enhance
Partnership for Risk Reduction

ENHANCE

Enhancing Risk Management Partnerships for Catastrophic Natural Disasters in Europe

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Deliverable 3.1: INVENTORY EXISTING RISK SCENARIOS

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SEVENTH FRAMEWORK PROGRAMME

Title	INVENTORY EXISTING RISK SCENARIOS
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X	PU	Public
	PP	Restricted to other programme participants (including the Commission Services)
	RE	Restricted to a group specified by the consortium (including the Commission Services)
	CO	Confidential, only for members of the consortium (including the Commission Services)

Contents

1 Introduction

This report provides an inventory of existing hazard data, spatial data sets and socio economic projections to process scenario information and future risk projections for the ENHANCE case studies. As a basis for this inventory, we conducted a small survey across the EHNHANCE cases study on their data needs. Table 1.1 provides a preliminary overview of the hazard- and socio economic data and scenario’s required within the different case studies. This overview on the case study data needs and the data availability within the different case study partners, was discussed during the project meetings in Venice, May 2013 and Ispra (September 2013).

During the meeting in Ispra, the case studies were offered a 2 days hands on workshop on how to use scenario and risk data or their case studies. This workshop was offered by IVM and JRC.

Table 1.1 Draft inventory of case study data needs

Case study input data										
	CS1	CS2	CS3	CS4	CS5	CS6	CS7	CS8	CS9	CS10
Spatial scale	EU	National	Regional	Regional	City	City	EU	Regional	EU	EU
Hazard										
Heath Wave				X			X			
Drought				X				X		
Coastal flood					X	X			X	
Climate	X	X	X							
River Flood		X	X			X				X
Socio Economic indicators										
Demographics and social indicators	X	X	X	X	X	X	X	X	X	X
Economics, technology and transport	X	X	X	X	X	X	X	X	X	X
Agriculture and forestry			X	X				X		
Environment, environmental resources and energy			X	X		X	X	X		X
Land cover/Land use		X	X	X	X	X	X	X	X	X

CS1: Air industry response to volcanic eruptions

CS2: Building railway transport resilience to Alpine hazards in Austria

CS3: Climate variability and technological risk Po Basin, Italy

CS4: Drought management Jucar Basin District, Spain

CS5: Flood risk and climate change implications for MSPs in the UK

CS6: Flood risk management for Rotterdam Port infrastructure

CS7: Health preparedness and response plans in the EU

CS8: Insurance and forest fire resilience in Chamusca, Portugal

CS9: Risk culture, perception and storm surge management

CS10: Testing the Solidarity Fund for Romania/Eastern Europe

Since the ENHANCE project follows a risk based approach, we similarly have focused this report on (1) data and projections for different types of natural hazards (Chapter 2) and (2) trends in socio economic factors that influence exposure and vulnerability to the natural hazard (Chapter 3). In addition, we have specifically outlined methods to process socio economic scenarios (Chapter 4) and probabilistic methods (Chapter 5) to describe extreme events with a very low probability. The main objectives of this report are to:

- Provide an inventory of dynamic hazard scenarios at the pan-European scale, based on existing information at JRC or other institutes;
- Provide an inventory of socio economic data and projections in Europe as well as some global outlook projections, possibly relevant for ENHANCE;
- Develop a probabilistic risk framework for identifying probabilities of extreme events in the case studies.

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2 Hazard scenarios

This chapter provides an overview of datasets available at (or through) the Joint Research Centre that could be useful for ENHANCE partners in the assessment of current and future risks of catastrophic natural hazards. The datasets can be used by the project partners in the frame of the ENHANCE project and will be made available upon request through FTP. In view of recent developments in climate science (e.g., new climate simulations based on RCP scenarios), exposure and vulnerability mapping, more products may emerge in the timeframe of ENHANCE. This will be communicated to the partners of the project. The table below shows the contact persons for the different thematic areas. These can be contacted directly for requesting the data. To have an overview of the use of the specific data and to ensure consistency amongst the case studies you should also inform the Case Study Leader and the JRC data coordinators when requesting for data (see bottom Table for contact details).

Thematic area	Contact person	Email
Observed climate	Peter Salamon	peter.salamon@jrc.ec.europa.eu
Climate projections	Alessandro Dosio	alessandro.dosio@jrc.ec.europa.eu
Heat	Simone Russo	simone.russo@jrc.ec.europa.eu
Drought	Luc Feyen	luc.feyen@jrc.ec.europa.eu
Floods	Luc Feyen	luc.feyen@jrc.ec.europa.eu
Forest Fires	Andrea Camia	andrea.camia@jrc.ec.eruropa.eu
Population	Filipe Batista	filipe.batista@jrc.ec.europa.eu
Land use	Carlo Lavalle	carlo.lavalle@jrc.ec.europa.eu

Role in ENHANCE	Contact person	Email
Case Study Leader	Jaroslav Mysiak	peter.salamon@jrc.ec.europa.eu
JRC data coordinator	Luc Feyen	luc.feyen@jrc.ec.europa.eu
JRC data coordinator	Antoine Leblois	antoine.leblois@jrc.ec.europa.eu

In the remainder of this chapter, the different products are shortly described in terms of spatial and temporal resolution, and some information is provided on the methodology underlying them. Figures are included for illustrative purposes. More detailed information on the different products can be found in the references and can be requested from the JRC.

2.1 Observed Climate data

2.1.1 EFAS-Meteo

EFAS-Meteo has been created as part of the development of the European Flood Awareness System (EFAS) and contains pan-European daily maps of meteorological variables at a spatial grid resolution of 5 x 5 km for the time period 1 January 1990 - 31 December 2011. It furthermore contains radiation calculated from sunshine duration, cloud cover and minimum and maximum temperature, as well as evapotranspiration calculated using the Penman-Monteith equation. All meteorological variables are interpolated using an inverse distance scheme based on a maximum number of stations available (Ntegeka et al., 2013). The variables contained in EFAS-Meteo are listed in Table 2.1. The extent of the gridded data set is shown in Figure 2.1.

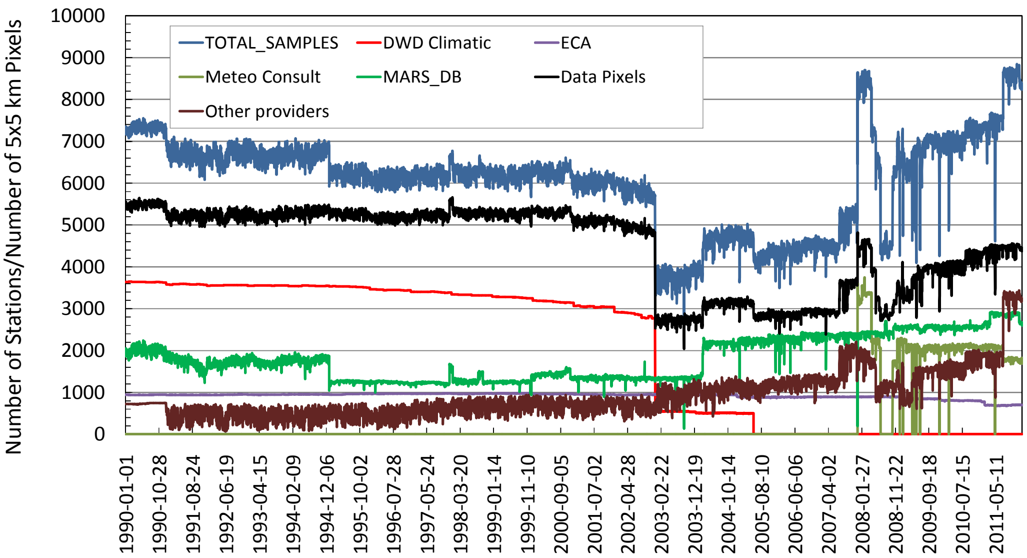


Figure 2.1. Evolution in time of available precipitation stations in EFAS-Meteo. The black time series shows the number of 5x5 km2 grid cells with one or more observations.

Table 2.1. List of variables contained in the EFAS-Meteo dataset

Variable	**Definition**
pr	Daily precipitation (mm) between 6 UTC on day specified and 6 UTC on next day
tn	Daily minimum temperature (°C) between 18 UTC and 6 UTC (i.e. during preceding night) at 2m height
tx	Daily maximum temperature (°C) between 6 UTC and 18 UTC (i.e. during daytime) at 2 m height
ta	Daily mean temperature (°C) is calculated as ta=(tx+tn)/2
ws	Mean daily wind speed at 10 metres (m/s) calculated from 3-hourly observations (0-24 UTC)

pd	Mean daily vapour pressure (hPa)
cr	Calculated radiation (KJ/m2/day)
e0	Penman potential evaporation from a free water surface (mm/day)
et	Penman potential transpiration from a crop canopy (mm/day)
es	Penman potential evaporation from a moist bare soil surface (mm/day)

→ Spatial resolution: 5x5 km

→ Spatial coverage: Europe

→ Temporal resolution: daily time step from 1990 until present

→ Data format: PcRaster maps

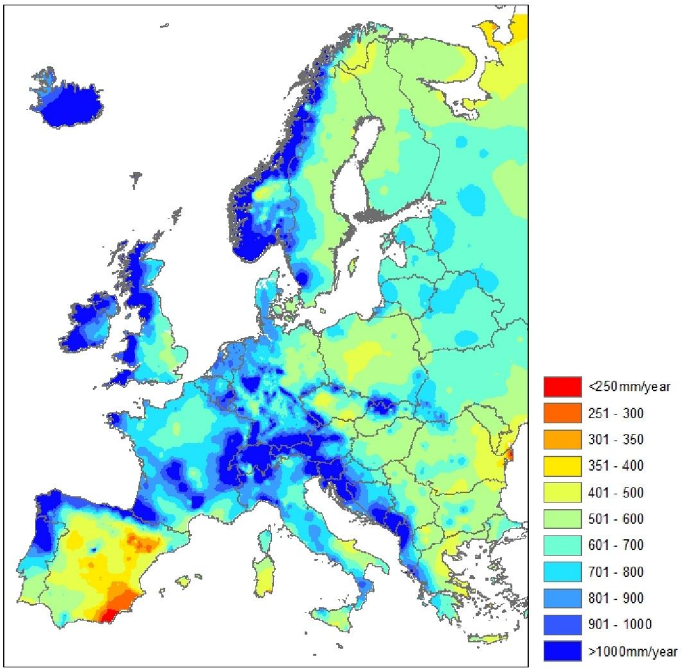
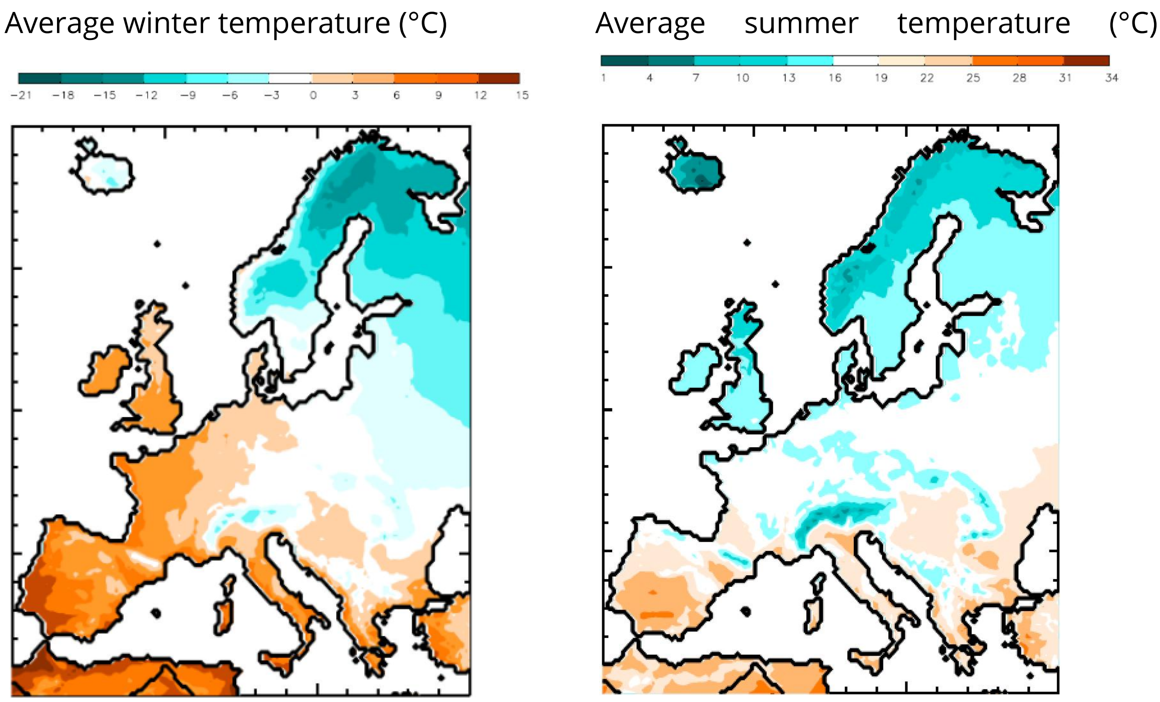


Figure 2.2. Annual average precipitation for period 1990-2011 derived from the EFAS-Meteo dataset.

2.1.2 E-OBS

The E-OBS data set (v3.0) (Haylock et al., 2008) (publicly available from http://eca.knmi.nl/) is a European land-only daily gridded data set for precipitation and minimum, maximum, and mean surface temperature for the period 1950–2006, that has been generated in the frame of ENSEMBLES (EU FP6 project, Contract number GOCE-CT-2003-505539). The aim of the E-OBS data set is to represent daily areal values in alternative grid-boxes, namely 0.5° and 0.25° regular lon-lat grids, and 0.44° and 0.22° rotated-pole grids. The station network used for interpolation in E-OBS comprises ca. 3000 stations for precipitation and ca. 1900 stations for temperature, spread (unevenly) over Europe. A robust three-step process to interpolate daily observations was employed; first, interpolation of monthly precipitation totals and monthly mean temperature using three-dimensional thin-plate splines; second, interpolation of daily anomalies using indicator and universal kriging for precipitation and kriging with an external drift for temperature; and third, combination of monthly and daily estimates. The E-OBS data set has been specially designed to represent grid box estimates, instead of point values. This is essential to enable a direct comparison with results obtained from RCMs.


Average winter temperature (°C)

Average summer temperature (°C)

Figure 2.3. Average winter (left) and summer (right) temperature for period 1961-1990 derived from the E-OBS dataset.

2.2 Regional climate projections

In recent years a large number of regional climate simulations have been generated for Europe (e.g., within PRUDENCE and ENSEMBLES project). It is currently standard practice not to rely on a single climate realisation, but rather to use an ensemble of realisations to account for uncertainty in climate projections. Currently, within EURO-CORDEX (http://www.euro-cordex.net/) a number of climate modelling groups are performing high resolution (~10km) climate simulations for Europe based on the RCP scenarios (http://tntcat.iiasa.ac.at:8787/RcpDb/). These simulations will likely become available for impact modellers by the end of 2013.

In the meantime, the most recent ensembles of high-resolution regional climate data for Europe are based on two trajectories of socio-economic developments:

- SRES A1B scenario – a (business-as-usual) scenario of very rapid economic growth, population that peaks mid-century, social, cultural and economic convergence among regions, dominating market mechanisms, and a balance across all fuel sources (Nakicenovic and Swart, 2000);
- ENSEMBLES E1 scenario – a climate mitigation scenario that corresponds to the A1B scenario with long-term stabilization of atmospheric concentrations of greenhouse gases at 450ppm CO2-equivalent (van der Linden and Mitchell, 2009).

The regional climate simulations originate from the ENSEMBLES project (FP6, contract number GOCE-CT-2003-505539). From the large database of climate projections generated within ESEMBLES, the JRC has selected for their impact analyses the runs fulfilling the following conditions:

    - dynamically downscaled with RCM (i.e., no GCM data)
    - full coverage of the period 1961-2100 (some models up to 2098)
    - data have daily (or higher) temporal resolution

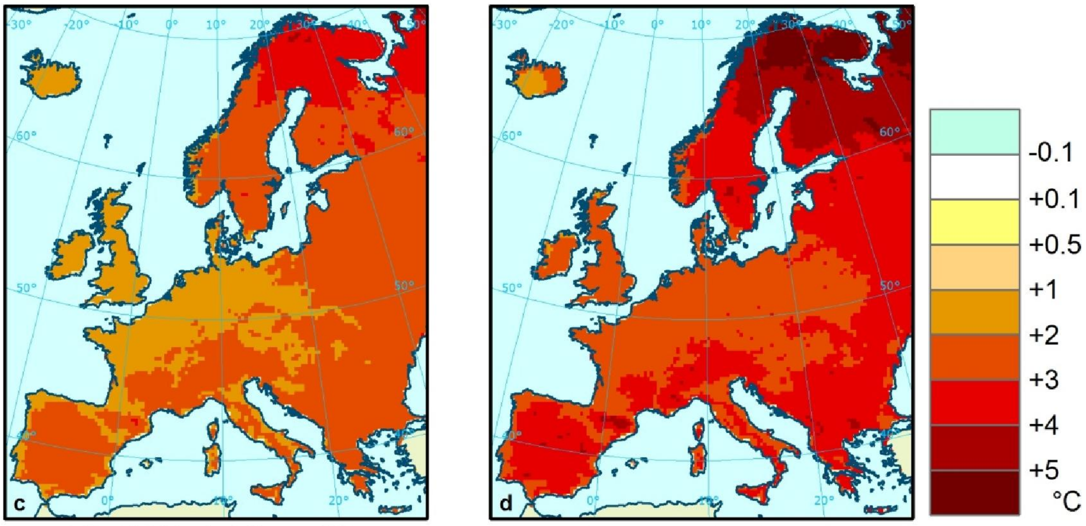
Table 2.2. List of regional-global climate model combinations.

Acronym	Regional Climate Model	Global Climate Model	Scenario
C4I-RCA-HadCM3	RCA	HadCM3	A1B
CNRM-ALADIN-ARPEGE	ALADIN	ARPEGE	A1B
DMI-HIRHAM5-ARPEGE	HIRHAM5	ARPEGE	A1B
DMI-HIRHAM5-BCM	HIRHAM5	BCM	A1B
DMI-HIRHAM5_ECHAM5	HIRHAM5	ECHAM5	A1B
ETHZ-CLM-HadCM3Q0	CLM	HadCM3Q0	A1B
KNMI-RACMO2-ECHAM5	RACMO2	ECHAM5	A1B
METO-HadRM3Q0-HadCM3Q0	HadRM3Q0	HadCM3Q0	A1B
MPI-REMO-ECHAM5	REMO	ECHAM5	A1B
SMHI-RCA-BCM	RCA	BCM	A1B
SMHI-RCA-ECHAM5	RCA	ECHAM5	A1B
SMHI-RCA-HADCM3Q3	RCA	HADCM3Q3	A1B
MPI-REMO-ECHAM5-r1	REMO	ECHAM5 - r1 BC	E1
MPI-REMO-ECHAM5-r2	REMO	ECHAM5 - r2 BC	E1
MPI-REMO-ECHAM5-r3	REMO	ECHAM5 - r3 BC	E1

For the A1B scenario climate simulations from 12 different RCM-GCM combinations were retained. The spatial resolution of the A1B climate simulations is around 25 km for Europe. For the E1 scenario, on the other hand, only output from three regional climate runs are available. Moreover, they are all based on the MPI-REMO regional climate model ran at 50 km spatial resolution, driven by three different ECHAM5 runs as boundary conditions. As such, the climate simulations available capture much less uncertainty in future climate for the E1 scenario compared to the A1B scenario. The climate model combinations are given in Table 2.2.

The temperature and precipitation fields have been bias-corrected for all the models listed in Table 2. The bias-correction was implemented by Dosio and Paruolo (2011) using the E-OBS data set. This method corrects for errors not only in the mean but also in the shape of the distribution. It is therefore capable to correct for errors in the variability as well, which is crucial for extreme event analysis (see also Dosio et al., 2012).

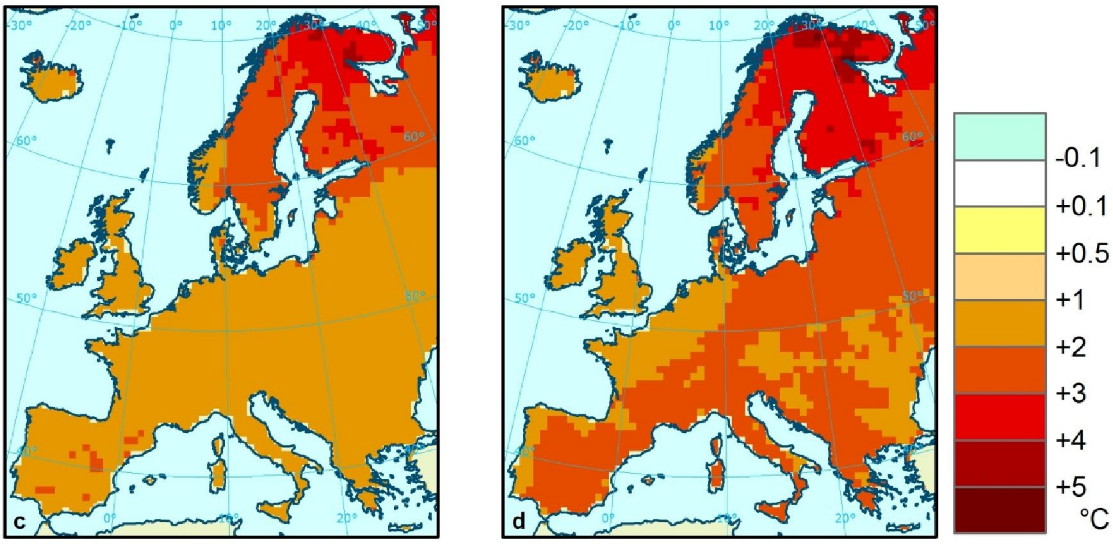
The bias corrected precipitation and temperature fields can be obtained from the JRC upon request. The other variables can be retrieved from the ENSEMBLES data repository (http://ensembles-eu.metoffice.com/).



mean: 2.32; std: 0.51; min: 1.21; max: 5.21

mean: 3.34; std: 0.77; min: 1.67; max: 7.44

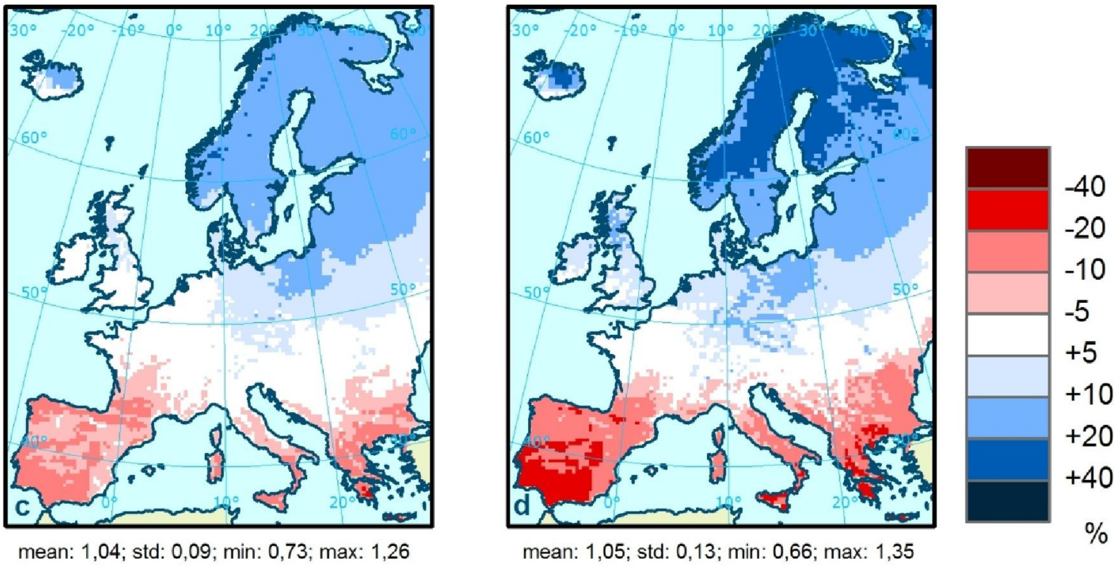
Figure 2.4. Ensemble-average change in mean temperature between 2050s (left) and 2080s (right) and baseline period (1961-1990) for the A1B scenario.



mean: 2.32; std: 0.51; min: 1.21; max: 5.21

mean: 2.38; std: 0.65; min: 1.06; max: 5.47

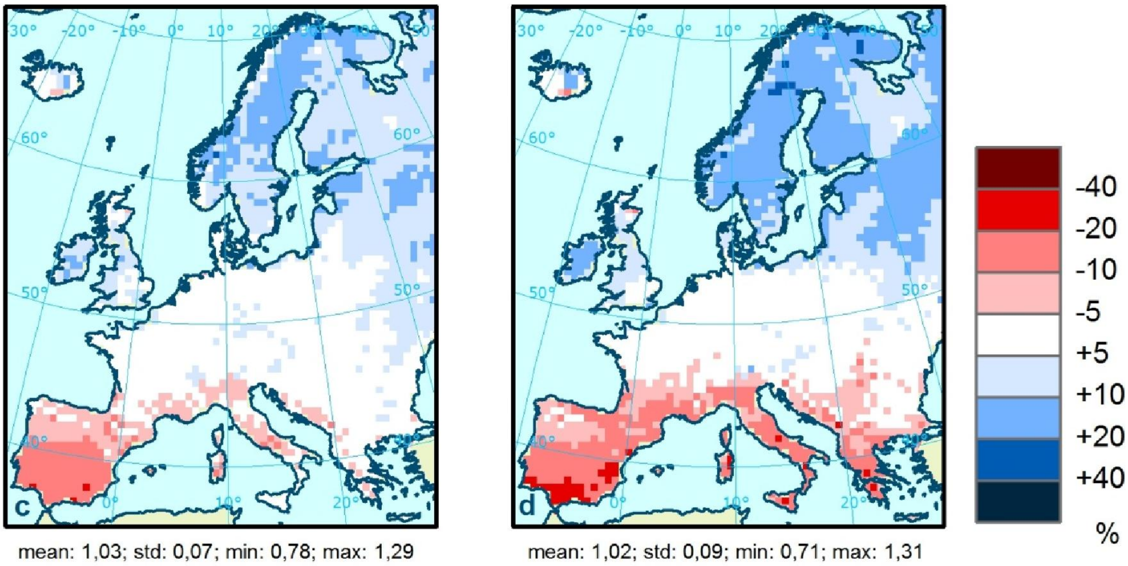
Figure 2.5. Ensemble-average change in mean temperature between 2050s (left) and 2080s (right) and baseline period (1961-1990) for the E1 scenario.



mean: 1,04; std: 0,09; min: 0,73; max: 1,26

mean: 1,05; std: 0,13; min: 0,66; max: 1,35

Figure 2.6. Ensemble-average change in mean precipitation between 2050s (left) and 2080s (right) and baseline period (1961-1990) for the A1B scenario.



mean: 1,03; std: 0,07; min: 0,78; max: 1,29

mean: 1,02; std: 0,09; min: 0,71; max: 1,31

Figure 2.7. Ensemble-average change in mean precipitation between 2050s (left) and 2080s (right) and baseline period (1961-1990) for the scenario.

Table 2.3. List of variables available from the JRC

Variable	Definition
pr	Bias-corrected daily precipitation (mm)
tavg	Bias-corrected daily mean temperature (°C)
tmax	Bias-corrected daily maximum temperature (°C)
tmin	Bias-corrected daily minimum temperature (°C)

- → Spatial resolution: 25x25 km
- → Spatial coverage: Europe
- → Temporal resolution: daily time step for the period 1961-2100 (some models up to 2098)
- → Scenario: SRES A1B
- → Realizations: 12 GCM/RCM combinations
- → Data format: NetCDF

Other climate variables from the same CGM/RCM combinations can be retrieved from the ENSEMBLES data repository (http://ensembles-eu.metoffice.com/).

2.3 Hazard layers

2.3.1 Heat

Heat-related indicators have been calculated using the bias-corrected temperature maps for the 12 RCM/GCM combinations listed in Table 2.2. They have been calculated at a spatial resolution of 25x25 km for 30-year time slices of the period 1961-2100. Below a short description is provided of the heat-related indicators that are available.

Heat wave duration index

This indicator, defined by Frich et al. (2002), expresses the frequency of occurrence of a heat wave event relative to the base period. It is defined as the maximum period of >5 consecutive days with maximum temperature >5°C above the baseline daily normal maximum. Note that this is a purely statistical indicator that reflects temperature deviations from the norm (hence also in colder climates) rather than the concept of heat experienced by the environment. This indicator also only takes into account the duration of a heat wave. At the JRC currently a new HW indicator is being defined and calculated that takes into account both duration and intensity of an HW event.

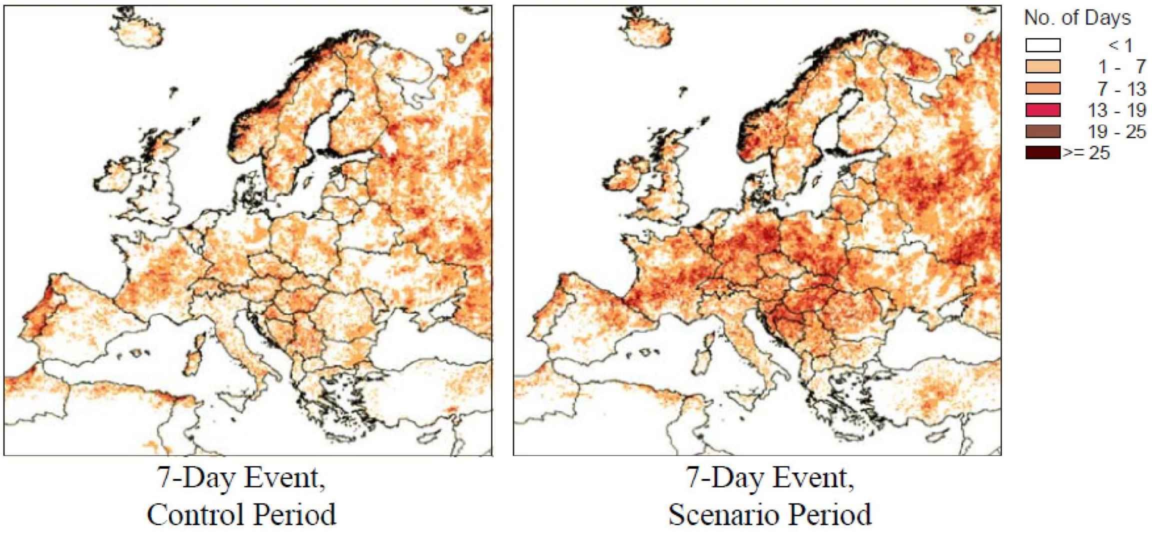


Figure 2.8. Frequency of 7-day heat wave event for HWDI during summer months for baseline period (1961-1990) and scenario period (2071-2100).

2.3.2 Summer days and extreme hot summer days

These reflect the number of summer days with $T_{max} > 25°C$ and $T_{max} > 35°C$, respectively, obtained by counting the number of days in summer when the maximum temperature exceeds either 25°C or 35°C.

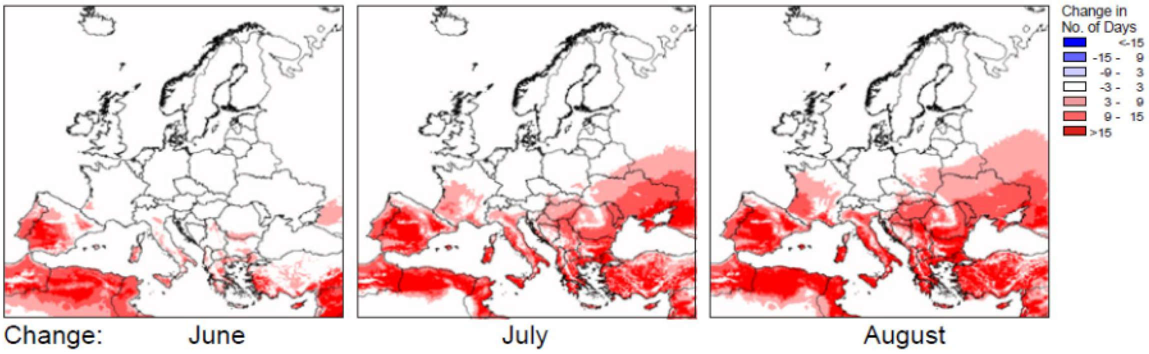


Figure 2.9. Change in extreme hot days in summer months between control (1961-1990) and scenario period (2071-2100). Figure needs to be updated for A1B ensemble results.

2.3.3 Tropical summer nights

This reflects the number of summer nights with T_{min} > 20°C, obtained by counting the number of nights in summer when the minimum temperature exceeds 20°C.

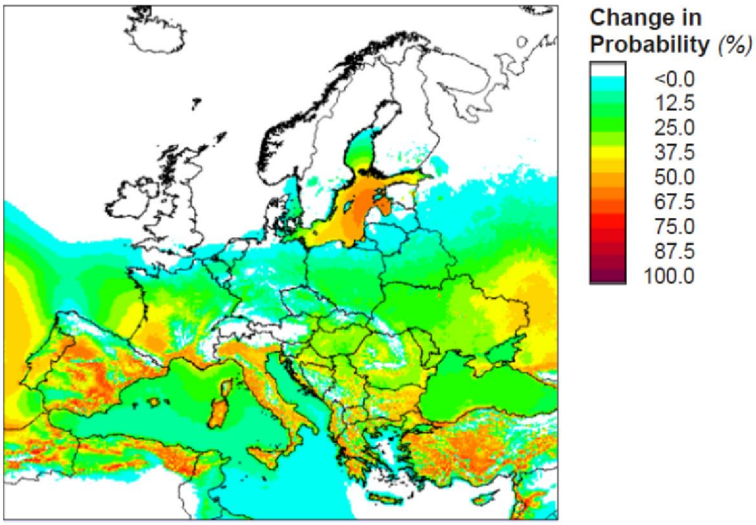


Figure 2.10. Change in probability between 1961-1990 and 2071-2100 of minimum daily temperature in summer exceeding 20°C. Figure needs to be updated for A1B ensemble results.

Table 2.4. List of variables available from the JRC

Variable	**Definition**
hwmi	Heat Wave Magnitude Index (HW scale)
hwdi*	Heat Wave Duration Index (nr of events)
exhotsumd*	Number of days with T_{max} > 35°C (days)
tropnight*	Number of summer nights with T_{min} > 20°C (days)

hwmi (data to be available from January 2014)

→ Spatial resolution: 25x25km to 1.8 degree, depending on climate realization

→ Spatial coverage: Europe

→ Temporal resolution: yearly

→ Scenario: SRES A1B and RCP2.6, RCP4.5 and RCP8.5

→ Realizations: 5 GCM/RCM combinations for SRES A1B, 16 GCMs for RCPs

→ Data format: NetCDF

***hwdi**, **exhotsumd**, **tropnight** can be produced on request

→ Spatial resolution: 25x25 km

→ Spatial coverage: Europe

→ Temporal resolution: 30 year time slices in the period 1961-2100

→ Scenario: SRES A1B

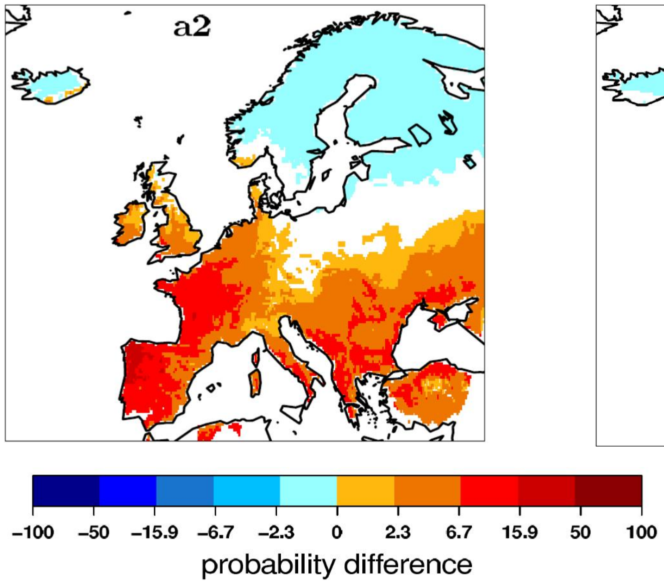
→ Realizations: 12 GCM/RCM combinations

→ Data format: NetCDF

2.3.4 Droughts

Extreme dry years and seasons

The probabilities of occurrence of extreme dry years and seasons in Europe have been estimated by using the Standardized non-stationary Precipitation Index (SnsPI). The latter differs from the normal SPI as it accounts for precipitation time dependence under climate change by fitting precipitation data with a non-stationary gamma distribution. Bias-corrected daily precipitation outputs from five different regional climate models provided by the ENSEMBLES project (see Table 2) have been used. The five RCMs have been selected as to represent the main statistical properties of the whole ENSEMBLES set, and the most extreme deviation from the ensemble mean. SnsPI has been calculated at a spatial resolution of 25x25 km over the period 1961-2098. More details can be found in Russo et al. (2013).



Summer (JJA)

Winter (DJF)

Figure 2.11. Probability changes between future period (2069-2098) and reference period (1971-2000) for extreme-dry summers (left panel) and winters (right panel). White areas represent the points where precipitation changes are not statistically significant at the 5% level according to the results of the log-likelihood ratio test.

Minimum flows and flow deficits

Changes in streamflow drought characteristics have been derived at spatial resolution of 5x5 km for the ensemble of A1B climate simulations listed in Table 2. In a first step, the LISFLOOD hydrological model has been driven by the bias-corrected ENSEMBLES climate simulations resulting in time series of 140 years of daily discharge simulations. For time windows of 30 years we fitted a Generalized Extreme Value distribution to the annual minima and a Generalized Pareto distribution to the shortfalls below a threshold in the low flow spectrum. From the fitted extreme value distributions minimum flows and maximum deficit volumes for different return periods (from 2 up to 100 years) have been derived. Drought characteristics have been derived in view of only climate change and in combination with changes in water demand. For the latter, we linked LISFLOOD with projections of water consumption under an A1B-consistent scenario ("Economy First" - EcF) from the EU FP6 SCENES project (Flörke et al., 2011). More detailed information on the methodology and an in-depth discussion of the results can be found in Feyen and Dankers (2009) and Forzieri et al. (2013).

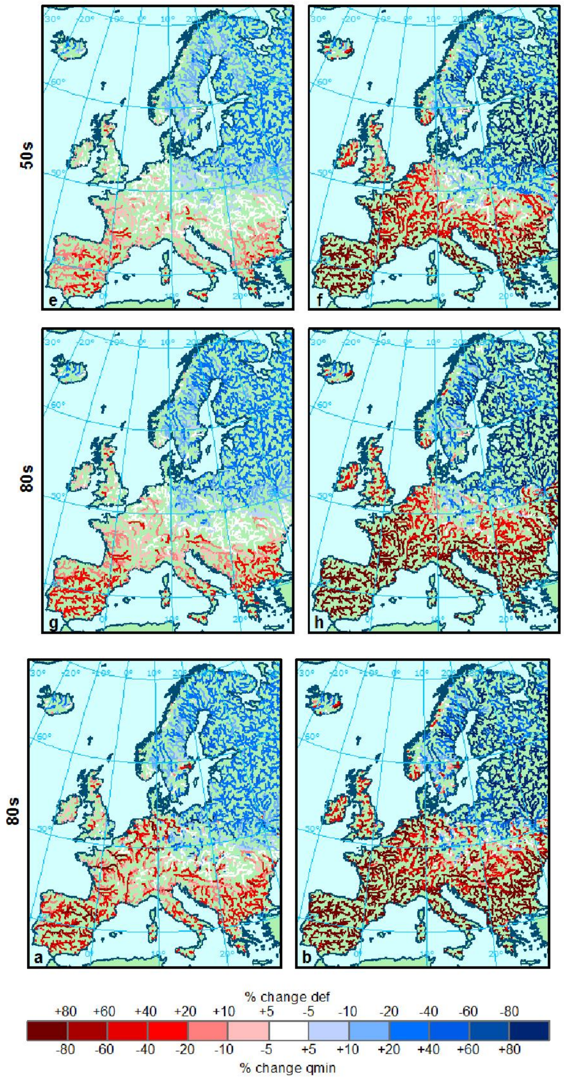


Figure 2.12. Change in minimum flows (left) and flow deficit volumes (right) between future time windows (top: 2050s; middle and bottom: 2080s) and reference period (1961-1990). Top and middle only effect of climate change, bottom row combined effects of climate change and water consumption.

Table 2.5. List of variables available from the JRC

Variable	**Definition**
exdryyear	Extreme dry years
exdryseas	Extreme dry seasons
Qmin	Minimum flows (m^3s^{-1})
flowdef	Flow deficits (m^3)

exdryseas and **exdryseas**

- → Spatial resolution: 25x25 km
- → Spatial coverage: Europe
- → Temporal resolution: 30 year time slices for the periods 1971-2000, 2021-2050 and 2069-2098
- → Scenario: SRES A1B
- → Realizations: ensemble of 5 GCM/RCM combinations
- → Data format: NetCDF

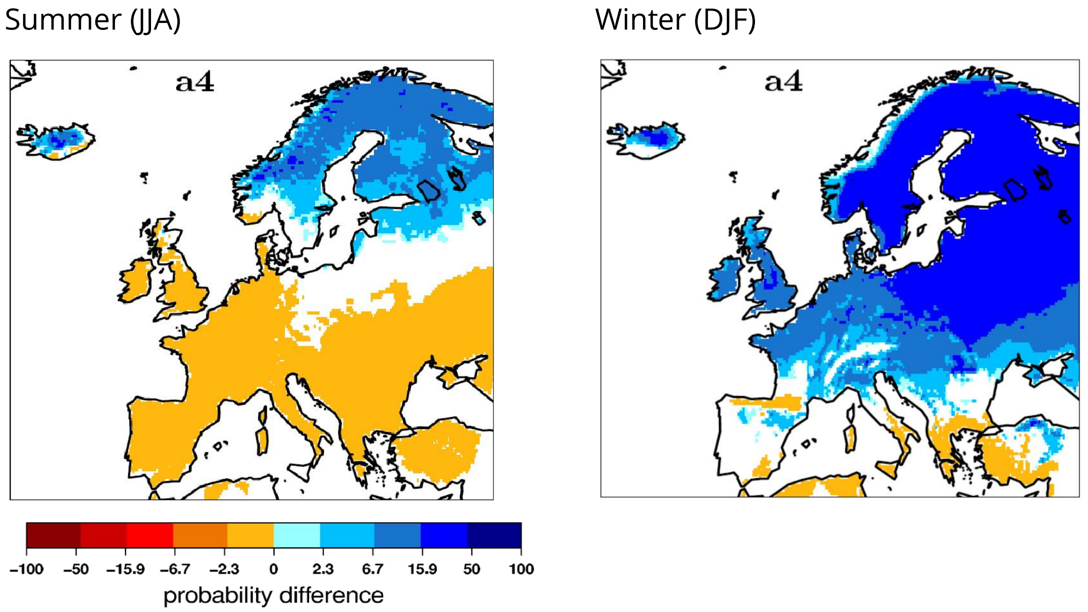
Qmin and **flowdef**

- → Spatial resolution: 5x5 km
- → Spatial coverage: Europe (Cyprus not included)
- → Temporal resolution: 30 year time slices for the periods 1961-1990, 1981-2010, 2011-2040, 2041-2070 and 2071-2100
- → Data are available for return periods of 2, 5, 10, 20, 50 and 100 years
- → Scenario: SRES A1B
- → Realizations: ensemble of 12 GCM/RCM combinations
- → Data format: ascii

2.3.5 Floods

Extreme wet years and seasons

The probabilities of occurrence of extreme wet years and seasons in Europe have been estimated by using the Standardized non-stationary Precipitation Index (SnsPI). The latter differs from the normal SPI as it accounts for precipitation time dependence under climate change by fitting precipitation data with a non-stationary gamma distribution. Bias-corrected daily precipitation outputs from five different regional climate models provided by the ENSEMBLES project (see Table 2) have been used. The five RCMs have been selected as to represent the main statistical properties of the whole ENSEMBLES set, and the most extreme deviation from the ensemble mean. SnsPI has been calculated at a spatial resolution of 25x25 km over the period 1961-2098. More details can be found in Russo et al. (2013).


Summer (JJA)

Winter (DJF)

Figure 2.13. Probability changes between future period (2069-2098) and reference period (1971-2000) for extreme-wet summers (left panel) and winters (right panel). White areas represent the points where precipitation changes are not statistically significant at the 5% level according to the results of the log-likelihood ratio test.

River flood discharges

Flood discharges have been derived for different return periods ranging between 2 and 500 years at a spatial resolution of 5x5 km. First, LISFLOOD has been driven by observed climate (EFAS-Meteo, 22 years) or climate simulations (bias-corrected ENSEMBLES climate simulations, 140 years), resulting in time series of daily simulations. Next, a Gumbel distribution is fitted through the annual maxima over 30-year time windows (or 22 years for observation-driven run) using the maximum likelihood estimation method. Finally, from the fitted Gumbel distributions flood return levels are derived for different recurrence intervals. More information on the procedure can be found in Dankers and Feyen (2008, 2009) and Rojas et al. (2011, 2012).

As an example, Figure 2.14 shows the ensemble-average change in magnitude of a 100-year flood event between the 2080s and baseline period (left panel) and the statistical significance of the changes (right panel). The ensemble consists of the 12 GCM/RCM combinations for the SRES A1B emission scenario listed in Table 2. The high p-values in northern and southern parts of Europe reflect the high variability in projected changes within the ensemble. A more in-depth discussion of these results can be found in Rojas et al. (2012).

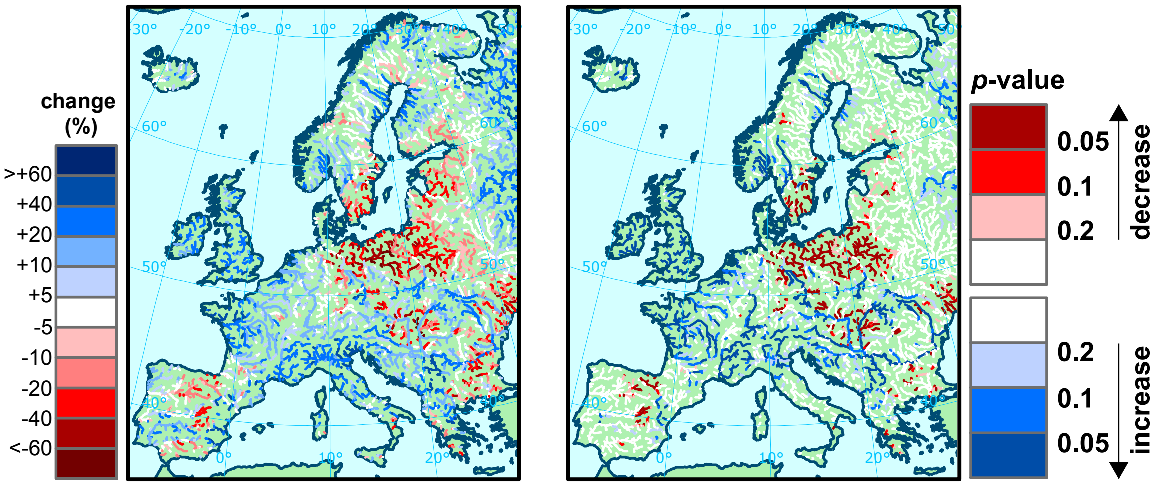


Figure 2.14. Change in magnitude of 100-year flood event between 2080s and control period (1961-1990) (left panel) and statistical significance of the change (right panel). Based on an ensemble of 12 climate experiments for the SRES A1B scenario. Only river pixels with an upstream area larger than 1000 km^2 are shown.

River Flood inundation maps

From the flood discharges flood inundation maps have been derived using a planar approximation approach. First, river discharges (for the different return periods) were translated into river water depths based on approximated river channel geometries. The river water depths were resampled to 100 m resolution based on the river network obtained from the pan-European River and Catchment Database CCM2 (Vogt et al., 2007). Finally, river water levels were extrapolated onto the high-resolution (100 m) digital elevation model (DEM) of the CCM2 database to delineate flooded areas and inundation depths. The DEM represents a surface model, and hence ground elevation may be overestimated in some areas such as forested areas, with the high vegetation canopy, and also in urban areas where the tops of buildings may be recorded. These errors are biased to underestimate areas at risk of flooding. On the other hand, the planar approach does not account for a volume restriction, which may result in an overestimation of the areas at risk of flooding. We also note that in this step, flood protection measures are not taken into account (unless represented in the DEM). The delineated flood areas hence reflect the area that can potentially be flooded for a given return period, given that there are no flood protection measures.

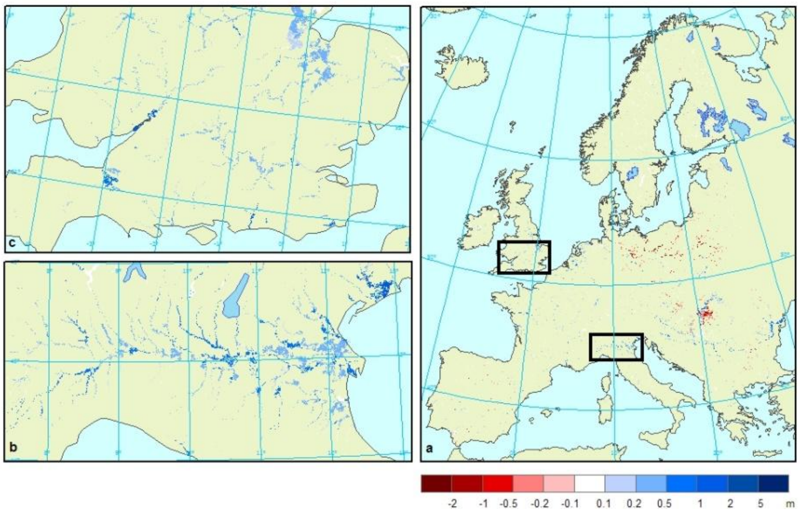


Figure 2.15. Change in inundation depth (in meters) for a flood event with 100-year recurrence interval between 2080s and control period (1961-1990); (a) Europe full domain, (b) Po River in Italy, (c) southern UK, including River Thames.

Coastal flood inundation and potential damage map

A coastal flood inundation map for current conditions has been derived by extrapolating the 100-year surge height acquired from the DIVA database (http://www.diva-model.net/) on the SRTM digital elevation model using the shortest hydraulic distance path between the DIVA segments and the SRTM derived coastline. By overlapping the inundation map with land use and linking with flood-damage functions, potential damages have been derived. The coastal inundation mapping and calculation of the flood damage potential was done at 100 m grid size. The metric shown in the map is the potential losses in Euros at Purchasing Power Parities (PPP). More details can be found in Barredo et al. (2009).

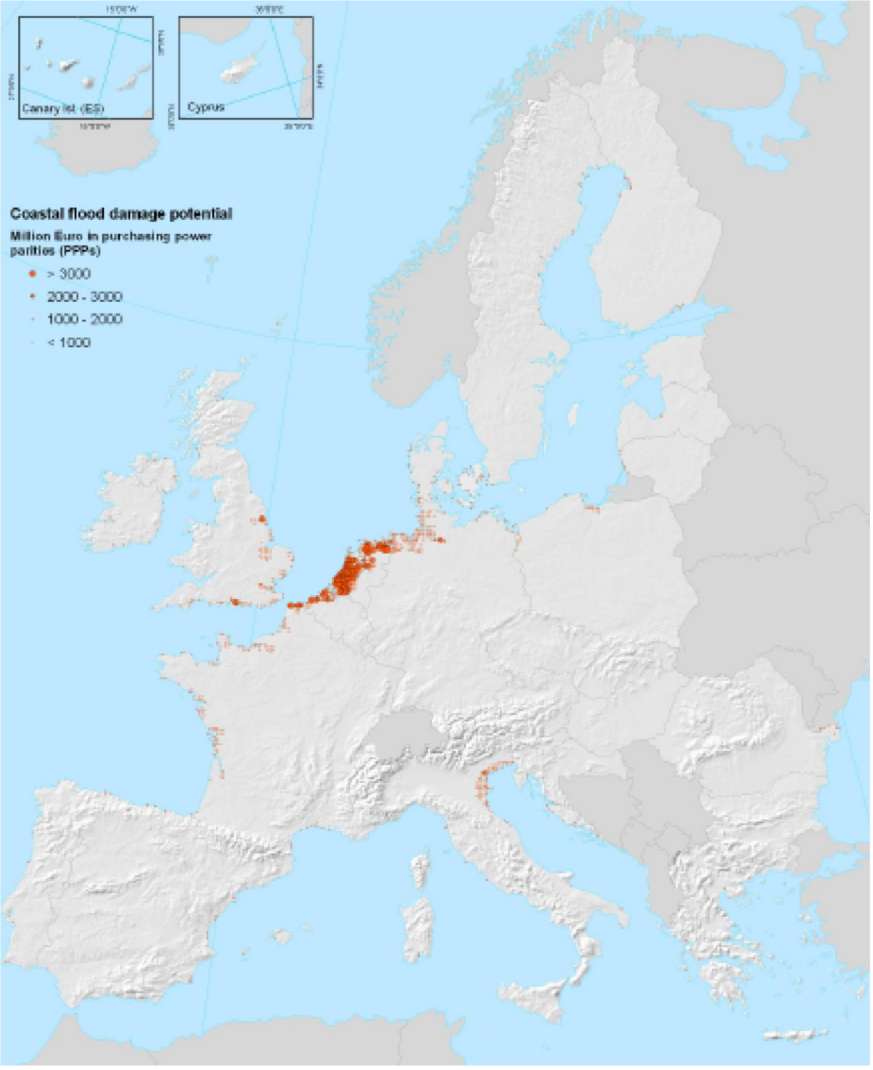


Figure 2.16. Current coastal flood damage potential of a 100-year coastal storm surge.

Table 2.6. List of variables available from the JRC

Variable	Definition
exwetyear	Extreme wet years
exwetseas	Extreme wet seasons
Qflood	Flood discharge (m^3s^{-1})
floodinund	Flood inundation height (m)
flooddam	Direct damage from flooding (€)
floodpaff	People affected (nr people)

exwetyear and **exwetseas**

- → Spatial resolution: 25x25 km
- → Spatial coverage: Europe
- → Temporal resolution: 30 year time slices for the periods 1971-2000, 2021-2050 and 2069-2098
- → Scenario: SRES A1B
- → Realizations: ensemble of 5 GCM/RCM combinations
- → Data format: NetCDF

Qflood

- → Spatial resolution: 5x5 km
- → Spatial coverage: Europe (Cyprus not included)
- → Temporal resolution: Data reflect conditions over 30 year time slices for the periods 1961-1990, 1981-2010, 2011-2040, 2041-2070 and 2071-2100
- → Data are available for return periods of 2, 5, 10, 20, 50, 100, 250 and 500 years
- → Scenario: SRES A1B
- → Realizations: ensemble of 12 GCM/RCM combinations
- → Data format: ascii

floodinund, **flooddam** and **floodpaff**

- → The spatial resolution is 100x100 m
- → Spatial coverage: Europe (not Cyprus) for **floodinund**, EU27 for **flooddam** and **floodpaff**
- → Temporal resolution: Data reflect conditions over 30 year time slices for the periods 1961-1990, 1981-2010, 2011-2040, 2041-2070 and 2071-2100
- → Data are available for return periods of 2, 5, 10, 20, 50, 100, 250 and 500 years
- → Scenario: SRES A1B
- → Realizations: ensemble of 12 GCM/RCM combinations
- → Data format: ascii

Biomass burning & forest fires

The potential impact of climate change on fires probability and burned area in Europe has been modelled with the terrestrial-biosphere Community Land Model (CLM), extended with a carbon-nitrogen biogeochemical model. The prognostic treatment of fires is based on the fire algorithm that includes both climatic and socio-economic drivers of fires. Simulations were conducted at a spatial resolution of 0.25 degree over a regular Lat/Lon grid for the period 1960-2099. The model runs were performed at half-hourly time steps, and aggregated at a monthly time-step. Simulations over the 21st century were conducted with scenarios of aerosol and GHG forcing under the SRES A1B climate change scenario, using bias-corrected temperature and precipitation from a selection of 5 RCM/GCM combinations from the ENSEMBLES project (see Table 1). Because of the lack of lightning scenarios, the mean monthly climatology of LIS/OTD was used, and, therefore, lightning is assumed constant from year to year up to 2099 (more details on the methodology can be found in Migliavacca et al. (2013a,b).

Table 2.7. List of variables available from the JRC

Variable	**Definition**
fwi	Fire Weather Index
fuelmap	Fuel Map
firesev	Fire Severity
potfiredam	Potential Fire Damage (€/ha)

fwi

→ Spatial resolution: 10x10 km

→ Spatial coverage: Europe and North Africa

→ Temporal resolution: daily for the period 2012-2013

→ Data format: Oracle (CSV dump)

→ Spatial resolution: 50x50 km

→ Spatial coverage: Europe and North Africa

→ Temporal resolution: daily for the period 2000-2011

→ Data format: Oracle (CSV dump)

→ Spatial resolution: 125x125 km

→ Spatial coverage: Europe and North Africa

→ Temporal resolution: daily for the period 1958-2006

→ Data format: CSV

fuelmap

→ Spatial resolution: 250x250 m

→ Spatial coverage: Europe

→ Thematic resolution = 42 fuel types

→ Data format: TIFF

firesev

→ Spatial resolution: 250x250 m

→ Spatial coverage: Europe (places where burned areas are mapped by EFFIS)

→ Temporal resolution: post-fire processing. Currently done on demand for specific fires (not systematically processed)

→ Data format: TIFF

potfiredam

→ Spatial resolution: 250x250 m

→ Spatial coverage: Europe

→ Temporal resolution: 2006

→ Data format: TIFF

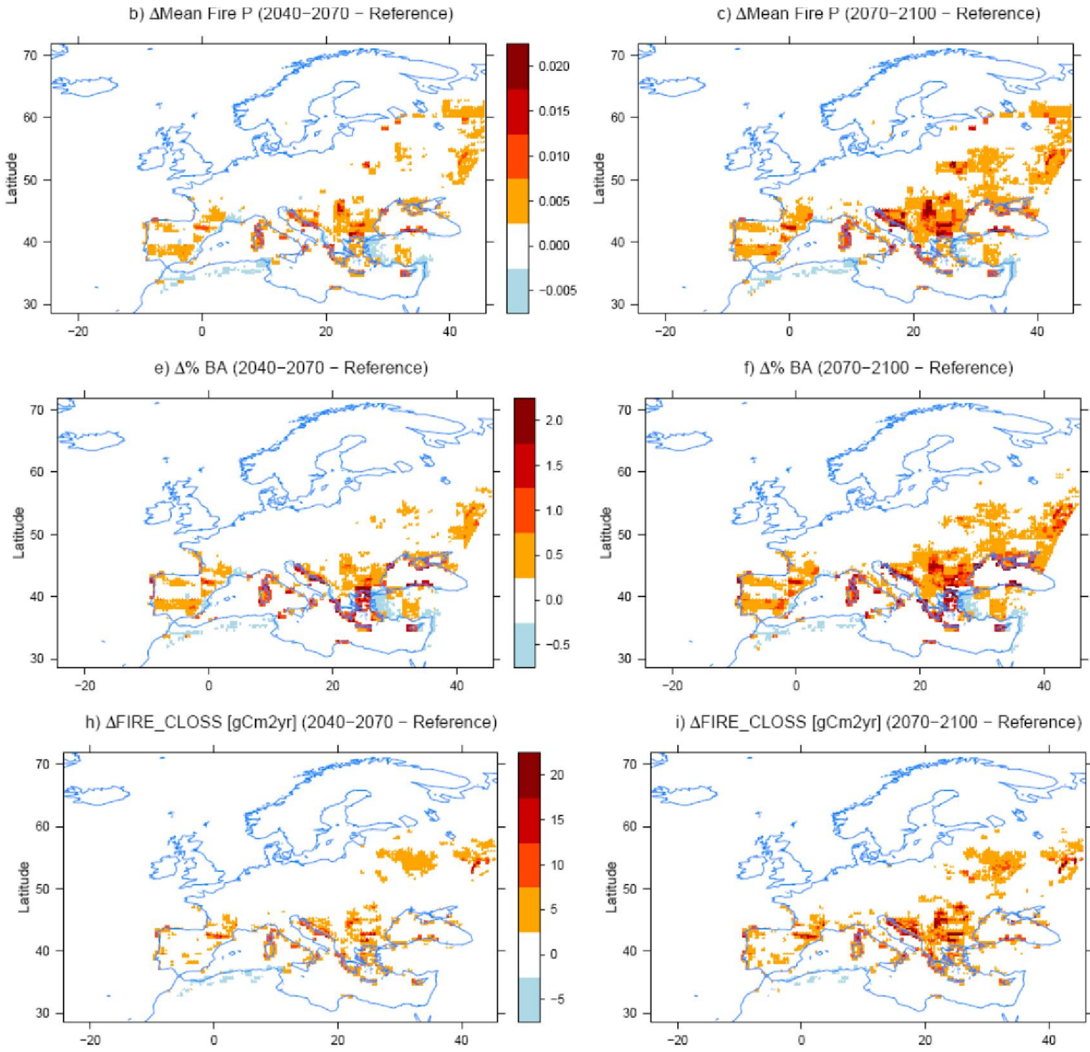


Figure 2.17. Changes between 2050s (left panels) and 2080s (right panels) compared to the baseline 1960-1990 of the ensemble mean of fire probability (Fire P), fractional burned area (%BA) and carbon emitted from fires (FIRE_CLOSS).

3 Socio Economic scenarios and data sets

3.1 Socio-economic scenarios

Climate impact and adaptation assessments are concerned with understanding changes in natural and socio-economic systems. Scenarios are sets of plausible and challenging but relevant stories about the future, developed to support decision-makers in their understanding of the wide range of possible futures, to give insight in the associated uncertainties, and to reveal what the future impact might be of decisions taken (Millennium Ecosystem Assessment, 2005). Socio-economic scenarios can be defined as global, providing an integrated picture of future developments and are frequently used to frame global assessments of environmental problems, or domain specific, with a focus on the developments of single issues or domains (Energy, Transport, Agriculture, Built environment, Environment and climate). Both global and domain specific socio-economic scenarios can be exploratory, extrapolatory or normative. Extrapolatory scenarios extrapolate current trends, normative scenarios picture a desirable society in future and exploratory scenarios create a stylized model of a system and make projection for the system given assumptions about the determinants of change assessments (Berkhout & Van Drunen, 2007; Van Drunen & Berkhout, 2009). This last exploratory approach is mainly applied in scenario studies and is next to that most relevant for climate assessments (Berkhout & Van Drunen, 2007; Van Drunen & Berkhout, 2009). Five dimensions of change can be identified for which the global socio-economic scenarios give an insight: economic development, the nature of governance, technological change, demographic change and social change (Raskin, 2005). Since scenarios do not result in future projections but rather depict uncertainty ranges, scenarios need to be tailored to the specific needs of climate impact and adaptation assessments.

3.1.1 Global socio-economic scenarios

Global socioeconomic scenarios often applied are the IPCC SRES, the GEO and the SSP scenarios. These scenarios are described below. Five other global socio-economic scenarios, more or less similar in set-up and developed pathways, are described in appendix I

IPCC SRES (Special Report on Emission Scenarios)

The IPCC SRES scenarios are developed by the IPCC in 2000 as input to ongoing climate change research. The scenarios were derived via an open process of participation and feedback. Six modeling groups can be distinguished with a corresponding emission scenario family. Within these modeling groups, a number of alternative social visions were linked to future energy-related and land-use emissions and assumptions on the main driving forces of human-induced climate change (Nakicenovic, 2000; Raskin, 2005; Morita, 2001). The IPCC SRES scenarios explicitly do not include policies for greenhouse gas mitigation and only simulate emissions in the absence of such policies. The scenarios are focused on climate change and greenhouse gas emissions and use a time horizon up to 2100. The four IPCC SRES scenarios widely known and applied are:

1. **A1**: Converging world. Rapid market-driven economic growth with convergence in incomes and culture, rapid introduction of new and more efficient technologies.
2. **A2**: Heterogeneous world. Self-reliance and preservation of local identities, fragmented economic and technological development, continuously increasing population, regionally oriented economic development.
3. **B1**: Converging world but with changes towards service and information economy, reductions in material intensity and introduction of clean and resource-efficient technologies. Emphasis on global solutions to economic, social and environmental sustainability.
4. **B2**: Local solutions to economic, social and environmental sustainability and intermediate rates of change with respect to population growth, economic development and technological change.

3.1.2 Global Environment Outlook scenarios

The UNEP Global Environment Outlook scenarios are integrated global and regional scenarios. The GEO-3 (2004) and GEO-4 (2007) scenarios are based on the drivers-pressures-state-impacts-responses (DPSIR) concept characterizing the interactions between society and environment (Raskin, 2005; UNEP, 2004; UNEP, 2007). The scenarios are based on the drivers: institutional and socio-political effectiveness, demographics, economic demand, trade and markets, scientific and technological innovation, value-systems, social and individual choices. Starting point for the GEO-4 scenarios was formed by the GEO-3 scenarios, while the GEO-3 scenarios were built on the work of the Global Scenario Group (Appendix I). The GEO-3 and GEO-4 scenarios have a focus on the environment and use respectively 2032 and 2050 as time horizon. Four scenarios are developed within GEO-3 and GEO-4 (UNEP, 2004; UNEP, 2007):

1. **Markets First:** Maximum economic growth pursued by the private sector and supported by the government as best path to improve environment and human well-being.
2. **Policy First:** Implementation of strong policies implemented by the government sector intended to improve environment and human well-being, meanwhile emphasizing economic development.
3. **Security First:** Government and private sector vie for control in efforts to improve or maintain human well-being for mainly the rich and powerful in society.
4. **Sustainability First**: Civic, government and private sectors collaborate in improving environment and human well-being, with a strong emphasis on equity.

Other than GEO-3 and GEO-4, the GEO-5 (2012) scenarios focus on choices and strategies that could lead to sustainable futures, compared to a business-as-usual scenario (UNEP, 2012). Goals and targets formulated within this sustainable future (time horizon: 2050) can be divided within the themes: Atmosphere, Land, Water, Biodiversity, and Chemicals and Waste.

Population, income and consumption are seen as the main drivers. Two storylines are developed within the GEO-5 scenarios (UNEP, 2012):

1. **Conventional world pathway**: The world in 2050 assuming business-as-usual paths and behaviors.
2. **Sustainable world pathway**: Alternative path that leads to results consistent with our current understanding of sustainability and agreed-upon goals and targets on the road to 2050. Two scenarios are developed within this pathway. Scenario A focuses entirely on additional investments in transforming technology and production in order to achieve the goals. Scenario B focuses on lifestyle changes and its added value in order to reduce investments.

3.1.3 SSP (Shared Socioeconomic Pathways)

Five Shared Socioeconomic Pathways (SSPs) are quantified by IIASA in 2011 for use in combination with a number of Representative Concentration Pathways (Moss et al., 2010) in order to analyze feedbacks between climate change and socioeconomic development (Kriegler et al., 2010; O'neill et al., 2012). Factors taken into account within the SSPs are population growth, economic development, technological progress together with environmental status, effectiveness of national institutional efforts against climate change, and progress in poverty alleviation (Kriegler et al., 2010; O'neill et al., 2012).

1. **SSP1 Sustainability**: A world making relatively good progress towards sustainability, with ongoing efforts to achieve development goals while reducing resource intensity and fossil fuel dependency. It is an environmentally aware world with rapid technology development, and strong economic growth, even in low-income countries.
2. **SSP2 Middle of the road**: This "business-as-usual" world sees the trends of recent decades continuing, with some progress toward achieving development goals. Dependency on fossil fuels is slowing decreasing. Development of low-income countries proceeds unevenly.
3. **SSP3 Fragmentation**: A world that is separated into regions characterized by extreme poverty, pockets of moderate wealth, and a large number of countries struggling to maintain living standards for a rapidly growing population.
4. **SSP4 Inequality**: A highly unequal world in which a relatively small, rich global elite is responsible for most of the greenhouse gas emissions, while a larger, poor group that is vulnerable to the impact of climate changes, contributes little to the harmful emissions. Mitigation efforts are low and adaptation is difficult due to ineffective institutions and the low income of the large poor population.
5. **SSP5 Conventional Development**: A world in which conventional development oriented towards economic growth is seen as the solution to social and economic problems. Rapid conventional development leads to an energy system dominated by fossil fuels, resulting in high greenhouse gas emissions and challenges to mitigation.

3.1.4 European tailored socio-economic scenarios

The European Observation Network for Territorial Development and Cohesion aggregates national, regional and local knowledge with respect to applied research and studies on territorial development and spatial planning. A number of studies within ESPON use European tailored scenarios as a tool for communication and discussion of policies. One of the research projects that is currently executed as part of the ESPON 2013 program and in which scenarios are developed is the ET2050 ESPON project (ESPON, 2012). Mission of the ESPON 2013 Program is to: Support policy development in relation to the aim of territorial cohesion and a harmonious development of the European territory by 1) Providing comparable information, evidence, analyses and scenarios on territorial dynamics and, 2) revealing territorial capital and potentials for development of regions and larger territories contributing to European competitiveness, territorial cooperation and a sustainable and balanced development (ESPON, 2007). The scenarios developed within this ET2050 ESPON project are summarized below. Other projects of ESPON and its associated socio-economic scenarios can be found at the ESPON website.

3.1.5 ESPON ET2050

The ESPON ET2050 project has the aim to support policy makers in formulating long-term integrated and coherent visions for the (smart, sustainable and inclusive) development of the European territory (ESPON, 2012). As a result of interactive participation, database management, forecast and foresight modeling one baseline scenario and three European Territorial scenarios are developed. Almost 100 prospective studies defining scenarios for 2030 and 2050 (including approximately 300 different scenarios) are reviewed at European and World level in order to support the development of the exploratory scenarios (ESPON, 2012). Thematic areas that are touched in the scenarios are demography, economy, technology, energy, transport, land-use, environment and governance, and their independency with territorial dynamics (ESPON, 2012). Currently an interim report is available that describes the research executed and the four scenarios developed and its variables. Final results and scenario descriptions are expected to become available in 2014 (February – June) (ESPON, 2012). The four scenarios developed within the ESPON ET2050 project can be described as followed:

1. **Europe of Flows**: Strong connections between cities and transport nodes. Political focus on enhancing connections and long distance networks and global integration. Economic and population growth and public investments are stimulated to take place within Europe's main corridors.
2. **Europe of cities**: Economic and population growth and public investments mainly stimulated to take place within existing cities structuring the European territory. Cities act as driving forces at a global, regional and local level. Economically strong and compact cities. Political focus on intensified use of urban space, preservation of open

3. space, reduction of long-distance traffic.
4. **Europe of regions**: Specific regional identities and strengths determine economic and population growth as well as public investments. Mosaic of different regions and types of territories with strong identities. Political focus lies on regional self-reliance, small-scale development and landscape protection.
5. **Baseline scenario:** The ET2050 Baseline Scenario is a structural description of the EU territory in the 2030 and 2050 time horizons and sticks to the principles of smart, sustainable and Inclusive growth and is built on the baseline scenarios developed in EU policy documents and recent studies. 23 key direction can be distinguished within this Baseline scenario: Aging population; Relative Economic Decline; Growing inequities; Risk Adverse Society; Insufficient technological innovation; More diversified energy sources; Subverted proximities; Differentiated territorial patterns; Increasing Urbanisation; Land scarcity; Climate changes; Corporative government; Multiple-speed and multi-level European governance; EU facing its permanent dilemmas; Towards a multiple –speed Europe; A frozen EU budget; Low ambition in making value of the territorial framework of the Cohesion policy; Agricultural policies more focused on rural development and natural preservation; Transport policies aim to better regulate markets and promote new technologies; More integrated Environmental Policies; Energy policies begin; European Research programs will grow; Migration policies maintained.

3.2 European land use outlook studies and their use of scenarios

Land use outlook studies provide land use and land cover (change) scenarios (figure 3.1). Input for the modeling procedure of land use outlook studies is formed by scenario specific conditions and assumptions collected within scenarios and storylines. These scenarios are translated into spatial explicit land use (patterns and changes) with the help of a cascade of models, ranging from economic models to integrated assessment models and spatially explicit land use change allocation models (Verburg et al., 2006; Schaldach & Priess, 2008; Westhoek et al., 2006; Verburg et al., 2008). An example of a modeling procedure as used within the Eururalis project is showed below (Verburg et al., 2008).

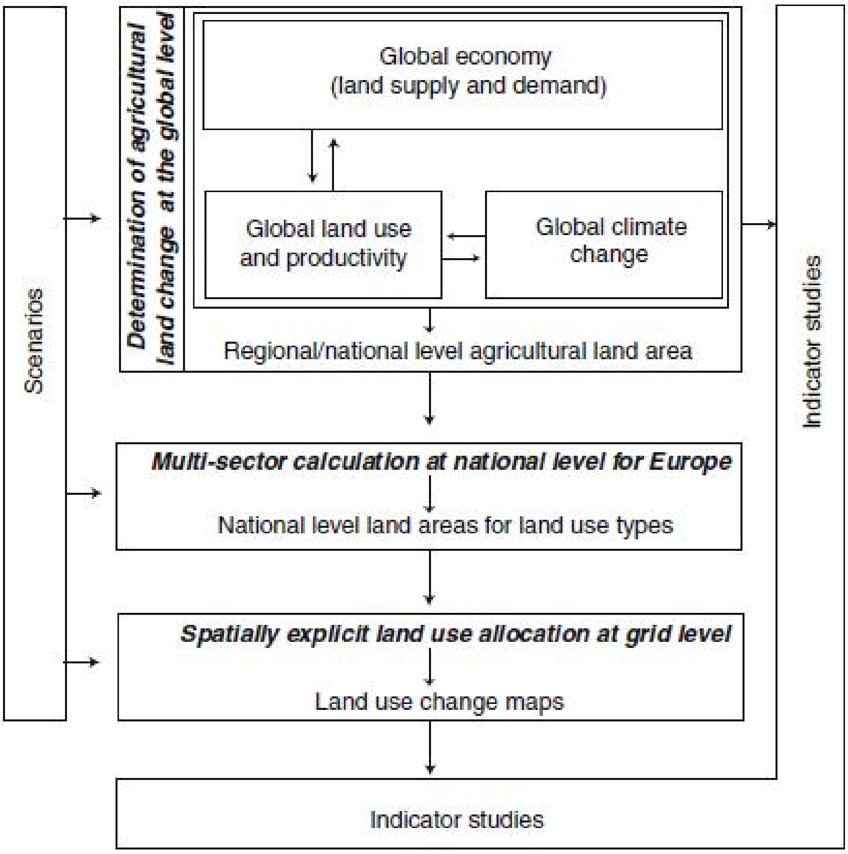


Figure 3.1: Land use change modeling procedure (Verburg et al., 2008, pp60)

Information of ten European land-use outlook studies was summarized by the RIKS (2010) in preparation for the State of the Environment Report 2010 (EEA, 2010). These land-use outlook studies can form a starting point for the land-use outlooks applied within the ENHANCE case studies. An overview of the most important parameters discussed by RIKS (2010) is given in table 3.1 and the remainder of this paragraph elaborates further on these models based on the information from RIKS (2010) and the European Environment Agency (2010).

Table 3.1 European outlook studies as summarized by RIKS (2010) for the SOER 2010

Outlook study	Temporal horizon	Spatial extent	Highest spatial detail	Models/methods used	Scenarios
SCENAR I	2020	EU-25	NUTS 2-3	LEITAP, IMAGE, ESIM, CAPRI, CLUE-s	Baseline; Regionalisation; Liberalisation.
SCENAR II	2020	EU-27	NUTS 2-3	LEITAP, IMAGE, ESIM, CAPRI, CLUE-s	Reference; conservative CAP; liberalization
LU Modelling – Implementation	2030	EU-27	1 km^2 grid	Dyna-CLUE, LEITAP, IMAGE	B1 reference scenario; B1+biofuel reference scenario; 8 additional policy scenarios
OECD-FAO Agricultural Outlook 2009-2018	2018	Global	Country - Country group	Aglink, Cosimo, Expert Judgement	Baseline, lower GDP/faster recovery, lower GDP/slower recovery (OECD macro-economic updates)
ETC-LUCI	2020	EU-27	NUTS 2, (H)SMU, HNV farmland	CAPRI, Aglink, ESIM, MITERRA-Europe, IDEAg	Baseline including EU biofuel directive, Counterfactual not including EU biofuel directive
EFMA Forecast	2019	EFMA-29	Member states	Expert judgement, EU models, IFA FAO databse	European Agriculture scenario combined with assumptions on fertilizer prices, international agricultural prices, energy crops and set aside land
Eururalis	2030	EU-27	1 km^2 grid	GTAP, IMAGE, CLUE-s	IPCC SRES A1, A2, B1, B2 scenarios combined with four policy instruments (CAP market support, CAP income support, Ambition to stimulate biofuels, Stimulate less favored areas)
SENSOR-SIAT	2025	EU-27+	NUTS-3	NEMISIS, SICK, B&B, TIM, EFISCEN, CAPRI, Dyna-CLUE	Reference scenario combined with 5 policy cases (Coming financial reform of EU budget, Bioenergy, Biodiversity policies, Forest Strategy, European transportation policy
SEAMLESS	2025	EU-25	Field, Farm, Region	SEAMCAP (CAPRI), FSSIM, EXPAMOD, APES	n.a.
LUMOCAP	2030	EU-27	1 km^2 grid	LUMOCAP	Baseline, Metropolitan Growth, Rural Development
DeSurvey IAM	2030	EU-27	1 km^2 grid	DeSurvey IAM	n.a.

3.2.1 SCENAR I and SCENAR II

Objective of the SCENAR I and SCENAR II land-use outlooks is to identify major future trends and driving factors on the future of European agriculture and rural regions. The outlooks compare how the agricultural sector might evolve under different, somewhat extreme, pathways. The scenarios used by SCENAR I and SCENAR II are respectively: Baseline, Regionalization, Liberalization and Reference, Conservative CAP, and Liberalization. Results are provided with an EU-25 (SCENAR I) and EU-27 (SCENAR II) spatial extent, a spatial resolution up to NUTS 2/3 and HARM-2 regions, and a time horizon up to 2020. Models and methods used in order to obtain the results are: LEITAP, IMAGE, ESIM, CAPRI, and CLUE-s. Results provided by the SCENAR I and SCENAR II land-use outlooks are:

- **Land use patterns**
- **Land use types**: cereals, oilseeds, other arable crops, vegetables and permanent crops, fodder activities, set aside and fallow land, all cattle activities, other animals
- **Land use classes Dynamic**: built-up area, non-irrigated arable land, grassland , (semi) natural vegetation, irrigated arable land, recently abandoned arable land, permanent crops, forest, recently abandoned grasslands
- **Land use classes Static**: inland wetlands, glaciers and snow, sparsely vegetated areas, beaches dunes and sands, salines, water and coastal flats, heather and moor lands.
- **Land-use intensities**
- **Economic indicators**: among others: sectoral structure of the economy in the EU-25, share of agriculture and food processing industries in the EU-15 and EU-10 in Gross Value Added, share of agriculture and food processing in the economy (%), nominal producer prices for agricultural and food products in the EU, growth of crop production – annual growth rates (%) for EU-15, EU-10 and the rest of the world, growth of livestock production – annual growth rates (%) for EU-15, EU-10 and the rest of the world, decomposition of production growth of protected agricultural products in EU-15, decomposition of production growth of less protected agricultural products in EU-15, production numbers.
- **Environmental indicators**: Import by anorganic fertilizer, import by manure, nutrient retention by crops, ammonia loss organic fertilizer, ammonia loss manure application, ammonia loss anorganic fertilizer, changes in nitrate surplus per NUTS-2 region, areas with over 10% land use change per NUTS-2 region, changes in arable,grassland, built-up area, and forest per NUTS-2 region, affection of agricultural abandonment.

3.2.2 Land use Modeling – Implementation

Objective of the Land Use modeling project is to show the potential of a European land-use modeling framework to support environmental policy making within the European Commission, using existing methodologies, modeling tools and databases. Results are provided with an EU-27 spatial extent on a 1km^2 grid and a time horizon up to 2030. Models and methods used in this land-use outlook are: Dyna-CLUE, LEITAP and IMAGE. This land-use outlook uses a B1 and a B1+biofuel reference scenario combined with eight additional policy scenarios. Results provided by the Land use Modeling land-use outlook are:

- **Land-use patterns**
- **Land use classes**: built-up area, non-irrigated arable land, pastures, (semi-) natural vegetation, inland wetlands, glacier and snow, irrigated arable land, permanent crops, forest, sparsely vegetated areas, beaches, dunes and sands, salines, water and coastal flats, heather and moorlands, recently abandoned pastures.
- **Social indicators**: total population, employment, employment per sector
- **Economic indicators**: value added per farmer, GDP, share of agriculture in GDP, real farm income, crop production
- **Environmental indicators:** carbon sequestrations, soil sealing, biodiversity index, land cover connectivity potential, soil erosion risk, increased river flood risk, urban sprawl related indicators.

3.2.3 OECD-FAO Agricultural Outlook

The OECD-FAO Agricultural Outlook produces forecasts of worldwide agricultural developments up to 2018. Focus of this outlook is on agricultural commodities and land use is derived here from supply and demand for agricultural products. The OECD-FAO study has a global scope. Space is not treated explicitly in this Outlook, results are given per group of countries. This outlook is partly based on expert judgment, models and methods applied are Aglink and Cosimo. Scenarios that function as input for the OECD-FAO agricultural outlook are derived from the OECD macro-economic updates. Three scenarios can be distinguished: Baseline scenario; Lower GDP/faster recovery scenario; Lower GDP/slower recovery scenario. Results provided by the OECD-FAO Agricultural Outlook are:

- **Land use intensities**: included as index of agricultural production by region
- **Land use types**: gross rain fed cropland, net rain fed cropland, net urban areas, net urban and protected areas, net urban protected and forested areas.
- **Economic indicators**: prices of agricultural commodities
- **Environmental indicators**: agricultural water use

3.2.4 ETC-LUSI

Objective of the ETC-LUSI land use outlook is to assess the environmental impact of net changes in market and related cropping area and livestock population as a result of implementation of the 10% biofuel mandate. Time horizon applied within ETC-LUSI is 2020 and the land use outlook has a spatial extent up to EU-27. Results of the ETC-LUSI land use outlook are calculated using CAPRI, AGLINK, ESIM, MITERRA-Europe and IDEAg. No land use patterns are included in this land use outlook but CAPRI results have been disaggregated to HSMU's in order to provide spatial detail in the study. Two CAPRI scenarios have been developed as input for the ETC-LUSI land use outlook: Baseline scenario including EU biofuel directive; Counterfactual scenario not including EU biofuel directive. Additionally, two water irrigation storylines (Irrigation patterns remain stable; Reduction of water abstraction for irrigation by 40%) are developed that are combined with the two CAPRI scenarios. Results provided by the ETC-LUSI land use outlook are:

- **Land use intensities and land use types**: livestock and 30 different types of crops per NUTS-2 in Europe
- **Economic indicators**
- **Environmental indicators:** land use changes (cropping areas), impact of increased biomass cropping in Europe on farmland birds and HNV farmland, change in (land based) GHG balance 2002-2020 from agriculture in total and per hectare kg CO2 equivalents, water quality (the nitrate concentration in leaching water expressed in mg NO3 per litre), water quantity (total and relative irrigation water requirement), risk for soil degradation in terms of increased erosion, and soil compaction.

3.2.5 EFMA Forecast

The EFMA forecast on food farming and fertilizer use in the European Union aims to forecast the use of fertilizers in the European Union. The study uses a European agriculture scenario combined with assumptions on fertilizer prices, international agricultural prices, energy crops and set aside land. The EFMA-forecast derives forecasts up to 2019 with a spatial extent of the EFMA-29 (EU-27 + Switzerland and Norway). Highest spatial resolution of the outlook results is at a scale of the individual member states of the European Union. The EFMA forecast is based on expert judgment, next to that a number of (unspecified) EU models are applied in the forecast. Results provided by the EFMA forecast are:

- **Land use intensities**: Arable land, Permanent crops, Idled land
- **Economic indicators**: Yield (kg/ha), production (Kt), fertilizer application (kg/ha) and fertilizer consumption (Kt).

3.2.6 Eururalis

The Eururalis land use outlook aims to provide a tool for a structured strategic discussion at a European scale between policy makers, stakeholders and scientists from different domains and/or countries. Next to that it has the objective to develop future scenarios for the European rural landscape. Eururalis develops scenarios for the EU-27 region, with a spatial resolution ranging from country level up to local level (1 km^2 grid). A time horizon up to 2030 is applied with 10-year time steps. The Eururalis project uses a model cascade in order to generate results. Within this model cascade the GTAP, the IMAGE and the CLUE-s models are included. Scenarios applied within the Eururalis project are based on the IPCC SRES A1, A2, B1, B2 scenarios combined with four policy instruments (CAP market support, CAP income support, Ambition to stimulate biofuels, Stimulate less favored areas). Eururalis provides results on:

- **Land use patterns and livestock density**: calculated at local level
- **Land use types**: built-up area, arable land, pasture, natural vegetation, inland wetlands, irrigated arable lands, permanent crops, forest, glacier snow sand and sparsely vegetated areas, recently abandoned farmland
- **Social indicators**: agricultural employment, value added per farmer, self sufficiency
- **Economic indicators**: Gross Domestic Production, agri share in GDP, real farm income, farmers welfare, crop production, animal production
- **Land use indicators**: land-use maps, urbanization hotspot amps, agricultural abandonment hotspot map are provided at a local level. At regional level % agricultural land, % non irrigated arable land, % permanent pasture land, % biofuels crops, % natural and semi natural land, % built up land is provided.

3.2.7 SENSOR-SIAT

The SENSOR-SIAT outlook assesses regional effects of land-use relevant EU-policy strategies and evaluates the impacts against sustainability indicators. Focus of the study is on multifunctional land use. The outlook provides results with a spatial extent of EU-27+ and a spatial resolution ranging from EU level up to NUTS-X regions, a combination of NUTS-2 and NUTS-3. Time horizon applied within SENSOR-SIAT is up to 2025. The model chain used to produce the information consists of the macro-econometric model NEMISIS (complemented with SICK, B&B, and TIM), the forestry model EFISCEN, the agricultural model CAPRI, and the land use allocation model DYNA-CLUE. Scenarios being used within SENSOR-SIAT are based on a reference scenario and 5 policy cases (Coming financial reform of EU budget, Bioenergy, Biodiversity policies, Forest Strategy, European transportation policy) for generating the alternative scenarios. Results provided by the SENSOR-SIAT are:

- **Land use**: built-up area, rotational non-irrigated arable land, grassland, permanent crops, irrigated arable land, (semi-) natural areas, forests, inland wetlands, abandoned arable land, abandoned grassland, sparsely vegetated areas, beaches, dunes and sands, salines, water and coastal flat, an heather and moorlands.

- **Land use intensity**
- **Social indicators**: visual attractivity, heritage, unemployment rate, employment by sector, deviation of income, deviation of unemployment rate, air/water pollution, exposure to fire risk, self-sufficiency index food, migration pressure, tourism pressure, recreational pressure.
- **Economic indicators**: net flow, labour costs, energy costs, labour productivity, inflation rate, value added, public expenditure, gross domestic product
- **Environmental indicators:** NH3 emission, NOx emission, N and P surplus, water abstraction rate, soil water erosion, soil sealing, carbon sequentration, methane and nitrous oxide emission, CO2 emission, biomass potential, % of terrestrial habitats at risk from eutrofication, trends in farmland birds, deadwood, high nature value farmland, spatial cohesion, pesticide use, land use cover, generation of municipal water by tourists, forestfire risk

3.2.8 SEAMLESS

The SEAMLESS outlook has a focus on the sustainability of agricultural systems and on the contribution of agricultural to sustainable development at large. This study only included agricultural land use types. Spatial scope of this study is EU-25 with a spatial resolution ranging from field and farm up to region, EU-25 and globe. Time horizon applied within these land use projections is 2013, 2020 and 2025. Models used within the SEAMLESS outlook study are SEAMCAP (CAPRI), FSSIM, EXPAMOD and APES. It is not clear if SEAMLESS has developed any scenarios for its land use outlook and to test the framework. Results provided by the SEAMLESS study are:

- **Land use intensity**
- **Land use types**: maize, sunflower, soybean, durum wheat, soft wheat, fall, oats, barley, canola, pear, tobacco, apple orchards, vineyards and grasslands.
- **Economic indicators**: farm income, premiums
- **Environmental indicators**: nitrate leaching, soil organic matter (%)

3.2.9 LUMOCAP

The LUMOCAP outlook aims to develop a tool for the support of impact assessments of (European) policies on the rural landscape. Main focus of LUMOCAP is on the agriculture within the broader context of future land use development. Geographic coverage of the LUMOCAP study is at a EU-27 scale, the highest spatial resolution applied is a 1km^2 grid for EU-27 and a 200 m^2 grid for a set of selected case study regions. Time horizon applied within the LUMOCAP project is 2030 with yearly time steps. LUMOCAP uses a modeling chain consisting of: an agricultural economic model, national and regional interaction and distribution models, a process model for local suitability, a land use model (Metronamica) and a crop choice model. A number of scenarios are being applied as part of different projects. The LUMOCAP project itself developed a base line scenario next to two CAP scenarios (No CAP after 2013, CAP shift Pillar 1 to Pillar 2) and alternative scenarios for external drivers (market prices, climate change). For DG Environment 2 scenarios are developed (Metropolitan growth, Rural development) based on the baseline scenario and on the ESPON socio-economic projections. Results provided by LUMOCAP are:

- **Land use patterns**
- **Land use intensity**
- **Dynamic land use types**: residential areas, industry & commerce, tourism & recreation, forest, cereals, oilseeds, rice, potatoes, sugar beets, tobacco raw, vegetables, fodder from arable land, other arable land, permanent grassland, wine grape vineyards, olives, total of other fruit crops, other permanent crops and kitchen gardens, set-aside land
- **Static land use types**: open spaces with little or no vegetation, infrastructure, port areas, airports, mineral extraction sites, dump sites, inland wetlands, marine wetlands, inland water bodies, marine water bodies, beaches dunes and sands, land outside modeling area, water outside modeling area.
- **Social indicators**: population, immigration, emigration, and population density.
- **Economic indicators**: number of jobs in agriculture, industry & commerce, tourism & recreation and total; job density; total production and average yield per crop type.
- **Environmental indicators**: afforested land; agricultural land, grassland or forest in Less Favoured Areas; agricultural land, grassland or forest in mountainous areas, arable land on areas with high erosion risk, crop diversity, degree of openness, increase of urban areas in locations with high erosion risk, increase of urban areas in suitable agricultural locations, increase of urban areas on high organic matter soils, land use in High Nature Value (HNV) farmland.

3.2.10 DeSurvey IAM

DeSurvey IAM focusses on the desertification processes in the broader context of rural development, including water resource management, sustainable agriculture and land degradation. DeSurvey IAM develops a tool to support the integrated assessment of the impact of external factors and policy options on different indicators related to rural development and desertification. Geographical coverage of the DeSurvey IAM is EU-27 with a spatial resolution ranging from country and region up to local (100 m^2 – 1km^2 grid). Time horizon applied is 2030, operating at (sub)daily, monthly and yearly resolution. Modeling components included in the DeSurvey IAM are an economic model, national and regional interaction and distribution, a demographic model, a local suitability model, a land use model

(Metronamica), an activity based version of the land use model, two crop choice models, a natural vegetation type model, climate components and models for hydrology, water resources, irrigation, vegetation growth, erosion and salinization. Scenarios used within the DeSurvey depend on the application and are not specifically defined. Results provided by the DeSurvey IAM are:

- **Land use patterns**
- **Land use types**: mix of urban, agricultural and natural classes
- **Land use intensity**
- **Social indicators**: population, immigration, emigration, population density, distance from residential location to recreation, nature and jobs.
- **Economic indicators**: GDP, number of jobs in agriculture, industry & commerce, tourism & recreation and total, job density, profit, total production and average yield per crop type
- **Environmental indicators**: environmentally sensitive areas, erosion, soil depth, land use change, vegetation type, vegetation cover, water scarcity, loss of productivity, soil moisture /soil water contents, salinisation.

3.3 Socio-economic data and databases

Different datasets, related to statistical socio-economic data or to land use data, are available for use within the different ENHANCE case studies. This section deals with the availability of socio-economic statistical data on a European scale within a number of datasets first. Secondly, it gives information on the two land use data sets most often applied, the Corine Land Cover and LUCAS. Finally, the last paragraph provides a table with useful data themes for the specific case studies.

Five databases are summarized below that provide information with respect to statistical data and socio-economic indicators. A number of general themes can be distinguished within these databases: Demographic and social indicators; Economics, technology and transport; Agriculture and Forestry; Environment, Environmental Resources and Energy; Land Use. A total overview of the themes available within the different databases can be found in Appendix II.

3.3.1 Eurostat

EuroStat collects and displays European statistical data at a number of scales and formats. Suitable for the different case studies within the ENHANCE project are mainly EuroStats' regional statistical data by NUTS classification, but also other sub-national statistical can be useful. The NUTS levels (Nomenclature of Territorial Units for Statistics), a three-level hierarchical classification, are developed by Eurostat in order to provide a single uniform breakdown of territorial units for the production of regional statistics for the European Union.

NUTS 1 stand for the major socio-economic regions, NUTS 2 for the basic regions for the application of regional policies and NUTS 3 for the small regions used for specific diagnoses. The current NUTS nomenclature (start January 2012) subdivides the economic territory of the European Union into 97 NUTS 1 regions, 270 NUTS 2 regions and 1294 NUTS 3 regions. At a higher scale the NUTS 0 relates to the 27 member states of the European Union. The NUTS levels are only defined for the European Union Member States. For the countries that make up the European Economic Area (EAA), for Switzerland and for the candidate countries, the regions also have been coded in a way that resembles NUTS. The ten case studies that are part of the ENHANCE project can be divided according to the NUTS nomenclature. For all case studies besides the Jucar Basin (Spain) case study there is a complete coverage at NUTS 3 level (Appendix III).

The EuroStat Data navigation Tree shows all available statistical data collected in databases and tables by theme and EU policy. Within the regional statistics by NUTS classification 15 themes can be distinguished which vary from regional agricultural statistics to regional poverty and social exclusion statistics. As the different case studies within the ENHANCE project differ in their preferences for data we discuss the availability of data for all these themes. Other (sub-national) statistics that can be distinguished are the sub-national statistical data with the metropolitan or the maritime regions as a spatial discriminator, statistics within an urban-rural typology, and water statistics by the River Basin Districts. Finally, statistical data is available with respect to the degree of urbanization and the European land covers, land uses and landscapes (LUCAS data).

Table 3.2: Data availability EuroStat

	Level of detail	Spatial Coverage	Time coverage
Demographics and social indicators	NUTS 2/ NUTS 3	Europe	1990/2000 - 2012
Economics, technology and transport	NUTS 1 - NUTS 3	Europe	1990/2000 – 2012
Agriculture and Forestry	NUTS 2/ NUTS 3	Europe	1970/2000 – 2005/2012
Environment, Environmental Resources and energy	NUTS 2	Europe	2000 – 2010
Land Use	NUTS 2	Europe	2009

EuroStat website: http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home/

3.3.2 FAO-STAT

FAO statistics collates and disseminates statistics globally since 1961. FAO enables access to time-series records from over 245 countries and territories. Databases that are part of the

FAO-STAT family are AQUASTAT, CountrySTAT, FishSTAT, Food Security Statistics, Prices, Production, Resources and Trade (link). Most of the data disseminated from FAO is country-based information which can be shown at a country or a multi-country scale. The GAUL (Global Administrative Unit Layers) project is a FAO initiative with the aim to provide reliable and standardized geographic information on national and sub-national administrative units for all countries in the world. However, FAO data cannot be downloaded from the FAOSTAT website at these GAUL scales yet. Time coverage for the core database (covering the primary commodities) is since 1990 for over 200 countries. Satellite modules (e.g. ProdSTAT, TradeSTAT, PriceSTAT) feed this core with more detailed time-series starting from 1961.

Table3.3: Data availability FAO-STAT

	Level of detail	Spatial Coverage	Time coverage
Demographics and social indicators	Country/GAUL	200 countries	1990 – 2010
Economics, technology and transport	Country/GAUL	200 countries	1990 -2010
Agriculture and Forestry	Country/GAUL	200 countries	1990 – 2010
Environment, Environmental Resources and Energy	Country/GAUL	200 countries	1990 – 2010
Land Use	Country/GAUL	200 countries	1990 – 2010

FAO-stat website: http://faostat3.fao.org/home/index.html#HOME

3.3.3 OECD regional statistics

The OECD database provides for all OECD countries statistical information at a national level with respect to 22 themes, ranging from General statistics to agriculture and fisheries to economic national accounts. Regional statistics are summarized in the OECD Regional database (theme: Regions and cities). Currently around 40 indicators of demography, economic accounts, labour market, social and innovation themes are summarized in this Regional statistics database. Two territorial levels (TL) can be distinguished within the OECD member countries. The higher level (Territorial level 2) consists of macro-regions, while the lower level (Territorial level 3) is composed of micro-regions in the 30 OECD member countries. This Territorial Level classification is for Europe largely compatible with the Eurostat classification levels.

Table 3.4:Data availability OECD statistics

	Level of detail	Spatial Coverage	Time coverage
Demographics and social indicators	TL2/TL3	OECD	Annual (1990 -2011)
Economics, technology and transport	TL2/TL3	OECD	Annual (1990 -2011)
Agriculture and Forestry	TL2/TL3	OECD	Annual (1990 -2011)
Environment, Environmental Resources and Energy	TL2/TL3	OECD	Annual (1990 -2011)
Land Use	-	-	-

OECD website: http://stats.oecd.org/

3.3.4 ESPON 2013 database

The ESPON 2013 database is part of the ESPON 2013 project. Goal of the ESPON 2013 database is to contribute to better understanding of territorial structures, the current situation and past and future trends of different types of European territories in relation to the various geographical contexts (from local to global) and within a large variety of themes. The data included in the ESPON Database mainly comes from European institutions such as EUROSTAT and EEA, and from all ESPON project. The time frame for which the ESPON database aggregates data is between 1990 and 2100. Regarding the spatial resolution of the data available, the ESPON 2013 database uses the EUROSTAT NUTS classification.

Table 3.5: Data availability ESPON 2013

	Level of detail	Spatial Coverage	Time coverage
Demographics and social indicators	NUTS 2/3	Europe	1990-2010
Economics, technology and transport	NUTS 2/3	Europe	1999-2010
Agriculture and Forestry	NUTS 2/3	Europe	1990, 2000, 2006, 2009
Environment, Environmental Resources and Energy	NUTS 2/3	Europe	1990, 2000, 2006, 2009
Land Use	NUTS 2/3	Europe	2000

ESPON 2013 database website: http://database.espon.eu/db2/home World dataBank

The World dataBank consists of annual global data with a national resolution over the time period 1960 – 2011, collected by the World Bank. Databases that are part of the World dataBank are, among others, the World Development Indicators, The Education Statistics, the Poverty and Inequality Database, the Global Economic Monitor and the Worldwide Governance Indicators. Most data from the World databank comes from the statistical systems of member countries; therefore the quality of the global datasets depends on how well the national systems perform. A number of themes can be distinguished within the World dataBank dataset: Agriculture & Rural development, Aid effectiveness, Climate change, Economic policy & External Debt, Education, Energy & Mining, Environment, Financial sector, Gender, Health, Infrastructure, Labor & Social protection, Poverty, Private sector, Public sector, Science & Technology, Social development and Urban development.

Table 3.6. Data availability World dataBank

	Level of detail	Spatial Coverage	Time coverage
Demographics and social indicators	Country	Global	1960 - 2011
Economics, technology and transport	Country	Global	1960 - 2011
Agriculture and Forestry	Country	Global	1960 - 2011
Environment, Environmental Resources and Energy	Country	Global	1960 - 2011
Land Use	Country	Global	1960 - 2011

World dataBank website: http://data.worldbank.org/

3.4 Land Use data

Studying changes in land-use or land cover is often done by land use modeling with making use of data on land-use and cover (Verburg et al., 2010). Matthews et al. (2007) and Schaldach & Priess (2008) provide an overview of the different modeling techniques in LUCC. With respect to land use and land cover data at the European scale the two data sets most often applied are the Corine Land Cover (CLC) and the Land-use/cover Area frame statistical Survey (LUCAS).

Table 3.7 Land use data Europe

Data set	*Spatial Scale*	*Coverage*	*Years*	*Data collected*
CORINE	1:100000	EU-27	1990, 2000, 2006	Maps with 44 land cover types and land flow data.
LUCAS	NUTS 2 and 3	EU-25[1]	2001, 2003, 2006, 2009	Land use (spec. for crops), land cover, photographs and soil samples

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[1] Excluding Cyprus and Malta

3.4.1 Corine Land Cover

The Corine Land Cover databases are the result of the Corine Programme (Coordination of Information on the Environment) implemented by the European Union from 1985 to 1990. The CLC 2006 is a direct continuation of the previous Corine Land Cover mapping campaigns (CLC1990, CLC2000) and was coordinated by the European Environment Agengy. The CLC data are based on satellite imagery and are therefore a source for land cover information for most European countries. The CLC 2006 data set is an updated version of the CLC2000, integrating changes in land cover larger than 5 hectare between the years 2000 and 2006. The Corine Land Cover database consists of a 3-level classification and makes a distinction between 44 land cover types (table 8).

A refined version of the Corine Land Cover 2006 map with an improved minimum mapping unit of 1 hectare for all types of artificial surfaces and inland waters has been generated by incorporating land use/cover information present in finer thematic maps available for Europe. These include the CLC change map, Soil Sealing Layer, TeleAtlas® Spatial Database, Urban Atlas, and SRTM Water Bodies Data. Relevant data from these datasets were extracted and prepared to be combined with CLC in a stepwise approach. Each step increased the level of modifications to the original CLC. The spatial resolution of the map is 100x100m.

Table 3.8: Corine Land Cover 2006 Nomenclature

Level 1	Level 2	Level 3
1. Artificial surfaces	1.1 Urban Fabric	1.1.1 Continuous urban fabric 1.1.2 Discontinuous urban fabric
	1.2 Industrial, commercial and transport units	1.2.1 Industrial or commercial units 1.2.2 Road and rail networks and associated land 1.2.3 Port areas 1.2.4 Airports
	1.3 Mine, dump and construction sites	1.3.1 Mineral extraction sites 1.3.2 Dump sites 1.3.3 Construction sites
	1.4 Artificial non-agricultural vegetated areas	1.4.1 Green urban areas 1.4.2 Sport and leisure facilities
2. Agricultural areas	2.1 Arable land	2.1.1 Non-irrigated arable land 2.1.2 Permanently irrigated land 2.1.3 Rice fields

	2.2 Permanent crops	2.2.1 Vineyards 2.2.2 Fruit trees and berry plantations 2.2.3 Olive groves
	2.3 Pastures	2.3.1 Pastures
	2.4 Heterogeneous agricultural areas	2.4.1 Annual crops associated with permanent crops 2.4.2 Complex cultivation 2.4.3 Land principally occupied by agriculture, with significant areas of natural vegetation 2.4.4. Agro-forestry areas
3. Forests and semi-natural areas	3.1 Forests	3.1.1 Broad-leaved forest 3.1.2 Coniferous forest 3.1.3 Mixed forest
	3.2 Shrub and/or herbaceous vegetation association	3.2.1 Natural grassland 3.2.2 Moors and heathland 3.2.3 Sclerophyllous vegetation 3.2.4 Transitional woodland shrub
	3.3. Open spaces with little or no vegetation	3.3.1 Beaches, dunes, and sand plains 3.3.2 Bare rock 3.3.3 Sparsely vegetated areas 3.3.4 Burnt areas 3.3.5 Glaciers and perpetual snow
4. Wetlands	4.1 Inland wetlands	4.1.1 Inland marshes 4.1.2 Peatbogs
	4.2 Coastal wetlands	4.2.1 Salt marshes 4.2.2 Salines 4.2.3 Intertidal flats
5. Water bodies	5.1 Inland waters	5.1.1 Water courses 5.1.2 Water bodies
	5.2 Marine waters	5.2.1 Coastal lagoons 5.2.2 Estuaries 5.2.3 Sea and ocean

Corine Land Cover 2006 website: http://sia.eionet.europa.eu/CLC2006

3.4.2 LUCAS

The Land use/cover area frame survey (LUCAS) was initially developed to deliver, on a yearly basis, European crop estimates for the European Commission. The European field survey program LUCAS is currently funded and executed by Eurostat. The LUCAS dataset is based on ground observations at sample points, which are placed in a regular grid. The sampling grid has been restructured between LUCAS 2003 and LUCAS 2009. In general, the point observations are a square of 3 x 3 m, with a 25 x 25 m observation area and a 250 meter eastward transect. Eurostat is currently carrying out the LUCAS 2012 survey which covers all 27 EU countries. Expected release of this data is in the second quarter of 2013. Data collected within the LUCAS dataset consist of land cover data, land use data, photographs and soil samples. Land cover is divided in the LUCAS 2009 dataset between 8 main categories and 76 sub-categories (table 9). Land use consists in LUCAS 2009 of 15 main categories and 34 classes (table 10).

Table 3.9: LUCAS land cover nomenclature

Main category	Classes
A. Artificial land	A10 Built-up areas (3) A20 Artificial non-built up areas (2)
B. Cropland	B10 Cereals (9) B20 Root crops (3) B30 Non-permanent industrial crops (7) B40 Dry pulses, vegetables and flowers (5) B50 Fodder crops (5) B70 Permanent crops: Fruit trees (7) B80 Other permanent crops (4)
C. Woodland	C00 Woodland (3) CXI-CXE Forest types (14)
D. Shrubland	D00 Shrubland (2)
E. Grassland	E00 Grassland (3)
F. Bareland	F00 Bare land (1)
G. Water	G00 Water areas (4)
H. Wetlands	H10 Inland wetlands (2) H20 Coastal wetlands (3)

Table 3.10: LUCAS land use nomenclature. LUCAS Eurostat website: http://epp.eurostat.ec.europa.eu/portal/page/portal/lucas/introduction

Main category	Classes
U110 Agriculture	U111 Agriculture U112 Fallow and abandoned land U113 Kitchen garden
U120 Forestry	U120 Forestry
U130 Fishing	U130 Fishing
U140 Mining and Quarrying	U140 Mining and Quarrying
U150 Hunting	U150 Hunting
U210 Energy production	U210 Energy production
U220 Industry and manufacturing	U221 Manufacturing of food, beverages and tobacco products U222 Manufacturing of textile products U223 Coal, Oil and metal processing U224 Production of non-metal mineral goods U225 Chemical and allied industries and manufacturing U226 Machinery and equipment U227 Wood based products
U310 Transport, communication networks, storage, protective works	U311 Railways U312 Roads U313 Water transport U314 Air transport U315 Transport via pipelines U316 Telecommunication U317 Storage U318 Protection works
U320 Water and waste treatment	U321 Water supply and treatment U322 Waste treatment
U330 Construction	U330 Construction
U340 Commerce, finance, business	U340 Commerce, finance, business
U350 Community services	U350 Community services

U360 Recreation, Leisure, Sport	U360 Amenities, museums, leisure U362 Sport U363 Holiday camps U364 Nature reserves
U370 Residential	U370 Residential
U400 Unused	U400 Unused

3.5 Land use projections

The Land Use Modelling Platform (LUMP) of the JRC combines various sector-specific models (such as macro-economic, hydrology, agriculture, forestry, energy, demography, transport) together with its core land use model component. This modelling platform provides projected land use maps at a detailed geographical scale (100x100m, regional or country level), translating policy scenarios into land-use related impacts (e.g. shifts in agricultural production, changes in water use and demand, afforestation/deforestation, pressure on natural areas, urbanization, etc.). LUMP takes full and detailed account of competing land use demands between different sectors (e.g. for households, industry and agriculture) and of spatial policy restrictions (e.g. Nationally Designated Areas), as well as planned transport infrastructures.

Recently a benchmark scenario has been generated with LUMP to reflect the impacts of current legislation on land use patterns across Europe until 2050. This reference scenario will form the basis for assessing the impacts and comparison of alternative policy decisions configured within LUMP (more information can be found in Lavalle et al., 2013). A run with LUMP has also been done in line with socio-economic developments under the SRES A1B scenario, but this run is undocumented (Lavalle, personal communication).

List of variables available from the JRC

Variable	Definition
refcorlu	Refined Corine Landuse
luproj	Projections of Landuse

refcorlu

→ Spatial resolution: 100x100 m

→ Spatial coverage: EU28 + EFTA countries + Balkan + Turkey

→ Temporal resolution: 2006

→ Thematic resolution: 45 land use classes

→ Data format: Raster/TIFF

luproj

- → Spatial resolution: 100x100 m
- → Spatial coverage: EU28
- → Temporal resolution: yearly time steps from 2007-2050
- → Thematic resolution: 10 land use classes
- → Scenario: Reference scenario climate/energy package and SRES A1B
- → Data format: Raster/TIFF

3.6 3.6 Population data and projections

3.6.1 Current Population

A high-resolution (100x100m) population grid map for Europe has been derived for the year 2006 based on a refined version of Corine Land Cover 2006 (with a minimum mapping unit of one hectare for artificial surfaces, Batista e Silva et al., 2012), combined with information on the soil sealing degree. Three dasymetric approaches were applied to create population grid maps for Europe (e.g. Figure 3.2). Each approach differed in the geographical ancillary datasets used to inform the disaggregation. In addition, due to the use of diverse ancillary datasets, different ways of attributing density weights to the target zones were necessary. The final product of this exercise is a comprehensive and highly detailed depiction and quantification of the spatial distribution of resident population in Europe. More detailed information on the methodology can be found in Batista e Silva et al. (2013).

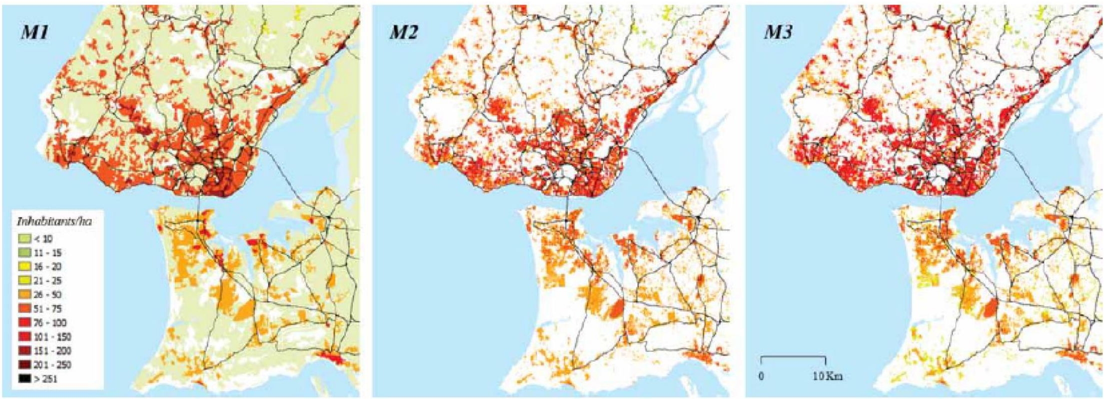


Figure 3.2. Population distribution in Greater Lisbon, Portugal. Results for each dasymetric approach. Pixel size is 100m×100m.

List of variables available from the JRC

Variable	**Definition**
popden	Population Density (inhabitants/ha)
popproj	Projections of Population Density (nr. of inhabitants per country/region)

popden

→ Spatial resolution: 100x100 m

→ Spatial coverage: EU27 + EFTA countries

→ Temporal resolution: 2006

→ Data format: Raster/TIFF

popproj

→ Spatial resolution: country level disaggregated to NUTS2 level

→ Spatial coverage: EU27 + EFTA countries

→ Temporal resolution: 5-year time steps for period 2010-2060

→ Thematic resolution: 5 year age groups (0-85, +85) / Both sexes

→ Scenario: EUROPOP2010

→ Data format: Table/Excel

3.6.2 Eurostat population projections

Eurostat produces population projections approximately every two to three years. The latest version of population projections is denominated 'EUROPOP 2010', updated in April 2011 and available on http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/en/proj_10c_esms.htm. The projections are originally provided at national level, covering both EU27 and EFTA countries for the period 2010-2060, by 5-year intervals, with estimates referring to 1st January of each available year. The breakdown of the EUROPOP 2010 per NUTS2 was obtained through a simple disaggregation procedure using regional population shares. These were, in turn, obtained from the previous version of the Eurostat's population projections, the 'EUROPOP 2008'. Similarly to EUROPOP 2010, its precedent version assumed a converge hypothesis between countries in the future, and estimates were produced for EU27 plus EFTA countries, but with yearly time-steps from 2008 to 2030. Moreover, it was provided with NUTS2 spatial breakdown. This level of spatial detail allowed us to derive regional population shares up to 2030. In order to disaggregate the whole EUROPOP 2010 dataset, the regional shares derived for 2030 from EUROPOP 2008 were kept constant up to 2060.

The data is provided as an MS Excel file, with population estimates per NUTS2 regions of EU27 and EFTA countries (rows). Only total population is provided (no age groups and no gender breakdown), for the interval 2010-2060, in 5-year time-steps (columns).

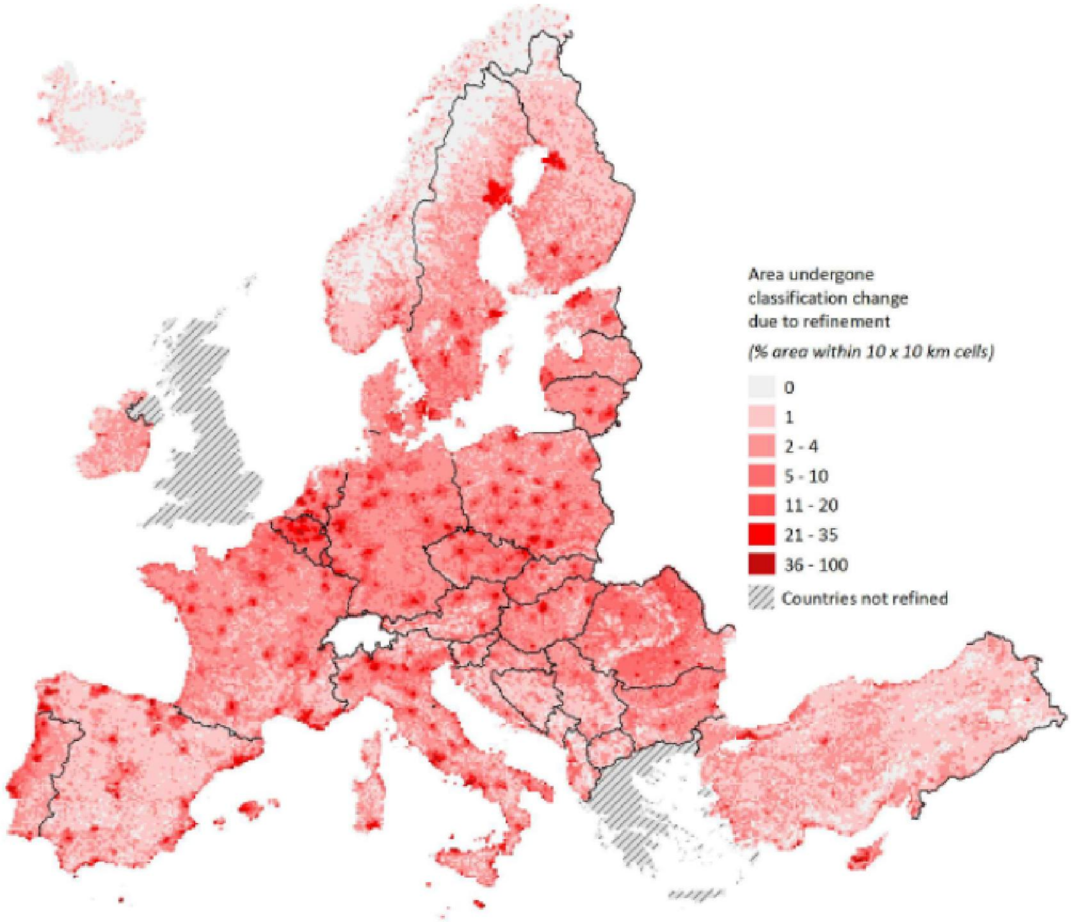


Figure 3.3. Percentage of area within 10km cells that has undergone a change in classification due to refinement of the CLC 2006.

4 Processing Socio – economic scenarios: Loss normalisation

The data sources and scenarios described in this report can be used for the assessment of past and future disaster risk. Loss normalisation methodologies must be used to compare economic exposure and risk across these periods, in order to have an 'apple-versus-apple' comparison of losses over time (Crompton, 2011).

The general approach taken in normalisation studies is to correct the original losses for inflation and changes in exposure that are related to population and wealth growth (Bouwer, 2011). When comparing regions or countries on the basis of population and GDP data, normalisation can be achieved using the following formula (Pielke and Landsea, 1998):

$$\mathbf{NL_{base} = L_{y\text{-}1} * I_y * W_y * P_{y,c}}$$

Whereby:

NL_{base} = normalized losses to base-year value (e.g. 2013)

y = year of loss event of analysis

c = country or region of impact

L_y = event loss in year y, in current currency units (i.e., not adjusted for inflation).

I_y = inflation factor, determined by the ratio of the implicit price deflator of the base year for GDP to the price deflator of year y.

W_y = wealth factor, determined by the ratio of the inflation adjusted base year GDP per capita to that of year y.

$P_{y,\,c}$ = population factor, determined by the ratio of the change in the population of the region of analysis from year y to the base year.

This method can be further specified on the basis of the data that is available for normalisation. Crompton (2011) presents a method applied for the normalisation of Australian disaster insurance data, which is an updated version of the approach of Crompton and McAneney (2008) and uses more specific exposure information than population and GDP. It converts losses recorded in season i (Li) to base year values according to the following equation (adjusted by the authors for general applicability):

$$L_{baseyear} = L_i \times N_{i,j} \times (D_{i,k} \times \frac{S_{i,total}}{S_{i,new}})$$

where j is the area impacted by the event; $N_{i,\ j}$ is the ratio of the number of dwellings in the base year in area j tot the number in year i; k is the administrative unit that contains the impacted area; $D_{i,\ k}$ is the ratio of the administrative unit's average nominal value of new dwellings in the base year to that of year i; $S_{i,total}$ / $S_{i,\ new}$ is the ratio of the factor increase in the average floor area of total residential dwellings to the factor increase in the average floor area of new residential dwellings between season i and 2011.

The loss dataset resulting from these normalisation approaches can then be compared consistently for the purpose of trend analysis or for the detection of driving forces (e.g. climate change versus socioeconomic growth) (Bouwer, 2011).

5 Assessing and managing dependencies of extremes from a risk based perspective

Workpackage 3.3: Development of low probability assessment of high impact events.

Overall goal:

- Assessing and managing dependencies of extremes from a risk based perspective
- Copula approach

What can/should the approach provide:

- Combining different kinds of hazards, e.g. flood and earthquake risk (for example in the form of distributions)
- Up-scaling risk information on different levels, e.g. one has loss distribution on the GRID level but want to have also a distribution on the regional (case study region) level.

What is needed (still has to be determined in more detail, dependent on approach adopted):

- Time series of losses or other interested useful parameters
- Loss estimates and some sort of connection between them on regional/time scales (see below)

5.1 Starting point

Assessing and managing rare extremes have to be done differently compared to frequent event risk. It is well known that using statistical standard estimation techniques which serve well where the data has its greatest density, may lead to severely biased results if used for estimating the behaviour of the tails (Coles, 2001). Additionally, one of the most important fundamental questions for extreme risk is how to model the rare phenomena outside the range of any available observation (Embrechts et al., 1997). As most data is concentrated toward the center of the distribution, extreme data is scarce and therefore estimation difficult (McNeil, Frey and Embrechts 2005). Extreme value theory deals with the modelling of extreme events, possibly never observed before. The classic statistical methods used here can be distinguished between block-maxima approaches and threshold exceedance (peak-over threshold) ones.

In the block-maxima approach, the observed data X_i are grouped into blocks of same length $X_1^{(j)},\dots,X_n^{(j)}$ and probability models are built for the sequence of block-maxima

$M_n^{(j)} = \max\{X_1^{(j)}, \ldots X_n^{(j)}\}$. Only the maxima in each block are used for further analysis. If the data X_i stem from an independent and identically distributed sequence of random variables, Fisher and Tippett (1928) have shown that the rescaled maxima $(M_n - d_n)/c_n$ (where $d_n \in \Re$ and $c_n > 0$ are sequences of norming constants) converge for large *n* in distribution to (if non-degenerate) one of three types of families, i.e. the Gumbel, Frechet, or Weibull distribution. All three of them can be put together to a one-parameter representation (Jenkinson 1955, Mises 1954) called Generalized Extreme Value (GEV) distribution, defined as

$$H_\xi(x) = \begin{cases} \exp[-(1+\xi x)^{-1/\xi}] & \text{if} \quad \xi \neq 0 \\ \exp[-\exp(-x)] & \text{if} \quad \xi = 0 \end{cases}$$

where $1+\xi x > 0$. The parameter ξ is called the shape parameter, the related location-scale family $H_{\xi,\mu,\sigma}(x)$ can be introduced by replacing the argument *x* above by $(x - \mu)/\sigma$ and adjusting the support accordingly. Parameters are usually estimated via Maximum likelihood (ML) techniques or Bayesian methods (Coles 2001, Yoon et al. 2010). One of the most critical issues in the block-maxima approach is the determination of the block size. There is a trade-off between bias and variance: too small blocks mean that approximation by the limit model is likely to be poor, leading to bias in estimation and extrapolation; on the other hand, large blocks generate only few block maxima data, leading to large estimation variance.

While the block-maxima method requires a careful choice of the block sizes, the alternative peak-over-threshold (POT) method requires a careful choice of a threshold parameter. If a threshold *u* is chosen, the threshold excesses are $\max(X_i - u, 0)$ conditioned on $X_i > u$. It can be shown (Balkema and the Haan,1974; Pickands, 1975) that the corresponding approximate distribution of threshold excesses follows for large *u* a Generalized Pareto (GP) distribution, defined as

$$G_\xi(x) = \begin{cases} 1 - (1+\xi x)^{-1/\xi} & \text{if} \quad \xi \neq 0 \\ 1 - \exp(-x) & \text{if} \quad \xi = 0 \end{cases}$$

where $x \geq 0 \text{ if } \xi \geq 0 \text{ and } 0 \leq x \leq -1/\xi \text{ if } \xi < 0.$ Again, a related location-scale family $G_{\xi,\mu,\sigma}$ can be introduced and parameters estimated with the ML method. A reasonable threshold level *u* is usually selected based on the mean residual life plot (Embrechts et al. 1997; Kotz and Nadarajah, 2000; Reiss and Thomas, 2007). In practice, the POT method is generally considered to be the most useful one, as it uses more efficiently the extreme value data. However, also the block maxima method is still applied, e.g. for fiscal planning (Mechler et al., 2009).

5.2 Problem statement

For correctly applying statistical techniques for the management and assessment of extreme risk it is not only necessary to model the tail behavior of the loss distribution using extreme value theory, but also to correctly model the interdependence between losses. Traditional methods of risk assessment widely used in the insurance sector fail here. For example, natural hazards, such as floods or windstorms, often impact entire regions and thus will affect all policyholders in these regions at once. Hence, the risk in insurance portfolios, for example, is highly correlated and the law of large numbers, stating that the variance of an average decreases with the number of items, is not applicable. In contrast, in highly correlated portfolios the variance of the average may be close to the variance of an individual loss. Consequently, the probability of ruin is much higher and different diversification strategies have to be applied, e.g. re-insuring or using international financial markets (Hochrainer, 2006; Cardenas et al., 2007; Linnerooth-Bayer et al., 2011).

Hence, dependency among risks is an important matter in managing extremes and in the most general form can be dealt with the use of “copulas”. Copulas are functions that join or “couple” the one-dimensional margins to a multivariate distribution function. For a random vector X of dimension m and marginal distributions F_i, the copula $C(\cdot)$ gives the cumulative probability of not exceeding $x=(x_1,\ldots,x_m)$ as

$$P(X \le x) = C(F_1(x_1),\ldots,F_m(x_m)).$$

As each multivariate distribution with continuous marginals has a unique copula representation (Sklar, 1959) the applicability of copulas is large. Example of an extreme value copula are the Gumbel copula

$$C_m^G(u;a) = \exp\left(-\left(\sum_{i=1}^m (-\log u_i)^a\right)^{1/a}\right)$$

(with $a \ge 1$, where a=1 implies independence) and the reflected Clayton copula

$$C_m^C(u;a) = \max\left(\left(\sum_{i=1}^m (1-u_i)^{-a} + m - 1\right)^{-1/a}\right)$$

(with $a \ge 0$). Both copulas belong to the family of Archimedean copulas. However, while these copulas may incorporate high tail dependence, they cannot accurately capture near independence for non-extremes. As a consequence, mixed type of dependency copulas and correlations have to be used to adequately reflect frequent events as well as extremes in statistical models (Kole, Koedijk and Verbeek, 2007; Durante and Salvadori, 2010).

5.3 Proposed solution

Natural hazard events are uncertain and produce outcomes (loss of assets or loss in biodiversity) that are not completely known in advance. Hence, for correct decision making the probability of future events as well as the corresponding consequences have to be quantified. State-of-the-art approaches to measure extreme outcomes are so-called “catastrophe models” (Grossi and Kunreuther, 2005; Hochrainer, 2006; Woo, 2011, Mechler et al., 2012; Michel-Kerjan et al., 2012). Such single hazard models combine three components: hazard *X,* exposure *e*, and physical vulnerability *v* to the loss variable *L*

$$L = f(X, e, v). \qquad (1)$$

The exposure component *e* describes the elements at risk, such as the number of houses in a region. The vulnerability component *v* estimates the damage to the elements at risk given the magnitude *X* of the hazard. Finally, a function *f* transforms the damages into monetary values. The simplest way to model this relationship is the multiplicative model

$$L = X \cdot e \cdot v. \qquad (2)$$

If *X* has distribution function *F*, then *L* has distribution function

$$G(l) = F(\frac{l}{e \cdot v}).$$

To capture the development in time, we introduce a time index *t* to all variables, writing

$$G_t(l_t) = F_t(\frac{l_t}{e_t \cdot v_t}) \; . \qquad (4)$$

In case of more than one hazard, copulas can be used to model dependency. However, establishing such copulas in real-world applications can be extremely complicated (Salvadori et al. 2007) and to our knowledge, such methods are not yet used for outputs of catastrophe models. One promising starting point here could be the concept of conditional comonotonicity, as defined by Jouini and Napp (2004). Assume for the moment that two loss distributions $G_{\mathrm{X,t}}(\cdot)$ and $G_{\mathrm{Y,t}}(\cdot)$ for two different types of hazard or hazards in different regions are estimated. If the two hazards are independent from each other, then the distribution $G_{\mathrm{Z,t}}(\cdot)$ of the total loss is equal to the convolution of the two distributions

$$G_{Z,t}(l) = \int_{-\infty}^{\infty} G_{X,t}(l-x)dG_{Y,t}(x), \qquad 0 \le l < \infty$$

On the other hand, if the two distributions are comonotone, i.e. the hazards *X* and *Y* are in monotone deterministic dependence, than the quantile functions (inverse distribution functions) are additive,

$$G_{Z,t}^{-1}(p) = G_{X,t}^{-1}(p) + G_{Y,t}^{-1}(p), \qquad 0 \le p \le 1$$

Now, we introduce a simple threshold-type copula, which takes the fact into account, that small events tend to be independent and large events are highly correlated. The mentioned Clayton or Gumbel may model this fact to a certain extent, but our model is simpler and easy to use (see Hochrainer, Lugeri and Radziejewski, 2013).

Assume that up to a given probability level, say p^* the variables *X* and *Y* are independent and beyond that they are comonotone. Then, the distribution of *Z* is given by separate formulae over the comonotone part and over the independent part. For the comonotone part we would have

$$G_{Z,t}^{-1}(p) = G_{X,t}^{-1}(p) + G_{Y,t}^{-1}(p), \qquad p^* \le p \le 1 \qquad (5)$$

and for the independent part

$$G_{Z,t}(l) = \int_{-\infty}^{G_{Z,t}^{-1}(p^*)} G_{X,t}(l-x)\,dG_{Y,t}(x), \qquad 0 \le l < G_{Z,t}^{-1}(p^*), \qquad (6)$$

with $G_Z^{-1}(p^*)$ given by (5). Obviously, the estimation of the threshold probability p_* is an important task in a multi-risk analysis.

One may summarize the formulas (5) and (6) by stating the form of the threshold-type copula

$$C(u,v) = \begin{cases} \frac{1}{p^*}\min(u,p^*)\cdot\min(v,p^*) & \text{if } \min(u,v) \le p^* \\ p^* + (1-p^*)\cdot\min(u,v) & \text{if } \min(u,v) > p^* \end{cases}. \qquad (7)$$

The advantage of this approach is the possibility to include threshold effects which (if overtopped) increase losses much faster than the Gumbel or Clayton copulas could do. As recent experiences have shown, such as the earthquake event in Japan in 2011 which triggered a tsunami that overtopped seawalls and caused much higher losses than the earthquake itself, threshold effects are an important issue within the risk assessment process and have to be included for correct decision making against disaster risk.

One disadvantage of the copula introduced above is the absence of non-linear dependencies over given impacts p and there is the question how to assess and model such behaviors. One example for a copula which partly incorporates such impact effects is the Clayton copula (see figure below).

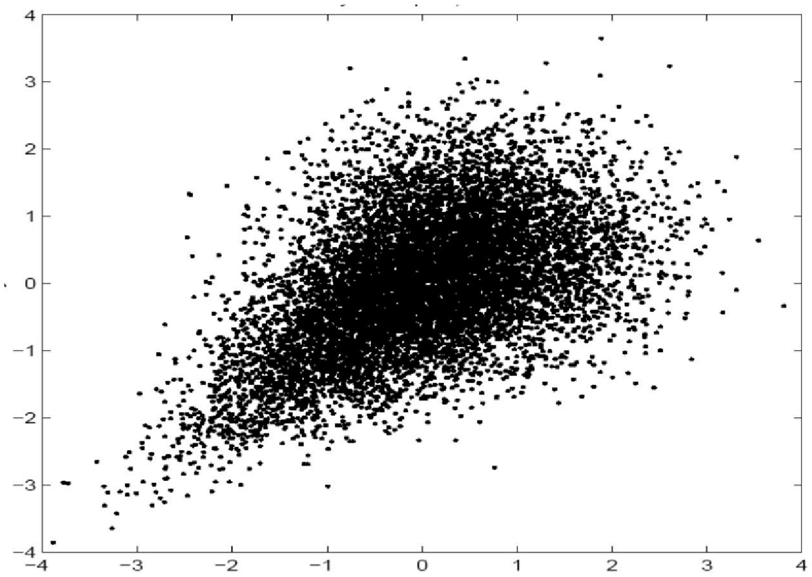


Figure 5.1. Example of a clayton copula

However, the Clayton copula is not able to distinguish between non-linear dependency structures, e.g. if cascading effects grow nonlinear or even like a step function after a given impact level of the primary hazard is reached, the same is true over dynamic path dependence time dependent vulnerabilities. The copula discussed in box 1 may be useful in this regard

Box 5.1. A non-linear form of an Archimedian type copula.

Let $\mathbb{S}$ be the simplex in $\mathbb{R}^d$

$$\mathbb{S} = \{x \in \mathbb{R}^d_+ : \|x\| = 1\}.$$

and let S be a random vector uniformly distributed on $\mathbb{S}$ and R be a non-negative random variable independent of S. Then the d-dimensional random variable X

$$X = R \cdot S$$

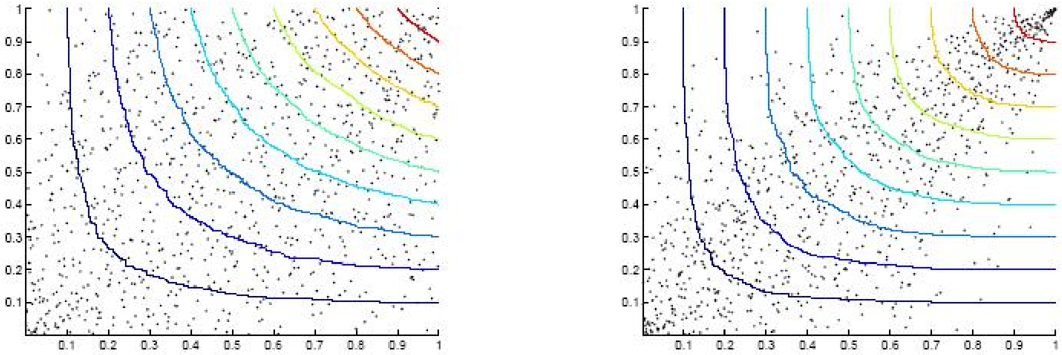
has a l_1-norm symmetric distribution. Its copula is Archimedian as was shown by McNeil and Neshlehova.

Generalized Pareto distribution function has the form

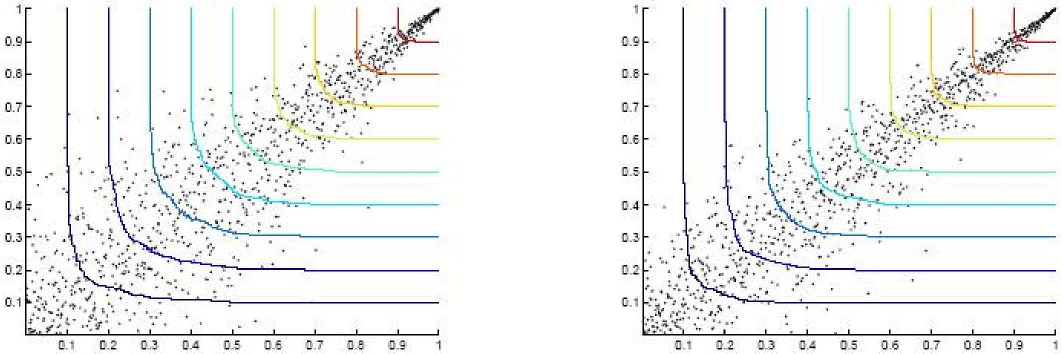
$$G_{K,\sigma}(x) = \begin{cases} 1 - \left(1 + \frac{Kx}{\sigma}\right)^{-1/K} & K \neq 0 \\ 1 - \exp(-x/\sigma) & K = 0 \end{cases}$$

Williamson transform
$\mathfrak{W}F(x) = \int_{(0,\infty)} \left(1 - \frac{x}{t}\right)^{d-1} dF(t) =$

With the specific parameters different forms of dependency models can be achieved as shown in the Figure below.



Left: $K = 0, \sigma = 10$; Right: $K = 2, \sigma = 10$



Left: $K = 5, \sigma = 10$; Right: $K = 8, \sigma = 10$

Figure 5.2. Different Parameter settings for suggested Copula.

Various applied analysis can be done with such form of dependency measures including:

- Copula could be used for multi risk assessment too but empirical data needed for testing/analyzing
- Could also be used for tackling cascading risks but empirical data needed
- Also for risk management strategies maybe valuable
- Time dependency within social and economic systems

5.4 Decision making context: Proposed solution

One way to deal with different dimensions of risk is to put prices on each of the loss dimensions (such as financial, environmental, loss of lives, poverty), while keep them separated if it is wished. This is especially important for making interactive tools for decision makers. An integrated multi-hazard risk and risk management software tool must combine different spatial scale risk estimates with corresponding risk instruments and should be prepared in a format which is easy to understand. Summarizing, policy/decision makers expect a methodology that is based on sound scientific understanding and allows for interactions and stakeholder input. Furthermore, results have to be shown in such a way that they are easy to understand while complex enough to incorporate the main characteristics of the risk and vulnerability under evaluation and risk management possibilities as well as cost and benefits of them (Hochrainer and Mechler, 2009b). To enable such an analysis, as proposed here, it is necessary to estimate hazard risk in a probabilistic, i.e. risk based manner, with the help of catastrophe models.

Such an approach also enables the integration of other important components too, such as climate change, global change and incorporation of indirect losses due to extreme events within the risk management strategy assessment. For example, climate change can be incorporated through frequency or severity changes in the hazard component, while vulnerability changes, e.g. due to technological change, and exposure, e.g. due to land use changes, could be also considered. The figure below shows a possible multi hazard risk approach based on the discussion above. It is important here to explicitly incorporate resilience which is determining the total risk. Afterwards the total risk can be separated either into quantitative risk metrics or other non-quantifiable dimensions which perceived by the stakeholder to be important. The risk management strategy is therefore an outcome of an interactive/iterative process.

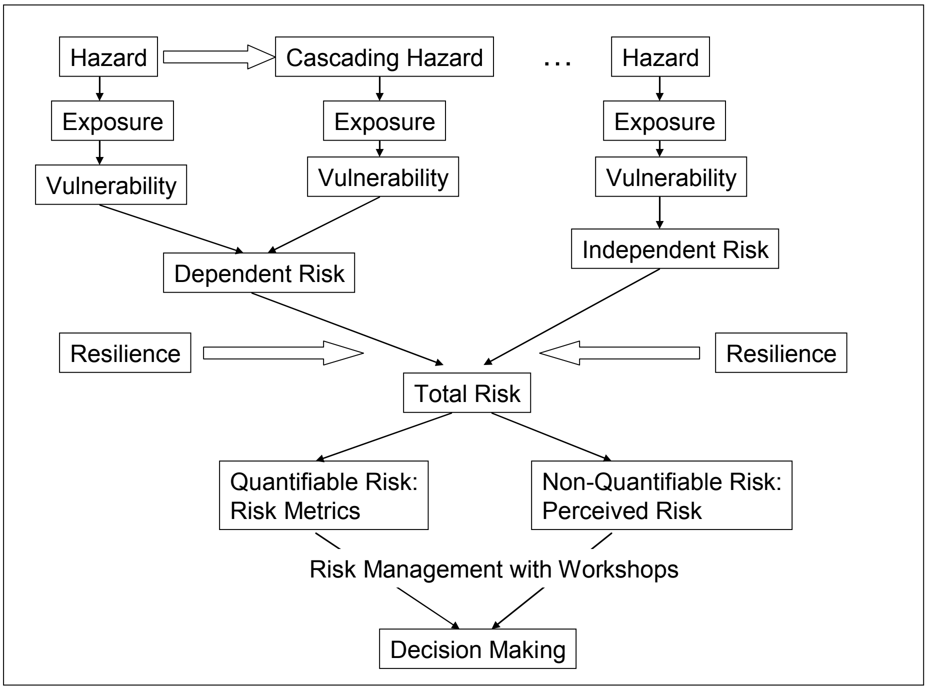


Figure 5.3. General approach to tackle multi-risk and cascading risk effects within a risk assessment and decision making framework.

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Appendix I: Global Scenarios

Global Scenario Group

The Global Scenario Group (1995) is an interdisciplinary and independent body with the task to develop integrated global and regional scenarios. The PoleStar system is used to quantify the GSG scenario narratives. The GSG study uses the year 2050 as time horizon. Focus of the Global Scenario Group lies in the Environment, Poverty reduction and Human values. A set of three scenarios is distinguished within the GSG with each two sub-scenarios:

1. **Conventional worlds**: Gradual convergence in incomes and culture toward dominant market model

Market forces: Market-driven globalization, trade liberalization, institutional modernization

Policy reform: Strong policy focus on meeting social and environmental sustainability goals

2. **Barbarization**: Social and environmental problems overwhelm market and policy response

Breakdown: Unbridled conflict, institutional disintegration, and economic collapse

Fortress world: Authoritarian rule with elites in 'fortressess', poverty and repression outside

3. **Great transitions**: Fundamental changes in values, lifestyles, and institutions

Eco-Communalism: Local focus and bio-regional perspective

New sustainability paradigm: New form of globalization that changes the character of industrial society

WBCSD

Three scenarios were developed by the World Business Council for Sustainable Development in order to engage the business community in the sustainable development discussion. The scenarios were developed via open discussions involving representatives of 35 organizations. The scenario narratives encompass a broad spectrum of possible futures correlated with a set of challenges to business and lessons to be learned. Time horizon within the WBCSD scenarios is 2050 and the scenarios developed have a focus on business and sustainability.

1. **FROG!:** Market-driven growth, economic globalization
2. **GEOpolity**: Top-down approach to sustainability
3. **Jazz**: Bottom-up approach to sustainability, ad hoc alliances, innovation

WWV

In order to increase awareness of a rising global water crisis the World Water Council developed the World Water Vision. The WWV is developed with a time horizon up to 2025. Focus of the WWV is awareness with respect to a (possible) freshwater crisis. Besides water issues, the scenario narratives extent on issues including lifestyle choice, technology, demographics and economics. This vision incorporates a set of three global water scenarios with a focus on issues of water supply and demand, water related conflicts, and water requirements for nature.

1. **Business-as-usual**: Current water policies continue, high inequity
2. **Technology, Economics and the Private sector**: Market-based mechanisms, better technology
3. **Values and Lifestyles**: Less water-intensive activities, ecological preservation

OECD

Focus of the Environmental Outlook, developed by the Organisation for Economic Co-operation and Development, is the critical environmental concerns facing OECD countries but within a global scope. Global economic patterns are related to drivers of environmental change and sectors that are most critical to the environment and resulting environmental impact are examined in the Global Environmental Outlook. Time horizon that is used by the OECD is up to 2020. The OECD scenario structure is based on a reference scenario with different policy variants (e.g., subsidy removal, eco-taxes).

7 Appendix II: Database themes

1. EuroStat

Regional agriculture statistics
Regional demographic statistics
Regional economic accounts
Regional education statistics
Regional science and technology statistics
Regional structural business statistics
Regional health statistics
Regional tourism statistics
Regional transport statistics
Regional labour market statistics
Regional labour costs statistics
Regional information society statistics
Regional migration statistics
Regional environmental and energy statistics
Regional poverty and social exclusion statistics

2. FAO-STAT

Production statistics
Trade statistics
Food supply statistics
Commodity Balances
Food balance sheets
Prices
Resources statistics
Population statistics

Investment statistics
Emissions – Agriculture
Emissions – Land Use
Forestry

3. OECD country statistics

General statistics
Agriculture and fisheries
Demography and population
Development
Economic projections
Education and training
Environment
Finance
Globalisation
Health
Industry and services
International trade and balance of payments
Labour
Monthly economic indicators
National accounts
Prices and purchasing power parities
Productivity
Public sector, taxation and market regulation
Regions and cities
Science, technology and patents
Social and welfare statistics
Transport

3.2 OECD regional statistics

Demographic statistics
Innovation indicators
Regional labor market
Economics
Social Indicators

4. ESPON 2013

Economy, finance and trade
Population and living conditions
Labor Market
Education
Information society
Agriculture and fisheries
Transport and accessibility
Environment and energy
Science and technology
Governance
Territorial structure

5. World dataBank

Agriculture & Rural development
Aid effectiveness
Climate change
Economic policy & External Debt
Education

Energy and Mining
Environment
Financial sector
Gender
Health
Infrastructure
Labor & Social protection
Poverty
Private sector
Public sector
Science & Technology
Social development
Urban development

8 Appendix III: NUTS coverage case studies

Case Study	NUTS0	NUTS1	NUTS2	NUTS3
Europe	*27 MS (+ CC &EFTA)*	*97 MS (+CC & EFTA)*	*270 MS (+CC & EFTA)*	*1294 MS (+CC & EFTA)*
CS1: Iceland/Europe	IS	IS0	IS00	IS001-IS002
CS2: Austria	AT	AT1-3	AT11-13, AT21-22,RO31-32,RO41-42	AT111-113, AT121-127, AT130, AT211-213, AT222-223, AT311-315, AT321-323, AT331-335, AT341-342
CS3: Po Basin – Italy	IT	ITC, ITD	ITC1-4, ITD1-5	ITC11-18, ITC20, ITC31-34, ITC41-49, ITC4A, ITC4B, ITD10, ITD20, ITD31-37, ITD41-44, ITD51-59
CS4: Jucar Basin - Spain	ES	ES4-ES5	ES42, ES52	ES423, ES523, one part of river basin not covered
CS5: London – UK	UK	UKI	UKI1, UKI2	UKI21-23, UKI11-UKI12
CS6: Rotterdam – Netherlands	NL	NL3	NL33	NL335
CS7: Europe				
CS8: Chamusca – Portugal	PT	PT1	PT18	PT185
CS9: North Sea Coast	NL, DE, DK, NO, UK, BE	DK0, NO0, BE2, NL3, NL1, DE9, UKJ, UKH, UKF, UKE, UKC, UKM	DK3, DK4, DK5, DE93, DE94, NO04, NO05, UKM6, UKM5, UKM2, UKC2, UKC1, UKE2, UKE1, UKf3, UKH1, UKH3, UKJ4	DK031-032, DK041-042, DK050, DE931-939, DE93A, DE93B, DE941-9, DE94A-H, NO041-043, NO051-053, UKM61-66, UKM50, UKM21-28, UKC21-23, UKC11-14, UKE21-22, UKE11-13, UKF30, UKH11-14, UKH31-33, UKJ41-42
CS10: Romania	RO	RO1-4		RO111-116, RO121-126, RO211-216, RO221-216, RO221-226, RO311-317, RO321-322, RO411-415,

	RO421-424

Appendix III Scenario Workshop Ispra

ENHANCE

Enhancing risk management partnerships
for catastrophic natural disasters in Europe

Scenario Workshop

Ispra, September 26th-27th, 2013

Joint Research Centre, VU-IVM Amsterdam

Via E.Fermi 2749

Scope of the meeting

The aim of the meeting is to provide an overview of the scenarios relating to climate, natural hazards, and socioeconomic development that can be produced by the JRC, and to discuss the possible applications in WPs 2, 3 and 7.

Venue

Joint Research Centre

Via E. Fermi 2749

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e-mail: Lorenzo.SALVIONI@ec.europa.eu

Audience

Researchers and case-study leaders in WPs 2, 3 and 7.

For logistical information see page 12.

Registration

In order to register please send the following details to Lorenzo Salvioni (Lorenzo.SALVIONI@ec.europa.eu) by August 26th, 2013.

Name & Surname

Affiliation

Place and date of birth

Nationality

ID type & nr

ID date of issue & issuing authority

Preliminary Agenda

Thursday 26 September 2013

10:00-11:00 **Transfer Milano - Ispra**

JRC bus will leave at 10 am from Milano Central Station.

11:00-12:00 **Registration JRC**

12:00-13:30 **Lunch**

13:30-14:00 Welcome coffee and address

Luc Feyen, JRC ; Brenden Jongman ,IVM

14:00-14:30 Outline meeting + overview scenarios

Luc Feyen, JRC

14:30 - 16:00 Session 1: Climate scenarios – availability, use and specific needs

Peter Salamon and Alessandro Dosio, JRC

16:00 - 16:30 Coffee break

16:30 - 18:00 Session 2: Hazard scenarios – droughts and floods

Rodrigo Rojas and Giovanni Forzieri, JRC

18.00 End of the meeting

19.30 Social Dinner

Hotel Europa, Ispra

Friday 27 September 2013

9:00 - 10:45 Session 3: Hazard scenarios – heat waves & forest fires
Simone Russo and Andrea Camia, JRC

10:45 - 11:15 Coffee break

11:15 - 13:00 Session 3: From socio-economic scenarios to land use

Carlo Lavalle, JRC

13:00 - 14:00 Lunch

14:00 - 15:00 Session 3: Socio-economic scenarios and population

Filipe Batista, JRC

15:00 - 16:00 Open discussion

Moderator: Luc Feyen (JRC)

16.00 End of the meeting

ENHANCE Scenario Workshop

Ispra, September 26th-27th, 2013

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