# LIFE URBANPROOF TOOLKIT

## METHODS, INPUT DATA, APPLICABILITY

LIFE URBANPROOF

CLIMATE PROOFING

URBAN MUNICIPALITIES

LIFE15 CCA/CY/000086

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# IMPACT ASSESSMENT

## OVERALL METHODOLOGY & APPROACH

# IMPACT ASSESSMENT METHODOLOGY

- The impact assessment methodology is based on the relevant conceptual framework presented within the 5th Assessment Report (AR5) of the IPCC (2014)
- Impacts are considered to result from the interaction of **hazard** and **vulnerability**, while the latter is considered to be a function of the **exposure**, **sensitivity** and **adaptive capacity** of population and infrastructure.
- **Hazard** indicators are used to reflect the relevant climatic information for each impact
- **Exposure** indicators reflect the exposure of population, land and/or critical infrastructure to an impact
- **Sensitivity** indicators are used to reflect the population groups which are considered sensitive to climate change
- The **adaptive capacity** indicators refer to both the capacity of the health care system and of the economy to address climate change impacts.


- ***IPCC 2014:*** *Summary for policymakers. In: Climate Change 2014: Impacts,Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L.White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and NewYork, NY, USA, pp. 1-32*

# IMPACT ASSESSMENT APPROACH

- For assessing total climate change impacts, the **composite indicator** approach is selected, as composite indices capture the multi-dimensionality of impacts in a comprehensible form and therefore may support practical decision-making processes.
- The assessment is made at **spatial level** with the use of maps, in order to provide relevant stakeholders with information about where the highest impacts are expected and to guide the allocation of resources for targeting adaptation assistance (USAID, 2014).
- Indicators were **normalized** by applying the min-max method (OECD 2008), while a five-class system was then applied representing values from "High" to "Low".
- Following, indicators were assigned with **weights** which were defined through expert judgement. The method used for **aggregating** the individual impact indicators into the composite impact indicator is the *weighted arithmetic aggregation method* (OECD 2008), which is also the one recommended in the Vulnerability Sourcebook (Fritzsche et al. 2014).


- ***Fritzsche**, K., Schneiderbauer, S., Bubeck, P., Kienberger, S., Buth, M., Zebisch, M., & Kahlenborn, W. 2014: The Vulnerability Sourcebook: Concept and guidelines for standardised vulnerability assessments. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH*
- ***OECD 2008:** Handbook on constructing composite indicators: methodology and user guide. Technical Report. Paris: OECD Publishing*
- ***USAID 2014:** Spatial Climate Change Vulnerability Assessments: A Review of Data, Methods, and Issues. USA: United States Agency for International Development.*

# LIMITATIONS

- The methodology used and the impact assessment approach followed although developed based on well-founded literature, is adjusted to the available resources, know-how and value judgment of the project consortium.
- The input data used, the indicators selected, the weights applied, as well as, the formulas developed for the impact assessment may however be modified and tailored through "Stage 5: Monitoring and review" of the toolkit, based on the contextual needs of the users. Specific guidance on this is provided in the manual of the tool.
- The results of the impact assessment may provide an indication of the intensity of impacts expected and of the areas that will be mostly affected, however, more detailed field research and consultation with stakeholders are necessary in order to determine what is needed for adaptation programming and how to develop local resilience.

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# CLIMATIC DATA

## CLIMATE CHANGE MODELS, SCENARIOS, RELIABILITY

# CLIMATIC DATA

- An extensive evaluation analysis of the outputs of four state-of-the-art Regional Climate Models (RCM) developed within the EURO-CORDEX initiative was performed.
- The outputs of the RCMs were evaluated against the gridded observational datasets of E-OBS(v17) for the period 1971-2000 as well as against observational data.
- Based on the analysis, the outputs of the model with the lowest biases were used in the UrbanProof toolkit, i.e. the MPI-ESM-LR/RCA4 RCA4, developed by the Swedish Meteorological and Hydrological Institute (SMHI) (Stranberg et al., 2014) and driven by the Max Planck Institute for Meteorology (MPI-ESM-LR) model (Popke et al., 2013).
- Daily bias adjusted temperatures and precipitation were used for the calculation of the hazard indicators for all urban municipalities.
- The indicator trends were calculated for the continuous periods 1971-2100 under two future GHG emission scenarios (Representative Concentration Pathways-RCP), namely the RCP4.5 and RCP8.5, which are implanted in the simulations after 2005.

# GHG EMISSION SCENARIOS

- **Stabilization of GHG levels, with mitigation policies (RCP4.5)**

  RCP4.5 is a stabilization scenario that assumes that global annual GHG emissions peak around 2040 and then decline, leading to a radiative forcing of 4.5 $W/m^2$ in the year 2100. This scenario assumes the imposition of emissions mitigation policies.

- **Increasing GHG levels, no mitigation policies (RCP8.5)**

  RCP8.5 is a so-called 'baseline' scenario that does not include any specific climate mitigation target. The greenhouse gas emissions and concentrations in this scenario increase considerably over time, leading to a radiative forcing of 8.5 $W/m^2$ at the end of the century.

The period 1971-2000 was used as the base period providing a reference for comparison with future projections for the period 2031-2060.

# RELIABILITY OF CLIMATIC DATA

- Due to the relative coarse resolution of the RCMs for municipality scale analysis, the models output was bias adjusted based on observational data.
- Bias correction methods applied: The local intensity scaling (LOCI) method (Schmidli et al., 2006) was applied to precipitation data and the variance scaling (Chen et al., 2011) to temperature data. In brief, the LOCI method adjusts the mean values as well as both wet-day frequencies and wet-day intensities of precipitation time series. The variance scaling method corrects both the mean values and the variance of temperature time series.
- Uncertainties related to the evaluation results are mostly associated to the quality of the observational dataset used to evaluate the model output. E-OBS is a product derived through interpolation from station data across Europe. In areas with low density of stations and/or in areas with complex topography, the gridding procedure tends to smooth the spatial variability of both temperature and precipitation.
- E-OBS despite its uncertainties is considered a state-of-the-art gridded interpolated product for the European domain compared to other gridded products available during the early stages of the project (ERA5 and AgMERRA). The use of observational data from the project municipalities for the evaluation, further verified the results of the evaluation analysis against the gridded observational dataset.
- It is noted that bias adjustment is a technique to post-process regional climate projections and it cannot overcome major model errors.

# REFERENCES


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- Popke, D., Stevens, B., & Voigt, A. (2013). Climate and climate change in a radiative-convective equilibrium version of ECHAM6. Journal of Advances in Modeling Earth Systems, 5(1), 1–14. doi.org/10.1029/2012MS000191
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- Stranberg G., Kjellström E., Poska A., Wagner S., Gaillard M.J., Trondman A.K., Mauri A., Davis B.S., Kaplan J.O., Birks H.J.B., Bjune A.E., Fyfe R., Giesecke T., Kalnina L., Kangur M., Van Der Knaap W.O., Kokfelt U., Kunes P., Latalowa M., Marquer L., Mazier F., Nielsen A.B., Smith B., Seppä H., Sugita S. (2014). Regional climate model simulations for Europe at 6 and 0.2 k BP: sensitivity to changes in anthropogenic deforestation, Clim. Past, 10, 661-680, doi:10.5194/cp-10-661-2014

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# SOCIAL VULNERABILITY INDEX

## AND SOCIO-ECONOMIC INDICATORS USED

# SOCIAL VULNERABILITY INDEX

- The social vulnerability indicators are combined to form the composite Social vulnerability index, which reflects the population groups sensitive to climate change impacts and the adaptive capacity of the health care system and of the economy.
- The socio-economic indicators selected are among those widely used in the literature for the assessment of the vulnerability to climate change impacts on the urban environment.
- The selection criteria for the indicators were: relevancy, adequacy as well as uniform and consistent data availability at the relevant geospatial level for the three project countries.
- The sensitivity indicators are proportionally related to vulnerability, as the higher the sensitivity the higher the vulnerability, while the adaptive capacity indicators are inversely related to vulnerability, as the higher the adaptive capacity, the lower the vulnerability.
- The indicators are normalized based on their position with respect to the respective European average value (above/below average EU value).
- The data are sourced from the National Statistical Services of the three countries as well as from Eurostat.

# SOCIO-ECONOMIC INDICATORS

- **Very young & elderly population :** The indicator refers to the percentage of people over 70 years old plus the percentage of people under 9 years old and is used to account for the increased sensitivity of these groups to the climate change impacts under study. The data are available at municipal level.
- **Illiteracy rate:** The indicator created to reflect this population group is actually the percentage of people within the age group 15-75, with educational level up to lower secondary school, including the illiterate and the literate with lack of an official educational level or those who gave up school. This is the lowest education attainment level for which data could be found for the same age groups at municipal level. However, it is considered to be indicative of the illiteracy level. The data are available at municipal level.
- **Population with chronic diseases :** The indicator refers to the percentage of people with chronic diseases (asthma, chronic lower respiratory- excluding asthma, high blood pressure, stroke or chronic stroke disease, diabetes, chronic depression). This information is available at national level only and therefore the values assigned to each municipality are the respective national ones.
- **Available hospital beds:** The indicator refers to the available hospital beds per 100,000 inhabitants and is available at regional level. Therefore the values assigned to each municipality are the respective regional ones.
- **Population with chronic diseases :** The indicator refers to the percentage of people with chronic diseases (asthma, chronic lower respiratory- excluding asthma, high blood pressure, stroke or chronic stroke disease, diabetes, chronic depression). This information is available at national level only and therefore the values assigned to each municipality are the respective national ones.
- **People at risk of poverty :** The indicator created to reflect this population group is actually the percentage of population exposed to poverty risk. This information is available at national level only and therefore the values assigned to each municipality are the respective national ones.
- **GDP per capita**: The indicator refers to "Euros per inhabitant" and is expressed as percentage of the EU average value. This information is available from Eurostat (2016) at regional (NUTS2) level and therefore the values assigned to each municipality are the respective regional ones.

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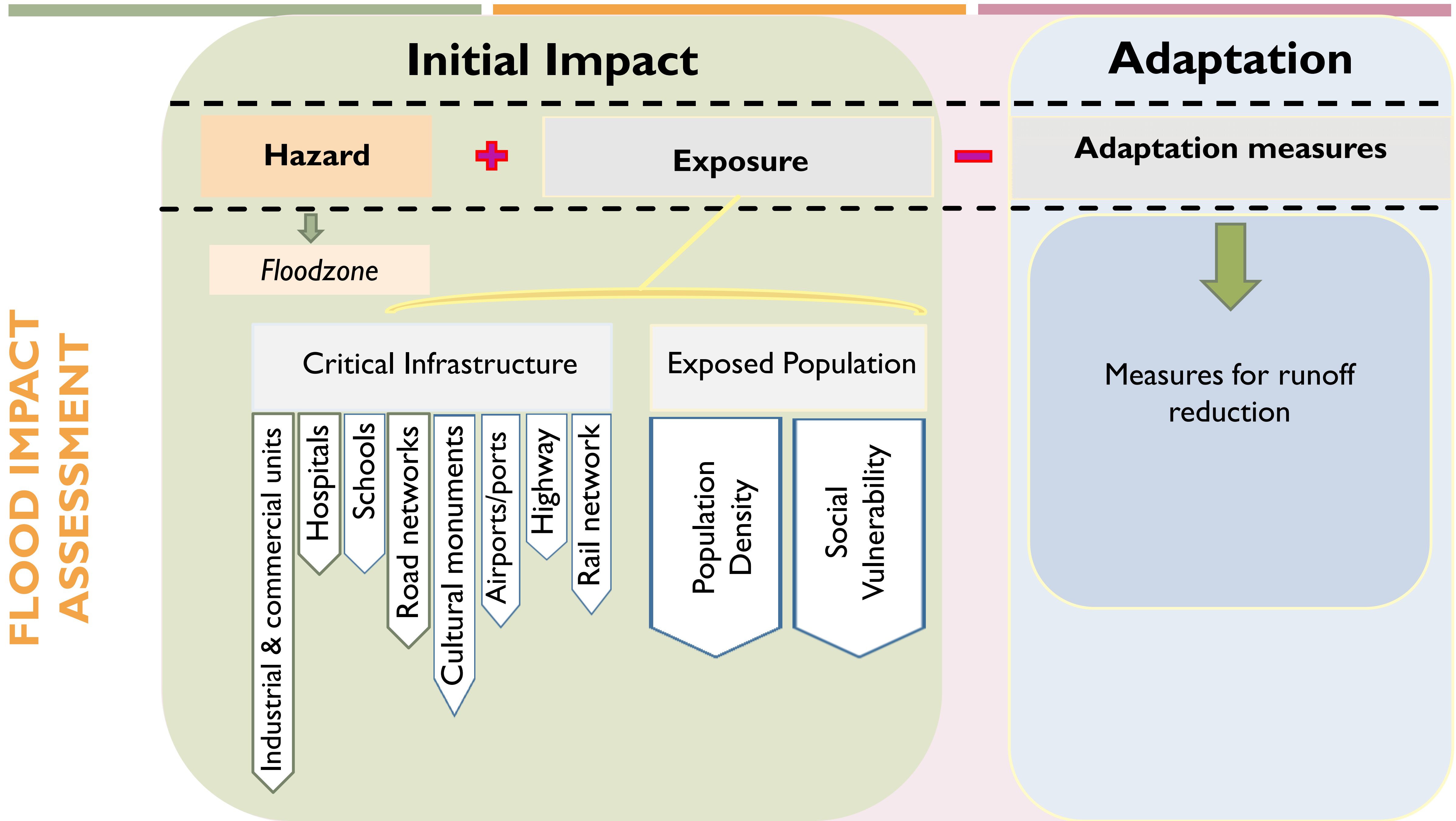
# CLIMATE CHANGE IMPACTS

## Relevant to the urban environment

# FLOOD IMPACT

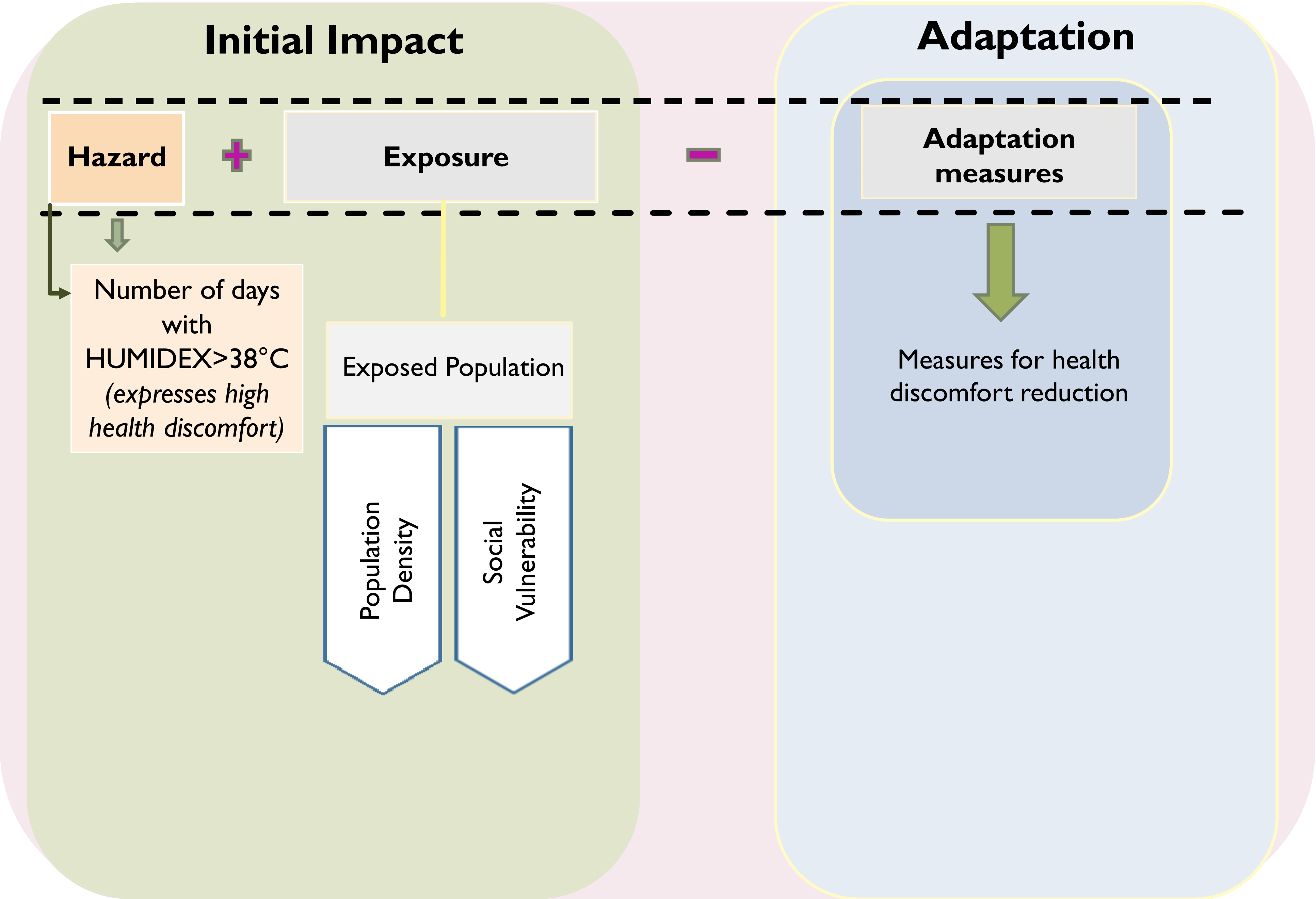
- The flood impact is conceived as a function of climate change hazards, exposure and social vulnerability, whereas adaptation is considered to reduce flood impact.
- To estimate hazard, flood hazard maps for 100-year flood return periods were used for identifying the location and extent of the area potentially affected by flooding.
- Exposure to floods was estimated based on both population density and critical infrastructure.
- Critical infrastructure with respect to floods, includes hospitals, schools, commercial and industrial areas, public facilities, cultural units and transport infrastructure.
- Adaptation is assessed through the permeability of surfaces, the increase of which reduces overall runoff and flood risk.


FLOOD IMPACT ASSESSMENT
Initial Impact
Adaptation
Hazard
Exposure
Adaptation measures
Floodzone
Critical Infrastructure
Exposed Population
Industrial & commercial units
Hospitals
Schools
Road networks
Cultural monuments
Airports/ports
Highway
Rail network
Population Density
Social Vulnerability
Measures for runoff reduction

# HEATWAVES AND HEALTH

- The impact of heatwaves on health is conceived as a function of climate change hazards and the vulnerability of the exposed population.
- HUMIDEX, which is a climatic indicator reflecting the impacts of temperature and humidity on human discomfort, was used to depict hazard. In specific, the number of days with HUMIDEX above 38°C which expresses high discomfort, was selected as indicator of hazard.
- The vulnerability of the exposed population was estimated based on the composite Social Vulnerability index and the population density.
- The implementation of adaptation measures addressing human discomfort due to heat is considered to reduce impact.

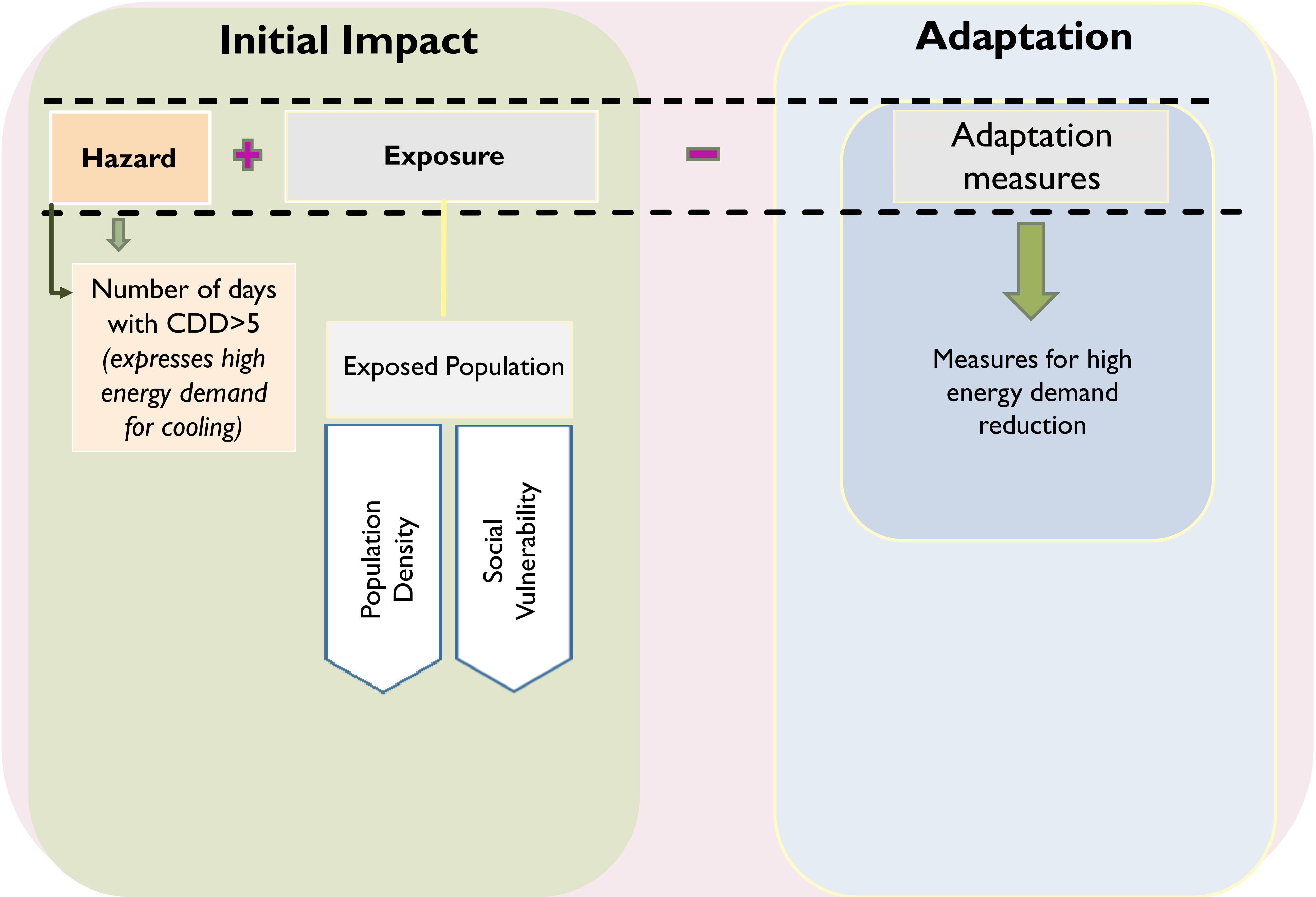
# HEATWAVES AND HEALTH IMPACT ASSESSMENT



# ELECTRICITY DEMAND FOR COOLING

- The impact of increased temperatures on the electricity demand for cooling is conceived as a function of climate change hazards and the vulnerability of the exposed population.
- The assessment was based on the indicator CDD (Cooling Degree Days), which reflects the demand for energy needed to cool a building.
- In specific, the number of days where the Cooling Degree Days (CDD) is above 5 (i.e. days with great electricity demand for cooling) was used for the assessment of the climatic hazard
- The vulnerability of the exposed population was estimated based on the composite Social Vulnerability index and the population density.
- The implementation of adaptation measures addressing increased electricity demand due to heat is considered to reduce impact.

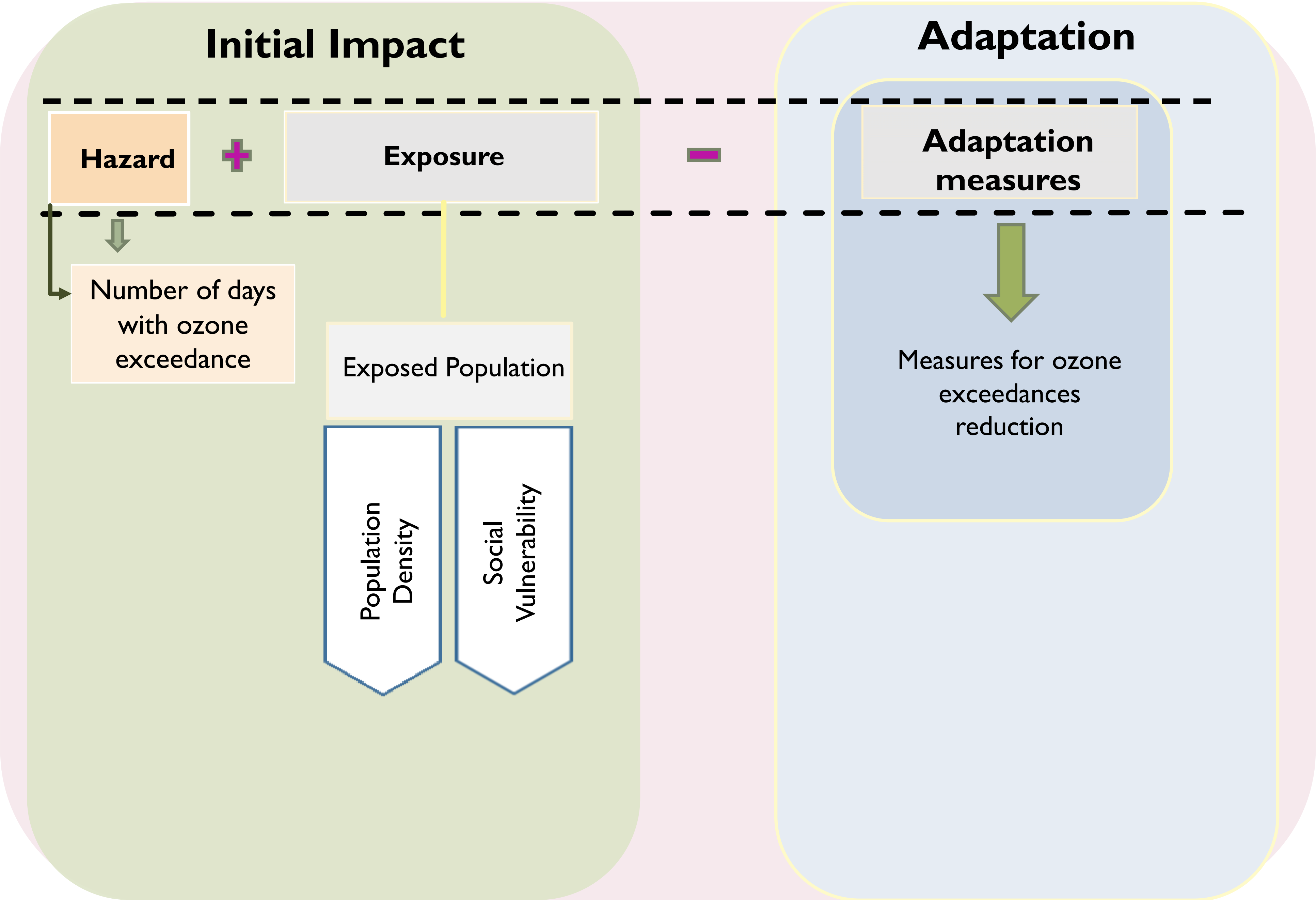
# ELECTRICITY DEMAND FOR COOLING IMPACT ASSESSMENT



# OZONE EXCEEDANCES

- The impact of ozone exceedances is conceived as a function of climate change hazards and the vulnerability of the exposed population.
- For the assessment of ozone exceedances, the number of days with ozone exceedances above the threshold value for protection of human health, was used for the assessment of the climatic hazard.
- The threshold value of ozone exceedance is 8-hour average ozone concentration above 120 μg/m3
- The vulnerability of the exposed population was estimated based on the composite Social Vulnerability index and the population density.
- The implementation of adaptation measures addressing ozone exceedances is considered to reduce impact.

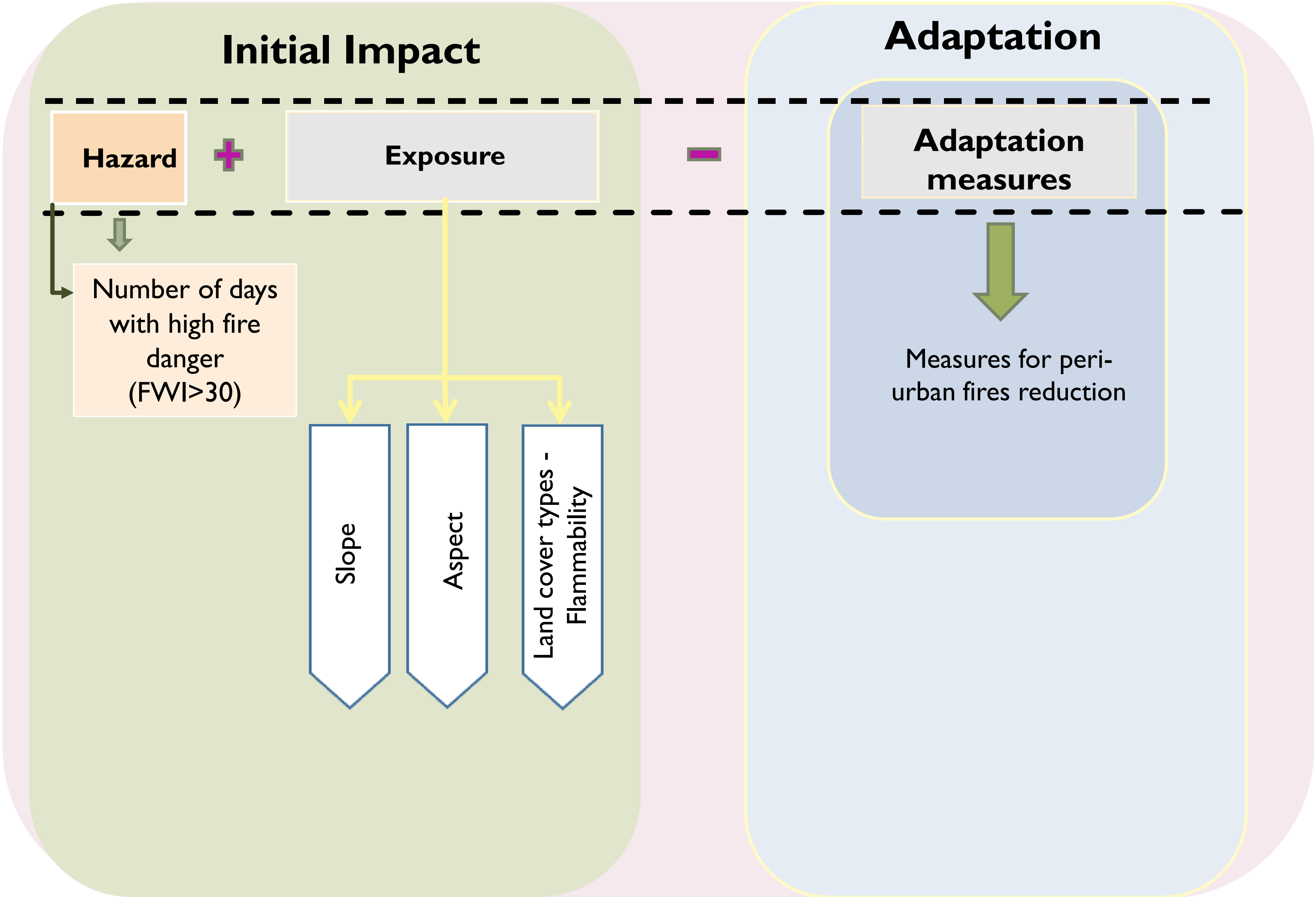
# OZONE EXCEEDANCES IMPACT ASSESSMENT



# PERI-URBAN FIRES

- For the assessment of peri-urban fires, the Fire Weather Index (FWI) was used for the assessment of climatic hazard
- FWI is a meteorologically -based index used to estimate fire danger based on temperature, relative humidity, wind speed and precipitation.
- In specific, the expected number of days with (FWI) above 30 (i.e. days with high fire danger) was used for the assessment.
- Other parameters of relevance for the assessment were also used, i.e. slope, aspect and land cover flammability.

# PERI-URBAN FIRES IMPACT ASSESSMENT



# APPLICABILITY OF THE TOOL

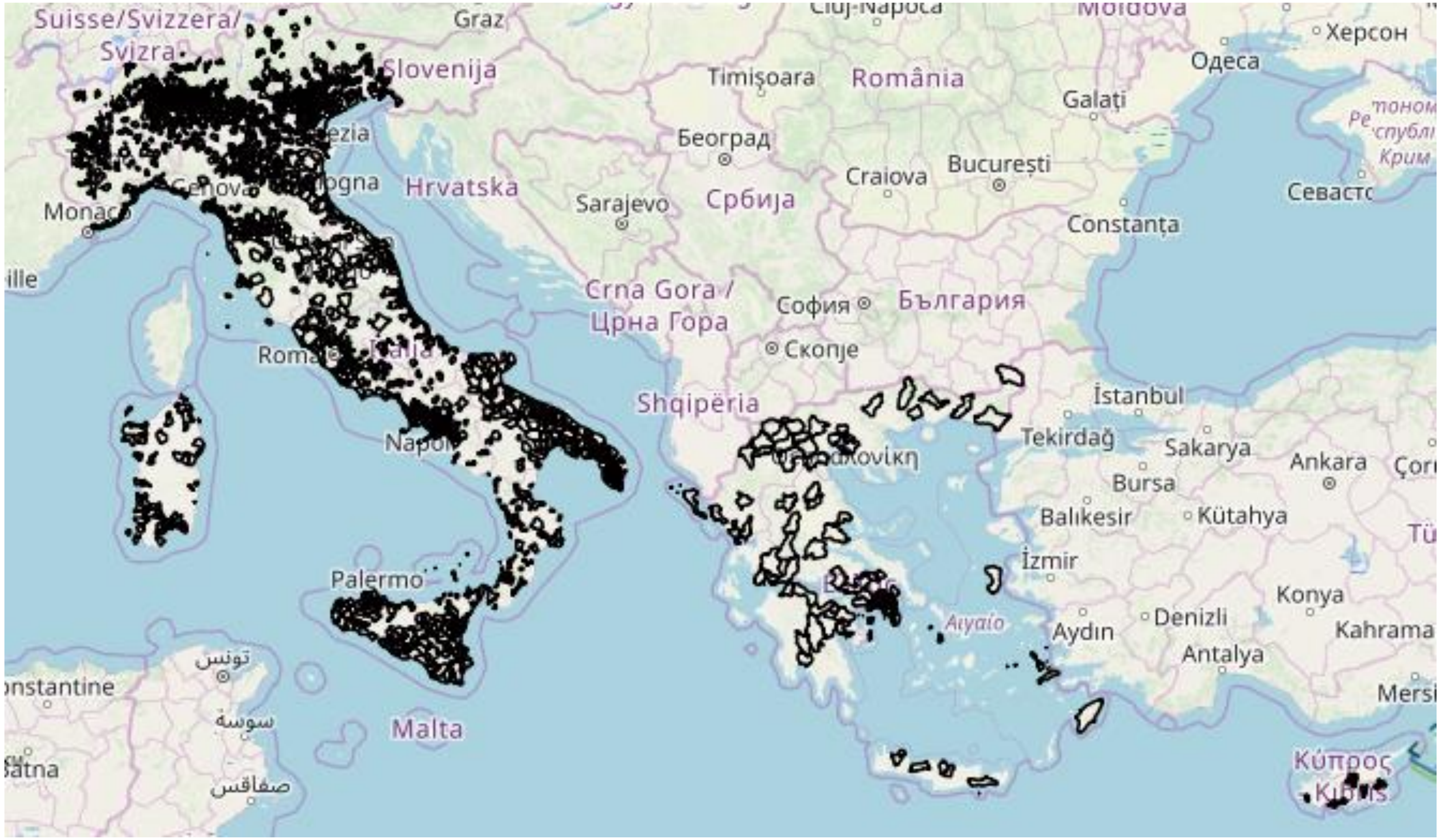
URBAN MUNICIPALITIES

# APPLICABILITY OF THE TOOLKIT

- The URBANPROOF toolkit may be used for conducting an impact and adaptation assessment for every urban municipality of Italy, Greece and Cyprus.
- Urban municipalities, as defined within the UrbanProof toolkit, include all the Local Administrative Units level 2 (LAU2 or communes) which are classified as: Cities (densely populated areas) and Towns & suburbs (intermediate density areas).
- This classification is based on the "New degree of urbanization" adopted by the European Commission (Dijkstra & Poelman 2014). In particular, these two groups are defined as:
- Densely populated area: (alternate name: cities or large urban area)
  - At least 50% lives in high-density clusters
- Intermediate density area (alternate name: towns and suburbs or small urban area)
  - Less than 50% of the population lives in rural grid cells and
  - Less than 50% lives in a high-density cluster

*Dijkstra, L., & Poelman, H. (2014). A harmonised definition of cities and rural areas: the new degree of urbanisation. Regional Working Paper 2014. Working Papers A series of short papers on regional research and indicators produced by the Directorate-General for Regional and Urban Policy. European Commission.*

# APPLICABILITY OF THE TOOLKIT



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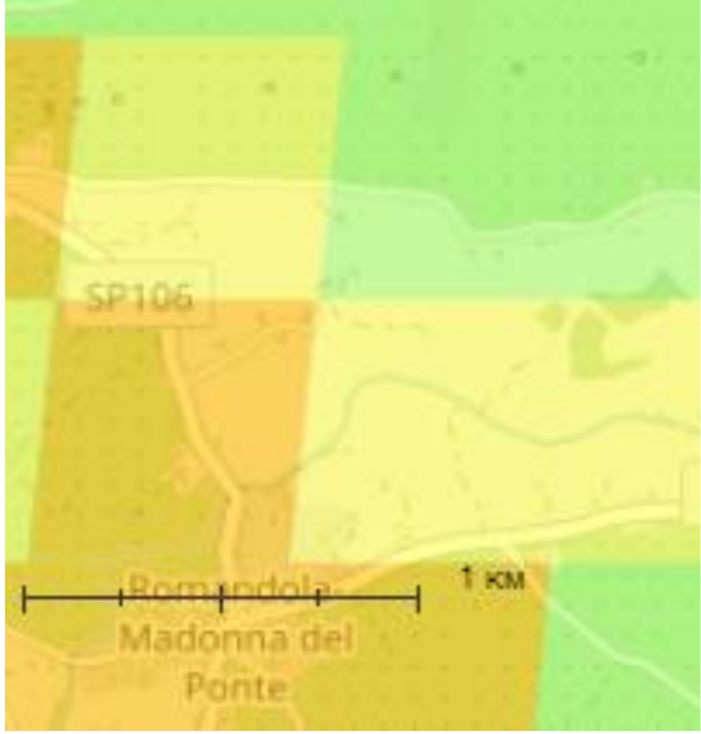
# RESOLUTION ANALYSIS

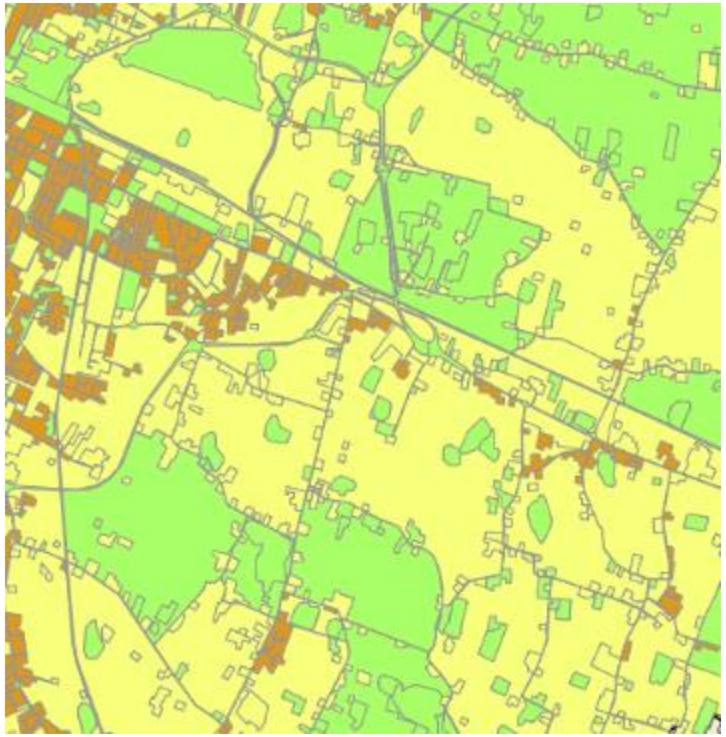
URBAN MUNICIPALITIES & PROJECT MUNICIPALITIES

# RESOLUTION ANALYSIS

All urban municipalities: Presentation of results in grid cells of 500x500m




LIFE URBANPROOF project municipalities: Presentation of results in urban block level



*This applies for Stage 2.The results of Stage 5 are presented for all urban municipalities in grid cells of 500x500m*

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# GEOSPATIAL DATABASES

# GEOSPATIAL DATABASES

| Geospatial data | Databases |
|---|---|
| Climatic data | CORDEX regional climate model (RCM) simulations for the European domain (EURO-CORDEX) database |
| Population density (urban block resolution) | Urban Atlas database - Copernicus Land Monitoring Service |
| Population density (grid resolution: 500x500m ) | Global Human Settlement (GHS) Population grid (LDS) – Joint Research Centre |
| Urban trees, urban green areas | Urban Atlas database - Copernicus Land Monitoring Service |
| Land use | Corine Land Cover - Copernicus Land Monitoring Service |
| Schools, Hospitals, Cultural units | OpenStreetMap - Open Data Commons Open Database License Geodata.gov.gr |
| Floods hazard zones | EIONET Reporting Obligations Database (ROD) - European Environment Agency |
| Soil-hydraulic properties | European Soil Data Centre (ESDAC) - Joint Research Centre |
| Socio-economic data | Eurostat, National Statistical Services |

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# EVALUATION OF ADAPTATION MEASURES

# EVALUATION OF ADAPTATION MEASURES

- The included adaptation measures are the outcome of an extensive literature review, including the reports of European and international organizations providing guidance on the available techniques and methods implemented worldwide for the adaptation of municipalities to climate change.
- The adaptation measures were evaluated and prioritized with the Multi-criteria analysis (MCA) method against technical, environmental, social and economic criteria.
- The evaluation criteria related to efficiency, environmental friendliness, economic viability and job growth.
- The measures were evaluated by a number of experts & stakeholders (national, regional, local authorities; neighbouring municipalities and Unions; NGOs & CSOs; companies; academic bodies & research institutes) from Italy, Greece and Cyprus.
- MCA enabled capturing stakeholder and policy-makers views with a consistent and transparent way.