a synthetic look at the existing context and analyze current trends. The indicators should be based on time series of at least 15 years. Moreover each indicator should refer as close as possible to the analyzed territorial unit (*i.e.* if the analyzed area is a municipality the indicators should refer at least to the municipal level). When selecting indicators, it is useful to take into account the following three criteria [7]:

- Relevance and utility, in that the indicators should give a representative view of a phenomenon, be easy to interpret and be responsive to changes in the phenomena they represent.
- Analytical soundness, meaning that the indicators should be technically and scientifically well founded.
- Measurability: the supporting data should be available at a reasonable cost-benefit ratio, well documented and regularly updated according to reliable procedures.

The selection of the indicators should be accompanied by a report on the environmental and socio-economic context, summarizing the results of the analysis carried out on each indicator. At the end of the paragraph the guidelines offer a list of indicators divided in 8 categories (population, industry, agriculture, land use, nature, hydrology, health, tourism), suggesting for each of them a measuring unit, time series, data source and their connection to the following steps.

The *second step* and the one that follows (identifying potential impacts) are closely linked. The former focuses on hazard, a concept that encompasses two notions: climate signals, meaning for instance a change in temperature trends, and potential impact, regarding the damage stemming from a climate event. The latter concerns potential impacts: while in the second step a potential impact is one that cannot be influenced through adaptation, that is the case with regard to the third step.

Some examples regarding climate signals, direct impacts and risks help clarify the matter: while the first two cannot be influenced through adaptation measures, the last one can. While the definition of hazards and impacts can be subjective, two guiding questions can help identifying them:

1) what kind of hazards linked to climate signals took place in the selected area in the past decades?
2) how are the sources of hazards expected to change in the selected area in the next decades?

Example indicators can be found in the first chapter (climate trends and projections). The primary sources are pre-existing frameworks and studies produced by a scientifically reliable source. As of 2018, the national adaptation strategy and plan are the most up to date available documents in Italy. It is important to start a participation process in this phase, as local knowledge of climate hazards can be a useful addition to the existing academic sources.

As far as the *third step* is concerned, the identification of potential impacts starts from the hazards acknowledged in the previous step. Local planning documents can help choosing the relevant impacts within the selected area. As in the second step, some guiding questions can help identifying the potential impacts:

1) have there been climate impacts in the area in the last decades?
2) what kinds of resources and opportunities were influenced as a result?
3) which socio-economic sectors were influenced as a result?

Some examples of indicators are shown in the text. In addition to the national adaptation strategy and plan, the primary sources are documents from local environment agencies as well as commercial and economic institutes. Participation in this phase is even more important than in the previous one, and should involve a larger target.

The *fourth step* regards exposure, which is the presence of people, ecosystems, resources that could be adversely affected by climate change, for instance the local population in an area. The selection of indicators can be based on the first step, because it is within the environmental and socio-economic context that exposed elements can be found. Some examples are provided in the text, divided in four categories: natural capital, human capital, infrastructure and finance.

Sensitivity, the degree according to which a system is influenced by climate stimuli, is the subject of the *fifth step*. It can be identified through four categories: natural factors, human factors, urban morphology factors, economic and financial factors. Some example indicators are described in the text and through some pictures. Indicators should be chosen according to the kind of impact that needs to be assessed and to the amount of information available. An indicator can be at the same time useful to assess the sensitivity of an area to an impact, but could be useless if there is little information available.

The *sixth step* regards adaptive capacity, that is the capacity of systems, institutions, humans and other organism to adapt to climate change. Four categories encompass the concept: institutions, knowledge and technology, production and infrastructure, economic resources. Identification and calculation of indicators should take place at the same time, as it is important that data for the indicators are easy to retrieve and calculate.

Finally, the *seventh step* is the result of the combination of the global indexes of Sensitivity and Adaptive Capacity.

The concluding chapter evaluates the guidelines in terms of the three larger topics it faces: climate trends, climate projections, and vulnerability assessment. The guidelines provide a robust methodology for the climate analysis of past trends, though data isn't always available in some areas. As regards the analysis of future projections scenarios are a useful tool, but the resolution of models is too low for local predictions. With respect to the vulnerability analysis the methodology is easy to understand and implement, but scarcity of robust data means that prospective users must resort to proxy indicators.

Summing up, the guidelines are one of the first attempts to quantify vulnerability in a local area. Its simplified approach means it cannot easily describe the complexity of the real world. The quality of data, both quantitative and qualitative, is important for the soundness of the results, so it is fundamental that it is retrieved carefully. A great amount of care must also be put in the normalization process. If the maximum and minimum values are chosen with respect to that particular data series it will mean that the vulnerability will be relative to that series, not an absolute value. It is important to keep this in mind to avoid errors. More research is needed in the future to improve the methodology for climate analysis and vulnerability assessments. Nevertheless this is an interesting attempt at exploring a relatively uncharted field, and can hopefully provide a base for new guidelines that further improve the knowledge on vulnerability assessments.

The focus area on northern Salento

This section is based on the results shown on the *report on climate analysis and vulnerability assessment results in the pilot region (Sardinia Region) and in the areas targeted in Action C3* [2]. The report examines the selected target areas, among which is the Union of municipalities in northern Salento, located in Lecce's province and including the municipalities of Campi Salentina, Salice Salentino, Guagnano, Novoli, Squinzano, Surbo, Trepuzzi .

For representing the methodological framework of vulnerability assessment, applied on the Master Adapt project, this part of article deals with the description of the seven steps described in the guidelines.

Steps 1 (Identifying the climate-related hazards), 2 (Identifying the potential impacts of climate change) and 3 (Defining the territorial and socio-economic context of the target area)

Now, in this section, we will discuss the description of the initial 3 steps of methodology, reporting the results of the analyses in a discursive form.

These analyses are based on available local studies, research, scientific sources and spatial planning documents also related to climate change and their impacts. But it was necessary too to consult local experts and technicians to ensure the capture of the relevants impacts affecting the area.

Once the most relevant potential impacts for this target area were identified, the next step was the definition and description of the general context, with the aim of providing a preliminary basis for vulnerability analysis have been described: location of the area, climate macro-region, hydrogeological structure, natural areas and resources, the social framework (eg. population and structure, density, main economic activities) etc.

This target area is characterized by a typical Mediterranean climate with very hot and dry summers and rainy and windy winters, with dominant winds coming from the West, causing heavy rainfall on the peninsula.

The area extends between the Adriatic and the Ionian Sea and presents arid and flat landscape. This is due both to the climate and to the geological characteristics of the area which does not have surface water courses but a hydrographic network of natural drainage channels in the rock. In this territory, saltwater intrusion has a high significance and is heavily influenced by periods of water crisis. As a matter of fact, an increase in withdrawals overlaps to the reduction of the natural recharge thus triggering a salt intrusion process from the coast. As far as hydrogeomorphological characteristics, the area is affected by many problems related to the anthropic impact on the karst environment which have altered the hydrogeological conditions of the area, accelerating the dynamics underway and causing several floods events. Some areas affected by flooding of such canals are found and due to possible water stagnation can arise health problems.

This territory is almost completely characterized by an agricultural soil use associated to reduced natural portions, such as small forested woods or green areas belonging to farmhouses and dry walls stone. The food and wine production brings in these areas about 200.000 tourists each year mainly along the Ionian coast and, to a lesser extent, in the rural areas. Agriculture is one of the most important item in the local economy, with the production of typical wines such as Negramaro and Malvasia Nera produced and distributed by cooperatives and private operators. This area has the highest italian wine production and produces many valuable grapes with numerous DOC products in the areas, such as: Salice Salentino DOC and Nardò DOC. Along with wine production, oil and vegetable processing characterize the local production.

This area is famous for the expansion of Xylella fastidiosa bacteria and this problem was very much felt by the citizens and also caused a great resonance in social networks and on TV, due to the forecast of destruction of secular olive trees infected by the bacterium. But in truth some studies have established that the virulence of this pathogen is the consequence, and not the cause, of the disease of olive trees which have become more vulnerable due to the loss of biodiversity caused by pollution and the increased use of pesticides and herbicides , together with climatic anomalies. In these areas, the consumption of herbicide per hectare is two to four times the use of other Apulia provinces and the percentage of organic farming is the lowest. Many soils are becoming sterile because of the high environmental impact of farming, resulting in a greater vulnerability of vegetation due to lower availability of nutrients and the almost complete destruction of microflora.

The Socio-economic framework analysis of the area has shown that the territory is characterized by the presence of many small urban centers, with a dotted countryside of farmhouses and villas apartment, which are the sign of the typical rural architecture of Salento, and the dispersal of residential and productive settlements in agricultural area.

Analysis of the local statistical data shows that since 2002 [8] [9], the local population has recorded a more or less constant decline, due in particular to the negative balance between birth and mortality rate. While the proportion of elderly people alone in 2011 increases, the presence of young couples with children decreases. In the last ten years, the education indicators show several trends: people aged between 25 and 64 who have completed at least the high school are in fact lower than the italian average of 55,1%. Also the structure of employment is changing: Approximately 18% of employment is absorbed by crafts or agricultural professions which are also decreasing by almost 7% compared to 2011.

Based on these indicators, some municipalities rank among the most critical and vulnerable from the social point of view. The percentage of households who are in a potential disadvantaged condition is higher than the national figure: the presence of sixty-five years old people and at least one 80 years old person is 3,3% compared to the average value of 3%. The share of young people who are not studying and who is at the same time out of the job market (14,5% vs 12,3% average value), however this value is improving with respect to the past.

Analysis of the social activities points out that the Union of Municipalities in Northern Salento aims to perform some joint administrative and service functions, such as: training and upgrading of Civil Protection staff personnel, urban and neighborhood road maintenance services, public green maintenance services, Informagiovani centre, social services, civilian disabled services. Furthermore, the Union has among its strategical objectives: planning and enhancing the territory by integrating the urban, environmental, rural and sustainable development dimension with integrated programs of interventions aiming at renovating the functions of historical centres, peripheries and rural areas in the area defined as the Park of Olives and Negroamaro.

On the basis of the past events occurred in the area and the results of the future scenarios (shown on the climate analysis) climate change hazards and the related potential impacts identified in the target area of Salento are the following:

- heavy rainfall with consequent flooding events;
- drought periods and increase in mean temperature with consequent losses in agriculture.

For representing the methodological framework of vulnerability assessment applied on master adapt project, this part of article deals with the assessment of point 1, flooding events vulnerability.

According to the most recent IPCC approach, exposure was not included in the vulnerability computation, after the Step 1 (Identifying the climate-related hazards), Step 2 (Identifying the potential impacts of climate change) and Step 3 (Defining the territorial and socio-economic context of the target area), we go to the Step 4 (Assessing exposure to climate-related hazards) which is not included in the concept of vulnerability. For this reason we considered the exposure assessment as a stand-alone step, supporting a more adequate contextualisation of the analysis.

Step 4 - Assessing Exposure of Union of Northern Salento area.

The analysis was performed in order to evaluate the level of exposure to flooding in the area of north Salento. The list of exposure indicators analyzed for flooding events presents the results for each selected indicator and its normalized values.

The list presents:

- HUMAN CAPITAL: Population density (Inhab/km2)
- MANUFACTURED CAPITAL: Road network (km); Urban areas (%)
- ECONOMIC CAPITAL : Agricultural areas (%)

The indicators have been selected from ISTAT (Italian national institute of statistics) 2011, Open street map, Artificial surface of Corine Land Cover.

*"*Population Density" was selected as the basic indicator of human capital exposure to potential flooding, as it indicates where the population is more concentrated in a given municipality. Clearly, a high exposure of the human capital is associated to higher population density values. The "Road Network" (km in the municipal area) and the "Urban Areas"(% over the total municipal area) were considered among the most important exposed elements of the manufactured capital. High exposure levels are found in the municipalities where the road network is more extended and the urban areas are larger. Finally, due to the importance of local agricultural activity, the extension of "Agricultural Areas" was included in the exposure analysis. The Global Exposure Index was elaborated as the weighted arithmetic mean using equal weights of the normalized values of the exposure indicators identified.

Table 2 - Global Exposure Index	
Campi Salentina	0,38
Guagnano	0,36
Novoli	0,38
Salice Salentino	0,50
Squinzano	0,45
Surbo	0,57
Trepuzzi	0,53

Table 2 - Exposure indicators and Global Index

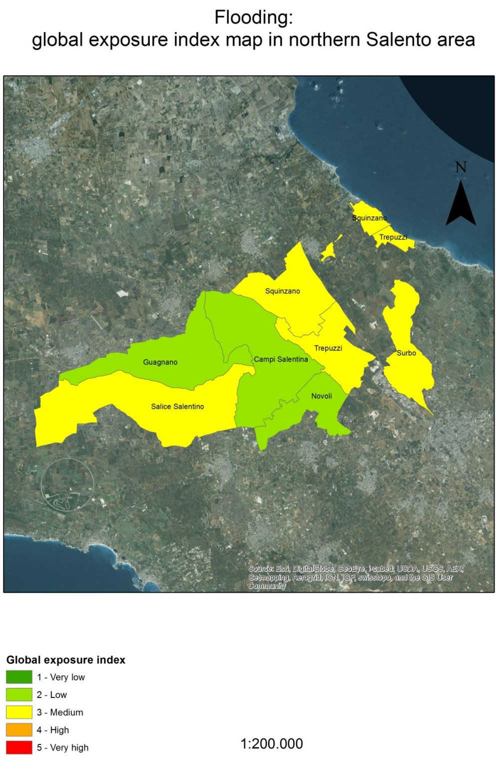


Figure 3 - Global Exposure Index.

At the end of the analysis we can say that:

<u>Human capital</u>-Surbo is the municipality with the highest value of population density, followed by Trepuzzi, while Salice Salentino has the lowest value of the indicator.

<u>Manufactured capital</u>-The influence of the infrastructure capital is prevalent in Salice Salentino , followed by Guagnano and Campi Salentina with about 204 and 203 km of roads. As referred to artificial surfaces, Surbo and Trepuzzi are the municipalities more exposed with the artificial surfaces respectively.

<u>Economic capital</u>-All the municipalities of Northern Salento have a very large agricultural area exposed (more than half of the total area), with Salice Salentino and Guagnano that have almost the totality of the municipality area.

<u>Global Exposure Index</u> - The results were classified into 5 equal classes ranging from 0 to 1. The map shows a medium-low level of elements exposed to flooding, mainly due to a general low population density in the area as well as a limited road network and a low presence of urban areas. On the other hand, one indicator such as "Agricultural Areas" shows very high values all over the target area. Figure 1 illustrates the final map of the Global Exposure Index.

Step 5 - Assessing Sensitivity of Union of northern Salento area

This step was addressed to identify the systems that are likely to be affected as a consequence of climate change, as they should be considered more sensitive to climate change. In order to elaborate the Global Sensitivity Index the same procedure described in Step 4 was implemented, specifically:

i. selection of the sensitivity indicators;
ii. data collection;
iii. normalisation of indicator values;

iv. alignment of indicators;
v. weighting of indicators (when feasible);
vi. aggregation of indicators into a Global Sensitivity Index;
vii. mapping the Global Sensitivity Index.

In order to analyse the sensitivity of the target area to flooding, human, manufactured and economic factors were taken into account (Table 3). As human elements, specific population categories were considered: “People over 65”, “Elderly people living alone”, “Children under 6”, and “Illiterates”. This is because older people, in particular if living alone, are more sensitive to health risks posed by flooding as they tend to be less mobile in case of disaster. Furthermore, very young children (under 6) have less capacity to react to potential risks in case of disaster. According to the studies also illiterates are reported as a population category with a poor ability to respond to the effects of natural hazards as they do not know well the risks (i.e. flooding) and are hardly reached by media, social network, early warning systems because they cannot read. Therefore, a high presence of these population categories in the area means a higher sensitivity to the climate hazard.

Furthermore, the incidence of buildings in a bad state of conservation is among the manufactured capital indicators and is considered to be representative of bad conditions in which people live, with a particular focus on people living in low floors.

Socio-economic factors were included in the economic capital. Indicators such as the Incidence of families living in potential discomfort conditions were because this people holding a lower socio-economic status is more likely to lack access to information, technologies and other resources needed for effective adaptation such as knowledge, adequate housing, insurance. The Global Sensitivity Index was also elaborated as the weighted arithmetic mean using equal weights of the normalized values of the sensitivity indicators identified.

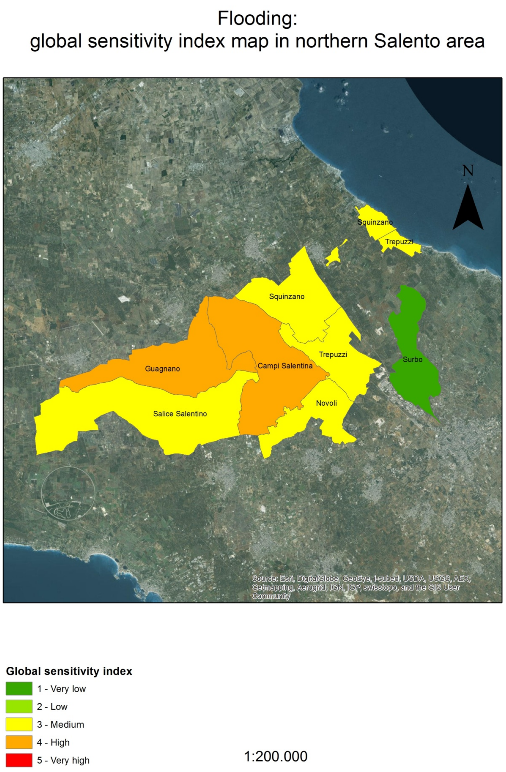
The list of indicators presents:

- HUMAN CAPITAL: Incidence of elderly people > 65; Incidence of very young people <6;Incidence of illiterates; Incidence of elderly people alone.
- MANUFACTURED CAPITAL: Incidence of buildings in a bad state of conservation %
- ECONOMIC CAPITAL: Incidence of families in potential discomfort %

Table 3 - Sensitivity indicators and Global Index

Table 3 - Global Sensitivity Index	
Campi Salentina	0,67
Guagnano	0,65
Novoli	0,52
Salice Salentino	0,47
Squinzano	0,49
Surbo	0,16
Trepuzzi	0,48

Figure 4 - Global Sensitivity Index map



The indicators have been selected from ISTAT (Italian national institute of statistics) 2011.

At the end of the analysis we can say that :

Human capital- Novoli and Guagnano are the municipalities with the larger incidence of elderly people > 65, and Novoli has also the larger incidence of elderly people alone, while Surbo has the larger incidence of very young people <6. Campi Salentina and Squinzano have the highest value of illiterates people, followed by Guagnano and Salice Salentino.

Economic capital - Guagnano has the larger number of families in potential discomfort (4,9%), followed by Squinzano (4,1%).

Global Sensitivity Index- On every table the results were classified into 5 equal classes ranging from 0 to 1. The map shows higher levels of sensitivity in the municipalities of Campi Salentina and Guagnano and the lower levels in the municipality of Surbo. The sensitivity levels of Campi could be mainly associated to the higher presence of illiterates in the overall area and buildings in a bad state of conservation, with relatively high percentages of elderly people living alone. The municipality of Guagnano shows the higher values of elderly people and the higher incidence of families living in potential discomfort conditions. Also the high presence of illiterates could contribute to the high sensitivity of this municipality.

Step 6 - Assessing Adaptive Capacity

Then we go to the next step who concern the adaptive capacity of the system, investigated with respect to each potential impact identified in the Step 2 and analyzed in Step 3. To elaborate this index the same procedure described in Step 4 and Step 5 was implemented. As indicated above, adaptive capacity includes the intrinsic quality of a system that makes it more or less capable to adapt, but can also reflect the abilities to collect and analyze information, communicate, plan, and implement adaptation strategies that ultimately reduce vulnerability to climate change impacts (Giordano et al., 2013).

Adaptive capacity was analysed through indicators of the following dimensions: Institutions; Knowledge and technology; Economic resources (Table 4).

The institutional contribution to the local adaptive capacity was analysed on the basis of the "Municipal budget commitment on environmental management" and the "International mitigation/adaptation commitment". The first indicator demonstrates the willingness and capability of the local institutions to invest in environmental protection, thus strengthening the capacity of the system to cope with climate change impacts. Even if the indicator is not strictly focused on expenses aimed at coping with climate change, higher levels of investment clearly mean higher capacities to cope with the future environmental and climate risks. The second indicator refers to the signatories commitments of the European Covenant of Mayors: Covenant of Mayors for Sustainable Energy Action Plans, Mayor's Adapt and the most recent Covenant of Mayors for Climate and Energy. By signing the Covenant of Mayors, municipalities voluntarily commit to actively supporting the implementation of climate change policies (both mitigation and adaptation) at EU level. With this decision the local council obliges the municipalities to translate their political action into practical measures and projects, by preparing local sustainable energy and/or adaptation plans. Those municipalities that have signed both the commitments are considered to have a higher adaptive capacity, while non-signatories cities have a very low interest in this kind of policies. Even if not directly engaged in adaptation policies, municipalities carrying out mitigation policies demonstrate a high attention to climate policies and are therefore assigned a 0,5 value. As suggested by the studies on this topic on knowledge and technology, it is considered that the presence in the target area of high "Adult incidence with degree" means that the society has a high capacity to respond and manage disasters, due to a facilitated/improved access and use of information (i.e. weather forecast on internet) and technology (i.e. early warning systems). Finally, the availability of economic resources clearly is a determinant of adaptive capacity: the "Per capita income" contributes to depict the welfare of a society, where an equitable distribution of economic resources implies a greater capacity to adapt due to a major possibility to invest in adaptive measures, included eventually investing money in insurance.

Table 4 -Global Adaptive Capacity Index	
Campi Salentina	0,25
Guagnano	0,63
Novoli	0,44
Salice Salentino	0,85
Squinzano	0,72
Surbo	0,59
Trepuzzi	0,68

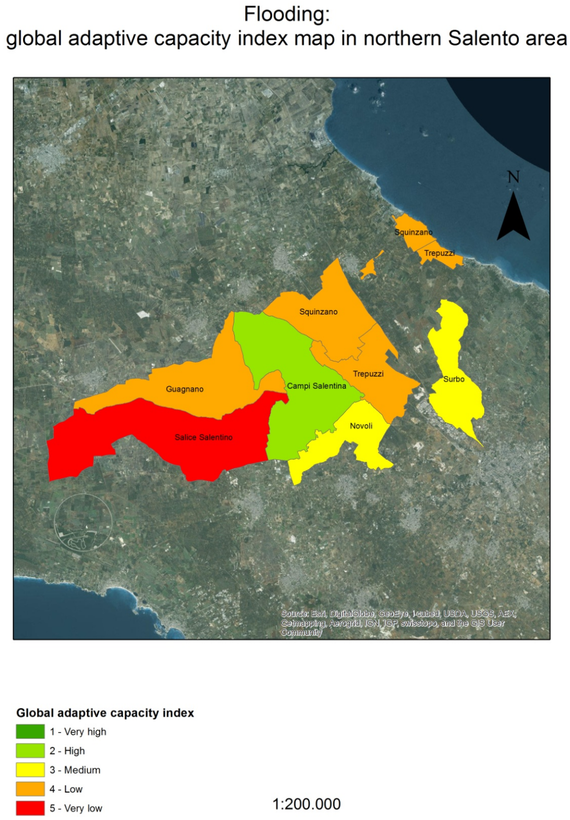
Table 4 - Global Adaptive Capacity Index

According to the applied methodology, the direction of adaptive capacity indicators was changed by subtracting the normalized value of the indicator from 1. This means that low results in terms of adaptive capacity (i.e. low municipal budget, low adaptation commitment, low adult incidence with degree, low per capita income) have higher normalized result (the lowest=1).

The report explains this method of opposite direction towards vulnerability.

Also the Global Adaptive Capacity Index was elaborated as the weighted arithmetic mean using equal weights of the normalized values of the adaptive capacity indicators identified.

Figure 5 - Global Adaptive Capacity index map



The list of indicators presents:

- INSTITUTIONS - Municipal budget commitment on environmental management (%), International mitigation/adaptation commitment (Y/N).
- KNOWLEDGE AND TECHNOLOGY - Adult incidence with degree%/inhab,
- ECONOMIC RESOURCES - Per capita income euro/inhab

The indicators have been selected from ISTAT (Italian national institute of statistics) 2011, Municipality data 2017, MEF (Ministry of Economics and Finance) 2015.

At the end of the analysis we can say that :

Institutions- Campi Salentina has the lowest value of budget commitment on environmental management (0,001%), while Surbo has the highest value (89%). However, Campi Salentina is the only municipality to have signed the EU Covenant of Mayors on both mitigation and adaptation policies.

Particularly the “Budget commitment” indicator was drawn up on the basis of the consultation of the municipalities target budgets. Expenditure commitments for the year 2017 have been added, relating to measures to protect natural areas (as areas that cooperate with water absorption), interventions on integrated water services (as interventions on sewage networks for the removal of waters of rainfall) and civil protection interventions, all in relation to the total expenditure set for the 2017 budget.

Knowledge and technology-Surbo and Salice Salentino are the municipalities with the lowest value of adult incidence with degree (6,4 and 7%), while Campi Salentina has the highest value of the indicator (10,5%).

Economic resources-The per capita income is rather homogeneously low in the whole target area. The higher value belongs to Campi Salentina, while Guagnano and Salice Salentino has the lowest values.

The results were classified into 5 equal classes ranging from 0 to 1, where higher values mean lower levels of adaptive capacity. The map shows that just one municipality is characterised by a high adaptive capacity, due to its commitment in international initiatives on climate change as well as the highest percentage of adults with degree and the per capita income. However, three municipalities in the area result in the low class of adaptive capacity: Squinzano, Trepuzzi, Guagnano. Finally, the municipality of Salice Salentino presents the lowest values of adaptive capacity, mainly due to the absence of a specific commitment in European initiatives on climate change and to relatively high values of all the indicators analysed.

Step 7 - Assessing Vulnerability to climate change

As we have already said , based on the IPCC AR5 framework, the procedure adopted within the MASTER-Adapt project the Global Vulnerability Index was elaborated as the combination result, elaborated as the weighted arithmetic of the Global Sensitivity and Adaptive Capacity components.

Global Sensitivity Index+ Global Adaptive Capacity Index =Global Vulnerability Index

Table 5 - Global Vulnerability Index	
Campi Salentina	0,46
Guagnano	0,64
Novoli	0,48
Salice salentino	0,66
Squinzano	0,61
Surbo	0,38
Trepuzzi	0,58

Table 5 - Global Vulnerability Index

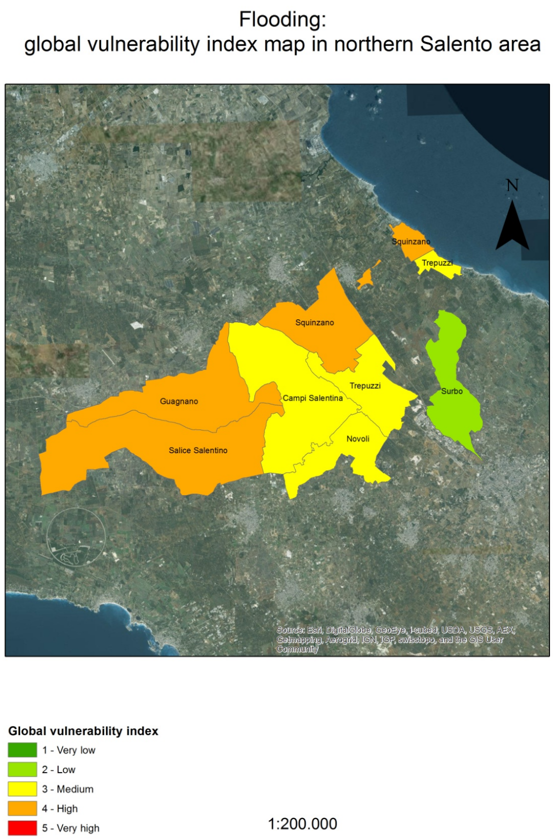


Figure 6 - Global Vulnerability map

Figure 6 shows the final map of the Global Vulnerability Index with results classified into 5 equal classes ranging from 0 to 1, and the final evaluation presents Salice Salentino as the most vulnerable municipality .

Salice Salentino presents the highest Global Vulnerability Index (0,66), followed by Guagnano and Squinzano respectively with 0,64 and 0,61. The most favorable situation is represented by Surbo (0,38), which shows the lowest values of vulnerability in the target area due to a low sensitivity and a medium adaptive capacity. The municipalities of the area are equally distributed among the medium and the high vulnerability class. Salice Salentino, Squinzano, Guagnano result as the highest vulnerable areas in the target area, and clearly these values result from a low adaptive capacity of all the municipalities combined with a relatively medium-high sensitivity to flooding.

On the *report on climate analysis and vulnerability assessment results in the pilot region (Sardinia Region) and in the areas targeted in Action C3*, the studies then deal with the issue of "*agriculture and the loss of productivity*" linked to climate change in the Northern Salento area. The structured methodology for the flooding theme is also applied on this theme and presents the 7 steps as defined in the Master Adapt Guidelines.

Conclusions

The vulnerability analysis performed and described above represents one of the first attempt in Italy to implement a standardized methodology to quantify vulnerability to climate change at local level.

The procedure adopted within the MASTER-Adapt project was mainly based on the experience and the guidelines published by Fritzsche et al [10] and was further adapted to the most recent IPCC AR5 vulnerability and risk framework [5], without referring to already implemented examples.

Past and current climate trend and future climate projections were elaborated over a time period useful to define adaptation policies (i.e. 2030-2050).

The methodological procedure identified seems to be quite easy to replicate, as long as appropriate, specific and significant indicators are selected for the context to be investigated. Data availability and technical expertise in the use of Geographical Information Systems (GIS), and of course human resources, are the prerequisites needed for the implementation of such analysis.

The seven-steps process, identified on Guidelines seems to be quite easy to replicate, as long as appropriate, specific and significant indicators are selected for the context to be investigated. Each step implies a certain degree of approximation. Weighting can have a major influence on the results, but this step is strongly required so as to get as close to reality as possible. Furthermore, the unavailability of the required data or the limited access to data sources may limit the choice and force to use proxy indicators, as it usually happened on adaptive capacity indicators.

Generally, many difficulties were detected in identifying indicators and above all adaptive capacity. For example the definition of the municipal budget commitment on environmental management is an original application of this project, obtained by identifying spending commitments in the budgets of the municipalities that can be classified as adaptation actions.

The normalization of metric data may represent a pitfall, but a context-specific knowledge (i.e. by an local expert's judgement) in defining appropriately thresholds, may be very useful. This step is particularly relevant when considering the need to compare the results between different areas. The classification of Global Indexes into equally distributed classes and finally, alignment of indicators and their aggregation, should be further analysed and discussed to minimize the subjectivity of each choice on the final results. For more information on the project see the website http://www.masteradapt.eu.

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