European Spatial indicators – temporal development and quality aspects

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1 ABSTRACT

The Spatial Planning Observatory, which is part of the Integrated Project **geoland**, funded within the 6th framework program of the EC, will generate products and services based on EO data, geo-spatial and statistical data, fulfilling the demand of spatial planning as guided by European, national and regional regulations and policies. The products and services comprise indicators, spatial typologies as well as models and scenarios, which are presented in tabular, graphical and map forms.

In this paper we will present the temporal development of spatial indicators for a central European test site that includes former Eastern bloc countries (CZ, SK, H, SLO) as well as Western European countries (D, I, A). The time span analysed ranges from 1990 to 2000. Data sets used for the derivation of the indicators comprise CORINE land cover data as well as socio-economic data (e.g. population) from Eurostat. Using this dataset a first European wide cross-border analysis on the main changes on landscape level is enabled. The second part of the paper will concentrate on quality aspects of the indicators. This includes discussion on the quality of the base data – in particular the limitations of the CORINE land cover data – and an estimation of the accuracy of the resulting indicators by comparison with detailed reference data.

From the analysis performed it can be concluded that the indicators not only represent a significant improvement compared to the traditional statistical representation but also allow for a spatially refined analysis of temporal developments. Regarding the quality of the indicators there is a certain limitation that derives from the methodological characteristics of the CORINE land cover map. These limitations refer both to spatial as well as to thematic generalisation aspects. Restrictions also result from lacking harmonisation of the socio-economic data on a European level. However although these data show considerable limitations, they are the only ones being available on a European scale. The restricted access to more accurate data like those being generated in the process of controlling agricultural subsidies (e.g. INVEKOS-GIS1) prevent more accurate analysis. By beginning of next year INSPIRE2 will be more developed and hopefully will provide a standardised access to core data sets.

2 INTRODUCTION

The Observatory Spatial Planning (OSP), which is part of the Integrated Project **geoland**, funded within the 6th framework program of the EC, will generate products and services based on Earth Observation (EO), geo-spatial and statistical data3. The project aims at developing a project portfolio that covers some key issues of spatial planning frameworks and concepts, especially the ESDP (European Spatial Development Perspective) as well as national and regional spatial planning directives and sustainability strategies. The products and services comprise indicators, spatial typologies as well as models and scenarios, which are presented in tabular, graphical and map forms.

Widely used frameworks for indicator development are the Pressure-State-Response framework of the OECD and the DPSIR (Driving Forces-Pressure-State-Impact-Response) framework of the European Environment Agency (EEA). Land cover change as derived by EO-based methods, has been related to the DPSIR as a "pressure indicator", which characterises the depletion of natural resources. At the same time, the status of land cover (that characterizes the intensity of land use) and of the depletion of natural resources can be regarded as indicators for state and impact. Both frameworks do not explicitly include the aspect of land potential, which may be expressed as land attractiveness for people or as the degree of (potential) biodiversity. Land potential, however, can be considered a loop factor in the DPSIR framework in the sense that it is on the one hand impacted (to a variable degree) by driving forces/pressure/state factors, and on the other hand constitutes a driving force by itself by attracting people or companies to certain places where landscapes attractiveness is high. The indicators conceived on the basis of user requirements take this effect into account.

An overview of all indicator groups derived for European, national and subnational level can be found in Steinnocher et al. (2005). In this paper we will concentrate on a selection of European indicators and their change over time. These indicators relate to the DPSIR framework and include in addition aspects of land potential. They characterize driving forces and pressures related to demographic developments and their manifestation in land consumption per capita. State of and impact on the environment is represented by land

[1] Integriertes Verwaltungs- und Kontrollsystem (engl.: IACS = Integrated Administration and Control System): established by the EC in 1992 to administrate and control agricultural subsidies.

[2] INSPIRE (Infrastructure for Spatial Information in Europe) is a recent initiative launched by the European Commission and developed in collaboration with Member States and accession countries. It aims at making available relevant, harmonised and quality geographic information to support formulation, implementation, monitoring and evaluation of Community policies with a territorial dimension or impact. (http://www.ec-gis.org/inspire/)

[3] http://www.gmes-geoland.info/OS/OSP/index.php

cover/use patterns, agricultural intensity, and availability of recreational areas. These indicators form the basis for spatial typologies and scenarios to be developed in the course of the **geoland** project.

Besides these aspects on the supply side of the products and services there is the question of how users actually digest and utilise the provided information for spatial planning decisions or other purposes, such as reporting obligations. The EO based products and services constitute not only information from another than conventional data source, but also in some respects a new type of information, i.e. spatially explicit information. This offers not only additional application potentials, but also bears the necessity to adapt to their utilisation. In addition, the information provided is directly linked to concepts such as the DPSIR and sustainable development, and thus has to be evaluated and used in this context.

3 DATA AND TEST SITE

The European indicators were developed in cooperation with an end user consortium comprising DG Regio, Tor vergata (project leader of ESPON 3.3), Metrex and Eurocities[4]. All indicators are based on aggregated CORINE land cover data (see 3.1) and statistical information.

For demonstrations on a European scale an area of approximately 420.000 km2 located in central Europe has been chosen as test site, covering several nations including new EU member states. The test site represents a wide range of heterogeneous geographic landscapes including Alpine areas, costal zones as well as flat terrain with urban and rural areas. It comprises the Czech Republic, Austria, Slovenia and parts of Germany, Slovakia, Hungary and Italy. Figure 1 gives an overview of the European test site.

3.1 Land cover data

CORINE Land Cover (CLC) is a compilation of national land cover inventories, which are integrated into a seamless land cover map of Europe. The land cover information is derived mainly from satellite imagery and ancillary data sources such as maps. Its production is based on a standard methodology and nomenclature (EEA, 1999), resulting in a digital vector data set where each polygon represents one of 44 land cover classes that are organised in a hierarchical structure with three levels of detail. The scale of the cartographic representation is 1:100.000 with a minimum mapping unit of 25ha, i.e. single land cover objects smaller than 25 ha are not represented in the data set. In order to cope with heterogeneous landscapes the nomenclature includes several mixed classes. At European level the data base is also available in a 100m grid format, representing the first two levels of the three level nomenclature (see Fig. 1 left).

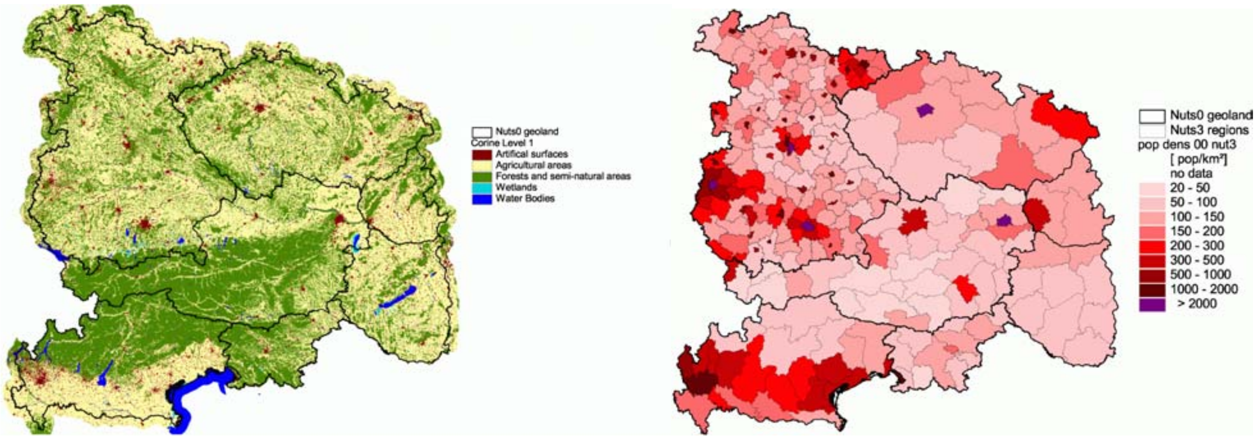

Fig.1: European test site. Left: CORINE land cover level 1 (2000), right: Population density per NUTS 3 area (2001)

In spring 2005 an update (CLC 2000) of the first data base (CLC 1990) was finished by the national teams of the participating countries. In the course of the update process the original data base (CLC 1990) was revised and corrected in order to obtain consistent and comparable data sets. This correction ensures that differences between the two data sets refer to actual changes in land cover rather than to interpretation errors and geometric inaccuracies.

In terms of data quality the grid representation of CLC (major CLC class per 1 ha cell) was found not to be sufficient for all analyses. This is less due to the spatial resolution of 100m – which seems to be appropriate when working on a European scale – but more related to the minimum mapping area of 25ha, which is defined within the standardised methodology. In particular for small built-up areas but also for certain agricultural structures the level of spatial detail is too coarse to reflect the full range of scales where landscape changes appear. This has an effect on both the spatial and temporal variability and significance of the indicators. Many land cover changes are not recorded because they are below the minimum mapping unit; likewise, the character and diversity of landscapes – as far as it is related to smaller land cover objects - is not expressed in the data. In all the subsequent analysis one has to

[4] DG Regio: EU Directorate-General 'Regional Policy' - http://europa.eu.int/comm/dgs/regional_policy/index_en.htm
ESPON 3.3: European Spatial Planning Observation Network project 3.3: territorial dimension of the Lisbon/Gothenburg process - http://www.espon.lu/online/documentation/projects/cross_thematic/cross_thematic_147.html
Metrex: The Network of European Metropolitan Regions and Areas - http://www.eurometrex.org/
Eurocities: Network of major European cities - http://www.eurocities.org/_INDEX.php

bear in mind that the interpretation is only valid for those changes that manifest in landscape changes that can be observed within the landscape scale defined by CORINE land cover (app. 1:100.000).

3.2 Statistical data

The statistical data at European level are derived from the REGIO database, Eurostat's harmonised regional statistical database. REGIO is a domain of the General Statistics of the New Cronos database (Eurostat 2004). It contains 14 different collections, such as agriculture, demographic statistics, economic accounts, education statistics, environment statistics, community labour force survey (annual average and second quarter), migration statistics, science and technology (research and development, patents), structural business statistics, health statistics, tourism statistics, transport and energy statistics and unemployment. These data are available at NUTS3 level which is used as spatial reference on the European scale (see Fig. 1 right).

Besides the complex structure of this data base – requiring interactive data retrieval in order to produce GIS compatible attributed polygon layers – problems occurred when searching for historic data. Linking land cover with statistical data requires more or less identical acquisition times of both data types. As the reference year for CLC is 1990 statistical data from that time are needed. Unfortunately statistical data from the New Member States are not available before the mid 1990s.

Another difficulty arises from the varying sizes of the NUTS3 areas in different countries. While in the New Member States the size of NUTS3 areas averages out to about 5.000 km2, in Germany they come down to 1.000 km2 in rural areas and to 100 km2 for urban areas. The smallest NUTS3 area of the European test site has a size of less than 36 km2, the largest a size of more than 11.000 km2. Comparison of statistical data is somewhat hampered by these disparities but the introduction of land cover data and the referencing of land cover based indicators to a common European grid can help to improve the situation.

4 TEMPORAL DEVELOPMENT OF INDICATORS

The three European indicators discussed in this study comprise *population density in urbanized areas, recreational areas within citizen reach,* and *agricultural intensity*. The methodology for deriving these indicators is based on GIS functions, especially intersections of EO data with other geo-spatial data and statistical information (Steinnocher et al., 2005a).

Representation of the indicators can be based on polygons or a regular grid. For the first approach the land cover layer is intersected with NUTS3 polygons, the proportion of the relevant land cover classes per polygon is calculated and the population data divided by it. This approach gives one value for each NUTS3 polygon. The grid-based approach goes one step further by mapping the calculated density measures on the relevant land cover units leading to a spatially refined density map. This layer is then intersected by regular grid allowing to calculate a density measure for each grid cell. In this paper we will confine ourselves to the grid representation.

All indicators were calculated for the reference year 1990 and the update year 2000. These dates refer to the production of the CLC land cover data. However, it is to be noted that the actual acquisition dates for CLC 1990 range from the mid 1980ies to the beginning of the 90ies. The CLC 2000 is mainly based on data from the year 2000. A similar problem occurs with the socio-economic data. While the up-to-date information refers mainly to 2001, the reference data come from a period between 1991 and 1995. The inconsistency resulting from these temporal differences in the data sources are accepted assuming that the main trends can still be derived. Furthermore, the major emphasis of this study lies in the methodology and its potential for the future, where it is expected that data collections will provide temporal concurrence as was the case in 2000/2001.

Fig. 2 shows the temporal development between 1990 and 2000 of two base data sets: the change of the proportion of residential areas per grid cell (given in percentage points) and the change of population per NUTS 3 area (given in absolute numbers).

4.1 Population density within urbanized areas

This indicator refers to the actual population density that occurs within built-up areas in contrast to the traditional measure that refers to population per statistical area, such as NUTS3. Assuming that people mainly live in residential areas – as observed by CORINE land cover - rather than in the agricultural or forested areas the population number of a statistical unit can be assigned to the actual built-up areas within this unit. Calculation of this indicator requires information on land cover – in particular on artificial surface types (CLC class 1 and sub-classes) – and on population statistics as provided by Eurostat on a NUTS3 level.

The indicator can be based either on the entire artificial surface areas or limited to residential areas. The first approach represents the general land consumption per capita, including commercial, industrial and transport related areas etc., while the second approach gives an indication on the density of housing within residential areas. In this paper we will refer to the second approach, population density in residential areas. Fig. 3 shows the indicator for 2000 and the absolute change between 1990 and 2000.

4.2 Recreational areas within citizen reach

This indicator represents the proportion of attractive landscapes (as potential recreational areas) within a specified distance from residential areas. For each “residential cell” the amount of “recreational areas” within its reach is calculated, for instance within a circle of 10 km, to express residential area attractiveness for short one-day or weekend trips.

Recreational areas are defined as green urban areas, permanent crops such as vineyards, forest and semi-natural areas, wetlands and water bodies within a specified distance from residential areas. In order to calculate this indicator raster representation of the land cover map is required (as e.g. provided by the CLC100m grid). First the amount of recreational area in a circular neighbourhood of each residential cell is calculated, resulting in a general availability of recreational areas in the surrounding of residential areas. In a second step this availability is weighed by the population density in residential areas, resulting in an availability of recreational areas per capita. While the first result represents land cover patterns only the second approach introduces population distribution thus indicating potential land use. Fig. 4 shows the second approach for 2000 and the absolute change between 1990 and 2000.

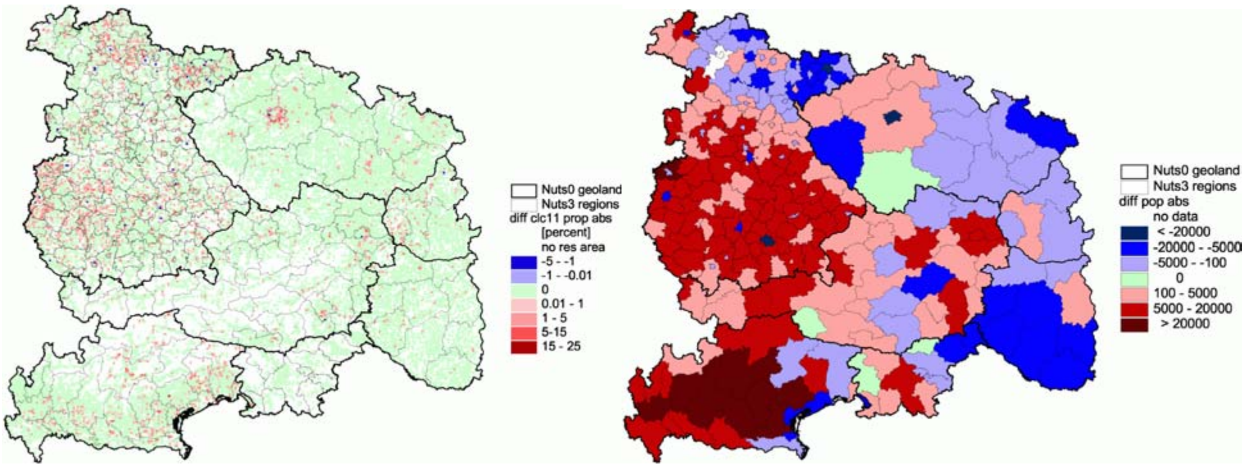

Fig.2: European test site. Left: absolute change of residential areas (1990/2000)), right: absolute change of population on NUTS 3 level (1993/2001)

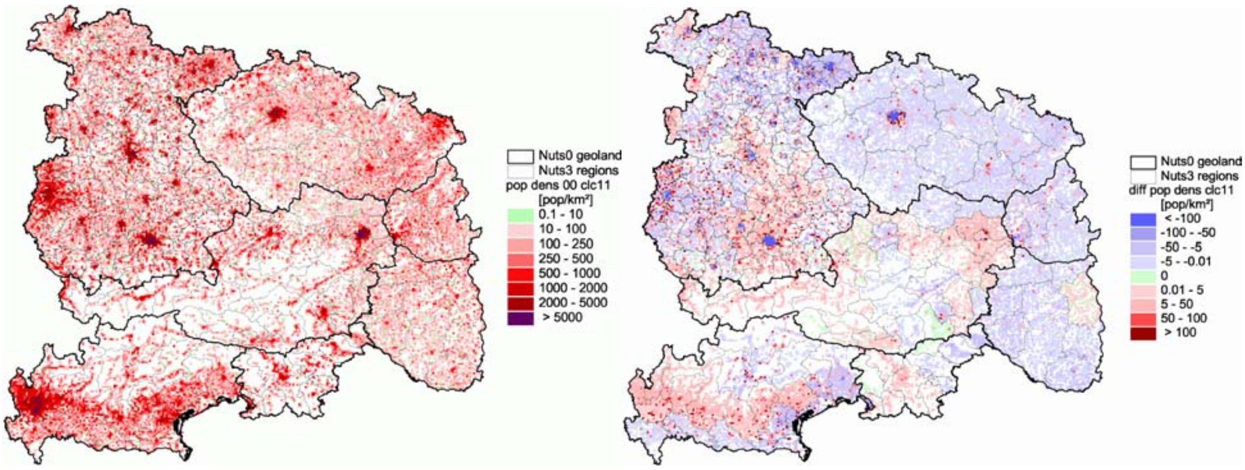

Fig.3: Left: population density per residential area (2000), right: absolute change of population density (1990/2000)

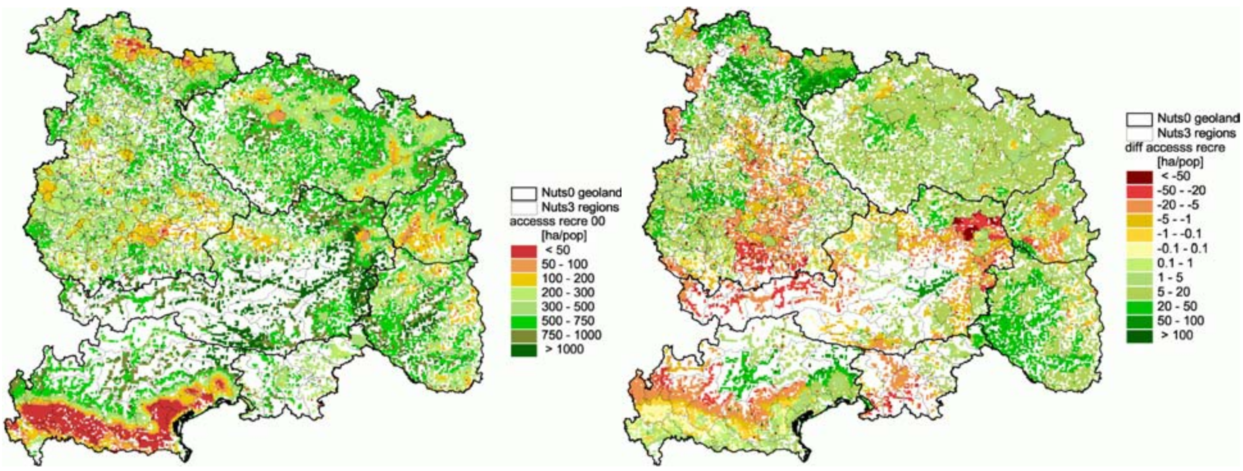

Fig.4: Left: access to recreational areas (2000), right: absolute change of access to recreational areas (1990/2000)

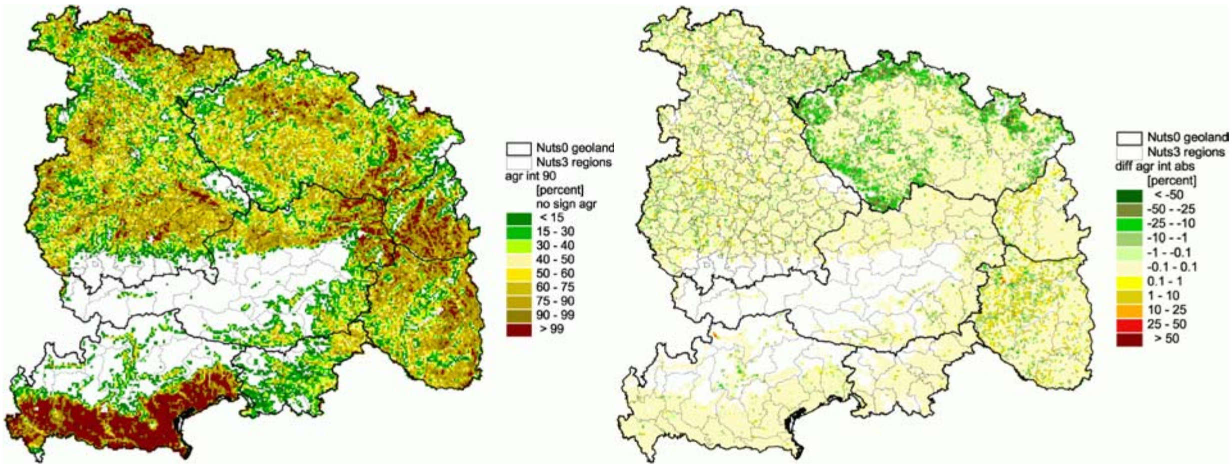

Fig.5: Left: agricultural intensity (2000), right: absolute change of agricultural intensity (1990/2000)

4.3 Agricultural intensity

This indicator refers to the percentage of arable land and permanent crops on the potential utilizable area. The potential utilizable area may be taken either as total agricultural area or as agricultural area plus forests and semi-natural areas. In the first case the indicator represents the ratio between intensive and extensive agriculture, as the total agricultural area without arable land and permanent crops leaves meadows and pastures. The latter approach represents the importance of intensive agriculture in terms of agricultural land consumption for the area under investigation. Fig. 5 shows the latter approach for 2000 and the absolute change between 1990 and 2000.

5 DISCUSSION

In the following the three European indicators and their development over time are discussed.

5.1 Population density in urbanized areas

This indicator shows how densely people live in cities, while also indicating the structure of the residential area. This can also be demonstrated by the reciprocal of the density that yields land consumption for housing per capita; high land consumption indicating single family housing, low land consumption indicating apartment buildings. Fig. 2 shows the basis for deriving this indicator: the increase in residential areas in grid representation and the change of population on a NUTS 3 level. The increase in residential areas is a clear example of the uncertainty that is linked to the standardised CORINE Land Cover methodology. The observed changes in residential areas may depend to a large extent on the quality of the revision of the CORINE 1990 data. Any underestimation of e.g. settlements in the original CLC 1990 data lead to an enormous overestimation of the increase in built-up areas in the CLC 2000 data, if not corrected adequately. Fig. 2 shows that most parts of southern Germany and the larger Po-Region in Italy have a large increase in built-up areas. As this increase is not bound to urban agglomerations but rather appears in rural areas, conclusions have to be drawn very carefully. Whereas Slovenia shows almost no changes at all, in the Czech Republic, Austria and partly also in Slovakia larger increases can be observed in the suburban areas of major cities.

With regard to the population changes in Fig. 2 one has to keep in mind that an absolute change in population depends largely on the size of the NUTS 3 region. Therefore the Po-region turns into dark read, reflecting on one hand a very high increase in population, but also the size of the NUTS3 regions which are larger than average. The German NUTS 3 regions have to be mentioned in particular, as they show a high increase of population despite of their small areas. The general trend of population decrease in peripheral regions is shown quite impressively. Not by occasion these areas are located mostly at the border line between countries or within a country in the most peripheral regions. Exceptions are the “new federal states” in Germany where a strong decrease in population has been observed during the last decade (most northern part of the German part of the test site – shown in blue in Fig. 2 right).

Looking at the **change of population density** between 1990 and 2000 (Fig. 3) one can see the different developments in central Europe (increase of population density is shown in red colours, decrease in blue colours, no change in green, white areas indicate no residential areas).

At this point it is to be mentioned that change of population density does not necessarily mean change of population but rather a change of the ratio between population and residential areas. Increase of population density is likely to be a result of high increase of population linked with low increase of residential areas. Decrease of population density is related to a low increase or even a decrease of population linked with a high increase of residential areas. No change in population density might result from no activities – neither migration nor urban sprawl – but might as well indicate a proportional increase of population and residential areas. On has to note that even with an increase in population the density may decrease. This occurs if the population increases in a slower rate than the built-up area (land consumption per capita is higher than it was before).

The areas with the **strongest decrease in population density** are larger cities (such as Munich, Prague and Chemnitz). This trend is largely due to a significant decrease in population while residential areas stay unchanged – leading to a lower density in 2000 compared to 1990. The largest changes appear in areas with change rates from –5 up to +5 population/km2.

Areas with **decreasing population density** can be grouped into two main process oriented categories:

- The first category comprises areas which show a decrease in population and almost no changes in residential areas, thus leading to a lower population density (most areas in HUN, CZ, and SK).
- The second category represents completely other processes. While on NUTS 3 level an increase of population is reported the residential areas are growing even stronger. Thus one can interpret that people moving to these – mostly rural – areas require more residential area per capita than the “old” population. Thus the population density decreases – as the increase in built up areas overcompensates the increase in population. Such developments usually are an impact of suburbanisation but also seem to appear in remote regions such as parts of southern Germany and Northern Italy. However, analysing this effect may be hampered by the quality of the built-up area change based on CLC 1990 data.

The interpretation of areas with an average **increase in population density** is doubtful because the criteria of the 25 ha minimum mapping unit may lead to wrong conclusions. As in these areas on NUTS 3 level quite a large increase in population is observed, the increase in built-up area may be underestimated, thus leading to apparently higher density figures compared to 1993.

Areas with the **highest increase in population density** (> +5 population/km2) are linked to those with a high absolute population density. Only in the neighbourhood of very densely populated areas very strong increase of population density can be observed. So to say no population hot spots are created in the open countryside, but population hot spots grow in the direct vicinity of previous population hot spots.

5.2 Recreational areas within citizen reach

The indicator on Recreational areas within citizen reach turned out to be an interesting representation of landscape features. As it takes local patterns into account we again face the problem of spatial detail in the land cover representation. The distance applied is to be seen as a proxy variable but does not represent the actual effort to reach recreational areas. Discussions with the users lead to the conclusion that this indicator should not be limited to residential areas but could be improved by introducing population numbers. Applying population density per residential area allows calculating the amount of recreational area available per capita, thus refining the significance of the indicator.

The results of the latter approach for the European test site are shown in Fig. 4 (red colours indicate low availability, green colours high availability of recreational areas). While the general availability of recreational areas indicates mainly landscape features, the availability per capita sets a focus on the highly populated urbanized areas. The reddish belt in northern Italy results from the combination of high population density and a dominance of agricultural land use, which is not defined as recreational area.

The change of the amount of recreational area per capita (Fig. 4 right) reflects the increase of population on one hand, but also takes into account the change of recreational areas. The latter do not change very strong but if they do have a significant influence on the resulting indicator.

The main conclusion that can be drawn is the “greening of cities” and the “browning of regions with urban sprawl”. Considering the cities it is known that various programmes are installed at least to keep the remaining urban green areas. And this conservative approach is accompanied by mostly decreasing population numbers, thus leading to more recreational areas per capita. The opposite trend is taking place in sub-urban regions. While they are faced with large increases in population, the “recreational areas” do not grow, but rather shrink in favour of new built-up areas. This effect can lead to a substantial decrease of recreational areas per capita in wider suburban regions, which somewhat counteracts the recreational effect of living in the countryside.

5.3 Agricultural intensity

This indicator represents the ratio between intensive agriculture and vegetation cover in general.

Agricultural intensity as represented by this indicator is not a measure of how intensively the arable land is managed but is a measure of the potential to grow high value agricultural products. Out of the history of agricultural production most land with a high potential for agriculture is already used as high value farmland (arable land and vineyards) today. Thus major changes refer to a decrease of arable land or vineyards while conversion into arable land almost never occurs.

Two general trends can be observed nowadays. On the one side high value farmland is turned into new settlement areas, as the value of building land is 10 to 1000 times higher than the value of the same piece of land for agricultural use. On the other side farmland of lower value is given up and turns into grassland or – in the long run – into forest.

The most impressive change in the agricultural intensity occurs in the Czech Republic (see Fig. 5). Due to the change of arable land to pastures – a decrease of almost 280.000 ha equalling 8% of all arable land in 1990 and an increase of pastures of almost 130% – this land cover change is unique within central Europe. According to Czech experts this change is due to

- cancellation of agricultural subsidies for crop production in less productive areas in 1990
- implementation of new subsidy schemes to support extensive agriculture in less productive areas in 1995/96
- changes in land ownership due to restitution in 1990 (in particular complicated/unclear ownership structure in former "Sudetenland" areas)

The second effect can be observed in Hungary. It is taking place in a complex agricultural landscape comprising more or less intense agricultural areas within local neighbourhoods. Both intensification and extensification takes place, whereas the intensification slightly dominates in this area.

Larger areas of extensification can also be observed in the “new federal states” in Germany mainly due to abandonment of arable land.

6 QUALITY ASSESSMENT

For the indicator population density a quality assessment was performed based on the comparison with reference data in Austria. The indicator data set is derived from the spatial disaggregation of NUTS 3 population statistics onto CLC residential areas (as described in chapter 4.1) and is provided in a 3x3km grid representation (see Fig. 6 left). The reference data set is an Austrian wide raster with 250m grid cells representing population. It was derived from the 2001 census by Statistik Austria (Kamiger et al. 2004). For the comparison the 250m population raster was aggregated to the 3km indicator grid (see Fig. 6 right).

A visual comparison shows the main difference of the two data sets: while in the reference data set a huge majority of cells are “inhabited”, the indicator data set shows large areas without population. The reason is that due to the CLC mapping rules settlements smaller than 25ha are not mapped and thus cannot be populated in the disaggregation process. On the other hand it is obvious that these small settlements will not comprise a large part of the population. Therefore it is likely that a majority of the population will be distributed correctly by the indicator. A numerical comparison proves this hypothesis: while the indicator populates only about 50% of the actually inhabited cells, it includes more than 90% of the actual population; i.e. only 10% of the population lives in the “white” areas of the indicator grid.

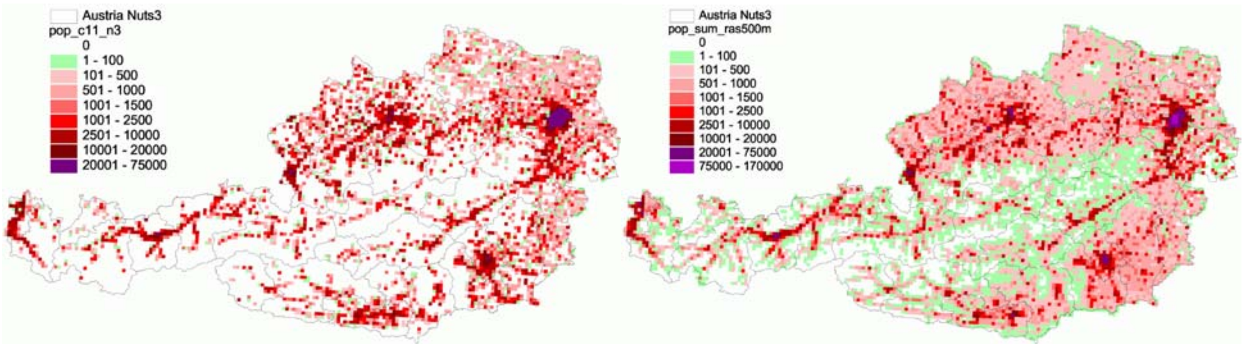

Fig.6: Population density in Austria Left: geoland indicator (2001), right: raster statistics (2001)

In order to cover most of the missing 10% a smaller minimum mapping unit (MMU) is required. Reducing the MMU to 1 ha should be sufficient to cover most settlements, only leaving out stand alone buildings such as single farm houses.

The remaining 90% of the population is distributed to the CLC residential areas. As we use a proportional distribution – assuming the same population density in all residential areas – the indicator will differ from the reference data set also in populated cells. Here the trend is an underestimation of highly populated areas such as city centres and consequently an overestimation of population in the surrounding areas. While the underestimation is restricted to a few hot spots, the overestimation has an areal dimension. This can be observed in Fig. 7 where the deviation of the indicator from the reference data set is shown for the city of Vienna and surroundings. The red colours represent cells where the reference data set states a higher population than the indicator, cells in blue indicate the opposite, green cells show equal numbers and white cells are uninhabited. It can be clearly seen that the population is strongly underestimated in the centre of Vienna (dark red) while in the outer districts is overestimated (dark blue). The wider surroundings are slightly underestimated (light blue) except for the densely populated axis south of the city and some regional centres shown in red.

In order to reduce this deviation housing density measures need to be included in the analysis. Steinnocher et al. (2005b) shows that the introduction of 3 density classes results in a significant improvement of the disaggregation results.

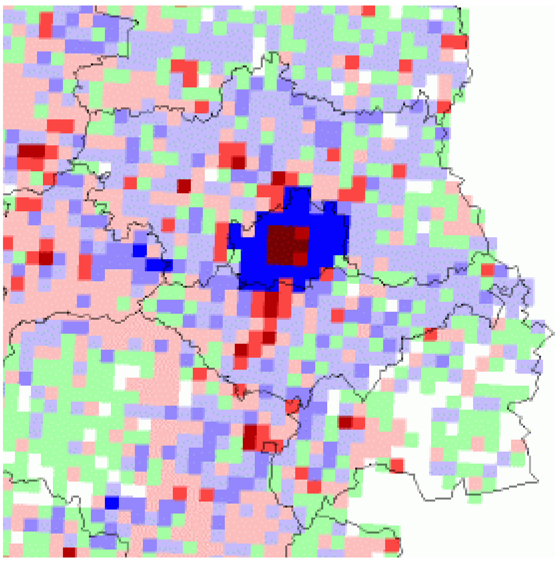

Fig.7: Vienna and surroundings: Differences between raster statistics and geoland indicator (2001)

7 CONCLUSIONS

The described indicators demonstrate the usefulness of EO based information in particular when linked to statistical information. However, improvements are required both in terms of land cover specification and indicator definition. In order to use land cover data efficiently more spatial detail is needed. While the thematic detail of CLC level 2 is generally sufficient – except for residential areas where different density classes would be helpful – the minimum mapping unit of 25ha is much too large for detailed analyses.

The temporal development of the three indicators discussed (population density in urbanized areas, recreational areas within citizen reach, agricultural intensity) has quite different interpretation qualities. For the interpretation of quality of trends, the indicators can be rowed in ascending order: agricultural intensity, population density and recreational areas.

As the agricultural intensity is a quite constant indicator those changes that are observed should be analysed carefully. However if they turn out to be reality, as is the case for the Czech Republic, it is a clear indicator for the effect of extensification of agriculture in peripheral and less favoured regions.

The population density is the indicator that needs a very sound interpretation. As it is based on two data sources (change of built-up areas and change of population) the interpretation has to take the matrix of potential intersections of the two variables into consideration. The main categories of change range from high decrease of population density over decrease, increase up to high increase of population density, but do not form homogeneous groups. Especially the category with decreasing population density has to be interpreted carefully as two different trends of the underlying variables can lead to the same effect. This is important when it comes to the point of defining adequate political scenarios and administrative measures that deal with this problem.

The change of recreational areas shows two major trends. The urban regions – characterised by a decrease in population – offer an increasing recreational potential, whereas the peripheral growing regions show a decrease in this indicator. Although the baseline values for these two types of regions are quite different (urban areas offer quite limited areas of recreation), the trend may in the long run lead to a shortage of this good in the peripheral sub-urban regions, which may lead to a significant loss of quality of life.

The quality of the population density indicator has been analysed by means of comparison with available reference data. The comparison has revealed two sources of systematic deviations. The first is related to the insufficient level of spatial detail of the land cover data. The second refers to a lack of thematic information in the land cover data. Both shortcomings can be overcome by applying improved mapping techniques. In terms of the statistical data it is to be mentioned that inconsistencies might occur between data from different sources. However the magnitude of these inconsistencies lies in the range of the expected accuracies of the indicators.

The introduction of land cover into socio-economic indicators clearly represents an improvement compared to pure statistical representations. However, the information content of such indicators can become quite complex and their acceptance will highly depend on a proper but simple description of what the indicator's message is. In that sense there is still effort required both in terms of indicator design and communication of results.

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9 ACKNOWLEDGEMENTS

The project geoland is funded by the European Commission in the frame of the GMES (Global Monitoring for Environment and Security) initiative of the 6th framework programme (Contract No SIP3-CT-2003-502871) and is co-ordinated by Infoterra GmbH, Friedrichshafen, and Medias France, Toulouse.