The enviroGRIDS scenarios

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Abstract

The enviroGRIDS scenarios comprise a number of plausible alternatives (storylines) based on a coherent set of assumptions, key relationships and driving forces, to create a set of quantitative, internally consistent and spatially explicit scenarios of future demography, climate and land use (LU) covering the entire Black Sea Catchment (BSC).

The aim of this report is to describe the technical specification of the final scenarios, the source data used and the different methodologies applied on each of them. We describe how the different sources were used and integrated in order to obtain the four alternatives storylines (HOT, ALONE, COOP and COOL), for a yearly time series from 2008 to 2050. The method applied to obtain the demographic growth according to the different storyline for the same time series is also described. Furthermore we describe also the results of the spatially explicit scenarios on climate change for the BSC (Task 3.6) of WP3, for a daily precipitation and temperature time series between 2071 and 2100.

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1 Introduction

This document presents the Deliverable 3.8 of enviroGRIDS, "Outputs from Spatially explicit combined scenarios". The produced spatially explicit enviroGRIDS scenarios for LU are based on plausible future alternatives (narrative storylines) and coherent sets of LU demand and demographic assumptions, key relationship and the influence of different driving forces as topographic, climatic, among others. The aim of this report is to describe the final data with the respective technical specifications, the input base data used and how it was processed in order to be used in Metronamica LU model (RIKS 2006), the demographic and the scenarios of climate change.

Chapter 2 illustrates the different phases leading to the creation of demographic scenarios: according with the enviroGRIDS scenarios, we analyze the UN projection variants for population, and we propose a methodology for the downscaling from national to regional level (NUTS2). Results include population trends up to 2050 for the 214 enviroGRIDS regions.

The LU scenarios are the results of combining several driving forces like demographic and biophysical factors with different storylines derived from the framework of IPCC SRES scenarios and then translated into LU demands. The final output are maps obtained by a LU allocation model (RIKS, 2006) taking into account historical patterns extracted by analysis of known LU datasets (MODIS 2001 and 2008). The description of the datasets used and final results are described in Chapter 3.

In Chapter 4, we also includes the results obtained for perturbation of observed time series of daily maximum and minimum temperature, and precipitation according to the Delta Method (DM), described in the enviroGRIDS Deliverable 3.6[1], "Delta-method applied to the temperature and precipitation time series - An example". The perturbation of the observed time series in Deliverable 3.6, were computed on the basis of Regional Climate Models (RCMs) temperature and precipitation outputs from the PRUDENCE[2] project using IPCC SRES A2 and B2 Green House Gas (GHG) emission scenarios (Nakicenovic et al., 2000).

[1] http://www.envirogrids.net/index.php?option=com_content&view=article&id=23&Itemid=40

[2] PRUDENCE : http://prudence.dmi.dk

2 Demographic Scenarios

2.1 Technical Product Specification

Our first objective consist to produce the population datasets to be used in the integrated model of population, LU and climate change for the four enviroGRIDS scenarios of change. The specificity of these datasets will conform to the Metronamica environment.

2.1.1 Content

The Demographic dataset consists of urban LU estimation projections in tabular format to use in the Metronamica framework, and present and future population figures (2001-2050), in GIS format (vector) at subnational level.

2.1.2 Status

The final version of the BSC demographic data and scenarios per administrative units (NUTS2) is available, while a gridded version 1km x 1km is in preparation and will be published before the end of the year.

2.1.3 Geographic coverage

Demographic scenarios coverage is identified as the coverage of entire administrative boundaries NUTS2 that are completely within the BSC or share a boundary with the catchment. This region comprises 214 administrative units, from 24 different countries (full list in Annex I).

2.1.4 Metadata

The Metadata provided respects the ISO 19139.

2.1.5 Extent

LEFT	4134000.000000
RIGHT	7277000.000000
BOTTOM	1679000.000000
TOP	4270000.000000

2.1.6 Format Description

Tabular and vector datasets.

2.1.7 Data Source

Demographic data (total population both male and female sexes, for urban and rural areas) were collected from international organizations (UN and Eurostat), national statistical offices, and by partners contribution (Deliverable 3.1)[3]. A detailed list of data sources is provided in Annex II.

[3] http://www.envirogrids.net/index.php?option=com_content&view=article&id=23&Itemid=40

2.2 Methodology

Downscaling total and urban population at regional level

Total and urban population collected at subnational level were harmonized and integrated: the total population was recalculated to match with the UN WPP totals for the 2001-2010 period. In order to solve the lack of agreement from the different sources of the urban dataset (due to different definition among countries) we have considered the urban datasets as the sum of cities population with at list 10k inhabitants in 2001. Both total and urban growths were recalculated in the same way in order to match the values provided by UN WUP totals for the period between 2001 and 2010.

Downscaling population projections at regional level

We collected data from Eurostat (Eurostat, 2010) for member countries until 2030, and from the Federal statistical office of Russia that published data up to 2031. Projections at regional level are scarce, for this reason the downscaling is mainly based on the "regional share" (Rsh): how population varies between regions inside the same country. The Rsh trends were analysed and successively extrapolated by linear regression to fill the missed years. These extrapolations only concern the distribution of people during time among regions; real population data will be further calculated using National data from UN projections. Results from downscaling will include regional (214) projections for the period 2010-2050 for urban and total population, according with the three UNSD variants (High, Medium and Low fertility).

Urban land cover projections

The final LU demand is computed using a density evaluation process, based on past local data on densities, and supposed future trends.

The past variations of densities are calculated on the variation of urban land surface in Corine Land Cover (CLC) between 2000 and 2006. Results point to: a general strong tendency to decrase the density during timeaccording to (Angel et al. 2010a), and the few regions that have increased their density (Istambul, Wien) are those where the space for their expansion was generally limited. In Europe, historical trends, since the mid 1950s, show that cities areas have expanded on average by 78 %, whereas the population has grown by only 33 % (EEA, 2006). Future trends (Angel et al. 2010b), suppose scenarios of densities annual decreases for selected countries from 2% to 0%.

The three different scenarios of density: down, medium, and up are resumed in the table bellow:

DS	AC	PW
up	0.5%	2.0
medium	0.0%	1.5
down	-0.8%	1.5

Table 1: Scenarios of Demographic Density

Where DS are the density scenarios per region, AC is the assumed constant annual change of density and PW is a coefficient that defines how much past data (density change2000-2006) must influence the DS.

Integration with enviroGRIDS scenarios

Each enviroGRIDS scenario is characterized by its own peculiar (urban) demographic trend, together with a specific urban land evolution path (Table 2). Our goal consists to translate these qualitative storylines into quantitative urban surfaces projections. The integration of our results of density scenarios and population projections allows nine theoretical possible combinations. Final urban area projections have been partially adjusted in function of the characteristics of each regions or group of regions (REF, OECD and Former USSR).

Storyline (qualitative)			Urban area projections	
EG scenario	**Population growth**	**Urban characteristics**	**Density Scenario**	**UN Population variant**
HOT	low	Increase urban areas and demand in high populated regions. Strong attraction of urban - agriculture areas around the existing settlements	Down	Low
ALONE	highest	Urban areas and demand will increase. Dispersed urban sprawl - new settlements are expected in touristic areas. Inertia in existing urban areas with strong interaction neighbors gradually failing – some expansion of existing small town.	Medium	High
COOP	low	Urban areas increase in density but not in area - compact growth urban areas will "stick" to its present location	Medium	Medium
COOL	medium	Urban smoothly increase Inertia for urban areas will stick to its present location – small changes	Medium	Medium

Table 2: Urban area projections versus EG scenarios

Results

Urban land demand is supposed to growth up to 2050 for all the four scenarios (Figure 1). Urban area in both HOT and ALONE scenarios is expected to increase of around 30%. The negative urban population trend for HOT, starting around 2020 (in the UN Low assumption) is insufficient to prevent the increase of urban surface due to a its low density .

COOP and COOL scenarios, are the more environmental friendly scenarios and we estimate an increase close to 10%. The moderate growth of urban population, together with a more compact urban area development, mitigates, especially in the case of COOP, a dispersed urban sprawl. Figure 1 gives an overview of the expected demands of urban cells for the four scenarios.

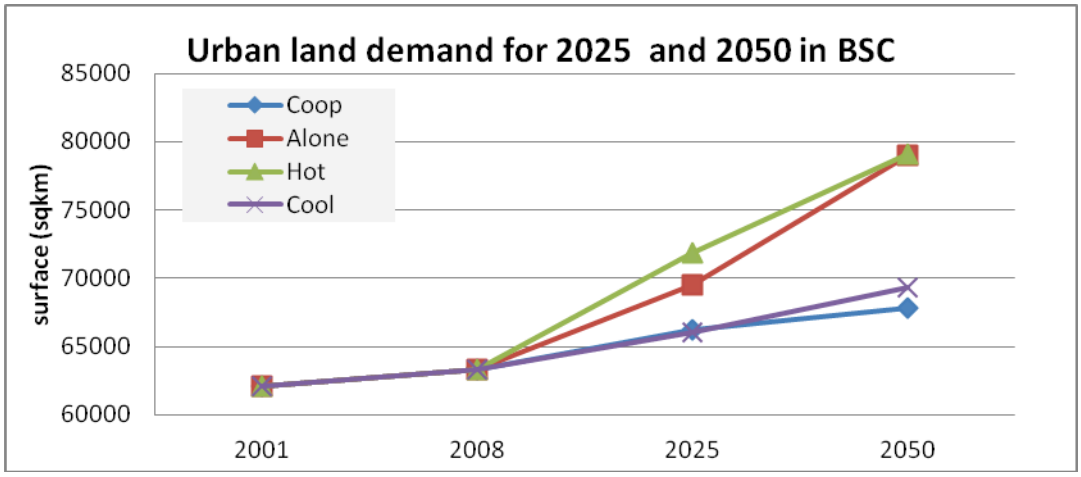


Figure 1: Urban land demand according to the four enviroGRIDS scenarios in the BSC

2.3 List of provided data

Urban and total population at subnational level (NUT2) 2001 to 2010 annually: GIS data, vector.

Urban and total population projections, subnational level (NUT2) 2010 to 2050 annually UN medium variant: GIS data, vector.

HOT scenario urban population and density, subnational level (NUT2) 2025 and 2050: GIS data, vector.

ALONE scenario urban population and density, subnational level (NUT2) 2025 and 2050: GIS data, vector.

COOL scenario urban population and density, subnational level (NUT2) 2025 and 2050: GIS data, vector.

COOP scenario urban population and density, subnational level (NUT2) 2025 and 2050: GIS data, vector.

Urban agglomerates: number of people, 1km x 1km 2001, GIS data raster.

3 Land Use Scenarios

3.1 Technical product specification

3.1.1 Content

The data consist in a set of GIS maps representing the LU for the total area of the black sea basin for the years 2025 and 2050 per each scenario (HOT, ALONE, COOP, COOL). More information about scenario storyline description is reachable in previous delivery D3.7[4]. Each map of LU is subdivided into 10 classes where *crops/natural vegetation, shrubland, barren or sparsely vegetated, forest, grassland, croplands* and *urban and built-up areas*, changing along the years and *water, snow and ice* and *permanent wetlands* remain fixed.

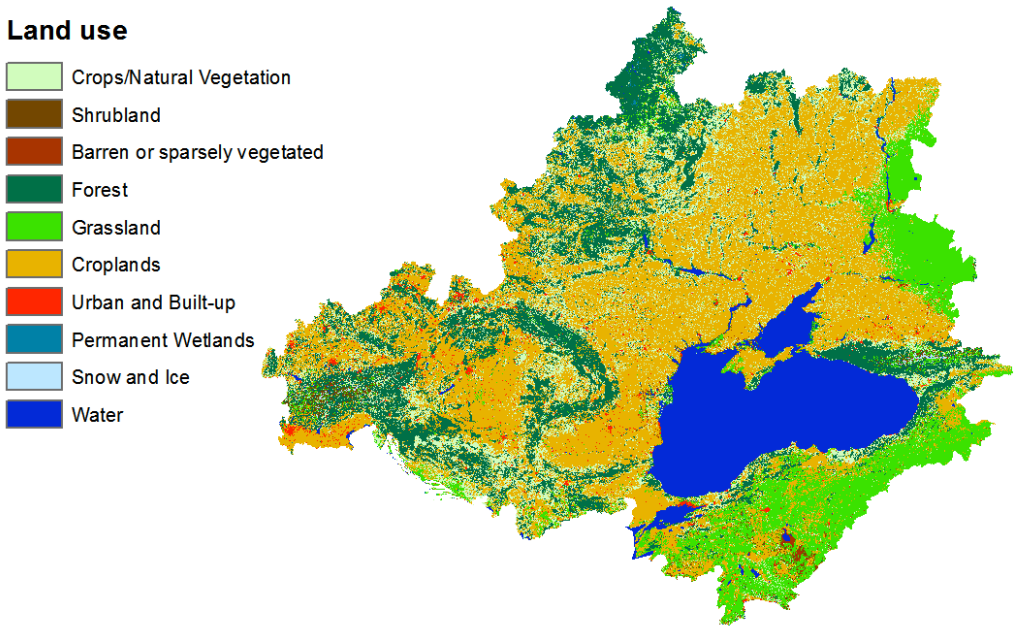


Figure 2: Land use classes in final map

3.1.2 Status

This is the first release of the LU scenarios. A final release should be available upon validation of the first release by the enviroGRIDS project partners. The final release will include additional indicators maps.

3.1.3 Geographic coverage

The LU and demographic scenarios coverage is identified as the coverage of entire administrative boundaries NUTS2 that are completely within the BSC or share a boundary with the catchment. This region comprises 214 administrative units, from 24 different countries (full list in Annex I).

3.1.4 Resolution

The data resolution is 1km^2.

[4] http://www.envirogrids.net/index.php?option=com_content&view=article&id=23&Itemid=40

3.1.5 Metadata

The Metadata provided respects the ISO 19139.

3.1.6 Extent

LEFT	4134000.000000
RIGHT	7277000.000000
BOTTOM	1679000.000000
TOP	4270000.000000

3.1.7 Format Description

Columns and Rows	3143, 2591
Number of Bands	1
Cellsize X.Y	1000, 1000
Uncompressed Size	˜31 MB (each map)
Format	GRID
Source Type	continuous
Pixel Type	unsigned integer
Pixel Depth	8 Bit
NoData Value	255
Compression	RLE

3.1.8 Spatial reference

Spatial Reference	ETRS 1989 LAEA
Angular Unit Degree	0,0174532925199433295
False Easting	4321000
False Northing	3210000
Central Meridian	10
Latitude of Origin	52
Datum	D_ETRS_1989

3.2 Data source

3.2.1 Land Use

The LU dataset used was obtained from the reprojection and resampling of the original LU MODIS combined (MCD12Q1) downloaded from USGS website[5] for the year 2001 and 2008.

[5] https://lpdaac.usgs.gov/products/modis_overview

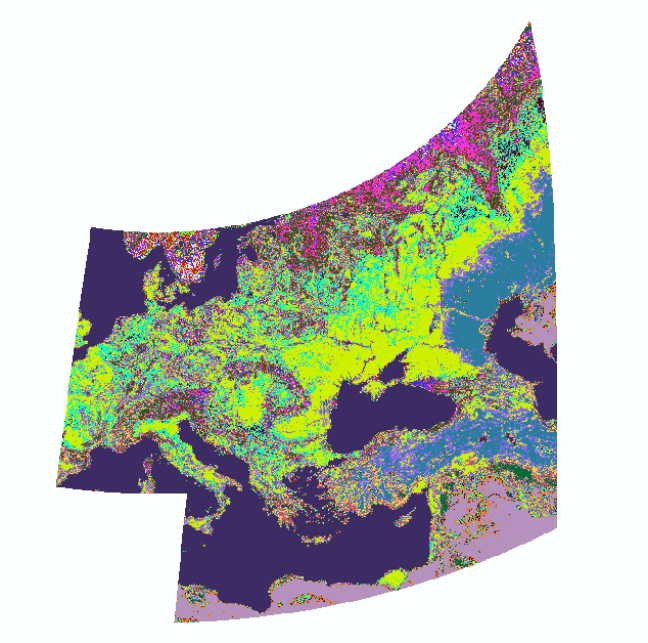


Figure 3: Mosaic of MODIS tiles before processing.

3.2.2 Biophysical and Climate data

These maps are used for creating the suitability maps, representing the physical suitability for the location of a specific LU. They were created using topographic and climatic driving factors that influence the spatial allocation of each LU type modeled.

a. Digital Elevation Model (DEM): the used dataset is a combination of SRTM 90 and DTED data. The Shuttle Radar Topography Mission (SRTM) obtained elevation data on a near-global scale to generate the most complete high-resolution digital topographic database of Earth.
b. Slope: derived from DEM.
c. Soil Quality Map: Soil Geographic Database of Eurasia (SGDE) 1:1,000,000.

The climate parameters are derived by Bioclimatic variables from WorldClim (Global Climate data) with a spatial resolution of ~ 1 $km^{2,}$ and are applied as weight factors in the suitability maps. The data are public and available on the WorldClim website[6].

3.2.3 Zoning and spatial plans

The areas delimitated by policy directives used to constrain the LU changes are:

a) Protected areas obtained from the UNEP-WCMC World database on Protected Areas website[7].
b) Fire Events and Flood Risk derived from a dataset develop by UNEP/GRID-Europe for the Global Assessment Report on Risk Reduction (GAR)[8].

3.2.4 Infrastructure

The infrastructure data consists of the Road Network (major and secondary roads) and Rail Network (rail network and rail stations), obtained from Global Road Data (2006)[9] and ESRI Data & Maps (2006).

[6] http://www.worldclim.org/

[7] http://www.wdpa.org/AnnualRelDownloads.aspx

[8] http://preview.grid.unep.ch/index.php?preview=home&lang=eng

3.3 Methodology

The first step of the methodology, consist in the modelling of the past changes, consequently the preparation of the LU dataset and the physical suitability of each LU category. The MODIS land cover dataset for 2001 and 2008 corresponded to the area of study previously defined were extracted and the LU classes aggregated in order to better adapt to the needs of the enviroGRIDS project and also to the LU model used (Metronamica, RIKS). A resume table about the adaptation of the MODIS categories is presented in Annex III.

Once the study area and physical suitability of each LU is determined, the amount of change occurring between the two time series was calculated. The LU demand was based on the values provided by the framework of Integrated Model to Assess the Global Environment (IMAGE, version 2.2: IMAGE team, 2001). This demand was used to estimate the LU changes in BSC, disaggregating to regional level and used as input to the regional/local LU allocation model (Metronamica, RIKS). An overview of the estimated demands based on IMAGE 2.2, is present in Annex IV. The enviroGRIDS LU changes scenarios give projections of LU on 1km x 1km grids in two time step (2025 and 2050) for four scenarios. The disaggregation method applied consists on the estimation of the LU demand for each of three regions (IMAGE 2.2 regions: OECD, REF EE and Former USSR) and disaggregated at NUTS2 level, on the simple assumption that all NUTS2 regions have the same growth rate as the Economic Region they belong.

Additionally the demographic data were interpolated to quantify the urban LU class (*enviroGRIDS D3.7*). For more information about the demographic scenarios, see *enviroGRIDS D3.5*.

Climate data (Bioclimatic variables, annual mean precipitation and annual mean temperature), biophysical data (DEM, Slope, Soil quality) were processed in in a GIS software to have same resolution, raster format, extent and projections in respect to the LU area. Each factor was reclassified in natural breaks in order to reduce the original number of classes to facilitate it analysis. Finally, all the factor maps were combined through the OVERLAY-Tool (RIKS) using a common measurement scale (0 to 10) and weights each according to the influence with each LU spatial distribution. Finally each map represents the suitability of in a given geographical unit to maintain a determined LU (Uljee, I., et al., 2006).

The Zoning Maps were also processed in order to have the same resolution, raster format, extent and projections of the rest of input data. Each theme was reclassified with integer values in order to have category maps and a weight was assigned per each class inside the model (Metronamica, RIKS) to constrain the changes in specific areas.

The infrastructure data, needed to simulate the accessibility effect, defined as the ease with which an activity can fulfil its need for transportation and mobility in a particular cell based on the transport system (RIKS, 2008). The dataset was processed in similar way as the other input data, and each type has an additional attribute to establish a priority order among the data. When entered in the model (Metronamica, RIKS), a weight is assigned according to the function LU category. Therefore the model recognizes the areas which are affected in a positive or negative way by the infrastructure network.

To run the model, in addition to all the inputs data described above, the model needs to be calibrated with parameters that rule the stochastic perturbation (the random factor) and the LU neighbourhood interaction, which are specific for each scenario and responsible to allocate LU demand at local level in the BSC. Once the most appropriate setting were selected, the changes between the historical data (MODIS 2001 and MODIS 2008) we modules and the results are verified and validated by different statistical methods as *Kappa* and *Fuzzy Kappa* (for more information on calibration and validation process, see *enviroGRIDS D3.7)*. Once we arrive to the most

[9] http://www.ciesin.columbia.edu/confluence/display/roads/Global+Roads+Data

accurate model parameters (*physical suitability*, *neighbour interactions* and *stochastic perturbation*), the model was used to estimate the four different scenarios, by attributing different demands for each LU as well as changing the *neighbour interactions* according to the scenario storyline.

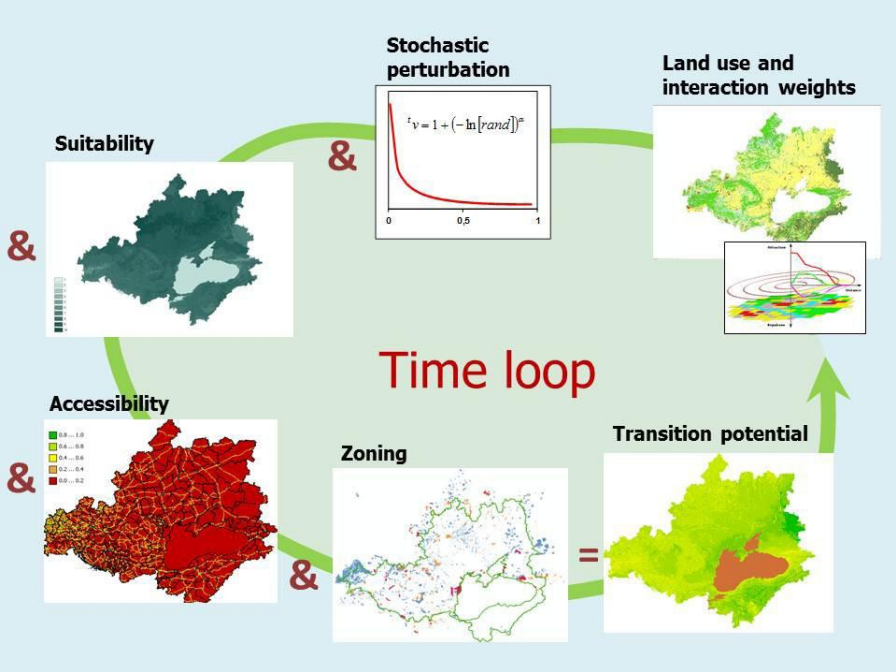


Figure 4: Resume of the factors involved in the calibration procedure in Metronamica

3.4 List of provided data

Initial land cover MODIS Grid format Resampled (1km^2) and LU categories aggregated, year 2008

HOT scenario Grid format from year 2010 to 2050 five-yearly;

ALONE scenario Grid format from year 2010 to 2050 five-yearly;

COOP scenario Grid format from year 2010 to 2050 five-yearly;

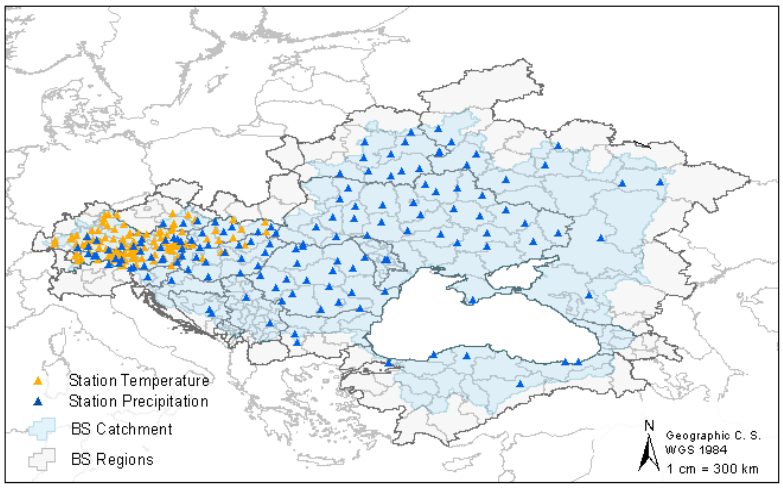
COOL scenario Grid format from year 2010 to 2050 five-yearly;

LU legend file lyr format.

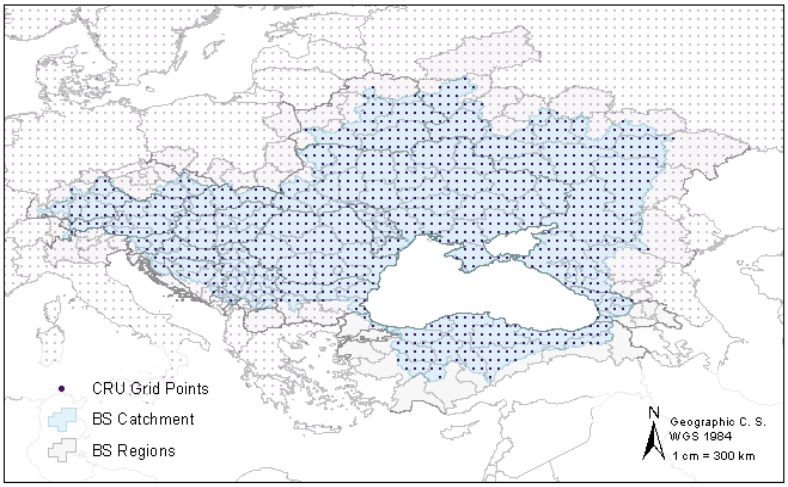
4 Scenarios of Climate change

4.1 Technical Product Specification

The data consists in a set of climate scenarios (A2 and B2) relevant to impact studies in the BSC. In addition to the Meteorological Stations, another set of observations obtained from the grid points of the Climatic Research Unit [10](CRU) dataset were also used.



Meteorological stations observation datasets
Black Sea Catchment



CRU Grid Points
Black Sea Catchment

Figure 5: PRUDENCE, Meteorological Stations and CRU Dataset - Black Sea Catchment

4.1.1 Content

The data consists in a set of Daily values of Temperature (max and min) and Precipitation, for the observation period, and for each climatic scenario (A2 and B2).

[10] http://www.cru.uea.ac.uk

4.1.2 Status

The first version of the BSC Weather Stations is available, while the final version including the full dataset of Weather Stations is in preparation to be published in the end of the year. The scenarios obtained with the CRU dataset are ready to be used.

4.1.3 Geographic coverage

The Climatic scenarios obtained with the Weather Stations dataset cover the BSC for the Precipitation, while the Temperature covers the West part of the BSC. The CRU dataset coverage is identified as the coverage of BSC.

4.1.4 Metadata

The Metadata provided respects the ISO 19139.

4.1.5 Extent

Meteorological Stations
Precipitation Left: 4346605.00m, Right: 6819791.00m, Bottom: 2188306.00m, Top: 3793563.00m
Temperature Left: 4238842.00m, Right: 5196091.00m, Bottom: 2616582.00m, Top: 2975322.00m

CRU Left: 4265277.00m, Right: 6987015.00m, Bottom: 1969504.00m, Top: 3871843.00m

4.1.6 Spatial reference

Spatial Reference	ETRS 1989 LAEA
Angular Unit Degree	0,0174532925199433295
False Easting	4321000
False Northing	3210000
Central Meridian	10
Latitude of Origin	52
Datum	D_ETRS_1989

4.1.7 Format Description

Daily datasets of Weather Stations and CRU grid points, for the observation period and each scenario.

4.1.8 Data Source

Regional Climate Model outputs (RCM)

The RCMs used in this work were simulated with the Danish RCM HIRHAM, driven by the United Kingdom's Hadley Center HadAM3H GCM outputs, used under the scope of the Fifth Research Framework Program of the European Union, the PRUDENCE project (Christensen and Christensen, 2007). The majority of the data produced by this project are freely available[11]. HIRHAM was first run to simulate data for a control period (HC), 1961 to 1990. A number of potential future climate were also simulated for the period of 2071 to 2100 (HS and HB), representing respectively the two IPCC's SRES GHG emission scenarios, A2 and B2 (Nakicenovic *et al.*, 2000).

Meteorological stations observation datasets

The meteorological observations for precipitation, maximum and minimum temperatures of 150 Meteorological Stations were provided for the BSC. The time frame for these measurements ranges from January 1, 1970 to December 31, 2008, depending on the station.

CRU dataset

The CRU is a gridded climate dataset created by the Climate Research Unit (CRU), University of East Anglia (New *et al*., 1999; New *et al*., 2000). The different variables were obtained from station observations and the two variables used in this work are part of the primary variables from the CRU monthly grids of terrestrial surfaces climate and were interpolated as a function of latitude, longitude and elevation by the thin-plate splines (New et al, 1999; New et al., 2000).

4.2 Methodology

The methodology used to create the Climatic scenarios is described in the Deliverable 3.6[12], "Delta-method (DM) applied to the temperature and precipitation time series - An example". The methodology applied was divided into two main steps: evaluation of the "deltas" and their application to predictions. The DM was implemented using R language for statistical computing (R, 2008) and the final scenarios downscaled to the Meteorological Stations' and CRU Grid points level were exported according to SWAT format requirements and compatible with the future development of webservices

4.3 List of provided data

Daily Meteorological Station Observations (1970-2008,1976-2005): TEMPmax, TEMPmin and PCP;
Daily Meteorological Station A2 Scenario (2071-2100): TEMPmax, TEMPmin and PCP;
Daily Meteorological Station B2 Scenario (2071-2100): TEMPmax, TEMPmin and PCP;
Daily CRU Observation (1901-2006, 1976-2005): TEMPmax, TEMPmin and PCP;
Daily CRU A2 Scenario (2071-2100): TEMPmax, TEMPmin and PCP;
Daily CRU B2 Scenario (2071-2100): TEMPmax, TEMPmin and PCP.

[11] PRUDENCE: http://prudence.dmi.dk/

[12] http://www.envirogrids.net/index.php?option=com_content&view=article&id=23&Itemid=40

5 Data access

All data, metadata, and web services (WMS, WCS, and WFS) can be freely accessed through:

GeoPortal enviroGRIDS at: http://www.envirogrids.cz/search or

GeoNetwork enviroGRIDS at: http://129.194.231.213:8080/geonetwork/srv/en/main.home

6 References

Angel, S., Parent, J., Civco, D., and Blei, A., 2010a. *The Persistent Decline in Urban Densities: Global and Historical Evidence of 'Sprawl'*. Cambridge, USA, Lincoln Institute of Land Policy.

Angel, S., Parent, J., Civco, D., Blei, A., and Potere, D., 2010b. *A Planet of Cities: Urban Land Cover Estimates and Projections for All Countries, 2000-2050*. Cambridge, USA, Lincoln Institute of Land Policy.

Christensen, J. H. and Christensen, O. B., 2007. *A summary of the PRUDENCE model projections of changes in European climate by the end of this century*. Climatic Change, vol. 81, p. 7-30

EEA, 2006. *Urban sprawl in Europe The ignored challenge*, EEA Report No 10/2006: Copenhagen, European Environment Agency.

Eurostat, 2010. *Regional population projections EUROPOP2008: Most EU regions face older population profile in 2030*, Eurostat: Statistics in Focus 1/2010.

IMAGE team (2001). *The IMAGE 2.2 implementation of the SRES scenarios: a comprehensive analysis of emissions, climate change and impacts in the 21st century*. RIVM CD-ROM Publication 481508018, Bilthoven: National Institute of Public Health and the Environment RIVM. Available at: http://www.rivm.nl/image

Nakicenovic, N. , Davidson ,O., Davis, G., Grübler, A., Kram, T., la Rovere, E. L., Metz, B., Morita, T., Pepper, W., Pitcher, H., Sankovski, A., Shukla, P., Swart, R., Watson, R. and Dadi, Z., 2000. *Special Report on Emissions Scenarios: A Special Report of Working Group III of the Intergovernmental Panel on Climate Change*. Cambridge University Press, Cambridge, U.K., 599 pp

New, M., Hulme, M. and Jones, P., 1999. *Representing Twentieth-Century Space–Time Climate Variability. Part I: Development of a 1961–90 Mean Monthly Terrestrial Climatology*. American Meteorological Society, Journal of Climate,12. Pp. 829-855.

New, M., Hulme, M. and Jones, P., 2000. *Representing twentieth century space-time climate variability. Part 2: Development of 1901-96 monthly grids of terrestrial surface climate.* American Meteorological Society, Journal of Climate, 13. pp. 2217-2238.

RIKS (2005). *The Metronamica modelling framework: model descriptions. Model documentation*. Maastricht: Research Institute for Knowledge Systems.

RIKS (2006). *Overlay tool Manual. Maastricht: Research Institute for Knowledge Systems*. Maastricht: Research Institute for Knowledge Systems.
RIKS (2008). *Assessment and scenarios of land use change in Europe*. Maastricht: Research Institute for Knowledge Systems.

Uljee, I., Van Delden, H., Luja, P., Van der Meulen, M., Hagen, A., Hurkens, J. Engelen, G. (2006). *METRONAMICA user manual*. Maastricht: Research Institute for Knowledge Systems.

UN/DESA, 2010. *World Urbanization Prospects The 2009 Revision Highlights*, ESA/P/WP/215: New York, UN.

UN/DESA, 2011. *World Population Prospects. The 2010 Revision Highlights* (in press), ESA/P/WP.210: New York.

7 Abbreviations and acronyms

BSC	Black Sea Catchment
CLC	Corine Land Cover
CRU	Climatic Research Unit
DEM	Digital Elevation Model
DTED	Digital Terrain Elevation Data
EG	enviroGRIDS
EEA	European Environment Agency
SGDE	Soil geographic database of Eurasia
IMAGE	Integrated Model to Assess the Global Environment
IPCC-SRES	Intergovernmental Union for Conservation of Nature
JRC	Joint Research Centre
MODIS	Moderate Resolution Imaging Spectroradiometer
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organization for Economic Co-operation and Development
REF EE	Eastern European countries undergoing Economic Reform
RIKS	Research Institute for Knowledge System
SRES	Special Report on Emission Scenarios
SRTM	Shuttle Radar Topography Mission
UMA	University of Malaga
UN	United Nations
UNEP-GRID	United Nations Environment Programme DEWA/GRID-Europe
UNIGE	University of Geneva
WDPA	World Database on Protect Areas
WPP	World Population Prospect
WUP	World Urbanization Prospects

8 Annex

8.1 Black Sea basin NUTS 2 regions

NUTS code	*Region name*
AL01	Shkoder
AL02	Tropoje
AL03	Malesi e Madhe
AT11	Burgenland (AT)
AT12	Niederösterreich
AT13	Wien
AT21	Kärnten
AT22	Steiermark
AT31	Oberösterreich
AT32	Salzburg
AT33	Tirol
AT34	Vorarlberg
BA01	Bosnia and Herzegovina
BA02	Republika Srpska and Brcko
BG31	Severozapaden
BG32	Severen tsentralen
BG33	Severoiztochen
BG34	Yugoiztochen
BG41	Yugozapaden
BG42	Yuzhen tsentralen
BY01	Minsk
BY02	Brest
BY03	Gomel
BY04	Minsk City
BY05	Grodno
BY06	Mogilev
BY07	Vitebsk
CH05	Ostschweiz
CZ01	Praha
CZ02	Strední Cechy
CZ03	Jihozápad
CZ05	Severovýchod
CZ06	Jihovýchod
CZ07	Strední Morava
CZ08	Moravskoslezsko
DE11	Stuttgart
DE13	Freiburg
DE14	Tübingen

DE21	Oberbayern
DE22	Niederbayern
DE23	Oberpfalz
DE24	Oberfranken
DE25	Mittelfranken
DE27	Schwaben
GE01	Apkhazeti
GE02	Atchara
GE03	Guria
GE04	Imereti
GE05	Kakheti
GE06	Kvemo Kartli
GE07	Mtskheta-Mtianeti
GE08	Ratcha-Lechkhumi
GE09	Samegrelo-Zemo Svaneti
GE10	Samtskhe-Javakheti
GE11	Shida Kartli
GE12	Tbilisi
HR01	Sjeverozapadna Hrvatska
HR02	Sredisnja i Istocna (Panonska) Hrvatska
HR03	Jadranska Hrvatska
HU10	Közép-Magyarország
HU21	Közép-Dunántúl
HU22	Nyugat-Dunántúl
HU23	Dél-Dunántúl
HU31	Észak-Magyarország
HU32	Észak-Alföld
HU33	Dél-Alföld
ITC4	Lombardia
ITD1	Provincia Autonoma Bolzano/Bozen
ITD2	Provincia Autonoma Trento
ITD3	Veneto
ITD4	Friuli-Venezia Giulia
LI00	Liechtenstein
MD01	Orhei
MD02	Tighina
MD03	Dubasari
MD04	Chisinau
MD05	Cahul
MD06	Balti
MD07	Soroca
MD08	Gagauzia
MD09	Edinet

MD10	Lapusna
MD11	Ungheni
ME01	Andrijevica
ME02	Kolašin
ME03	Plužine
ME04	Pljevlja
ME05	Mojkovac
ME06	Rožaje
ME07	Berane
ME08	Žabljak
ME09	BijeloPolje
ME10	Plav
ME11	Šavnik
ME12	Nikšic
ME13	Podgorica
MK00	Poranesna jugoslovenska Republika Makedonija
PL21	Malopolskie
PL22	Slaskie
PL31	Lubelskie
PL32	Podkarpackie
PL34	Podlaskie
PL51	Dolnoslaskie
RO11	Nord-Vest
RO12	Centru
RO21	Nord-Est
RO22	Sud-Est
RO31	Sud - Muntenia
RO32	Bucuresti - Ilfov
RO41	Sud-Vest Oltenia
RO42	Vest
RS11	Juzno-banatski
RS20	Srednje-banatski
RS21	Pomoravski
RS22	Moravicki
RS23	Zajecarski
RS24	Zlatiborski
RS27	Rasinski
RS28	Kolubarski
RS29	Nisavski
RS30	Toplicki
RS31	Pirotski
RS32	Kosovsko-mitrovatski
RS33	Jablanicki

RS34	Kosovski
RS35	Pecki
RS36	Raski
RS37	Prizremski
RS39	Severno-backi
RS40	Severno-banatski
RS41	Zapadno-backi
RS42	Sremski
RS43	Juzno-backi
RS44	Sumadijski
RS47	Pcinjski
RS49	Grad Beograd
RS50	Macvanski
RS51	Branicevski
RS52	Podunavski
RS53	Borski
RS54	Kosovsko-pomoravski
RU01	Saratov Region
RU02	Kursk Region
RU03	Belgorod region
RU04	Tambov region
RU05	Volgograd Region
RU06	Rostov Region
RU07	Republic of Kalmykia
RU08	Voronezh Region
RU09	Krasnodar Territory
RU10	Orel region
RU12	Penza Region
RU13	Bryansk region
RU14	Tula Region
RU15	Kaluga Region
RU16	Ryazan Region
RU17	Smolensk region
RU18	Lipetsk region
RU19	Republic of North Ossetia - Alania
RU25	Kabardino-Balkar Republic
RU26	Karachay-Cherkessia
RU38	Stavropol Territory
RU45	Tver region
RU48	Republic of Adygea
SI01	Vzhodna Slovenija
SI02	Zahodna Slovenija
SK01	Bratislavský kraj

SK02	Západné Slovensko
SK03	Stredné Slovensko
SK04	Východné Slovensko
TR10	Istanbul
TR21	Tekirdag
TR22	Balikesir
TR33	Manisa
TR41	Bursa
TR42	Kocaeli
TR51	Ankara
TR52	Konya
TR61	Antalya
TR71	Kirikkale
TR72	Kayseri
TR81	Zonguldak
TR82	Kastamonu
TR83	Samsun
TR90	Trabzon
TRA1	Erzurum
TRA2	Agri
UA01	Avtonomna Respublika Krym/M.Si
UA05	Vinnyts'ka
UA07	Volyns'ka
UA12	Dnipropetrovs'ka
UA14	Donets'ka
UA18	Zhytomyrs'ka
UA21	Zakarpats'ka
UA23	Zaporiz'ka
UA26	Ivano-Frankivs'ka
UA32	Kyivs'ka
UA35	Kirovohrads'ka
UA44	Luhans'ka
UA46	L'vivs'ka
UA48	Mykolaivs'ka
UA51	Odes'ka
UA53	Poltavs'ka
UA56	Rivnens'ka
UA59	Sums'ka
UA61	Ternopil's'ka
UA63	Kharkivs'ka
UA65	Khersons'ka
UA68	Khmel'nyts'ka
UA71	Cherkas'ka

UA73	Chernivets'ka
UA74	Chernihivs'ka
UA80	Kyiv
UA85	Sevastopol

8.2 Data source resume

Land Use data sources

Theme	*Data*	*Provider*
Land Use	Modis 2001, 2008	LP DAAC
DEM, Slope	SRTM90, DTED	NASA, EEA
Soil quality map	Soil geographic database of Eurasia (SGDE)	JRC
Bioclimatic data	Mean precipitation, Main temperature.	WorldClim
Protected areas	World Database on protect Areas (WDPA)	UNEP
Infrastructure Network	Road Network (major and secondary roads) and Rail Network (rail network and rail stations)	Global Road Data, 2006; ESRI Data & Maps, 2006
Fire events, Flood risk	Global Assessment Report on Risk Reduction (GAR)	UNEP/GRID-Europe

Demographic data sources

iso2	***Attribute (NUTS2)***	***Geom (GIS file)***
AL	Albanian Institute of Statistics	GISCO NUTS 1, 2, 3 Edition 2006
LI	Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
AT	Eurostat, 04.02.2011, Total population resident in a region. Statistics Austria (National Office): Stadtregionen 2001 - Zuordnung der Gemeinden	GISCO NUTS 1, 2, 3 Edition 2006
BG	Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
CH	Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
CZ	Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
DE	Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
HR	Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
IT	ISTAT Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
PL	Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
RO	Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
TR	Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
MK	Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
HU	Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
SI	Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
SK	Eurostat, 04.02.2011, Total population resident in a region.	GISCO NUTS 1, 2, 3 Edition 2006
ME	Montenegro statistical office	GAUL 2008 admin level1
MD	Macedonia statistical office	GAUL 2008 admin level1
BY	Bielorussia statistical office population census 1999, 2009 and data for 2010	GAUL 2008 admin level1
UA	Regional Centre for Integrated Environmental Monitoring and Ecological Studies of Odessa National I.I. Mechnikov University	Regional Centre for Integrated Environmental Monitoring and Ecological Studies of Odessa National I.I. Mechnikov University

BA	Statistical Office of the Federation of Bosnia and Herzegovina	GAUL 2008 admin level1
	Republika Srpska Institute of Statistics	GAUL 2008 admin level1
	AGENCY FOR STATISTICS OF BOSNIA AND HERZEGOVINA (Brcko District)	GAUL 2008 admin level1
RS	Espon (from serbian office), Municipalities of Serbia, 2008 for Agricultural population 2002	GAUL 2008 admin level1
	Wikipedia: District of Central Serbia	GAUL 2008 admin level1
RU	Russian Federation, Federal State Statistical Office	GAUL 2008 admin level1
GE	Mixed: 2003 census, The Department of Statistics of Georgia estimated Abkhazia's 2005 Encyclopedia Britannica (2007)	Geographics

8.3 MODIS land use classes and the new classes created to fit the Metronamica land use model

MODIS Land use classes		Metronamica land use classes		Category
0	Water	**9**	Water	Feature
1	Evergreen needleleaf forest	**3**	Forest	Function
2	Evergreen broadleaf forest			
3	Deciduous needleleaf forest			
4	Deciduous broadleaf forest			
5	Mixed Forests			
6	Closed Shrubland	**1**	Shrubland	Vacant
7	Open Shrubland			
8	Woody Savannas			
9	Savannas			
10	Grasslands	**4**	Grassland	Function
11	Permanent wetlands	**7**	Permanent wetlands	Feature
12	Croplands	**5**	Croplands	Function
13	Urban and build-up	**6**	Urban and build-up	Function
14	Crops/natural vegetation	**0**	Crop/ Natural Vegetation	Vacant
15	Snow and ice	**8**	Snow and Ice	Feature
16	Barren or sparsely vegetated	**2**	Barren or sparsely vegetated	Vacant

8.4 Estimation of land use demand from IMAGE 2.2

A1	*Forest*		*Grassland*		*Crops*	
	2025	2050	2025	2050	2025	2050
OECD	-0,0448	-0,1246	-0,0035	-0,0037	0,0456	0,1409
Eastern	0,1166	-0,0519	0,0020	0,0000	-0,1172	0,0524
Former	0,0052	0,0269	0,0019	0,0019	-0,0064	-0,0172

B1	*Forest*		*Grassland*		*Crops*	
	2025	2050	2025	2050	2025	2050
OECD	-0,0176	-0,0521	-0,0029	-0,0041	0,0157	0,0631
Eastern	0,1141	-0,0233	0,0020	0,0000	-0,1147	0,0237
Former	0,0096	0,0355	0,0028	0,0085	-0,0114	-0,0285

A2	*Forest*		*Grassland*		*Crops*	
	2025	2050	2025	2050	2025	2050
OECD	-0,0194	-0,0500	-0,0048	-0,0041	0,0197	0,0592
Eastern	0,0821	0,0019	0,0020	0,0000	-0,0827	-0,0015
Former	0,0031	0,0080	0,0003	0,0013	-0,0032	0,0035

B2	*Forest*		*Grassland*		*Crops*	
	2025	2050	2025	2050	2025	2050
OECD	-0,0039	-0,0288	-0,0033	-0,0051	0,0025	0,0376
Eastern	0,0101	0,0016	0,0008	-0,0115	-0,0127	-0,0002
Former	0,0031	0,0080	0,0000	0,0039	-0,0104	-0,0071