Proposed demographic scenario

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Abstract:

This document illustrates the different phases leading to the creation of demographic scenarios for the countries included in the Black Sea Catchment (BSC). 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 urban and total population trends over the period 2010-2050 for the 214 enviroGRIDS regions, consistent with BS HOT, BS ALONE, BS COOP and BS COOL scenarios.

Successively, we illustrate the methodology do define the estimation of future urban area surfaces, based mainly on the historical and future trends of urban densities.

Contents

Introduction

enviroGRIDS[1] is a EU FP7 project, aiming to address the subjects of ecologically unsustainable development and inadequate resource management in the Black Sea Catchment area.

The Workpackage 3 (WP3) is going to implement a set of models and tools for the production of demographic (Task 3.1), climatic (Task 3.2) and land cover change (Task 3.3) scenarios at the Black Sea Catchment scale. Scenarios hold a number of plausible alternatives (storylines) which are based on a coherent set of assumptions, with key relationships and driving forces. The storylines are based on the IPCC – SRES (Nakicenovic et al., 2000) four marker scenarios which represent different global socio-economic development pathway (UAB, 2010).

These scenarios provide different views on the future of the BSC study through the exploration of what might happen given certain assumptions about the development of society and environmental change. The enviroGRIDS simulation of the future scenarios for land use is based on a dynamic spatial system based on a cellular automata model. The inputs to the model are different types of spatially referenced digital data including:

• Land use maps showing the distribution of land use types in the area of interest. These maps include MODIS 2001 and 2008, respectively the start and end of the calibration period.

• Suitability maps showing the inherent suitability of the area of interest for different land use types. These maps are created using an overlay analysis of maps of various physical, environmental and institutional factors.

• Zoning maps showing the zoning status (i.e. protected areas) for various land uses in the area of interest.

• Accessibility maps showing accessibility to transportation networks for the area of interest.

• Socio-economic data, for the main administrative regions of the area of interest, comprising demographic statistics.

The model outputs consist of maps showing the quantification of the four alternative scenarios for the predicted evolution of land use change in the area of interest, over the next fourth years.

In this deliverable we will describe the different phases of demographic data collection and analysis focusing on their integration into a regional model including land use and climatic scenarios of change. This regional Black Sea Catchment (BSC) model is created using the *Metronamica* (Riks, 2005, 2009; UAB, 2010) software environment.

Metronamica is a unique generic forecasting tool for planners to simulate and assess the integrated effects of their planning measures on urban and regional development. As an integrated spatial decision support system, *Metronamica* models socio-economic and physical

[1] http://www.envirogrids.net/

planning aspects, by incorporating a mature land use change model that helps to make these aspects spatially explicit.

Purpose and Scope

The main objective of Task 3.1 is to set up an infrastructure and to implement analytical modules that will enable the production of time series of prospective demographic data, to be used as input for the hydrological basin models (WP 4: SWAT) as well as for previous impact assessments on different societal benefit areas.

The final outputs of Task 3.1 correspond to two main objectives:

Objective 1): set-up the demographics inputs to build the integrated scenarios of change: Regional urban population (this Deliverable)

The first objective is to produce the population datasets to be used in the integrated model of population, land use and climate change for the four scenarios of change. The specificity of these datasets will conform to the *Metronamica* environment. Its simplified workflow includes:

- Setting up of a demographic database at regional level ("NUTS2-like") including Urban and Total population for the base years 2001 and 2008, and cities > than 10,000 inhabitants
- Population projection until 2050 according to the enviroGRIDS (task 3.4) scenarios and UN variants
- Estimation of urban area surfaces until 2050 following the enviroGRIDS scenarios.

Objective 2): Spatial disaggregation of population data for demographic scenarios of change (winter 2011)

This second objective is to transfer the regional demographic database from the original politico-administrative units to a reference grid (downscaling). By producing raster grids of population at the relevant spatial resolution, it is possible to further re-aggregate the cell values to any size of spatial units. In order to allow for future eventual interaction with land use products, the population data must be as much as possible free from information about land use. Although the outputs of Task 3.1 will be used as input for the hydrological catchment models (WP 4) and for the impact assessments in WP5, the demographic data and models should also be of use for any other users interested in harmonized, disaggregated and projected information on population distribution. The workflow of the second objective includes:

- Setting up of a demographic database at sub-national level ("NUTS3") and urban areas
- Gathering of ancillary data ("suitability" and "zoning") maps for population allocation
- Downscaling phase based on selected methodologies already described in Deliverable 3.1 (UniGe, 2010)

- Calibration / verification of the results using very fine settlements data for Ukraine and Georgia

This objective will not be discussed in this deliverable and will be further developed in a specific publication at the end of 2011.

1 Proposed Demographic scenarios: UN National scenarios and assumptions

In deliverable 3.1, we discussed about different demographic projections adopted by several organizations (UN Eurostat, Espon) and we proposed the use of data from the UN Population Division: the World Prospect Population (WPP), and the World Urbanization Prospectus (WUP) (UN/DESA, 2009, 2010)

The most common tool in population projections, at the national level, is the so-called cohort-component method. Eurostat, the UN and most national statistical bureaus use this method for their population projections. The cohort-component model is a deterministic population projection method, which means that it does not describe uncertainty, but refers to a set of scenarios chosen to represent plausible, possible or relevant (e.g., to investigate the impact of a policy change) future paths of migration, fertility and mortality.

In order to conduct a cohort-component population projection, one needs a description of the base population in the initial year of the projection. Information on the number of individuals by gender in every age group is required. Age-specific (using one- or five-year age groups) assumptions on future fertility, mortality and migration rates are used to project the population, normally in one- or five-year time intervals.

Cohort-component models are essentially “what-if” estimation of the future, where population trends are determined by a set of assumptions. These assumptions could reflect a continuation of past trends or an investigation into what would happen if there is a (constant) change in one or more of the demographic variables.

Demographic components: Fertility
Fertility assumptions are usually expressed as period fertility, i.e., total fertility rate (TFR) which is the sum of age-specific fertility at one point in time. Assumed increases or reductions in TFR could either be caused by proportional shifts in fertility across the reproductive life span or changes in early or late childbearing patterns.

Demographic components: Mortality
Mortality assumptions for projections are often simplified to changes in e(0), i.e., life expectancy at age 0. This involves implicit assumptions on the ages at which mortality is reduced (e(0) could increase due to mortality reductions primarily early or primarily late in life).

Demographic components: Migration
Migration flows fluctuate strongly and may depend on a large range of factors, including business cycles in both the sending and receiving countries, family connections in a destination

country, cost of migration, destination's reputation, attitudes to immigration and immigration laws. Migration is strongly influenced by policies. (Skirbekk et al., 2007) This contrasts with mortality and fertility where the impact of policy is much less evident. Migration regulations and practices are difficult to foresee, which makes migration the possibly most difficult demographic component to predict.

To project the population until 2050, the United Nations Population Division (UNPD) evaluates the most recent information available on each of the three major components of population change: fertility, mortality and international migration, using assumptions regarding their future trends. Because future trends cannot be known with certainty, a number of projection variants are produced.

1.1 UN Assumptions

The 2010 Revision (UN/DESA, 2011) includes eight different projection variants (Figure 1). Five of those variants differ among themselves only with respect to the level of fertility in each, that is, they share the assumptions made with respect to mortality and international migration. The five fertility variants are: low, medium, high, constant-fertility and instant-replacement fertility. A comparison of their results allows an assessment of the effects that different fertility paths have on other demographic projections

	Assumptions		
Projection variant	Fertility	Mortality	International migration
Low	Low	Normal*	Normal
Medium	Medium	Normal*	Normal
High	High	Normal*	Normal
Constant-fertility	Constant as of 2005-2010	Normal*	Normal
Instant-replacement-fertility	Instant-Replacement as of	Normal*	Normal
Constant-mortality	Medium	Constant as of 2005-2010	Normal
No-change	Constant as of 2005-2010	Constant as of 2005-2010	Normal
Zero-migration	Medium	Normal*	Zero as of

* Including the impact of HIV/AIDS in 58 countries

Fig.1: Eight projections variants from UN Population Division. The first three variants Low, Medium and High (in the red box) are kept for the Envirogrids project.

Mortality assumption:

Mortality is projected on the basis of models of change of life expectancy produced by the United Nations Population Division (UN/DESA, 2009). The selection of a model for each country is based on recent trends in life expectancy by sex. For countries highly affected by the HIV/AIDS epidemic, the model incorporating a slow pace of mortality decline has generally been used to project a certain slowdown in the reduction of general mortality risks not related to HIV/AIDS.

Normal migration assumption:
Under the normal migration assumption, the future path of international migration is set on the basis of past international migration estimates and consideration of the policy stance of each country with regard to future international migration flows. Projected levels of net migration are generally kept constant over most of the projection period.

1.1.1 Medium-fertility assumption

Total fertility in all countries is assumed to converge eventually toward a level of 1.85 children per woman. However, not all countries reach this level during the projection period, that is, by 2045-2050. Projection procedures differ slightly depending on whether a country had a total fertility above or below 1.85 children per woman in 2005-2010.

Fertility in high and medium fertility countries is assumed to follow a path derived from models of fertility decline established by the United Nations Population Division on the basis of the past experience of all countries with declining fertility during 1950-2000.

1.1.2 High-fertility assumption

Under the high variant, fertility is projected to remain 0.5 children above the fertility in the medium variant over most of the projection period. By 2045-2050, fertility in the high variant is therefore half a child higher than that of the medium variant. That is, countries reaching a total fertility of 1.85 children per woman in the medium variant have a total fertility of 2.35 children per woman in the high variant at the end of the projection period.

1.1.3 Low-fertility assumption

Under the low variant, fertility is projected to remain 0.5 children below the fertility in the medium variant over most of the projection period. By 2045-2050, fertility in the low variant is therefore half a child lower than that of the medium variant. That is, countries reaching a total fertility of 1.85 children per woman in the medium variant have a total fertility of 1.35 children per woman in the low variant at the end of the projection period.

1.1.4 Constant-fertility assumption

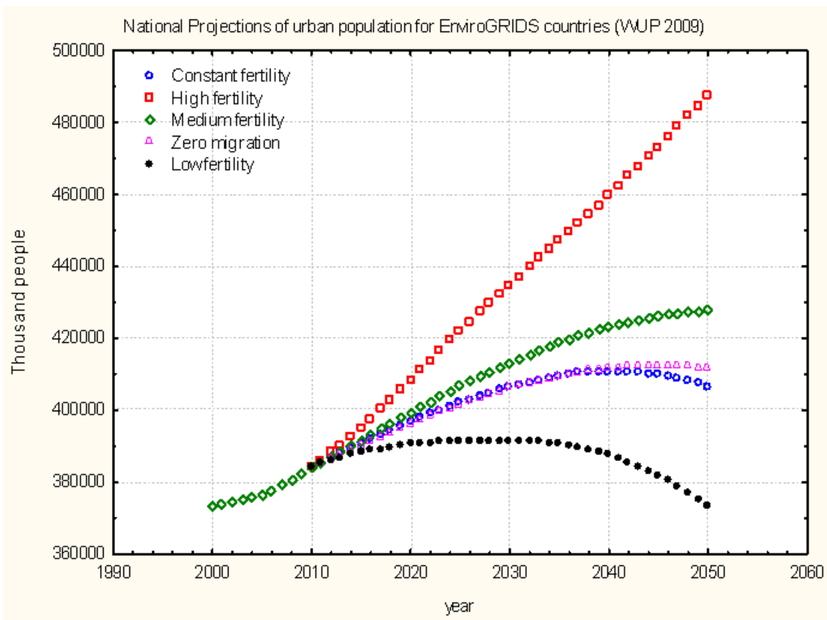
For each country, fertility remains constant at the level estimated for 2005-2010.

1.1.5 Urban Population Projections

Europe is one of the most urbanized continents on Earth. Today, approximately 75 % of the European population lives in urban areas (UN/DESA, 2010). The urban future of Europe, however, is a matter of great concern. More than a quarter of the European Union's territory has now been directly affected by urban land use. By 2020, approximately 80 % of the Europeans will be living in urban areas, while in seven countries the proportion will be 90 % or more (EEA, 2006).

The projections calculated for Urban areas by the United Nations are included in the World Urban Prospectus published in 2009 (WUP09). They estimate future data using the medium variant fertility assumption.

Urban projections are recalculated by applying the Urban/Total population ratio, using the three standard fertility assumptions (high, medium and low), constant fertility and zero migration. Figure 2 summarizes the different scenarios for the full BS Catchment and for its urban areas.



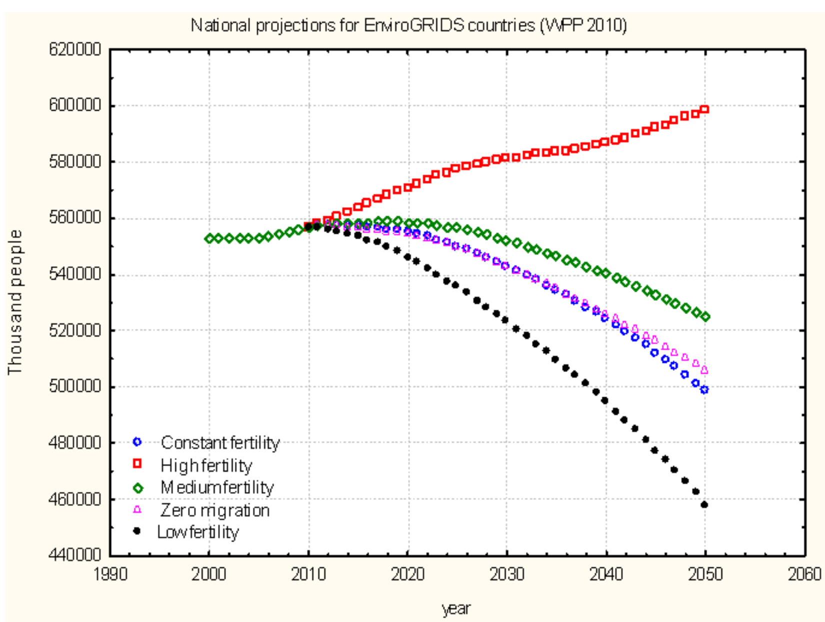


Fig.2: Urban and total population projections for BSC countries including six variants (WUP 2009, WPP 2010)

While total population for the sum of the countries of the BSC is predicted to decrease for all the WPP10 variants, except for High fertility, the urban one shows a clearly different pattern where only the data estimate with a low fertility assumption has a strong decreasing trend (fig. 2).

Projected values, using the medium variant, point to a generalized increase of urban population for all single countries in the BSC (fig.3).

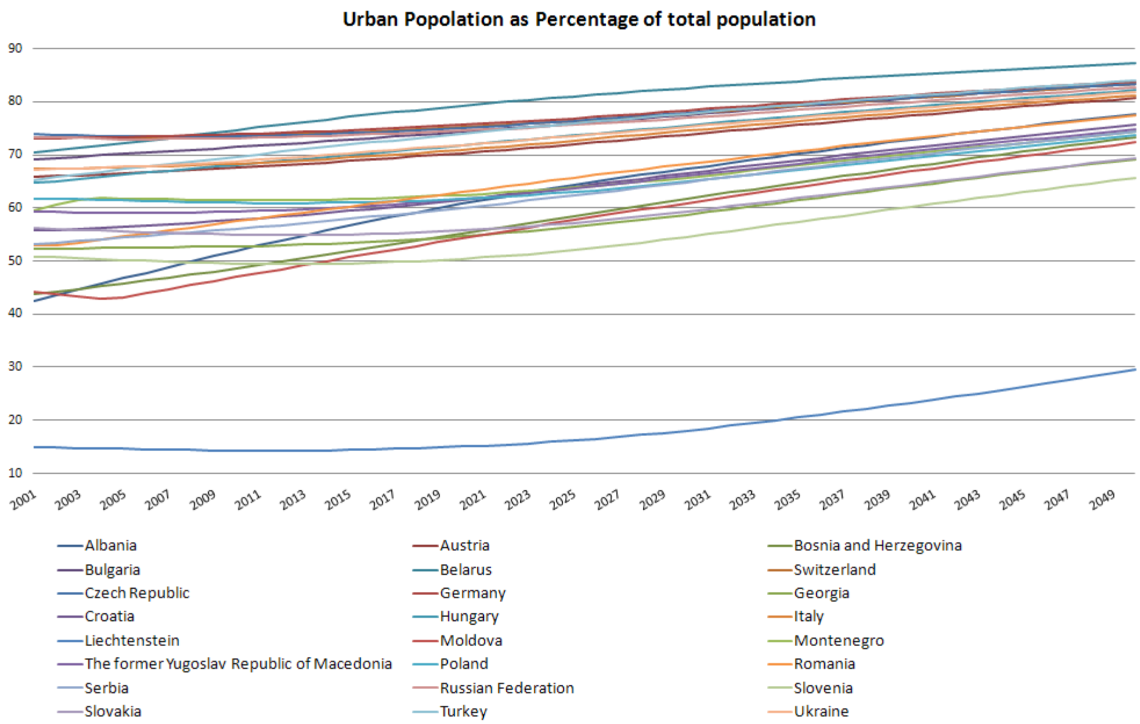


Fig.3: Urban population is growing everywhere in UN Projections (medium variant) in the BSC countries (WUP 2009)

1.2 Integration into the enviroGRIDS scenarios

The proposed enviroGRIDS scenarios are a number of plausible alternatives (narrative storylines) which are based on a coherent set of assumptions, about key relationships and driving forces, to create a set of quantitative information, internally consistent and spatially explicit scenarios of future climate, demography and land use covering full Black Sea Catchment (UAB, 2010).

These scenarios provide different views on the future of the BSCC study through the exploration of what might happen given certain assumptions about the development of society and environmental change.

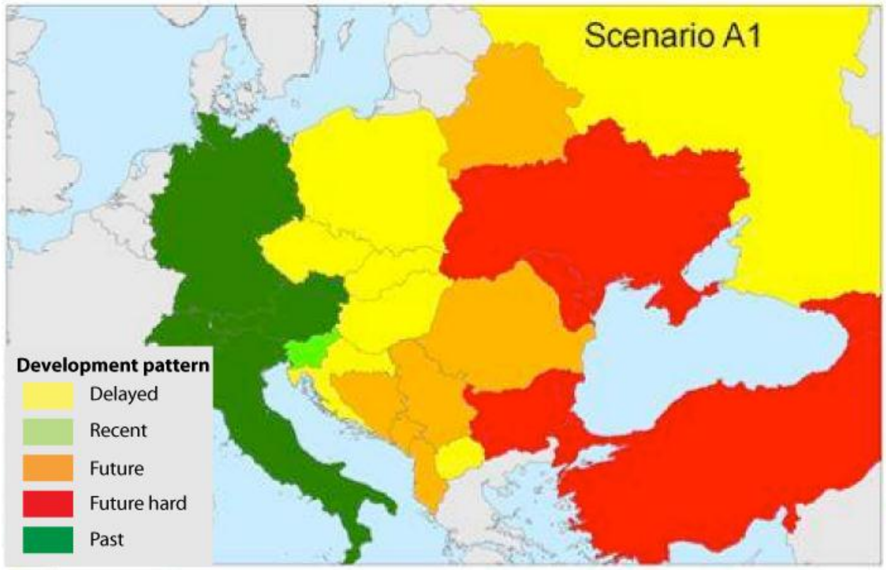
Four main scenarios of the Black Sea Region based on IPCC-SRES scenarios (Nakicenovic et al., 2000) are presented here:

- Global Competitive/trend (A1) named “BS HOT”
- BS Region fragmented (A2) named “BS ALONE”
- BS Region strong cooperation (B1) named “BS COOP”
- Adaptive/ Sustainable (B2) named “BS COOL”

	Scenarios			
Driving forces	**HOT (A1)**	**ALONE (A2)**	**COOP(B1)**	**COOL (B2)**
Population growth	low	highest	low	medium
GDP growth	highest	low	high	medium
Area of Forest	increase	decrease	increase	decrease
Area of Grassland	increase	decrease	increase	decrease
Area of Cropland	decrease or stable	increase	decrease	increase
Area of Build-up area	increase	increase	increase	increase
Protected Areas	stable	stable	increase	stable
Climate change	high	high	low	low
Technological Development	high	low	high	medium
Water Demand	high	---	low	---

Fig.4: Resume of driving forces from (UAB, 2010)

1.2.1 Global Competitive/trend (A1): BS HOT

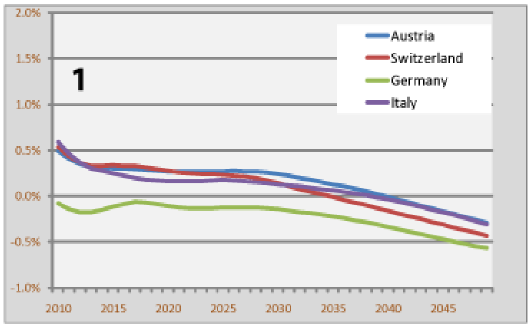


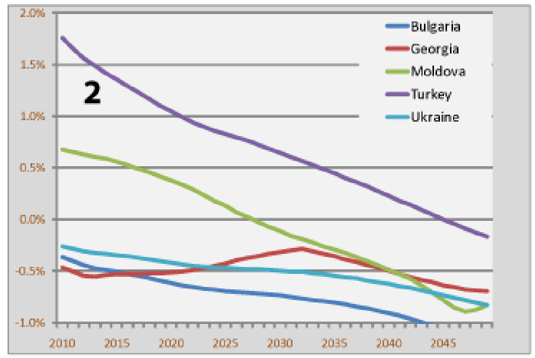
The BS **HOT** scenario contains the highest economic growth, with low population increase and highest increase in Greenhouse gas emissions and consequently global climate change.

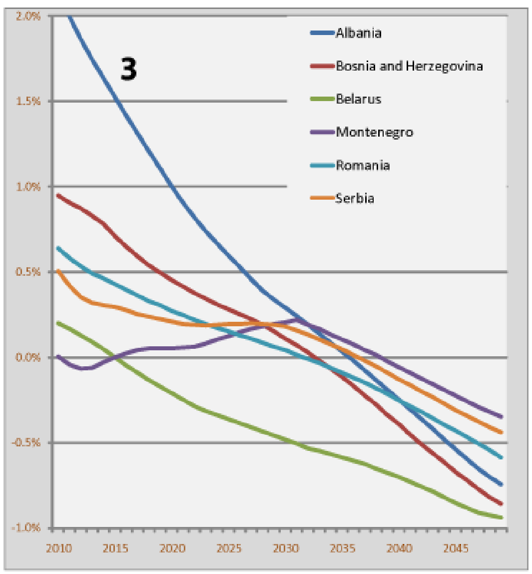
Fig.5a: Development pattern (UAB, 2010)

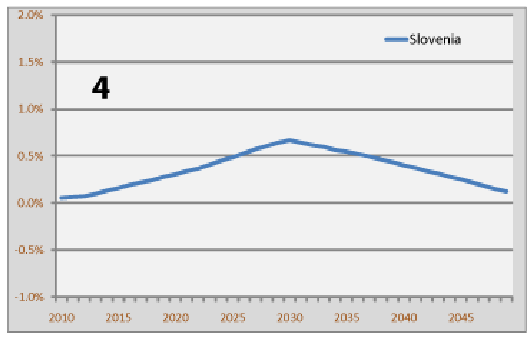
- Germany, Austria and Italy, Switzerland are included in the *past development countries group*, showing at present the highest GDP with smallest rates of future economic growth. They are also expected to have a certain increase in population growth at least during the first period 2000-2025.
- Turkey, Ukraine, Bulgaria, Georgia, Moldova are included in the *future hard development pattern* group. This pattern outlines the association between future highest economic growths countries expected to exhibit also the strongest depopulation.
- Belarus, Romania, Serbia, Bosnia and Herzegovina, Montenegro and Albania are included in the *future development pattern* group which are currently states of changing economic status and also expected to have population growth, with less depopulation process in the future.
- Slovenia is the only country with high economic status, also expected to undergo substantial future economic growth, but with less depopulation process in the future.
- Russia, Poland, Croatia, Hungary, Slovakia, Czech Republic, Macedonia are included in the delayed development pattern which consists of different states expected to reach higher economic prospects in the future and also with depopulation processes.

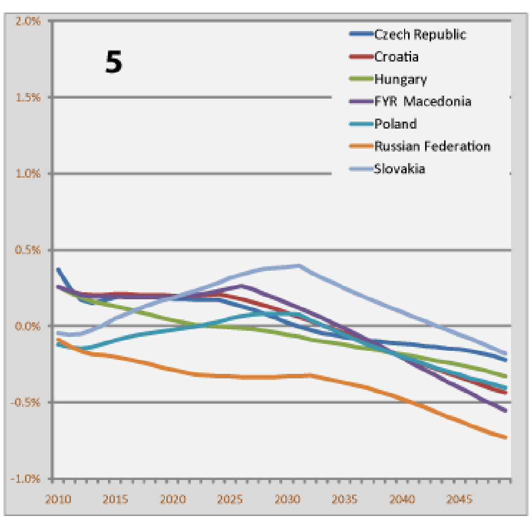
Hot (A1) Annual urban population growth rate











Urban population:
annual growth rate (percent)
LOW projection variant

1) Past development countries

2) Future hard development pattern

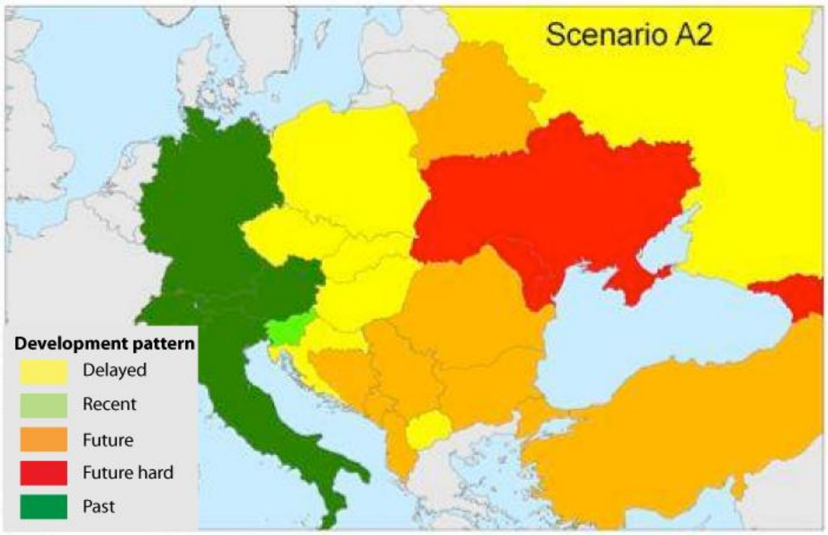
3) Future development pattern

4) Recent development pattern

5) Delayed development pattern

Population data source: WPP2010, WUP 2009

1.2.2 BS Region fragmented (A2): BS ALONE



The BS **ALONE** scenario is characterized by lower trade flows and regionally oriented economic growth

Small economic growth is expected, however the estimations for the BSC countries indicate mostly future economic growth in the Eastern Europe surrounding the Black Sea

Fig.5b: Development pattern (UAB, 2010)

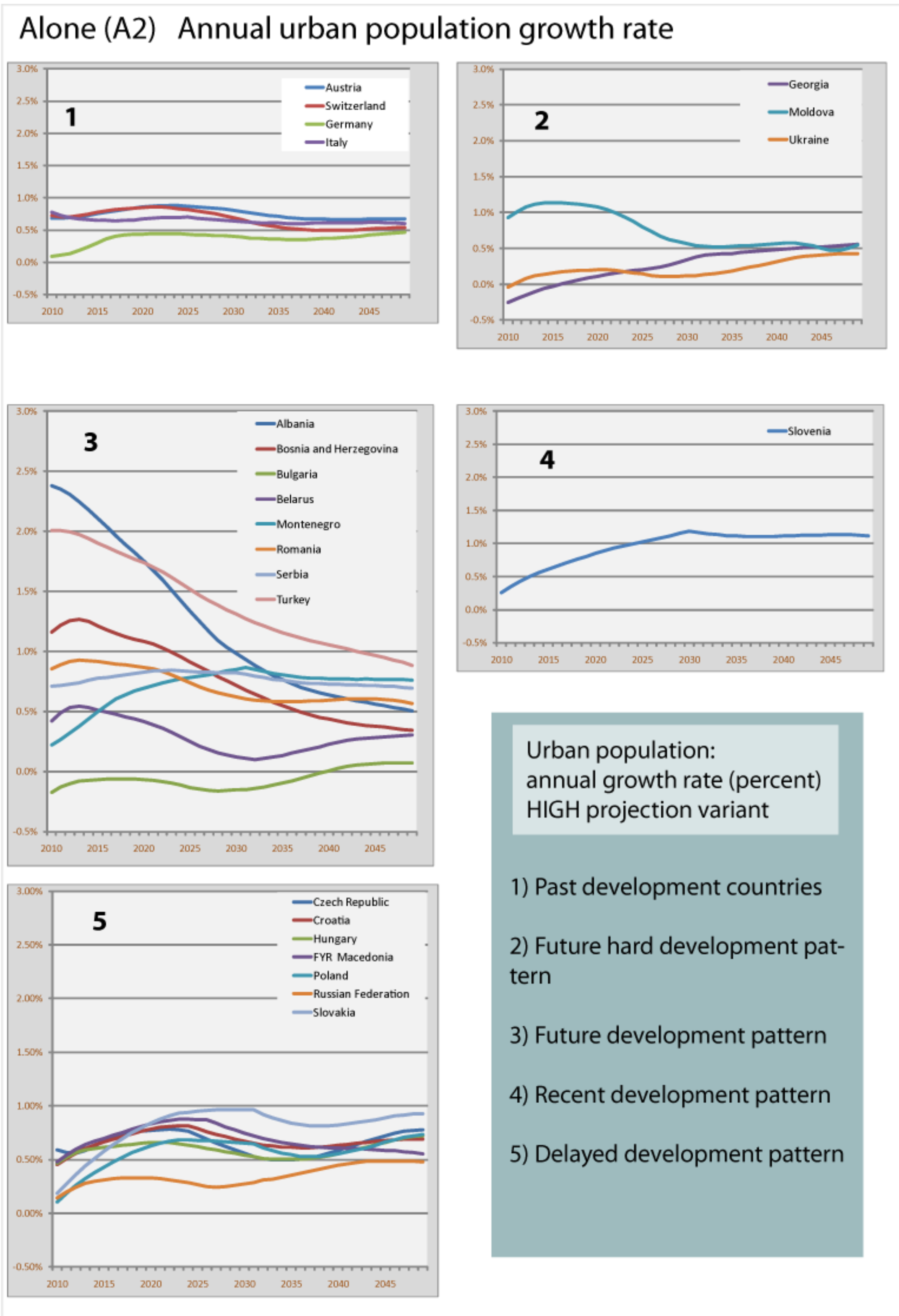
- Germany, Austria and Italy, Switzerland are included in the past development countries, showing at present the highest GDP with smallest rates of future economic growth. They are also expected to have a certain increase in population growth at least during the first period 2000-2025.

- Ukraine, Georgia, Moldova are included in the future hard development pattern. This pattern outlines the association between future highest economic growth countries expected to also exhibit the strongest depopulation.

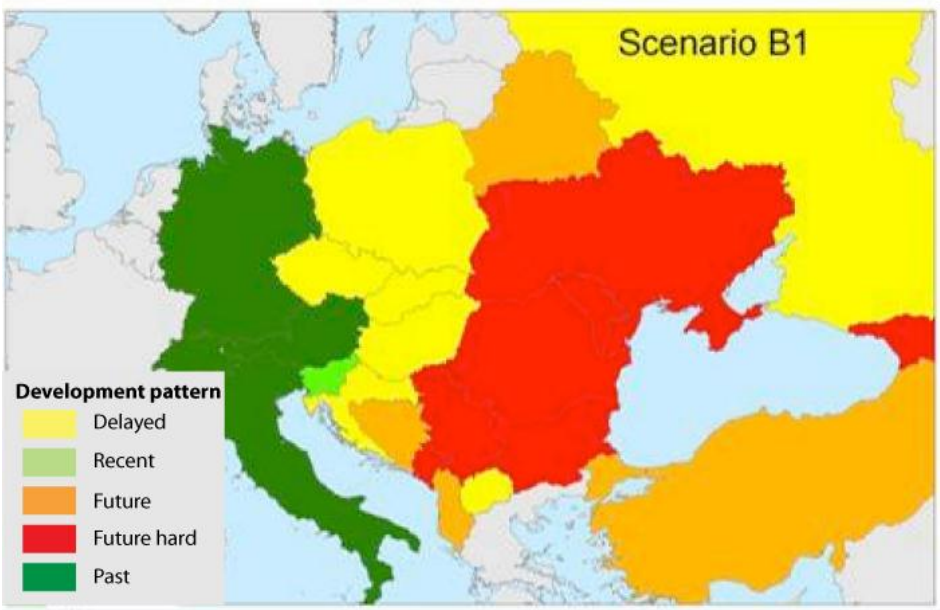
- Turkey, Bulgaria, Belarus, Romania, Serbia, Bosnia and Herzegovina, Montenegro and Albania are included in the future development pattern which are currently states of varying economic status, also expected to have population growth, with less depopulation process in the future.

- Slovenia is the only counter with high economic status, also expected to undergo substantial future economic growth, but with less depopulation process in the future.

- Russia, Poland, Croatia, Hungary, Slovakia, Czech Republic, Macedonia are included in the delayed development pattern which includes different states expected to reach higher economic prospects in the future and also with depopulation processes.


Alone (A2) Annual urban population growth rate
1
Austria
Switzerland
Germany
Italy
2
Georgia
Moldova
Ukraine
3
Albania
Bosnia and Herzegovina
Bulgaria
Belarus
Montenegro
Romania
Serbia
Turkey
4
Slovenia
5
Czech Republic
Croatia
Hungary
FYR Macedonia
Poland
Russian Federation
Slovakia
2010 2015 2020 2025 2030 2035 2040 2045
Urban population:
annual growth rate (percent)
HIGH projection variant
1) Past development countries
2) Future hard development pattern
3) Future development pattern
4) Recent development pattern
5) Delayed development pattern

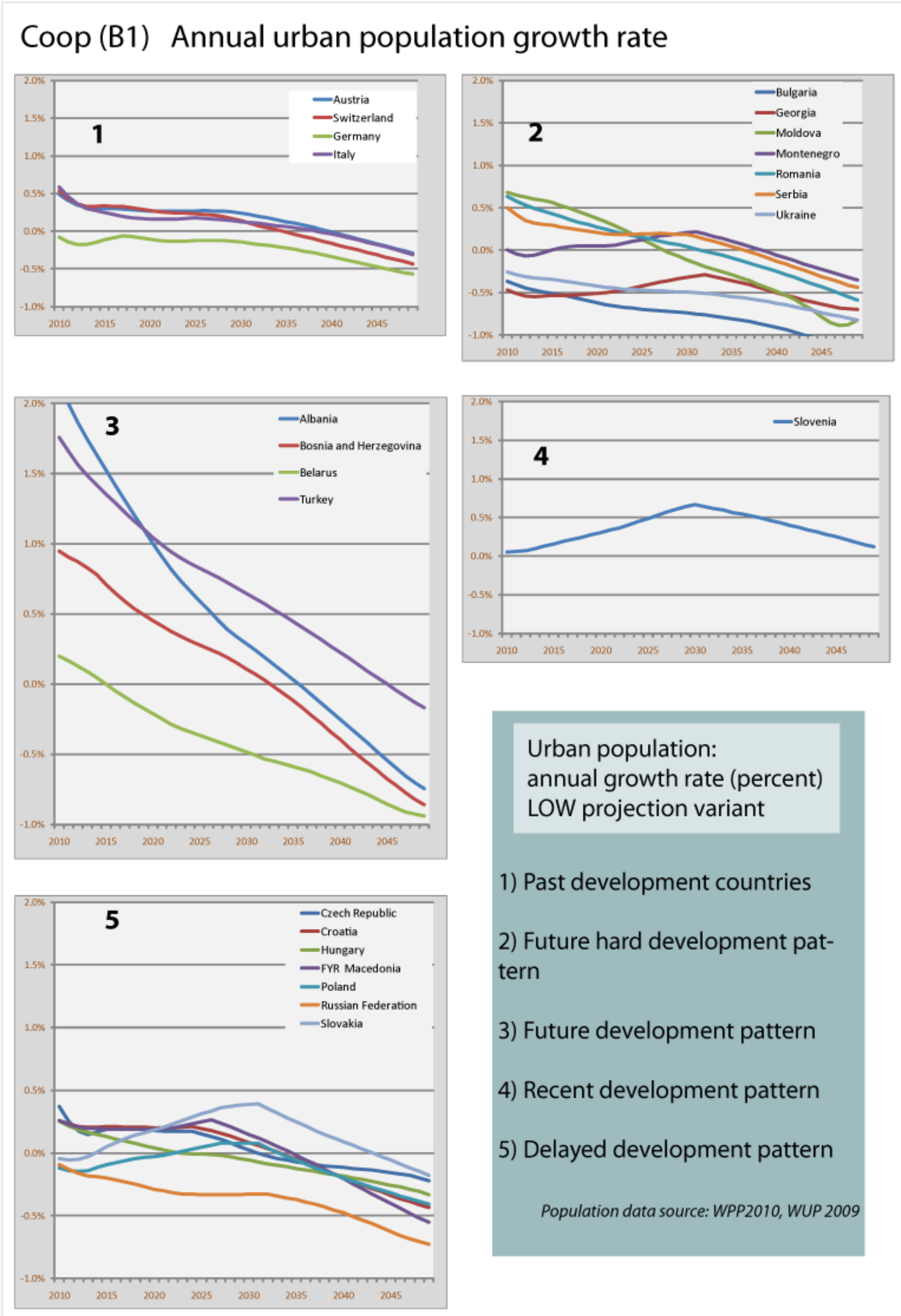
1.2.3 BS Region strong cooperation (B1): BS COOP



The BS **COOP** Scenario combines high economic development with prospects of low population increase. The depopulation processes are only prominent during the first period (2000-2025) and nearly no further population changes are estimated afterwards.

Fig.5c: Development pattern (UAB, 2010)

- Germany, Austria and Italy, Switzerland are included in the past development countries, showing at present the highest GDP with smallest rates of future economic growth. They are also expected to have a certain increase in population growth at least during the first period 2000-2025.
- Romania, Serbia and Montenegro, Ukraine, Bulgaria, Georgia, Moldova are included in the future hard development pattern. This pattern outlines the association between future highest economic growths countries expected to exhibit also the strongest depopulation.
- Turkey, Belarus, Bosnia and Herzegovina, and Albania are included in the future development pattern which are currently states of varying economic status, also expected to have population growth, with less depopulation process in the future.
- Slovenia is the only counter with high economic status, also expected to undergo substantial future economic growth, but with less depopulation process in the future.
- Russia, Poland, Croatia, Hungary, Slovakia, Czech Republic, Macedonia are included in the delayed development pattern which includes different states expected to reach higher economic prospects in the future and also with depopulation processes.


Coop (B1) Annual urban population growth rate
1
Austria
Switzerland
Germany
Italy
2
Bulgaria
Georgia
Moldova
Montenegro
Romania
Serbia
Ukraine
3
Albania
Bosnia and Herzegovina
Belarus
Turkey
4
Slovenia
5
Czech Republic
Croatia
Hungary
FYR Macedonia
Poland
Russian Federation
Slovakia
Urban population:
annual growth rate (percent)
LOW projection variant
1) Past development countries
2) Future hard development pattern
3) Future development pattern
4) Recent development pattern
5) Delayed development pattern
Population data source: WPP2010, WUP 2009

1.2.4 Adaptive/ Sustainable (B2): BS COOL

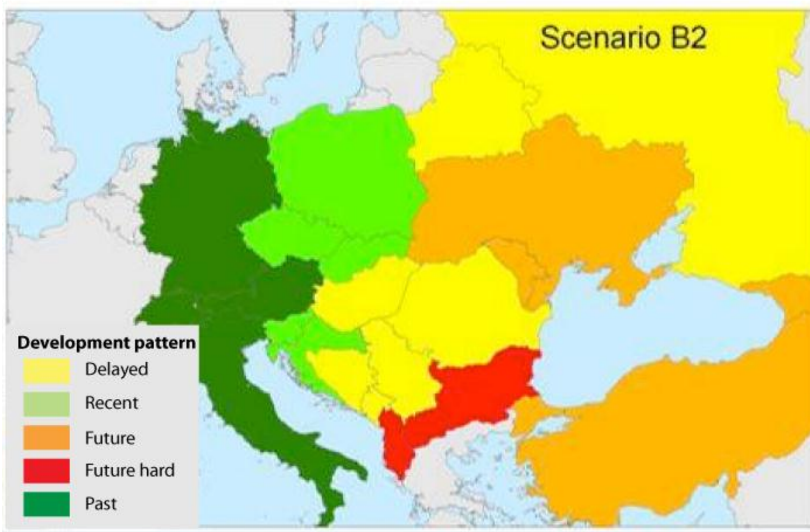


Fig.5d: Development pattern (UAB, 2010)

The BS COOL scenario combines intermediate economic growth with medium population density increase globally. In the BSC however, population numbers are only expected to increase in the group of recent development. Generally this scenario reveals the most heterogeneous patterns of developments in the BSC countries.

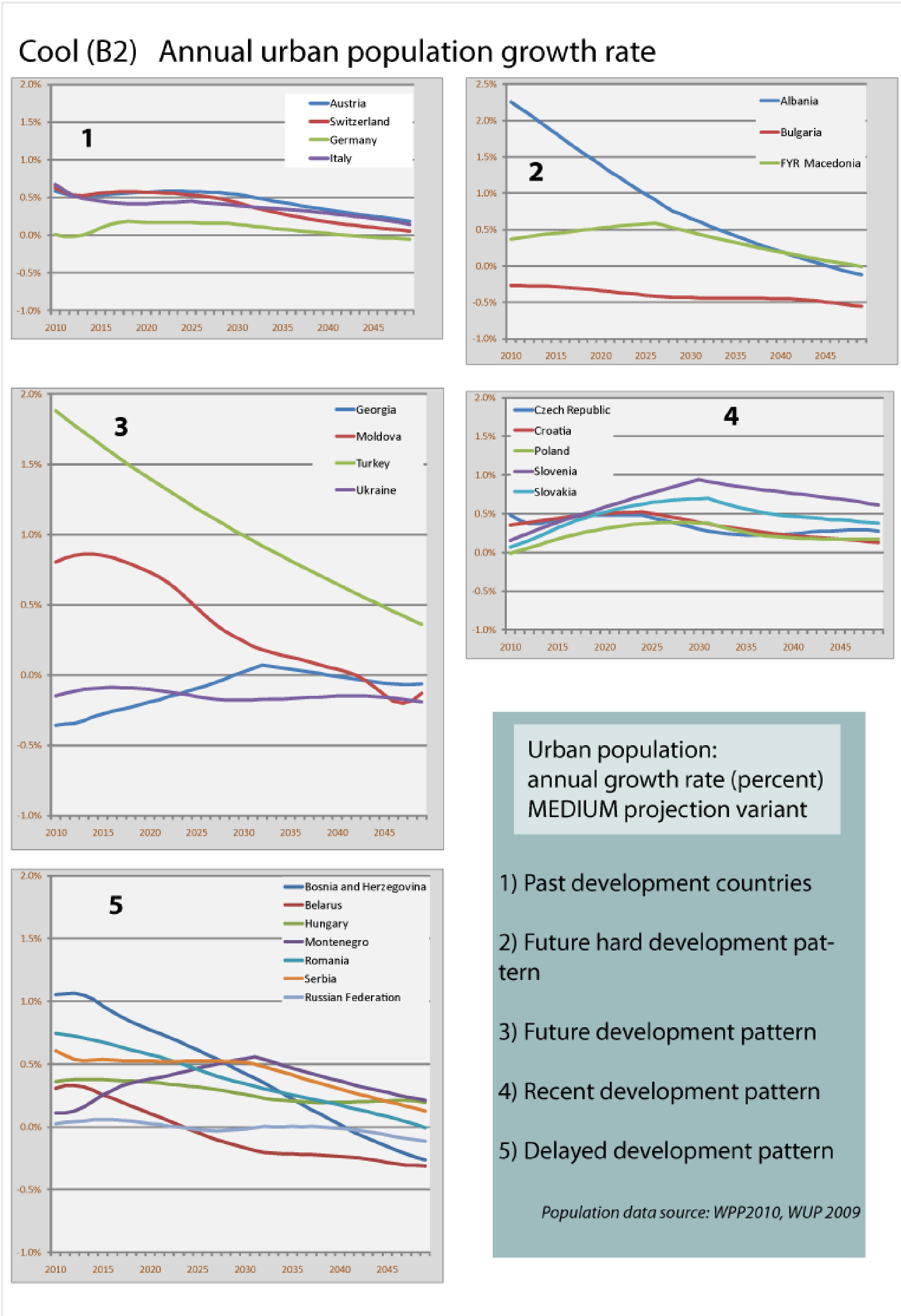
- Germany, Austria and Italy, Switzerland are included in the past development countries, showing at present the highest GDP with smallest rates of future economic growth. They are also expected to have a certain increase in population growth at least during the first period 2000-2025.

- Bulgaria, Albania, Macedonia are included in the future hard development pattern. This pattern outlines the association between future highest economic growths countries expected to exhibit also the strongest depopulation.

- Turkey, Ukraine, Moldova, Georgia are included in the future development pattern which are currently states of varying economic status, also expected to have population growth, with less depopulation process in the future.

- Slovenia, Poland, Slovakia, Czech Republic, Croatia are included in the recent development pattern, showing high economic status, also expected to undergo substantial future economic growth, but with less depopulation process in the future.

- Russia, Belarus, Romania, Hungary, Bosnia and Herzegovina, Serbia and Montenegro are included in the delayed development pattern which includes different states expected to reach higher economic prospects in the future and also with depopulation processes.


Cool (B2) Annual urban population growth rate
1
Austria
Switzerland
Germany
Italy
2
Albania
Bulgaria
FYR Macedonia
3
Georgia
Moldova
Turkey
Ukraine
4
Czech Republic
Croatia
Poland
Slovenia
Slovakia
5
Bosnia and Herzegovina
Belarus
Hungary
Montenegro
Romania
Serbia
Russian Federation
Urban population:
annual growth rate (percent)
MEDIUM projection variant
1) Past development countries
2) Future hard development pattern
3) Future development pattern
4) Recent development pattern
5) Delayed development pattern
Population data source: WPP2010, WUP 2009

2 Demographic Scenarios Quantification: regional demographic model

The aim of this section is to illustrate the workflow used to transpose the demographic scenarios of each country to a sub-national level, in order to build regional scenarios of urban population that will be used with the land use (and Climate) scenarios into the *Metronamica* environment.

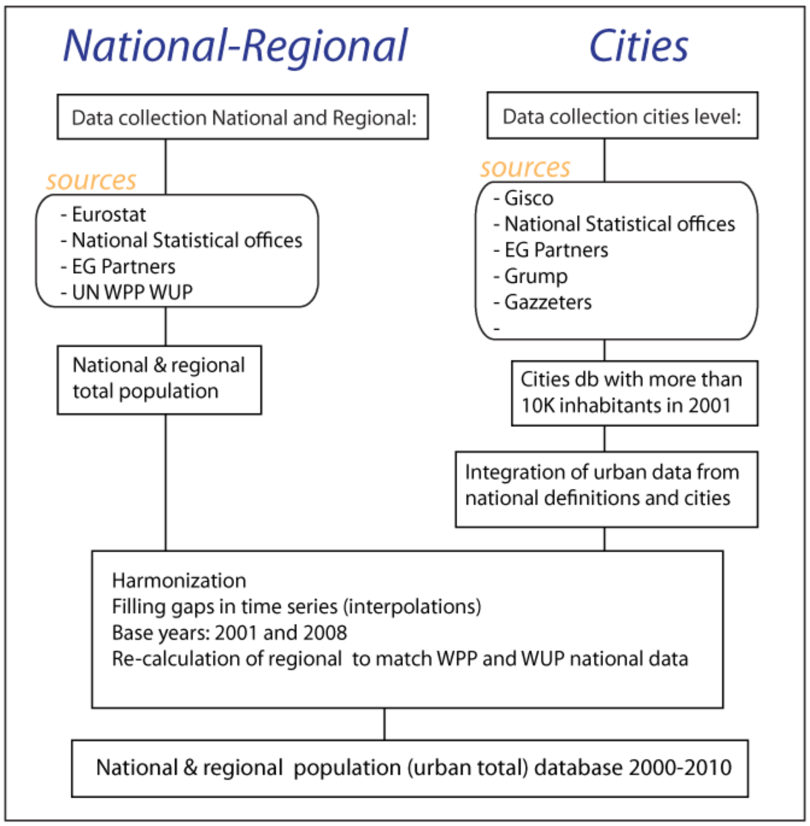


Fig.6: data processing workflow

Metronamica needs the following demographic inputs:

- Number of cells of urban people for 2001 and 2008 at regional level for the calibration phase,
- Number of cells of urban people for 2009-2050 according to the three main UN assumptions (high-low-medium) for the scenarios phase

2.1 Choice of regions

The main reason to use a regional model is the fact that single countries are only partially included in the enviroGRIDS coverage. We need to disaggregate countries into smaller entities and then re-aggregate them.

Another good reason is that regional dynamics are more active than national dynamics; the regional model simulates distribution of overall growth or decline of population. This simulation is based on a spatial interaction or gravity model operating on a regional scale. Each region attracts people and jobs from each other region proportional to its own attractiveness.

For EU countries in the EG BSC the regions correspond to the NUTS2 level (for further information about NUTS see Terminology paragraph). For those regions outside the EU the regions are selected to correspond as much as possible in terms of size and data availability with the NUTS2 .

NUTS2 level is the best compromise in terms of spatial resolution versus availability of data (i.e. projections) and timing of calculation during the calibration phase in "*Metronamica*."

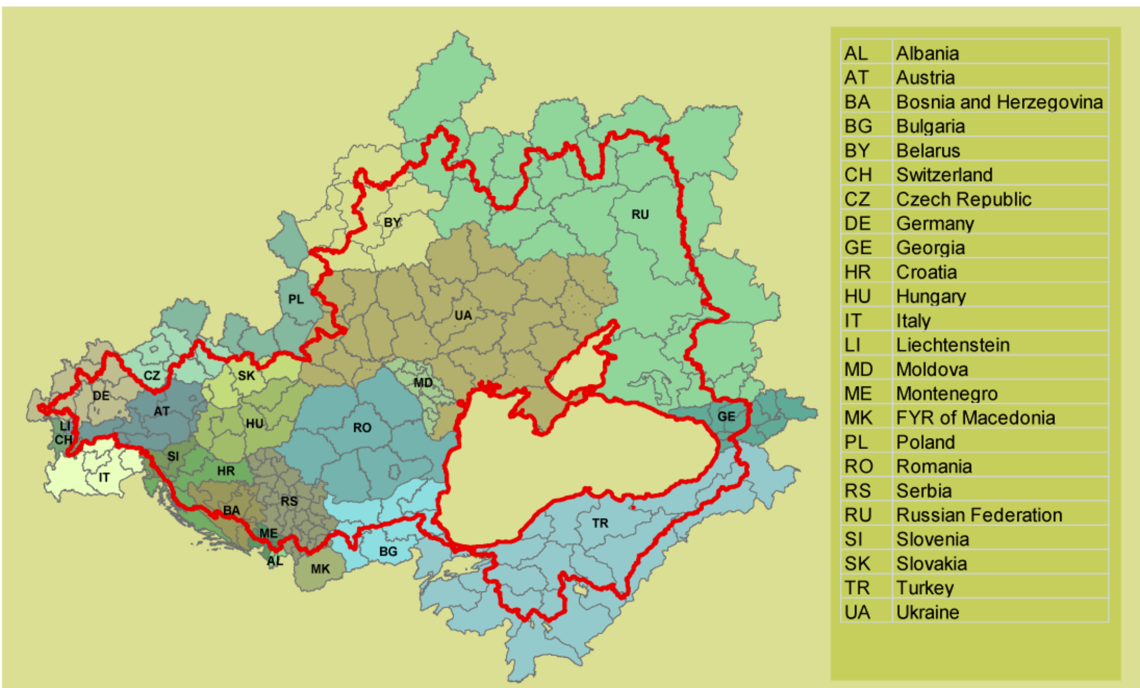


Fig.7: the 214 regions, in red the BSC

We selected all the regions included in the Black Sea Catchment (BSC) including those that are partially (even if only by 1 km^2) comprised in the BSC, as a result of the fact that the statistical data associated within the regional boundaries is not (easily) spatially divisible.

These 214 regions (fig 7) will be the extent of Reference for the WP3 integrated scenarios.

2.2 Region boundaries

Three main sources were used to prepare the GIS regional layers at level NUTS2

- GISCO/Eurogeographics[2]
- FAO Global Administrative Unit Layers (GAUL)[3]
- Local enviroGRIDS partners (UNO and Geographics).

The procedure to assemble these heterogeneous sets of data consists in 10 different geoprocessing steps and a final validation phase.

Unfortunately several regions have changed status or delimitation boundaries between the edition on the GAUL layer and the date of publication of the statistical data. The necessary manual corrections have been carried out.

2.3 Population figures

The data on population per region were collected for all available years from several sources including Eurostat, several National statistical offices, and enviroGRIDS partners (e.g. Ukraine (ONU) and Georgia (Geographics)).

Data were heterogeneous and needed a robust process of harmonization before the integration in the regional geodatabase.

The integration process consists in three main steps

- Formatting the original data from the statistical offices in a uniform way. Sometimes it is not in tabular format or it is in a local language; moreover in some cases administrative boundaries do not correspond with the statistical nomenclature.
- Match the statistical and geometric data together (except for EU 27) by using regions names 'like' and often a manual join.
- Generate a unique ID.
- Filling gaps for missing years.

Years 2001 and 2008 correspond to the start and end of the calibration period used in the *Metronamica* calibration (see next chapters). Our effort was to concentrate on collecting data for these periods as far as possible directly from the sources.

Once the two years of the calibration period were completed, a time series was built for the period 2000-2010:

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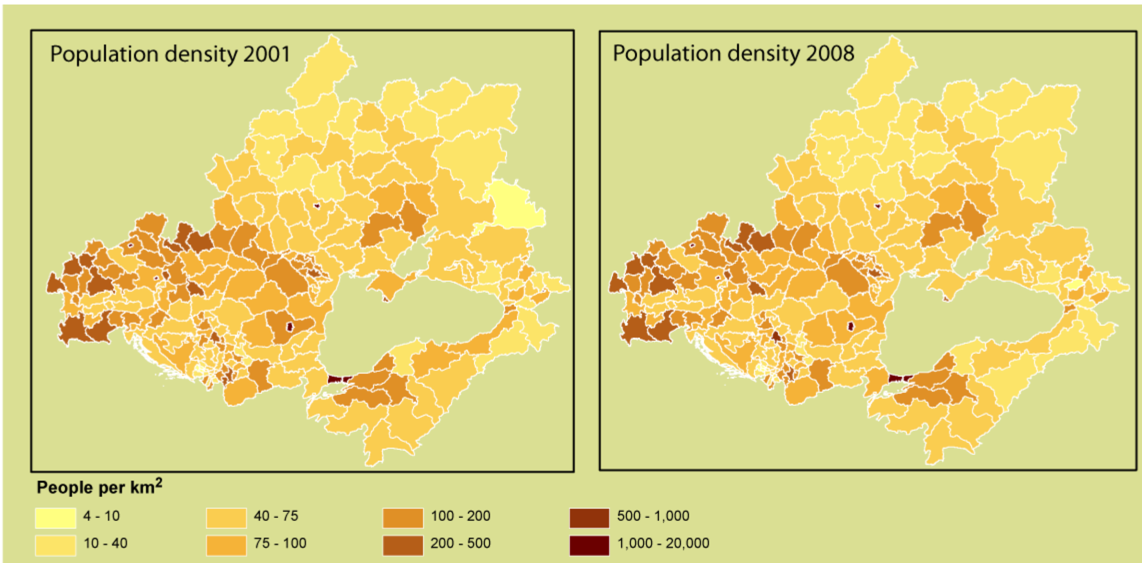
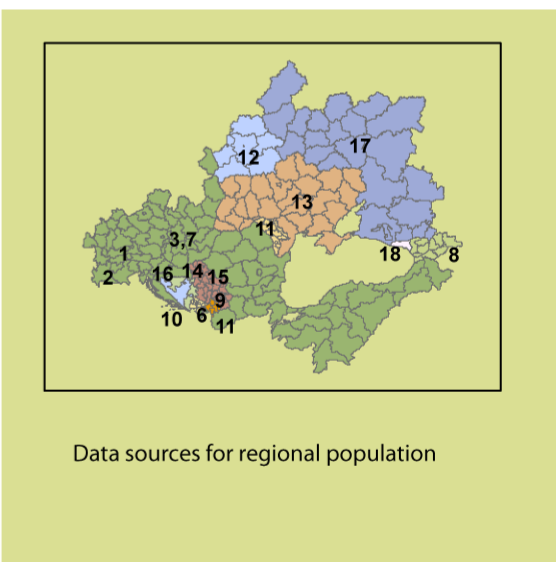
[2] http://epp.eurostat.ec.europa.eu/portal/page/portal/gisco_Geographical_information_maps/introduction

[3] http://www.fao.org/geonetwork/srv/en/metadata.show?id=12691

We calculate the annual growth ratio using the difference of population figures between known years. Successively the ratio where applied to estimate the missing years. For the majority of regions calculations were filled by interpolation: estimations within the range of a discrete set of known years. The first set of results includes regional maps at circa NUTS2 level for 2001 and 2008

The same process was also applied to generate data at circa NUTS3 level for the year 2001. These data were further utilized in the spatial disaggregation of population data.





ID	name_source
1	Statistics Austria (National Office): Stadtregionen 2001 - Zuordnung der Gemeinden
2	ISTAT
3	Eurostat: Population by sex and age groups on 1 January - NUTS level 3 regions (demo_r_pjanaggr3)
5	AGENCY FOR STATISTICS OF BOSNIA AND HERZEGOVINA (Brcko District)
6	Albanian Institute of Statistics
7	Eurostat, 04.02.2011, Total population resident in a region. Average of population at the beginning of the year and population at the end of the year.
8	Geographics
9	Wikipedia: District of Central Serbia
10	Montenegro statistical office
11	Macedonia statistical office
12	Bielorussia statistical office population census 1999, 2009 and data for 2010
13	Regional Centre for Integrated Environmental Monitoring and Ecological Studies of Odessa National I.I. Mechnikov University
14	Republika Srpska Institute of Statistics
15	Espon (from serbian office), Municipalities of Serbia, 2008 for Agricultural population 2002
16	Statistical Office of the Federation of Bosnia and Herzegovina
17	Russian Federation, Federal State Statistical Office
18	Mixed: 2003 census, The Department of Statistics of Georgia estimated Abkhazia's 2005 Encyclopedia Britannica (2007)

Fig.8: regional population data for 2001 and 2008, within sources

2.4 Urban population and cities

The land use data used in the *Metronamica* regional model is the Moderate Resolution Imaging Spectroradiometer (MODIS) data at 1-km spatial resolution which is included as part of the MODIS Collection 4 (C4). The Global Land Cover Product MODIS (USGS, 2010) has the advantage that it comprises several releases over the time. Data for 2001 and 2008 were utilized during the *Metronamica* calibration phase (deliverable 3.6, UMA in progress). MODIS has another great interest: it has the best accuracy to detect “artificial surfaces” (Potere and Schneider, 2007; Schneider et al., 2009)

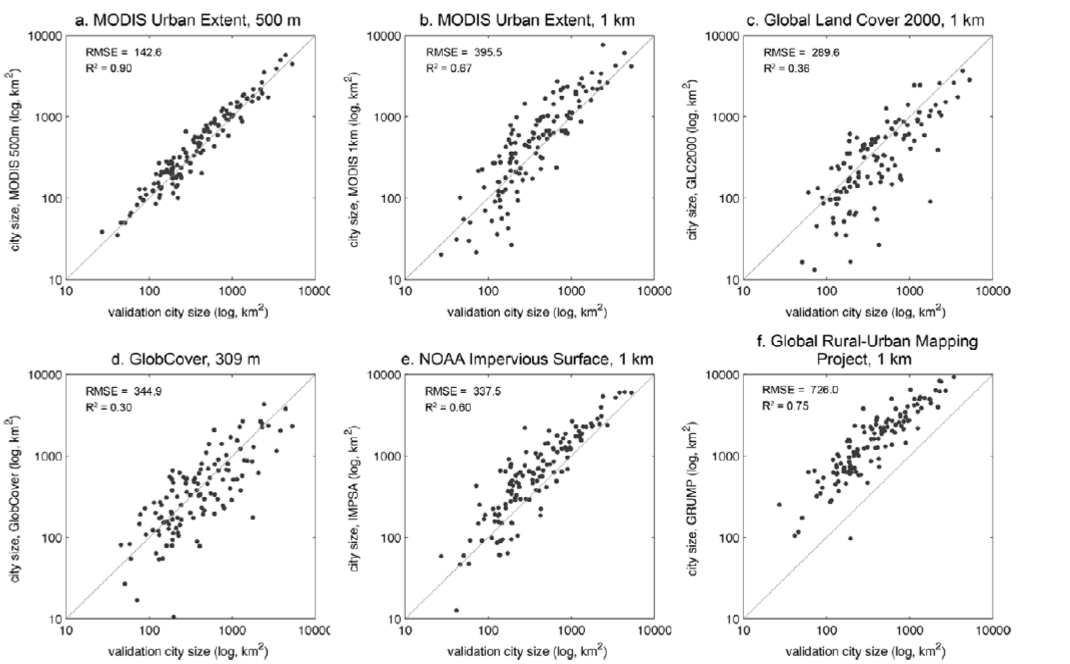


Figure 3. Scatter plots of the 140 cities in the validation sample, where each plot shows the city size from the high resolution Landsat-based reference maps (x-axis, assumed to be ‘truth’) and the global urban maps (y-axis). Note the log scale on both axes.

Fig.9: Comparisons in artificial class detection between six classical datasets from (Schneider et al., 2009)

On the MODIS land use (2001 and 2008) the built environment is represented by the artificial surfaces class (Af). It includes all non-vegetative, human-constructed elements, such as roads, buildings, runways, etc (i.e. human made surfaces), and ‘dominated’ implies a coverage greater than 50% of the cell size. Therefore, this class includes both residences and infrastructure.

The number of the people who live in these regions is known. It can reasonably be supposed that the urban part of the total population of the region is concentrated (to live or work) in these artificial surfaces or “urban land”.

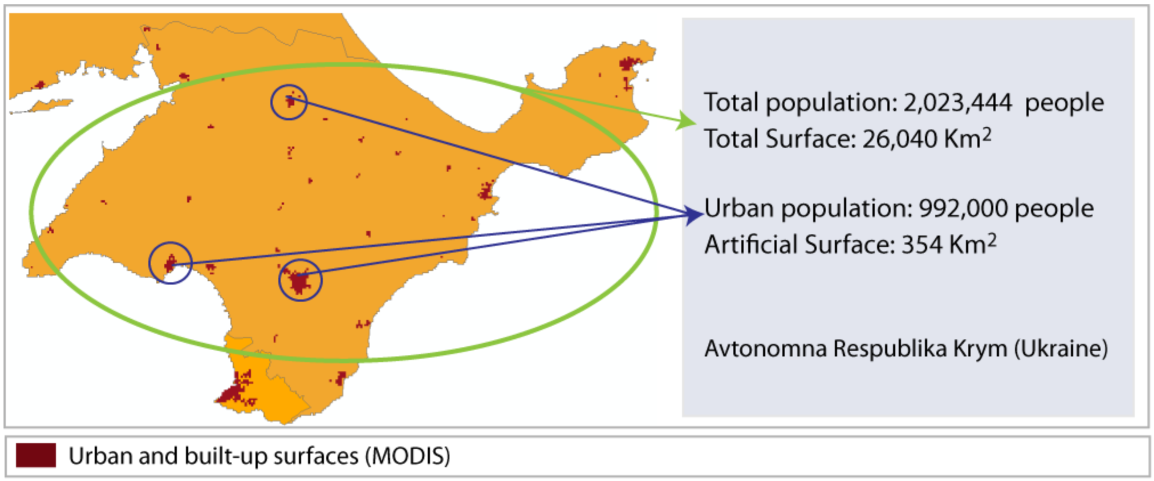


Fig.10: total and urban population & urban land cover: example from Crimea (Ukraine)

However, we cannot assume that all urban land identified in the MODIS land cover map corresponds exactly to cities and towns. Since the map designates all land with impervious surfaces as 'urban', it must necessarily include considerable amounts of village and farm land as "urban" (Schneider et al., 2010). Our goal consists therefore to estimate the urban fraction of the population in the BS regions. We have to deal with two main challenges: the lack of urban data at regional level for several countries, and the different definitions of "Urban" between countries (see terminology for more detail). The Eurostat urban data for example was recalculated by using the ratio of households living in urban areas delimited as zones with more than 500 inhabitants per km^2). Russian and Belarus define urban-area according to the criteria of number of inhabitants and predominance of agricultural, or number of non-agricultural workers and their families. Switzerland considers communes of more than 10,000 inhabitants, including suburbs as urban. Other national statistical offices deliver data without giving a clear definition of the "urban" data.

To solve the lack of harmonization from the different sources of the urban dataset, we propose to find a single and common way to define the urban population.

Geopolis (e-Geopolis, 2011) is a global database that allows an international comparison of city sizes, beyond the diversity of national official definitions of urban units; they define an urban agglomeration as a continuous built-up area where at least 10.000 inhabitants live. Keeping in mind the amount of data available and our final objectives, we suggest to use the population size of cities as the discriminating parameter to define the limit between urban and rural areas in a region.

Finally, we have created a geodatabase of cities containing their population and geo-localization for cities having more than 10k inhabitants in 2001.

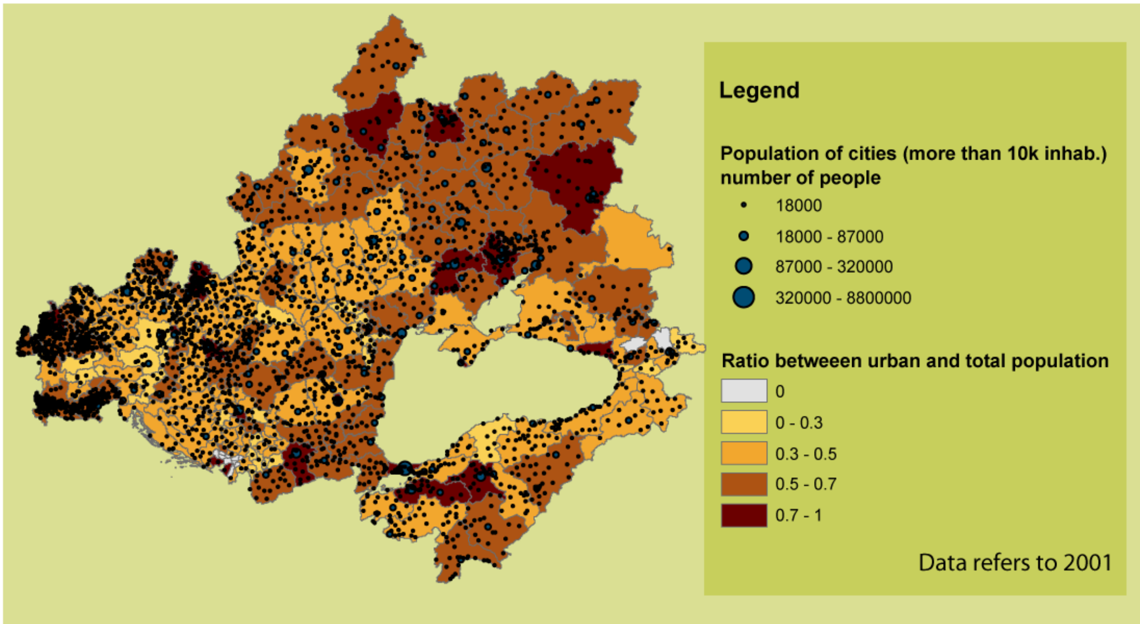


Fig.11: map showing the 3130 cities with more than 10k inhabitants in 2001 and the ratio between urban and total population per region

The cities geodatabase was created by using several sources both for spatial location of cities and their population (mainly collected for the period 2000-2010)

The urban population for a region (PuRegCty) was defined as:

$$PuRegCty_{(2001)} = \sum Pcities_{(2001)}$$

Where $\sum Pcities_{(2001)}$ is the sum of all the cities of the region having more than 10,000 inhabitants in 2001

Population from cities and from urban areas as defined by national statistical offices show generally a very strong correlation ($R^2 > 0.95$, figure 12). However few values are discordant; most countries (90 percent EU27) display more inhabitants for cities than urban (ratio < 1) due to a difference of Eurostat definition. Non EU27 countries have generally more urban population than cities population.

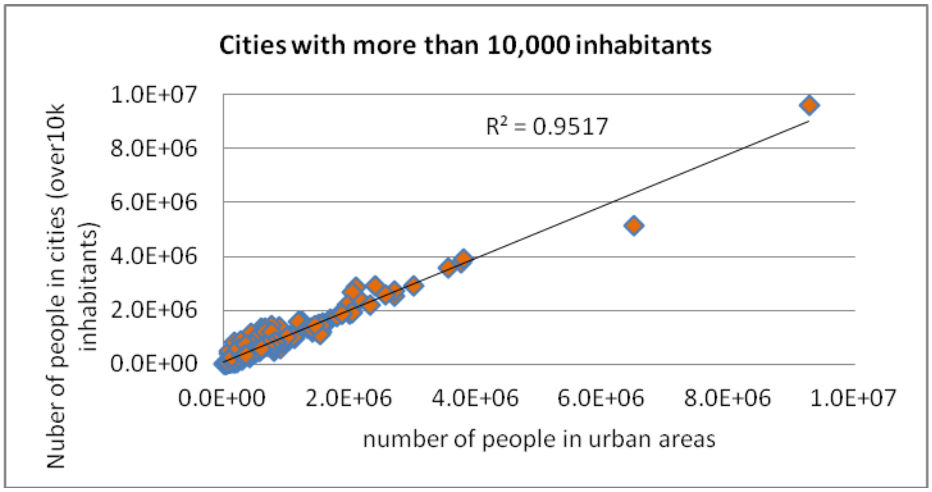


Fig.12: Relationships between population in cities (over 10k) and urban areas as definited by National statistical officies

Data for cities were collected mainly for the years 2001 and 2008. A time series for the period 2000-2010 is planned. Unfortunately we do not dispose actually of population projections at cities level: UNSD/WUPP has released a database including projections until 2050 only for cities having more than 750,000 inhabitants in 2005.

2.5 Regional projections and assumptions

Projections at regional level are scarce. Eurostat produced regional population projections figures for EU 27 countries and Switzerland for the period 2008-2030 included in the EUROPOP project (Eurostat, 2010). In EUROPOP, Population projections are "what-if" scenarios about the likely future size and structure of populations compiled using the standard demographic cohort-component model. Population growth is the result of two components: (N) natural change (births minus deaths) and (M) total net migration (international and internal migration).

Assumptions were made about national residential mobility and the degree of attractiveness of the regions; therefore, assumptions were made about internal mobility as a whole (intra- plus interregional moves) plus the convergence/divergence of the regions in terms of attractiveness (full convergence would signify that net inter-regional migration is zero). In the current regional EUROPOP2008 population projections, internal mobility and regional differences are assumed not to change from the recent situation (calculated as an average of internal migration flows in recent years depending on countries' data availability).

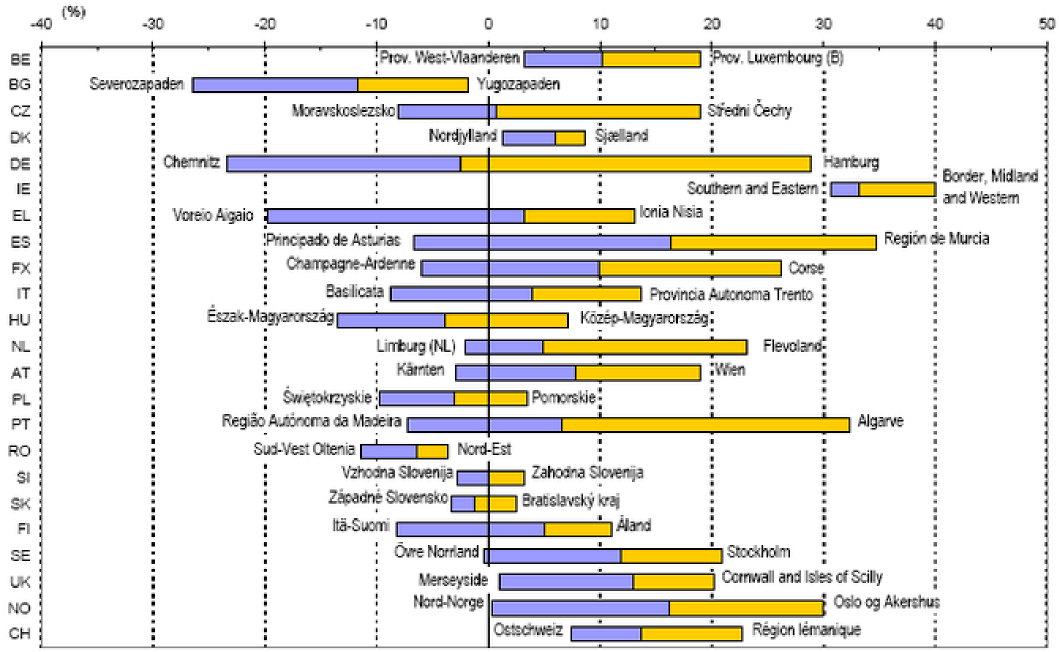


Fig.13: Range of the regions' relative population change between 2008 and 2030 (from EUROPOP). Yellow colour indicates population increase while the blue one the decrease. This figure clearly illustrates the difference of regions population dynamics inside the same country.

Outside the EUROPOP countries coverage we only have projections at regional level for the Russian Federation. The Federal statistical office published regional data (oblast) for the period 2010-2016 and for separate years including 2021, 2026 and 2031.

For all the BSC countries during the period 2030 to 2050 we do not have any data at regional level; for non EU 27 no data is available for after 2010.

2.6 Downscaling projections from UN national data

The objective is to estimate regional projections for the period from 2030 to 2050 for EUROPOP countries and from 2010 to 2050 for all other countries. Estimations will be based on the extrapolation and downscaling from UN national data.

Extrapolation builds on the assumption that future demographic developments can be derived from past population trends and hence, a continuation of observed demographic change is assumed. This method is widely used and refers to approaches where one uses past values of only the factor of interest and the error term (and disregards other variables) to calculate future trends.

In order to estimate the regional projections we analyze how population varies between regions inside the same country: we calculate the “regional share” across the time (see text box). We will base all our further analyses on this parameter.

Regional share:

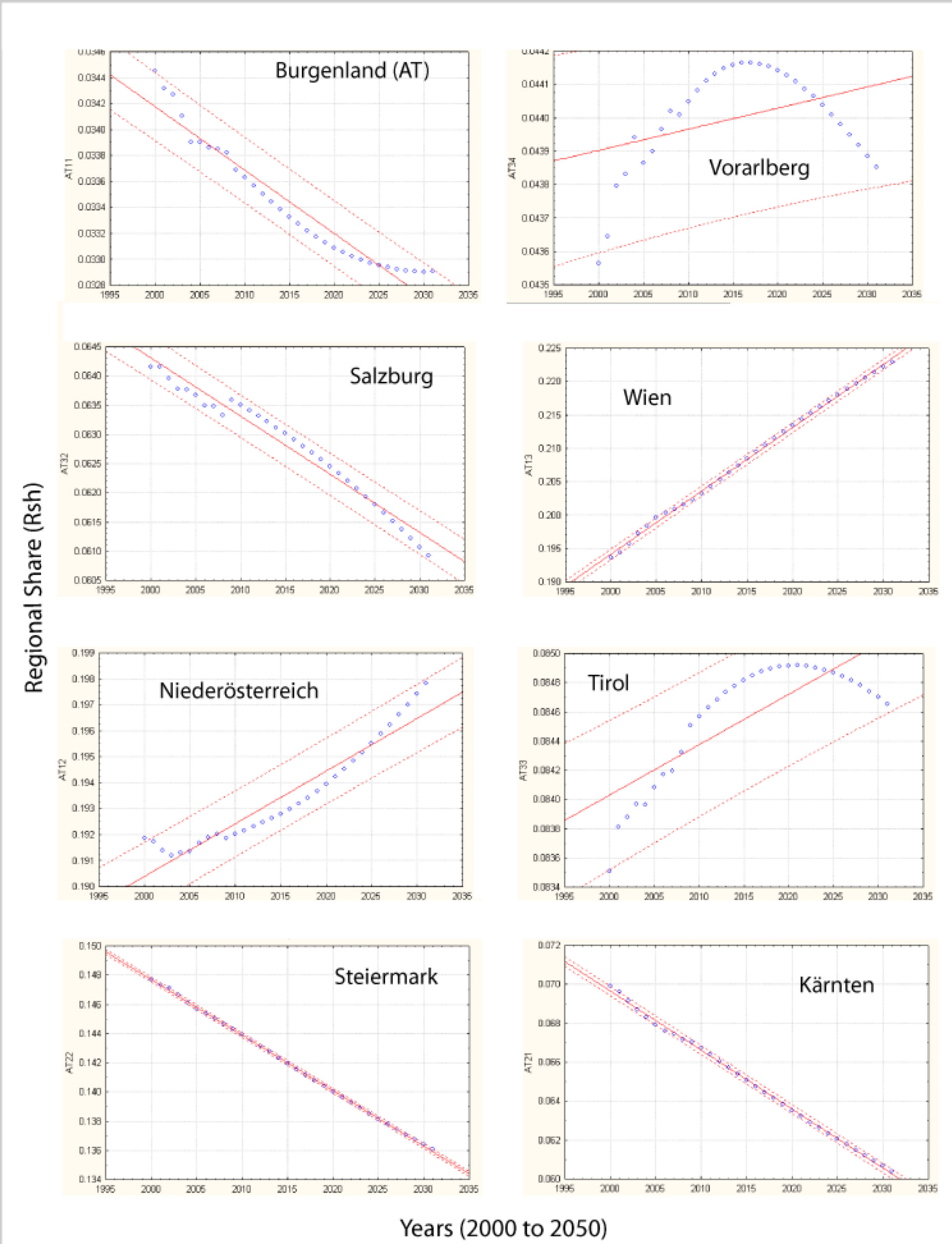
$$Rsh_{(t)} = Pr_{(t)} / Pn_{(t)}$$

Where Rsh represents the fraction of the total population living in the region at time t; Pr represents the population living in the region and Pn is the national population (as defined by the National statistical office).

Trend analyses:
All the 214 regional share (Rsh) trends were analyzed individually (here the example of eight Austrian regions).

Even if the majority of cases trends show a linear pattern, some regions display an inversion of tendency, mainly localized around 2020.

The trends illustrate very well the diversity of regions inside the country.



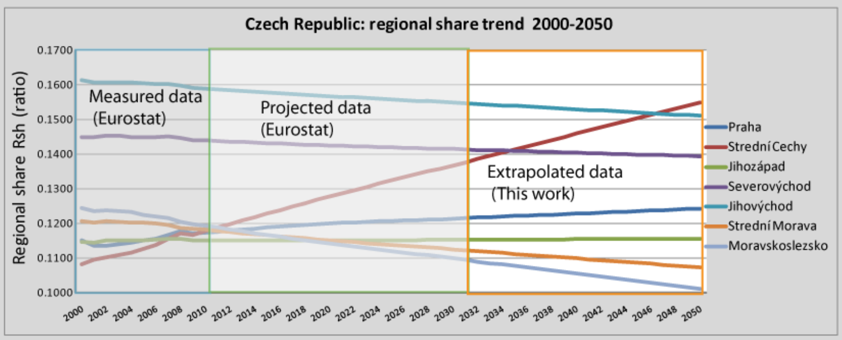
Extrapolation of regional share:

For each Rsh trend we extrapolate the new values using a linear regression; the choice of the known values is evaluated case by case on the basis of the Rsh function.

For EUROPOP countries we have to extrapolate data based already on projections only for the period 2030-2050.

For non EUROPOP countries extrapolations are based only on past data, and distributed for all the period 2010-2050.

We have to keep in mind that these extrapolations only concern the distribution of peoples during time among regions; real population data (from UN) will be further calculated.



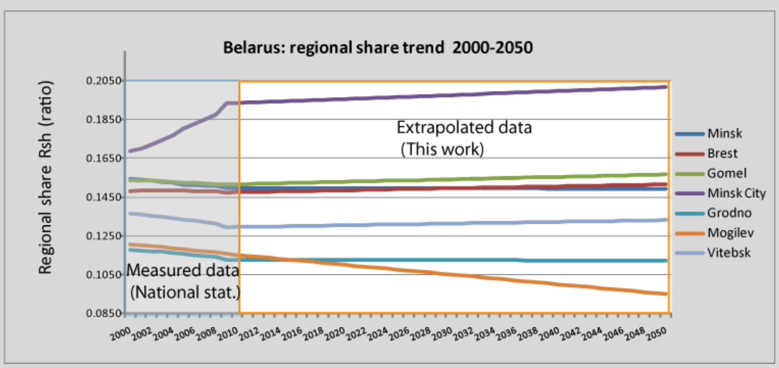
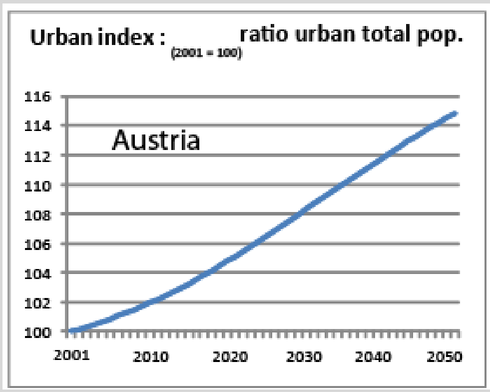


Fig.14: Example of trends of regional share for Cz Republic (EUROPOP country) and Belarus

Text box: workflow example for Austria



National Urban Index (RUIdx):

We calculate the evolution of the ratio between the urban and total population during time. (2001-2050) at national level, using WUP and WPP data

Results are expressed as an Index where the base year is 2001 (2001 = 100): the RUIdx

Downscaling the National Urban Index to the regions:

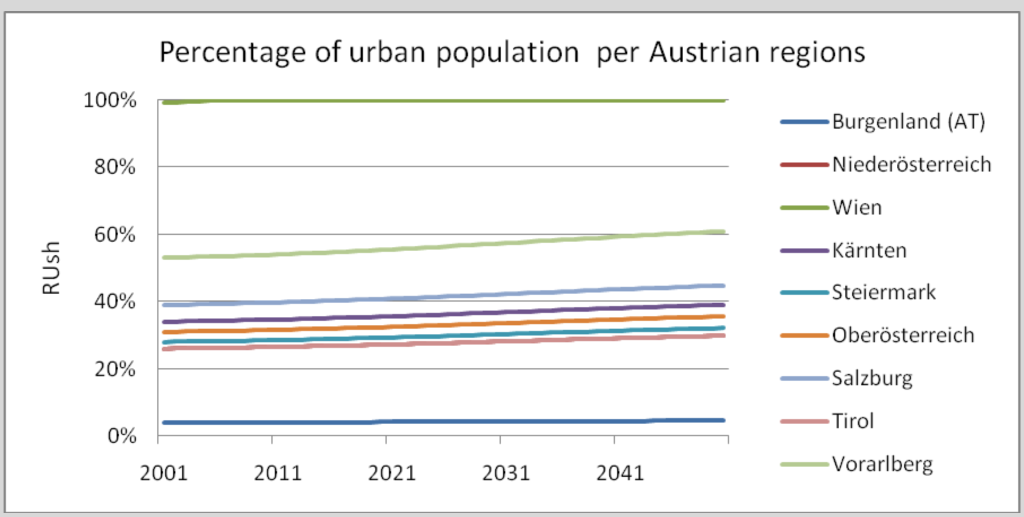
Assumption: the urban growth rate is distributed uniformly between regions: this represents clearly a limitation of our model.

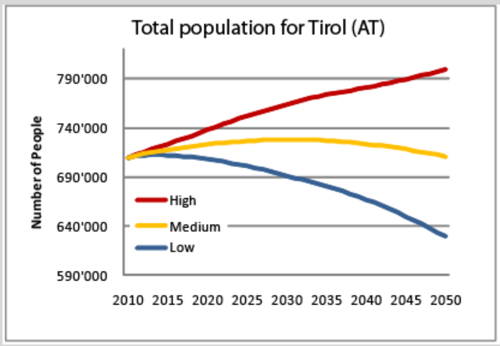
$$RUsh_{(t)} = (PtReg_{(2001)} / PuRegCty_{(2001)}) * RUIdx_{(t)}$$

$RUsh_{(t}$ is the percentage of urban population per region at time t

$PtReg_{(2001)}$ corresponds to the regional total population in 2001

$PuRegCty_{(2001)}$ corresponds to the regional urban population in 2001



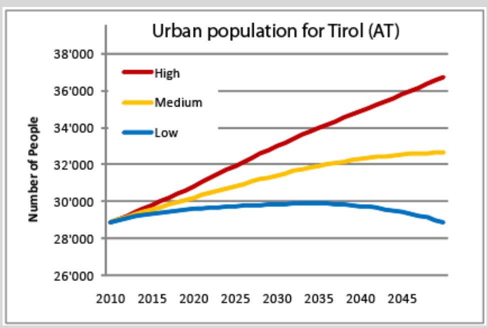


downscaling total population

PtReg (t,v) = $Rsh_{(t)}$ * Pnat(t,v)

PtReg (t,v) corresponds to the regional total population at time t for the selected UN variant v (high medium low)

Pnat(t,v) is the national population at time t for the selected variant v



downscaling: urban population

PuReg (t,v) = $RUsh_{(t)}$ * PtReg (t,v)

PuReg (t,v) corresponds to the regional urban population at time t for the selected UN variant v (high medium low)

$RUsh_{(t}$ is the percentage of urban population per region at time t

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)

3 Metronamica integrated tool for land cover change modelling: demographic inputs

3.1 Demographic data inputs

Metronamica (Riks, 2005, 2009)is a unique generic forecasting tool for planners to simulate and assess the integrated effects of their planning measures on urban and regional development. As an integrated spatial decision support system, Metronamica models socio-economic and physical planning aspects, by incorporating a mature land use change model that helps to make these aspects spatially explicit. Metronamica allows the planner to interactively enter policy and planning measures as well as trend lines for external pressures and scenarios.

The regional model in METRONAMICA is used to allocate the total population and jobs in the main economic sectors at the national level over the regions and to simulate the migration between regions (Riks, 2005, 2009).

The allocation of the growth amongst the regions depends to a large extent on the relative attractiveness of each region. In modeling the national socio-economic growth and migration distance between urban areas also play a crucial role. The underlying assumption is that regions can benefit from each other attractiveness, as long as the distance is not too far. Furthermore, people and jobs are reluctant to migrate over greater distances.

In MODIS Land cover, urban areas are places dominated by the built environment. The 'built environment' includes all non-vegetative, human-constructed elements, such as roads, buildings, runways, etc. In other words, habitations and places of works are merged and is not possible to distinguish between them.

Our regional model distributes the population of the entire study area over the regions. It knows only a single population class (neither cohorts nor socio-economic groups).

3.2 Calibration

For each region the number of inhabitants for both base years 2001 and 2008 is essential in order to compute these values into urban surface or the "cell demand" in the Metronamica environment. For 2001 we can extract directly the values by a simple "zonal statistics" per region from the urban land cover class of MODIS. Concerning 2008 we have a problem: the number of cells linked to the Artificial class (Ac) from MODIS 2001 to 2008 records only a marginal change. Is it related to effectively small change in the physical parameters? Probably urban zones have not changed so much in seven years. Moreover they have a relative inertia to record the change at 0.5x0.5 and 1x1 km^2 cell size; but it is not enough to explain such a small variation in MODIS. It reflects probably a generalized error due to limitations of remote sensing at this resolution, to detect small changes in the artificial surfaces.

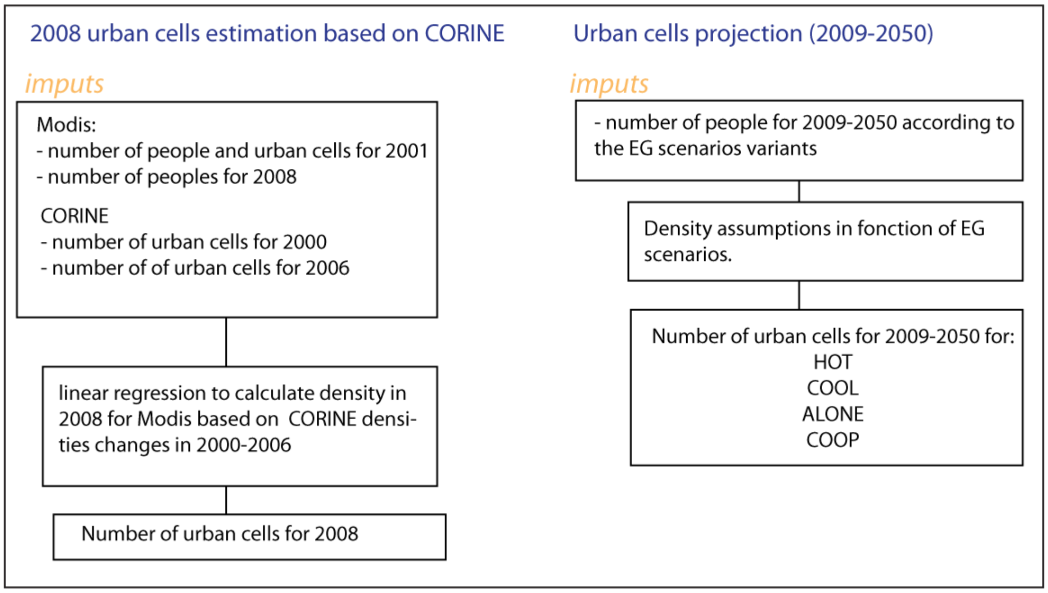


Fig.15: the figure summarizes the workflow used to estimate the urban cells demand.

The challenge consists of estimating the effective number of cells demanded for urban surface in 2008 (fig. 15).

3.2.1 Cells allocation for MODIS 2008: the Corine Land Cover approach

In order to estimate the real urban surface (number of cells) for MODIS 2008, we will base our considerations on the variation of urban land surface in Corine Land Cover (CLC) at 250 m for the year 2000 and 2006

Relations between CLC and MODIS artificial surfaces per regions indicate a coarse correlation (r^2 =0.6) with a generalized under estimation of MODIS Artificial class. (fig.16)

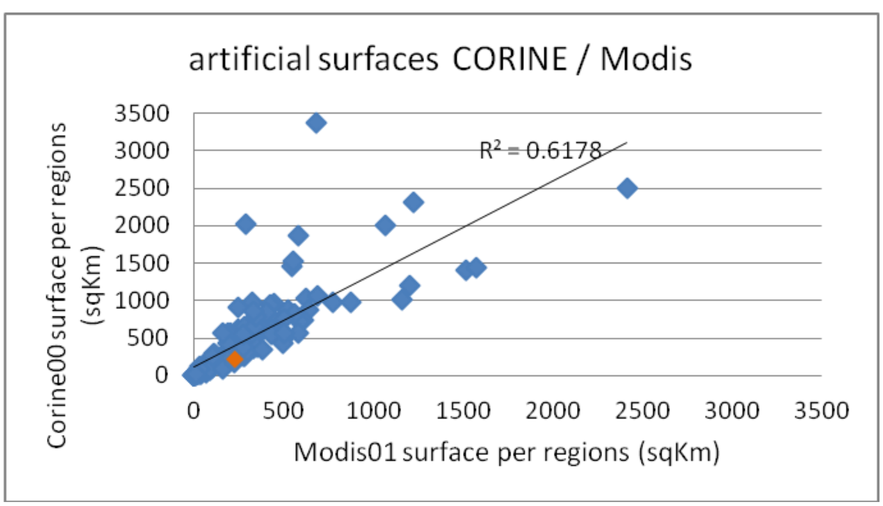


Fig.16: Weak correlations between CLC and MODIS

Such a weak correlation prevents the direct use of values from CLC surfaces. Outliers are more represented in rural areas with strong underestimation of MODIS.

We plotted the variation of densities (percentage per year) from CLC 00 and CLC 06 using our urban population (01-08) against regions (fig. 17).

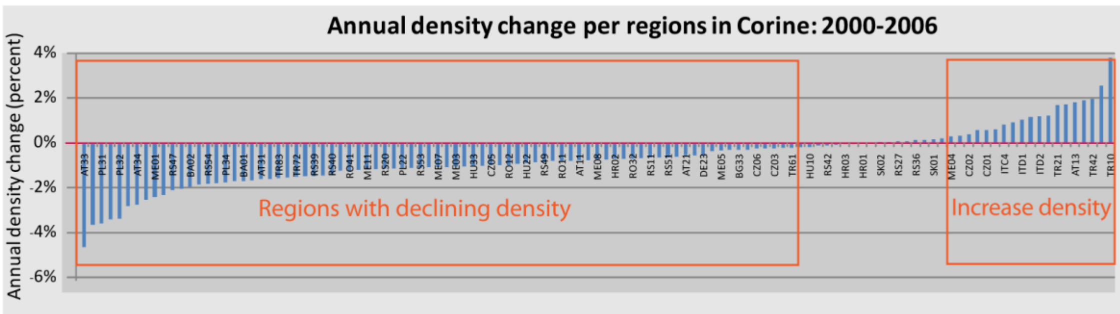


Fig.17: Variation of densities from Corine Land Cover between 2000 and 2006Two important considerations can be derived from the chart:

- There is a general strong tendency to decrase the density according to (Angel et al., 2010c).
- The regions (few) that have increased their density (Istambul, Lombardia, Trentino, Wien) are those where the space for their expansion is (now) limited.

From the analysis of the correlation between densities in CLC and MODIS 2008, two other assumptions are made:

- For regions that are included inside CLC coverage the same annual ratio of change of density multiplied by the regional urban population will be used.
- For regions that are outside the CLC coverage the value of density in 2008 is calculated using a linear regression, based on a strong correlation between CLC densities in 2000 and 2006 (fig.18). Urban land surface will equal the urban population in 2008 multiplied by the calculated density from CLC.

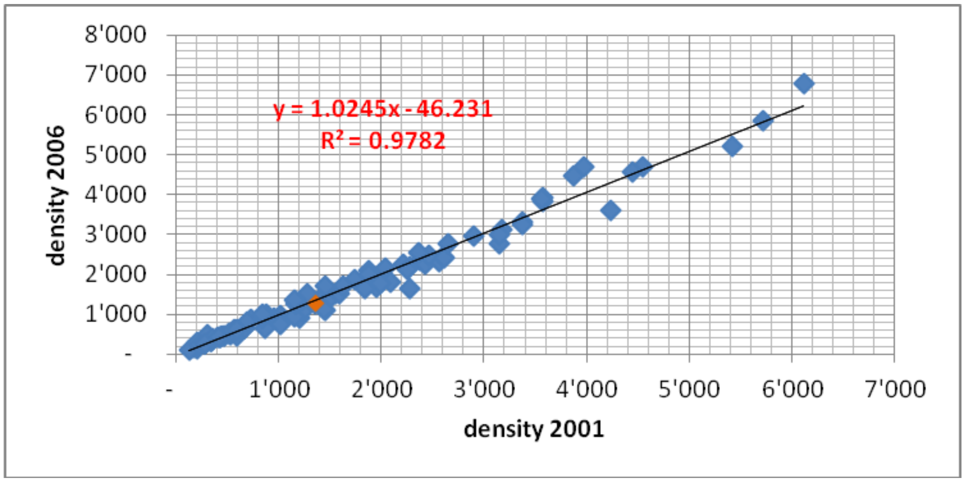


Fig.18: relationships between densities in CLC 2000 and 2006

3.3 Scenarios

The regional model in *Metronamica* requires the number of supposed future cells for each land use class according to the selected scenario.

3.3.1 Projections of urban land cover surface

The estimation of the future number of cells for urban land is not an easy task, since the available data are estimations of urban population, according to UN projections and assumptions. Furthermore it is not known how this population is distributed across the territory: if cities become denser or if, alternatively, they will extend their surface.

In a recent work, the Environmental European Agency (EEA, 2006), focuses on the physically expansion of urban areas also known as *"urban sprawl"* (see terminology for more detail), mainly characterized by a low density mix of land uses on the urban border. In Europe, cities have traditionally been much more compact, developing a dense historical core shaped before the emergence of present day transport systems.

The main driver leading to cities growth, historically, was the increase of urban population. However, in Europe at present, a variety of factors are still driving sprawl, even if the urban population shows small or no increase. Global socio‑economic forces are interacting with more localized environmental and spatial constraints to generate the common characteristics of urban sprawl evidenced throughout Europe today. EEA identified urban areas particularly at risk of uncontrolled urban sprawl in the southern, eastern and central parts of Europe.

Urban population, income, and the availability of land for urban expansion are three key explanations of why urban land cover varies among countries (Angel et al., 2010a; Angel et al., 2010c). This explanation is supported by several sets of multiple regressions models at global scale with country urban land cover as the dependent variable and urban population, GDP, arable land, transport cost as independent ones. Outcomes from the model seem to confirm the classical economic theory of urban spatial structure predicting that urban land cover will increase with population and income, as well as with a reduction in transport costs (Brueckner, 1987).

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). A major consequence of this trend is that European cities have become much less compact (fig. 18).

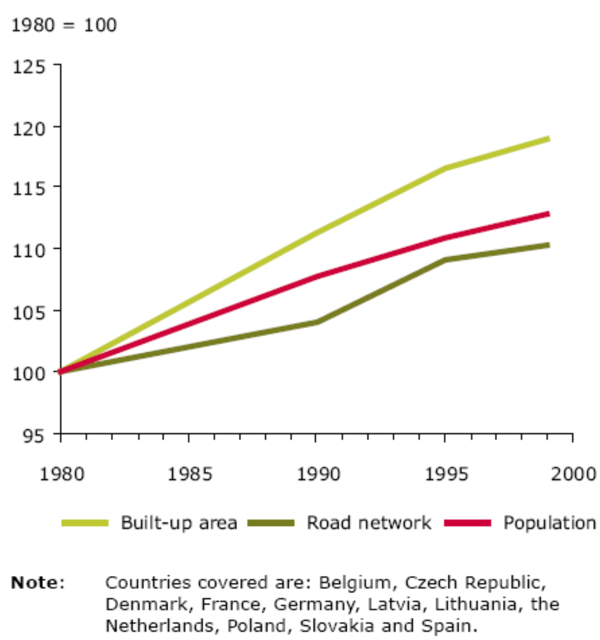


Fig.18: Built up area, population and road network density for selected EU and accession countries (EEA, 2002)

Text box 1: Results from cities density patterns

• Cities with rapidly growing populations have significantly slower rates of density decline.

• Cities in countries with rapidly growing incomes have significantly faster rates of density decline.

• Cities with high initial densities or low initial incomes have significantly faster rates of density decline.

• Cities with larger populations have significantly slower rates of density decline.

• Cities with no geographical constraints on their expansion in all directions have significantly faster rates of density decline.

• Densities in cities in land-rich countries do not decline at faster or slower rates than cities in other countries

Source: (Angel et al., 2010b)

Trends towards new low density environments are also evident in the space consumed per person in the cities of Europe during the past 50 years, which has more than doubled. In particular, over the past 20 years the extent of built-up areas in many western and eastern European countries has increased by 20 % while the population has increased by only 6 %. Sprawl is greater, and in many cases significantly greater, than it would be expected on the basis of population growth alone (JRC, 2006).

Future developments of urban land cover are often predicted on assumptions that are largely based on past trends. The average density in the built-up areas of a global sample of 120 cities declined at a mean annual rate of about 2 percent between 1990 and 2000 (Angel et al., 2010b). There was no significant difference in the rate of decline between more-developed and less-developed countries.

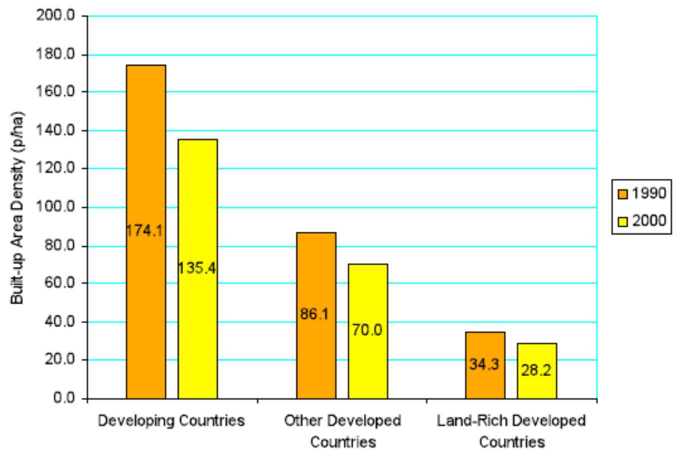


Fig.19: Density differences among selected world cities in three regional sub-groups 1990 and 2000 (Angel et al., 2010b)

On the basis of these analyses the authors propose three density scenarios to project urban land area until 2050:

- “High projection”: assuming a 2% annual rate of density decline, corresponding to the average rate of decline of the global sample of 120 cities, 1990-2000;
- “Medium projection”: assuming 1% annual rate of density decline, corresponding to the long-term rate of density decline in an historical sub-sample of 30 cities;
- “Low projection”: assuming constant densities, or a 0% annual rate of density decline, more realistic for US cities that are more subjected to urban sprawl than European ones.

They also calculate the urban land cover projections, based on the three density assumption for the whole countries of the world. The 23 enviroGRIDS countries are showed in figure 20:

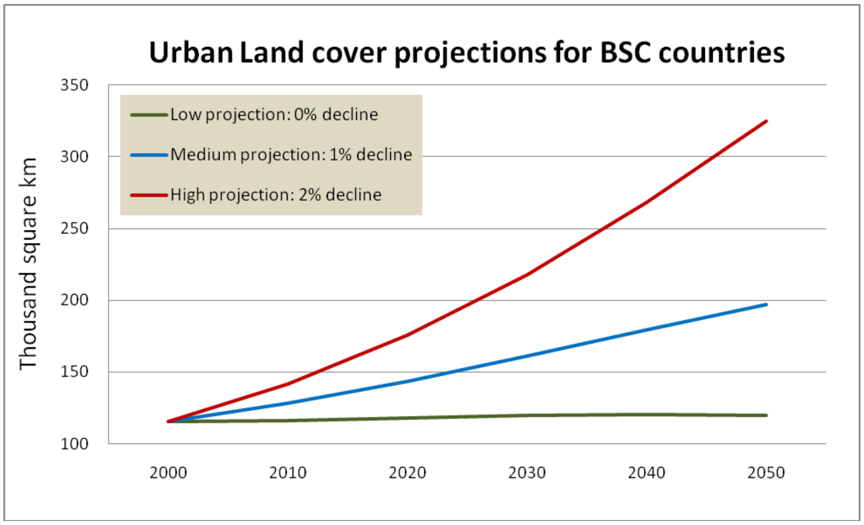


Fig.20: density scenarios from (Angel et al., 2010c) applied to the BSC (whole) countries

In the PLURIEL FP7 EU project (Rickebusch, 2010) artificial surfaces projections until 2025 were estimated using a multiple regression model. In this model, the proportion of artificial surfaces per NUTS2 (EU 25 coverage only) is a function of GDP per capita, population, and urban type: large city vs smaller city/rural region. A similar model was already applied by (Reginster and Rounsevell, 2006)

By lack of projections data at regional level (GDP) for non EU countries, we cannot use the methodology described above. Urban land-use future trends will be based on an interpretation of qualitative storylines in terms of density variations, and in a quantitative way in terms of population by using the UN projection variants.

We have quite good estimation of population trends and we have to suppose in a qualitative way the evolution of urban densities to estimate the urban land cover. The following example illustrates the different possibilities for the Austrian region of Tyrol by applying several combinations of urban population and densities.

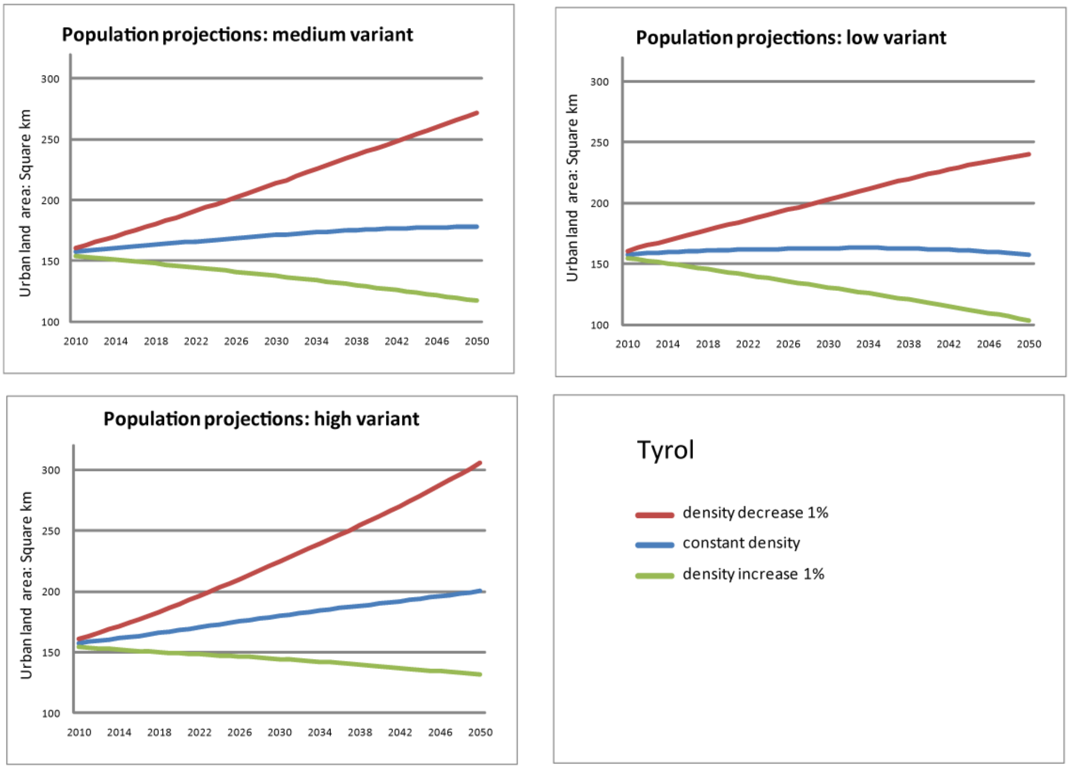


Figure 21: Urban land cover projections: regional example for Tyrol:

Each enviroGRIDS scenario is characterized by its peculiar demographic trend, together with a specific urban land evolution path. We derivate the regional figures for inhabitants from UN and national statistical offices, while the urban patterns will be based in function of the different assumption of the density. In other words, the population positive (or negative) growth will be the same for all the regions according to the selected UN variant, although the variation of density will be set in function of the characteristics of each regions according with the criteria explained in the figure 22

The definitive designation of the regional densities is still under testing and validation.

scenario	population growth	urban land cover	density assumptions
HOT	low	Increase urban areas and demand in high populated regions. Strong attraction of urban - agriculture areas around the existing settlements	general decline for almost all regions (1-2% annual)
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. Easy conversion of natural areas into urban	general decline for almost all regions (1% annual)
COOP	low	Urban areas increase in density but not in area - compact growth urban areas will “stick” to its present location	Constant to increase (1% annual) for almost regions
COOL	medium	Urban areas smoothly increase. Inertia for urban areas will stick to its present location – small changes	Constant to increase (1% annual) for almost regions

Figure.22: Proposed annual trend of densities for the four EG scenarios. These values are at present still under test.

4 Conclusion and Perspectives

The main purpose of Task 3.1 was to set up an infrastructure and to implement analytical modules that will enable the production of time series of prospective demographic data. These data will be used as input for the hydrological basin models (WP 4: SWAT) as well as for previous impact assessments on different societal benefit areas. Afterward, our first objective consist to produce the population datasets to be used in the integrated model of population, land use and climate change for the four enviroGRIDS scenarios of change. The specificity of these datasets will conform to the Metronamica environment

The expected outputs include dataset of public domain that will be available for download at the end of 2011

1. Regional maps (NUTS2 level) for total and urban population 2001-2010 (GIS output)
2. Regional maps (NUTS2 level) for total and urban population 2011-2050 according to the three UN variants: Normal, High and Low fertility (GIS output)
3. Cities geodatabase: includes inhabited places with more than 10,000 people in 2001 (GIS output)
4. Urban land cover surfaces in MODIS 2001 and MODIS 2008 (Tabular output)
5. Projected urban land cover surfaces in MODIS for the period 2009-2050 (Tabular output)

Measured data and projections of urban land areas (outputs 4 & 5): are the specific requirements for Metronamica. The next step will consists to integrate them within the other land Modis cover classes (D 3.7 enviroGRIDS) at spatially explicit level (1km x 1km) for the entire

BSC using the Metronamica model, according with the four alternative scenarios. The enviroGRIDS deliverable 3.8 will focus on the result of this process of integration.

Our second objective will be axed on the spatial disaggregation of population data; as previously descript on purpose and scope chapter, it will be developed in a further publication. It will consist in a set of raster grids of population at 1km x 1km resolution, resulting of a downscaling from politico-administrative units onto a reference grid. In this deliverable we focus only on these demographic data that were essential to produce the inputs for Metronamica in order to produce a set of integrated land cover maps. The expected future raster grids of population will illustrate an evolution during time of people distribution independently from land use. One direct application will be the possibility to evaluate the number of inhabitants per spatial units by cell aggregation, for example to estimate the number of persons living in a specific sub-basin.

The Integrated outputs of spatially explicit scenarios from WP 3 will be primarily used as input for the hydrological catchment models (WP 4), furthermore several end products from Task 3.1 will also offer a useful and precious support to others EG workpackages. The regional maps of population (outputs 1 & 2) at NUTS2 level as well as the cities databases (output 3) will be of use for any other users interested in harmonized, disaggregated and projected information on population distribution. Especially in case of WP5: Impacts on selected Societal Benefit Areas, notably in those objectives concerned by vulnerability analysis.

Probably the greatest defy and time consuming task of this work was the collection and harmonization of datasets at regional and cities level. National statistical offices and international organisations together with gazetteers provided the essential of demographic figures; we aware that this heterogeneity of sources could be represent a supplementary incertitude in the final model.

Further improvements of the model can be also obtained refining the potential of each region in terms of people displacement: we experienced that an estimation of urban densities and regional attractiveness could be better developed if coupled with economic data, such as gross domestic product or unemployment figures. Unfortunately these kinds of data and especially their projections at regional level are extremely scarce or inexistent for several BSC countries.

The outputs 1 & 2 will be the first release, in the public domain, of a GIS dataset including past and projected harmonized population figures at Nuts2 level (Nuts3 is under process) including both Western, Central and Eastern European countries.

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Annexes

Terminology

Metronamica is a unique generic forecasting tool for planners to simulate and assess the integrated effects of their planning measures on urban and regional development. As an integrated spatial decision support system, *Metronamica* models socio-economic and physical planning aspects, by incorporating a mature land use change model that helps to make these aspects spatially explicit. More information at: *http://www.metronamica.nl/*

NUTS2: The Nomenclature of Territorial Units for Statistics (NUTS) was introduced by Eurostat more than 30 years ago in order to provide a single uniform breakdown of territorial units for the production of regional statistics for the European Union. NUTS 2: basic regions for the application of regional policies. More information at *http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-07-020/EN/KS-RA-07-020-EN.PDF*

Urban: (UN) Urban/rural is a derived topic based on geographic information obtained from place of occurrence and place of usual residence. Because of national differences in the characteristics that distinguish urban from rural areas, the distinction between urban and rural population is not amenable to a single definition applicable to all countries. For this reason, each country should decide which areas are to be classified as urban and which as rural, in accordance with their own circumstances. For national purposes as well as for international comparability, the most appropriate unit of classification is the size of locality or, if this is not possible, the smallest administrative division of the country. It must be recognized, however, that a distinction by urban and rural based solely on the size of the population of localities does not always offer a satisfactory basis for classification, especially in highly industrialized countries. Some countries have developed a classification of localities based not on population size alone but on "socioeconomic structure of the population". Others have tried to express degrees of urbanization by use of indices of population density etc.

> **Urban** (UN, Demographic Yearbook, table 6:
> http://unstats.un.org/unsd/demographic/products/dyb/dyb2008.htm):
> *Georgia:* Cities and urban-type localities, officially designated as such, usually according to the criteria of number of inhabitants and predominance of agricultural, or number of non-agricultural workers and their families.
> *Turkey:* Population of settlement places, 20 001 and over.
> *Albania*: Towns and other industrial centres of more than 400 inhabitants.
> *Austria:* Communes of more than 5 000 inhabitants.
> *Belarus:* Cities and urban-type localities, officially designated as such, usually according to the criteria of number of inhabitants and predominance of agricultural, or number of non-agricultural workers and their families.
> *Bulgaria:* Towns, that is, localities legally established as urban.
> *Czech Republic:* Localities with 2 000 or more inhabitants.
> *Hungary:* Budapest and all legally designated towns.
> *Poland:* Towns and settlements of urban type, e.g. workers' settlements, fishermen's settlements, health resorts.
> *Republic of Moldova:* Cities and urban-type localities, officially designated as such, usually according to the criteria of number of inhabitants and predominance of agricultural, or number of non-agricultural workers and their families.
> *Romania:* Cities, municipalities and other towns.
> *Russian Federation:* Cities and urban-type localities, officially designated as such, usually according to the criteria of number of inhabitants and predominance of agricultural, or number of non-agricultural workers and their families.
> *Slovakia:* 138 cities with 5 000 inhabitants or more.
> *Switzerland:* Communes of 10 000 or more inhabitants, including suburbs.
> *Ukraine:* Cities and urban-type localities, officially designated as such, usually according to the criteria of number of inhabitants and predominance of agricultural, or number of non-agricultural workers and their families.

Urban areas (EEA) urban areas are defined by morphology and the distribution of urban land across the territory based on CLC classes.

Urban land use refers to land that is covered by buildings and other man-made structures, such as services, industries, and transport infrastructure.

Urban population (UN) De facto population living in areas classified as urban according to the criteria used by each area or country. Data refer to 1 July of the year indicated.

Urban agglomeration (UN) Refers to the de facto population contained within the contours of a contiguous territory inhabited at urban density levels without regard to administrative boundaries. It usually incorporates the population in a city or town plus that in the sub-urban areas lying outside of but being adjacent to the city boundaries. (Geopolis) Urban agglomeration is a continuous built-up area where at least 10.000 inhabitants live. The continuity is defined by a maximum distance of 200 meters between two constructions. (*http://egeopolis.eu/spip.php?article196*)

Urban morphological zone (UMZ) (EEA) An UMZ is an area that includes all the man made areas that are closer than 200 m to each other.

Urban sprawl is commonly used to describe physically expanding urban areas. The European Environment Agency (EEA) has described sprawl as the physical pattern of low-density expansion of large urban areas, under market conditions, mainly into the surrounding agricultural areas. Sprawl is the leading edge of urban growth and implies little planning control of land subdivision. Development is patchy, scattered and strung out, with a tendency for discontinuity. It leap-frogs over areas, leaving agricultural enclaves. Sprawling cities are the opposite of compact cities — full of empty spaces that indicate the inefficiencies in development and highlight the consequences of uncontrolled growth.

Region names and population

cnty id	region id	region name	area regions km2	urban area km2	urban pop 2001	urban pop 2008	total pop 2001	total pop 2008
AL	AL01	Shkoder	1'357	17	85'384	85'121	185'618	185'046
AL	AL02	Tropoje	1'072	1	7'549	4'468	27'960	16'549
AL	AL03	Malesi e Madhe	1'088	-	-	-	36'767	36'122
AT	AT11	Burgenland (AT)	3'974	171	11'040	11'280	276'000	282'000
AT	AT12	Niederösterreich	19'203	624	400'920	416'260	1'542'000	1'601'000
AT	AT13	Wien	415	274	1'547'370	1'664'190	1'563'000	1'681'000
AT	AT21	Kärnten	9'535	111	190'400	190'400	560'000	560'000
AT	AT22	Steiermark	16'409	245	331'800	337'680	1'185'000	1'206'000
AT	AT31	Oberösterreich	11'988	307	426'250	436'790	1'375'000	1'409'000
AT	AT32	Salzburg	7'160	91	201'240	205'920	516'000	528'000
AT	AT33	Tirol	12'636	106	175'240	182'780	674'000	703'000
AT	AT34	Vorarlberg	2'600	55	186'030	194'510	351'000	367'000
BA	BA01	Bosnia and Herzegovina	26'657	215	862'382	864'226	2'330'762	2'335'746
BA	BA02	Republika Srpska and Brcko	24'557	131	502'753	496'291	1'523'495	1'503'913
BG	BG31	Severozapaden	19'052	328	546'960	489'190	1'032'000	923'000
BG	BG32	Severen tsentralen	14'803	250	535'140	501'120	991'000	928'000
BG	BG33	Severoiztochen	14'647	446	633'640	615'040	1'022'000	992'000
BG	BG34	Yugoiztochen	19'801	426	734'580	708'120	1'166'000	1'124'000
BG	BG41	Yugozapaden	20'297	644	1'593'720	1'607'400	2'097'000	2'115'000
BG	BG42	Yuzhen tsentralen	22'360	410	866'700	832'680	1'605'000	1'542'000
BY	BY01	Minsk	40'189	232	877'401	833'226	1'539'300	1'461'800
BY	BY02	Brest	32'649	330	355'656	344'424	1'481'900	1'435'100
BY	BY03	Gomel	40'478	213	1'166'600	1'116'136	1'535'000	1'468'600
BY	BY04	Minsk City	87	78	390'793	417'404	1'699'100	1'814'800
BY	BY05	Grodno	25'013	195	246'519	232'386	1'173'900	1'106'600

BY	BY06	Mogilev	28'931	150	504'378	474'432	1'200'900	1'129'600
BY	BY07	Vitebsk	40'369	139	530'517	496'587	1'360'300	1'273'300
CH	CH05	Ostschweiz	11'319	181	261'250	270'000	1'045'000	1'080'000
CZ	CZ01	Praha	497	286	535'900	562'580	1'165'000	1'223'000
CZ	CZ02	Stredni Cechy	11'017	423	663'160	717'440	1'124'000	1'216'000
CZ	CZ03	Jihozápad	17'617	368	752'640	768'000	1'176'000	1'200'000
CZ	CZ05	Severovýchod	12'443	416	1'472'130	1'486'980	1'487'000	1'502'000
CZ	CZ06	Jihovýchod	13'990	494	907'500	911'900	1'650'000	1'658'000
CZ	CZ07	Stredni Morava	9'229	467	826'780	826'110	1'234'000	1'233'000
CZ	CZ08	Moravskoslezsko	5'428	474	748'710	737'500	1'269'000	1'250'000
DE	DE11	Stuttgart	10'557	1'161	1'224'500	1'242'170	3'950'000	4'007'000
DE	DE13	Freiburg	9'403	463	2'146'000	2'196'000	2'146'000	2'196'000
DE	DE14	Tübingen	8'919	353	637'920	650'520	1'772'000	1'807'000
DE	DE21	Oberbayern	17'344	1'204	1'645'200	1'729'600	4'113'000	4'324'000
DE	DE22	Niederbayern	10'327	330	531'450	536'850	1'181'000	1'193'000
DE	DE23	Oberpfalz	9'691	333	486'900	488'250	1'082'000	1'085'000
DE	DE24	Oberfranken	7'232	337	511'980	499'560	1'113'000	1'086'000
DE	DE25	Mittelfranken	7'248	497	1'134'980	1'147'710	1'694'000	1'713'000
DE	DE27	Schwaben	9'989	392	1'302'400	1'322'380	1'760'000	1'787'000
GE	GE01	Apkhazeti	8'671	55	172'682	119'680	253'944	176'000
GE	GE02	Atchara	2'894	29	193'443	193'902	379'300	380'200
GE	GE03	Guria	2'048	23	79'475	76'340	144'500	138'800
GE	GE04	Imereti	6'520	206	291'144	283'136	519'900	505'600
GE	GE05	Kakheti	11'338	68	287'140	281'330	410'200	401'900
GE	GE06	Kvemo Kartli	6'424	125	331'175	316'485	509'500	486'900
GE	GE07	Mtskheta-Mtianeti	6'792	25	52'500	44'184	125'000	105'200
GE	GE08	Ratcha-Lechkhumi	5'070	5	29'986	27'956	51'700	48'200
GE	GE09	Samegrelo-Zemo Svaneti	7'547	118	225'694	229'173	460'600	467'700
GE	GE10	Samtskhe-Javakheti						

			6'438	15	110'611	110'081	208'700	207'700
GE	GE11	Shida Kartli	5'687	51	170'640	161'082	316'000	298'300
GE	GE12	Tbilisi	225	102	674'870	704'692	1'088'500	1'136'600
HR	HR01	Sjeverozapadna Hrvatska	8'667	203	1'045'800	1'052'730	1'660'000	1'671'000
HR	HR02	Sredisnja i Istocna (Panonska) Hrvatska	23'197	262	891'000	856'020	1'350'000	1'297'000
HR	HR03	Jadranska Hrvatska	24'688	202	987'390	1'012'230	1'431'000	1'467'000
HU	HU10	Közép-Magyarország	6'916	776	1'132'000	1'164'400	2'830'000	2'911'000
HU	HU21	Közép-Dunántúl	11'115	453	459'610	452'640	1'121'000	1'104'000
HU	HU22	Nyugat-Dunántúl	11'323	434	431'290	429'140	1'003'000	998'000
HU	HU23	Dél-Dunántúl	14'168	330	687'240	660'330	996'000	957'000
HU	HU31	Észak-Magyarország	13'435	366	754'000	713'400	1'300'000	1'230'000
HU	HU32	Észak-Alföld	17'720	529	1'451'730	1'402'440	1'561'000	1'508'000
HU	HU33	Dél-Alföld	18'336	612	537'030	518'700	1'377'000	1'330'000
IT	ITC4	Lombardia	23'876	2'416	1'172'470	1'260'090	9'019'000	9'693'000
IT	ITD1	Provincia Autonoma Bolzano/Bozen	7'410	72	267'960	287'680	462'000	496'000
IT	ITD2	Provincia Autonoma Trento	6'206	115	71'400	77'550	476'000	517'000
IT	ITD3	Veneto	18'403	1'518	1'536'460	1'652'060	4'519'000	4'859'000
IT	ITD4	Friuli-Venezia Giulia	7'854	337	-	-	1'182'000	1'226'000
LI	LI00	Liechtenstein	160	6	-	-	33'000	35'000
MD	MD01	Orhei	2'568	64	187'298	180'362	263'800	254'031
MD	MD02	Tighina	2'490	23	139'695	134'051	208'500	200'076
MD	MD03	Dubasari	4'991	265	360'431	327'972	610'900	555'884
MD	MD04	Chisinau	3'273	202	1'244'532	1'254'807	1'121'200	1'130'457
MD	MD05	Cahul	3'087	39	181'784	175'520	293'200	283'097
MD	MD06	Balti	3'781	148	308'685	305'377	474'900	469'810
MD	MD07	Soroca	3'142	105	174'050	164'291	348'100	328'582
MD	MD08	Gagauzia	1'618	34	46'293	42'292	118'700	108'442
MD	MD09	Edinet	3'318	94	144'092	137'105	277'100	263'663
MD	MD10	Lapusna						

			3'210	36	181'090	175'369	278'600	269'798
MD	MD11	Ungheni	2'349	47	138'363	134'747	271'300	264'209
ME	ME01	Andrijevica	346	1	1'959	1'878	5'937	5'690
ME	ME02	Kolašin	884	2	2'029	1'965	10'144	9'827
ME	ME03	Plužine	843	-	1'996	1'877	4'435	4'170
ME	ME04	Pljevlja	1'279	8	39'771	39'828	39'771	39'828
ME	ME05	Mojkovac	318	-	5'606	5'492	10'193	9'986
ME	ME06	Rožaje	407	-	7'959	7'932	22'740	22'663
ME	ME07	Berane	689	9	15'000	14'558	35'715	34'663
ME	ME08	Žabljak	444	-	3'675	3'511	4'323	4'130
ME	ME09	BijeloPolje	1'003	4	25'558	24'883	51'115	49'765
ME	ME10	Plav	475	1	7'508	6'748	14'722	13'232
ME	ME11	Šavnik	539	-	1'474	1'378	3'071	2'870
ME	ME12	Nikšic	2'035	8	33'082	33'150	75'186	75'342
ME	ME13	Podgorica	1'584	35	89'792	92'294	166'281	170'914
MK	MK00	Poranesna jugoslovenska Republika Makedonija	25'450	357	1'194'160	1'207'730	2'024'000	2'047'000
PL	PL21	Malopolskie	15'182	591	1'838'820	1'871'310	3'226'000	3'283'000
PL	PL22	Slaskie	12'333	1'579	808'690	790'500	4'757'000	4'650'000
PL	PL31	Lubelskie	25'123	359	815'480	800'680	2'204'000	2'164'000
PL	PL32	Podkarpackie	17'846	281	1'240'770	1'237'820	2'103'000	2'098'000
PL	PL34	Podlaskie	20'188	299	762'300	750'960	1'210'000	1'192'000
PL	PL51	Dolnoslaskie	19'947	565	-	-	2'911'000	2'878'000
RO	RO11	Nord-Vest	34'173	291	283'900	272'300	2'839'000	2'723'000
RO	RO12	Centru	34'111	549	237'600	227'250	2'640'000	2'525'000
RO	RO21	Nord-Est	36'862	680	2'493'400	2'418'000	3'836'000	3'720'000
RO	RO22	Sud-Est	35'751	1'067	1'761'000	1'693'200	2'935'000	2'822'000
RO	RO31	Sud - Muntenia	34'477	1'229	865'750	821'500	3'463'000	3'286'000
RO	RO32	Bucuresti - Ilfov	1'805	382	816'840	809'280	2'269'000	2'248'000
RO	RO41	Sud-Vest Oltenia						

			29'246	580	431'460	407'520	2'397'000	2'264'000
RO	RO42	Vest	32'029	557	934'720	885'960	2'032'000	1'926'000
RS	RS11	Juzno-banatski	4'146	141	44'023	42'498	314'451	303'560
RS	RS20	Srednje-banatski	3'249	62	43'983	40'986	209'444	195'171
RS	RS21	Pomoravski	2'680	108	50'236	47'996	228'345	218'164
RS	RS22	Moravicki	3'092	44	-	-	225'301	217'130
RS	RS23	Zajecarski	3'677	33	-	-	138'879	126'175
RS	RS24	Zlatiborski	6'260	39	-	-	314'477	299'384
RS	RS27	Rasinski	2'707	88	145'867	138'005	260'477	246'438
RS	RS28	Kolubarski	2'557	21	-	-	193'012	182'021
RS	RS29	Nisavski	2'724	88	-	-	382'706	375'833
RS	RS30	Toplicki	2'263	9	-	-	102'786	95'842
RS	RS31	Pirotski	2'686	34	-	-	106'554	97'229
RS	RS32	Kosovsko-mitrovatski	2'063	22	-	-	278'392	260'973
RS	RS33	Jablanicki	2'725	43	-	-	242'176	229'568
RS	RS34	Kosovski	3'117	49	-	-	678'356	635'911
RS	RS35	Pecki	2'501	13	334'338	313'418	417'923	391'773
RS	RS36	Raski	3'862	68	235'420	241'919	290'642	298'665
RS	RS37	Prizremski	1'876	24	220'097	206'325	379'477	355'733
RS	RS39	Severno-backi	1'798	29	94'103	90'905	200'220	193'415
RS	RS40	Severno-banatski	2'304	44	131'809	122'708	166'847	155'326
RS	RS41	Zapadno-backi	2'408	32	94'519	87'083	214'817	197'917
RS	RS42	Sremski	3'417	106	120'354	118'347	334'317	328'743
RS	RS43	Juzno-backi	4'107	129	312'683	321'331	589'967	606'284
RS	RS44	Sumadijski	2'382	63	191'873	186'119	299'802	290'811
RS	RS47	Pcinjski	3'465	24	111'369	112'114	227'283	228'804
RS	RS49	Grad Beograd	3'198	277	847'990	874'695	1'570'352	1'619'805
RS	RS50	Macvanski	3'232	65	135'664	128'727	330'887	313'969
RS	RS51	Branicevski	3'907	91	108'665	103'852	201'231	192'318

RS	RS52	Podunavski	1'217	92	80'147	77'750	210'913	204'605
RS	RS53	Borski	3'482	32	141'645	129'036	147'547	134'412
RS	RS54	Kosovsko-pomoravski	1'400	9	85'679	80'318	219'690	205'944
RU	RU01	Saratov Region	101'479	401	565'740	542'640	2'694'000	2'584'000
RU	RU02	Kursk Region	29'796	202	531'468	488'040	1'265'400	1'162'000
RU	RU03	Belgorod region	27'122	218	1'218'240	1'230'390	1'504'000	1'519'000
RU	RU04	Tambov region	34'452	144	570'486	519'820	1'213'800	1'106'000
RU	RU05	Volgograd Region	113'201	923	1'170'546	1'121'870	2'722'200	2'609'000
RU	RU06	Rostov Region	101'259	969	2'038'168	1'957'300	4'430'800	4'255'000
RU	RU07	Republic of Kalmykia	73'776	33	286'136	268'840	304'400	286'000
RU	RU08	Voronezh Region	52'108	298	1'451'760	1'368'000	2'419'600	2'280'000
RU	RU09	Krasnodar Territory	75'177	1'315	2'101'824	2'100'020	5'126'400	5'122'000
RU	RU10	Orel region	24'725	86	411'532	386'340	875'600	822'000
RU	RU12	Penza Region	43'386	164	1'068'912	999'360	1'484'600	1'388'000
RU	RU13	Bryansk region	34'685	140	633'420	589'050	1'407'600	1'309'000
RU	RU14	Tula Region	25'517	217	1'512'544	1'378'080	1'718'800	1'566'000
RU	RU15	Kaluga Region	29'402	89	573'048	543'240	1'061'200	1'006'000
RU	RU16	Ryazan Region	39'577	108	654'680	605'800	1'259'000	1'165'000
RU	RU17	Smolensk region	49'773	83	498'180	452'180	1'083'000	983'000
RU	RU18	Lipetsk region	24'303	153	673'420	642'950	1'224'400	1'169'000
RU	RU19	Republic of North Ossetia - Alania	7'953	281	299'280	301'860	696'000	702'000
RU	RU25	Kabardino-Balkar Republic	12'388	344	255'954	258'390	882'600	891'000
RU	RU26	Karachay-Cherkessia	14'256	221	210'720	204'960	439'000	427'000
RU	RU38	Stavropol Territory	66'719	1'198	985'104	973'800	2'736'400	2'705'000
RU	RU45	Tver region	84'698	135	714'494	648'600	1'520'200	1'380'000
RU	RU48	Republic of Adygea	7'976	249	174'798	171'990	448'200	441'000
SI	SI01	Vzhodna Slovenija	12'215	174	637'200	636'020	1'080'000	1'078'000
SI	SI02	Zahodna Slovenija	8'066	151	401'280	414'920	912'000	943'000
SK	SK01	Bratislavský kraj						

			2'045	230	227'620	233'320	599'000	614'000
SK	SK02	Západné Slovensko	14'986	694	1'178'100	1'174'950	1'870'000	1'865'000
SK	SK03	Stredné Slovensko	16'260	342	582'220	580'500	1'354'000	1'350'000
SK	SK04	Východné Slovensko	15'721	402	716'220	725'880	1'557'000	1'578'000
TR	TR10	Istanbul	5'312	875	3'977'220	4'951'894	10'198'000	12'697'164
TR	TR21	Tekirdag	18'849	193	394'690	435'684	1'361'000	1'502'358
TR	TR22	Balikesir	23'756	194	478'640	497'571	1'544'000	1'605'067
TR	TR33	Manisa	45'352	347	1'529'000	1'457'055	3'058'000	2'914'110
TR	TR41	Bursa	29'106	436	1'223'600	1'377'148	3'059'000	3'442'871
TR	TR42	Kocaeli	20'213	583	1'040'060	1'191'891	2'737'000	3'136'555
TR	TR51	Ankara	24'878	504	931'500	1'046'256	4'050'000	4'548'939
TR	TR52	Konya	48'160	330	812'130	726'004	2'461'000	2'200'013
TR	TR61	Antalya	35'937	499	607'680	603'402	2'532'000	2'514'175
TR	TR71	Kirikkale	31'341	163	542'400	477'697	1'695'000	1'492'804
TR	TR72	Kayseri	59'782	276	1'000'400	919'882	2'501'000	2'299'704
TR	TR81	Zonguldak	9'539	189	273'240	275'607	1'012'000	1'020'767
TR	TR82	Kastamonu	26'487	159	499'380	427'639	861'000	737'308
TR	TR83	Samsun	38'012	504	1'497'500	1'359'977	2'995'000	2'719'954
TR	TR90	Trabzon	35'083	228	1'035'210	827'438	3'137'000	2'507'387
TR	TRA1	Erzurum	40'789	122	513'760	403'289	1'352'000	1'061'287
TR	TRA2	Agri	29'936	108	566'440	558'882	1'156'000	1'140'575
UA	UA01	Avtonomna Respublika Krym/M.Si	26'040	354	991'488	965'825	2'023'444	1'971'072
UA	UA05	Vinnyts'ka	26'495	549	652'652	618'720	1'763'925	1'672'217
UA	UA07	Volyns'ka	20'163	255	412'138	404'210	1'056'764	1'036'436
UA	UA12	Dnipropetrovs'ka	31'886	1'045	2'705'604	2'582'782	3'560'005	3'398'398
UA	UA14	Donets'ka	26'511	1'673	3'906'316	3'676'524	4'822'612	4'538'918
UA	UA18	Zhytomyrs'ka	29'838	147	611'321	574'398	1'389'365	1'305'450
UA	UA21	Zakarpats'ka	12'771	339	326'200	323'078	1'254'614	1'242'606
UA	UA23	Zaporiz'ka	27'295	351	1'329'633	1'264'693	1'927'004	1'832'888

UA	UA26	Ivano-Frankivs'ka	13'940	233	435'276	428'607	1'404'115	1'382'603
UA	UA32	Kyivs'ka	28'085	175	829'265	799'144	1'802'751	1'737'269
UA	UA35	Kirovohrads'ka	24'582	147	528'926	488'678	1'125'375	1'039'740
UA	UA44	Luhans'ka	26'684	917	1'778'494	1'648'742	2'540'705	2'355'346
UA	UA46	L'vivs'ka	21'843	449	1'328'232	1'305'487	2'604'377	2'559'779
UA	UA48	Mykolaivs'ka	23'952	160	732'118	698'065	1'262'273	1'203'560
UA	UA51	Odes'ka	33'323	661	1'447'949	1'412'890	2'454'151	2'394'728
UA	UA53	Poltavs'ka	28'729	297	826'897	777'700	1'621'366	1'524'902
UA	UA56	Rivnens'ka	20'047	124	456'659	449'276	1'170'920	1'151'990
UA	UA59	Sums'ka	23'833	231	725'670	670'219	1'295'840	1'196'820
UA	UA61	Ternopil's'ka	13'823	147	352'428	340'572	1'136'866	1'098'618
UA	UA63	Kharkivs'ka	31'436	583	1'881'493	1'817'347	2'894'604	2'795'919
UA	UA65	Khersons'ka	26'398	152	527'720	498'376	1'172'710	1'107'502
UA	UA68	Khmel'nyts'ka	20'636	171	628'207	594'133	1'427'743	1'350'303
UA	UA71	Cherkas'ka	20'935	255	671'285	631'435	1'398'510	1'315'490
UA	UA73	Chernivets'ka	8'090	301	284'478	280'403	917'671	904'527
UA	UA74	Chernihivs'ka	31'899	141	582'996	533'873	1'240'417	1'135'899
UA	UA80	Kyiv	889	289	2'554'375	2'712'798	2'580'177	2'740'200
UA	UA85	Sevastopol	891	116	352'005	352'935	378'500	379'500