PLUREL

Land Use Relationships
in Rural-Urban Regions

Module 2

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PERI-URBAN LAND USE RELATIONSHIPS – STRATEGIES AND SUSTAINABILITY ASSESSMENT TOOLS FOR URBAN-RURAL LINKAGES, INTEGRATED PROJECT, CONTRACT NO. 036921

Report on response functions for population- and household structure

D2.3.3

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SIXTH FRAMEWORK PROGRAMME

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Contents

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Classification of results/outputs:
For the purpose of integrating the results of this deliverable into the PLUREL Explorer dissemination platform as fact sheets and associated documentation please classify the results in relation to spatial scale; DPSIR framework; land use issues; output indicators and knowledge type.

Spatial scale for results: Regional, national, European	EUROPEAN at NUTSx level
DPSIR framework: Driver, Pressure, State, Impact, Response	Driver
Land use issues covered: Housing, Traffic, Agriculture, Natural area, Water, Tourism/recreation	Social and demographic aspects general allocation of human activities Population – land use relationships
Scenario sensitivity: Are the products/outputs sensitive to Module 1 scenarios?	yes
Output indicators: Socio-economic & environmental external constraints; Land Use structure; RUR Metabolism; ECO-system integrity; Ecosystem Services; Socio-economic assessment Criteria; Decisions	Statistical relationships between socio-demographic indicators and land use Response functions to estimate effects of land use change on socio-demographic structure addressing the urban, peri-urban and rural compartments of the NUTSx regions
Knowledge type: Narrative storylines; Response functions; GIS-based maps; Tables or charts; Handbooks	Response functions; tables, diagrams, maps; interpretations and conclusions

How many fact sheets will be derived from this deliverable?	2

Abstract

The objective of the task, described in this deliverable, is

(a) to develop response functions to estimate changes in population and household structure as a reaction on, or as reason of, certain spatial development trends in the urban, peri-urban and rural sub-regions in Europe,

(b) to apply the response functions to the NUTSx regions of the entire EU 27 to show the effects of different peri-urbanisation trends on population and household structure.

Within this task various population – land use relationships have been explored at different scales This has been carried out through various analyses (regression and variance analyses) at case study level (to some extent for municipalities) as well as at European level (for Rural-Urban Regions (RURs) regions for selected countries, where data was available). These results have been delivered in earlier versions of the report.

Finally it was decided to carry out response functions for NUTSx regions and to concentrate on explanatory data derived for the PLUREL scenarios (population numbers, artificial surface for the urban, peri-urban and rural sub-regions, GDP). This was conducted in 2 parts. A first part explores the relationships for the urban, peri-urban and rural sub-regions, concentrating on the sub-regional differences. The second part describes a straight forward development of response functions on population and household structure and projections of selected effects for the PLUREL scenarios.
Here we present these NUTSx level investigations, carried out in 2009 and 2010.

The latter deals not with direct effects of population on land use, (this is done through the RUG model) but with indirect effects of land use – and thus peri-urban development on allocation of population groups evolving certain structural changes. It is obvious that the spatial structure and the urbanisation trends do not directly release changes in population and household structure, but reflect changes in lifestyle which are provoked (also) through urbanisation. But, changes in population and household structure as effect of changes in lifestyle have again consequences on spatial development

Additionally indicators describing age structure have been carried out, by extracting the IIASA-based population projections for NUTS2 regions. As results the share of young and old population and the respective changes as projected for the PLUREL scenarios are presented.

The final output for the PLUREL scenarios' delivers social and demographic issues - population shares for the age groups "till 15 years" and "above 60 years", extracted from the IIASA projections, shares of population living in single person and 4+ person households as well as shares of population with higher education for the target years 2015 and 2025 per NUTSx region (the latter 3 estimated via response functions).

1. Population and land use

1.1. General aspects of drivers and pressures

The relationships between population and land use regarding urban and peri-urban development is twofold

a) one issue is the effect of population development on peri-urbanisation as a trigger of and a pressure on land use change,
b) the opposite issue refers to effects of urban and peri-urban development on population and households influencing the behaviour of dwellers as a reaction on the physical framework provided through urban and peri-urban structures – residential areas, social, educational and recreation services, workplaces, and further infrastructure supporting the urban/ peri-urban life, and as a reaction on the society where the dwellers are embedded

The aspect (a) is usually investigated – this has been already carried out by Sophie Rickebusch/Univ. Edinburgh for developing her regional urban growth (RUG) model in a rough way, to model growth of artificial surface as effect of population growth. We add some explorations to proof those relationships in terms of artificial surface, open space and economic wealth.

A first part in this report explores the relationships for the urban, peri-urban and rural sub-regions, concentrating on sub-regional differences.
But the main part refers to aspect (b) explaining the change in local population structure as a reaction on urbanisation and peri-urbanisation which triggers and releases movement of population groups of certain age and education and of households by certain household structure, attracted either from urban areas or peri-urban areas (and to some extent from rural areas. It is obvious that the urbanisation trends do not directly release changes in population and household structure, but reflect changes in lifestyle which are somehow provoked by urbanisation. But, changes in population and household structure as effect of changes in lifestyle have – referring to aspect (a), having effect on further urban/peri-urban development - e.g. a growing number of small households, will demand additional residential area even if the number of dwellers remain the same.

Therefore we develop response functions to estimate these changes in population and household structure as a reaction on or as reason of certain urban and peri-urban development trends. To quantify future changes in demographic and social structure it is necessary to apply indicators which describe the changes in spatial structure - of population allocation, as well as of built up area as precondition framework.

In order to derive these investigations and the final population-related response functions for the NUTSx-regions, urban, peri-urban and rural sub-regions were delineated and the artificial surface, as well as the population shares, is allocated to these sub-regions. This step was conducted within the urban-rural (RUR) region classification and delineation task for the NUTSx regions (and for NUTSx clusters describing Rural Urban Regions – RURs). Figure 1 shows the distribution of the urban, the peri-urban and rural sub-regions for entire Europe. A magnified cut out allows to see some details. Details regarding the RUR sub-regions are presented in deliverable D2.1.4 (Loibl W., 2008a), dealing with RUR-typology and delineation.

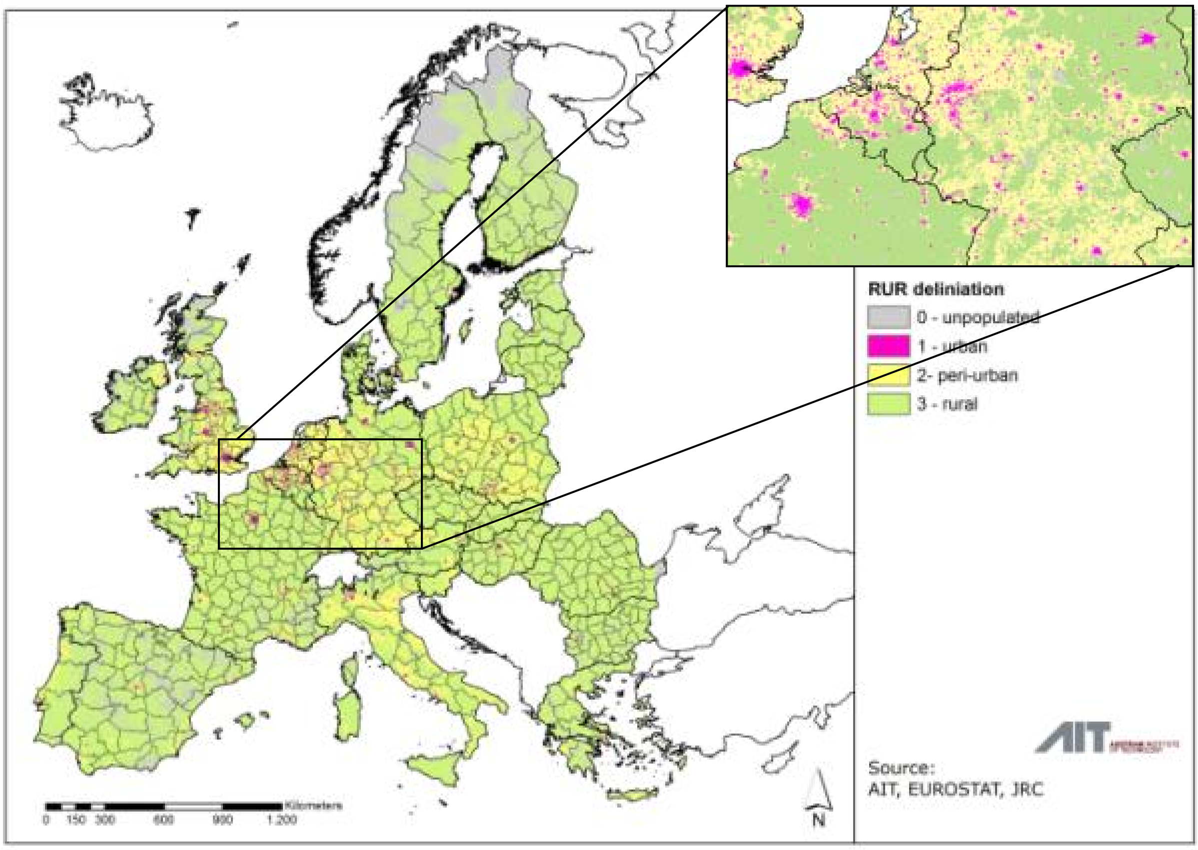

Figure 1: Urban/peri-urban/rural sub-region delineation, based on land use and population density (AIT, PLUREL Deliverable 2.1.4)

1.2. Response function basics

The relationships will be quantified with response functions carried out by applying regression analysis. Regression analysis can be used as a descriptive method without relying on any assumptions about underlying processes generating the data but the selection of the data sets has been performed considering certain assumptions as result of the investigations described in the previous chapters. And - when paired with assumptions, regression models can be used for prediction and modelling of causal relationships. (Draper & Smith (1998), Berk (2004) and SAS Institute Inc. (1985))

This analysis technique examines the relationships of a dependent variable (response variable) to specified independent variables (explanatory variables). The key relationship is quantified with the regression equation. The estimated parameters measure the relationship between the dependent variable – here certain population sub-sets and each of the independent variables – in our case indicators which "explain" the reaction of the subsets on the specific spatial framework regarding peri-urban characteristics.

Supposing a variable y can be predicted by a linear combination of some explanatory variables $\{x1, x2, \dots xn\}$ the general form of a multiple linear regression model is:

$$y_i = \alpha + \beta_1 x_1 + \beta_2 x_2 + \dots + \beta_n x_n + \varepsilon_i,$$

where α is the intercept, β are the regression coefficients weighting the explanatory variables, and ε_i, is the error term, representing the unpredictable part of the response variable y_i.
The calculation of α and β is conducted by least square estimates which are given by:

$$\hat{\beta} = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2}$$

and

$$\hat{\alpha} = \bar{y} - \hat{\beta}\bar{x}$$

2. Analysis of relationships between population and land use within the RUR sub-regions

2.1. Relationship: population in settlements and total area / settlement area consumption

In earlier versions of this deliverable we have presented various relationship issues on a finer scale for selected regions and countries, as the applied data could not be made available either for case studies, nor for entire EU27. Here we present additional recent investigations regarding artificial surface and related to the urban, peri-urban and rural sub-region compartments. This is somehow a proxy indicator for land consumption for human activities and is not always populated (like urban green, harbor and mining areas etc. also belonging to the artificial surface fraction) and on the other hand certain populated areas are not indicated as artificial surface. Over all in rural areas - not all urban fabric patches are considered as settlements due to the size limits with respect to the CORINE land cover classification rules considering single patches only when larger than 2500 ha. The following figure 2 gives an overview about the differences of area consumption by population within the 3 sub-region compartments of the NUTSx regions (each dot presents the population number -area size relations within a region):

- The left column diagrams show the total sub-region population versus the total sub-region area (ar),
- The center column diagrams show the population allocated to the settlement areas versus the artificial surface area (ASURF) referring to the RUG model results (Rickebusch, 2009), all based on CORINE Land Cover and JRC's population density calculations, (Loibl 2008, Gallego J.F., 2007a, b),
- The right column diagrams show the population allocated to the settlements based on Gallego, (2007b) against settlement areas, stratified by AIT based on CORINE land cover (C11A).

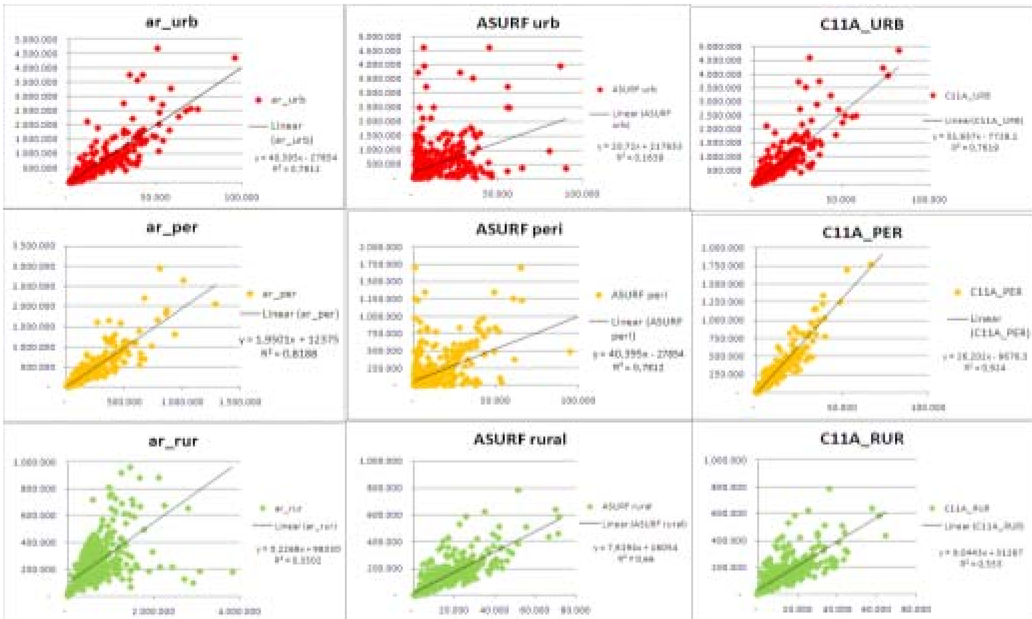

Fig. 2: Area consumption and population in the EU-27 NUTSx regions: total area, artificial surface area, housing area (CORINE land cover class 1.1) (from left to right) in the 3 RUR sub-regions: urban, peri-urban, rural (from top to bottom).(AIT)

The comparison of the scattergrams, equations and correlation coefficients figure 2 give some insights: regression lines and equations give hints regarding land consumption per capita (for artificial surface additional zero-constant equations have been added to show the influence of the non-dwelling related artificial surface.)

The land use-population relationships show in all 3 sub-regions moderate to high “land consumption coherence” by relating total population with total area with and relating settlement population with settlement area (CORINE land cover class 1.1).

- The artificial surface area delivers lowest correlations for the urban sub-regions, either because of the many included non-dwelling areas (mining, harbor, industry, urban green) or because of the very differences in population density – due to partly large numbers of residents in high rise building areas in some of the core cities and partly rather small numbers of residents in mixed usage areas.
- The peri-urban artificial area shows again a higher correlation with population in settlements although the scattergram shows several outliers – obviously due to many non-dwelling areas stratified as artificial surface (same reason as in the urban sub-regions).
- The artificial surface area in the rural sub-region shows highest correlations with rural population as there is only little “disturbance” of dwelling areas from other land uses (although in some regions most rural-people are not allocated to settlements because of lack of classified dwelling areas).

The distinct population – artificial area relation with a very narrow distribution along the regression line in the peri-urban sub-region is somehow unexpected. This could be perhaps explained by the initial CORINE land cover related population distribution procedure, assuming certain (empirically observed) average population densities for the different land uses which concentrates population in the urban fabric land use classes (c.f. Gallego J. F., 2007a, b).

2.2 Relationship: total population and artificial surface

While figure 2 presents the relationship between the sub-regional artificial surfaces and the population in the sub-regions, figure 3 depicts the relationship between the total population in the NUTSx regions and the artificial surface areas in the 3 sub-regions of the respective NUTSx entities. The numbers refer to year 2000/2001 and thus show current conditions.

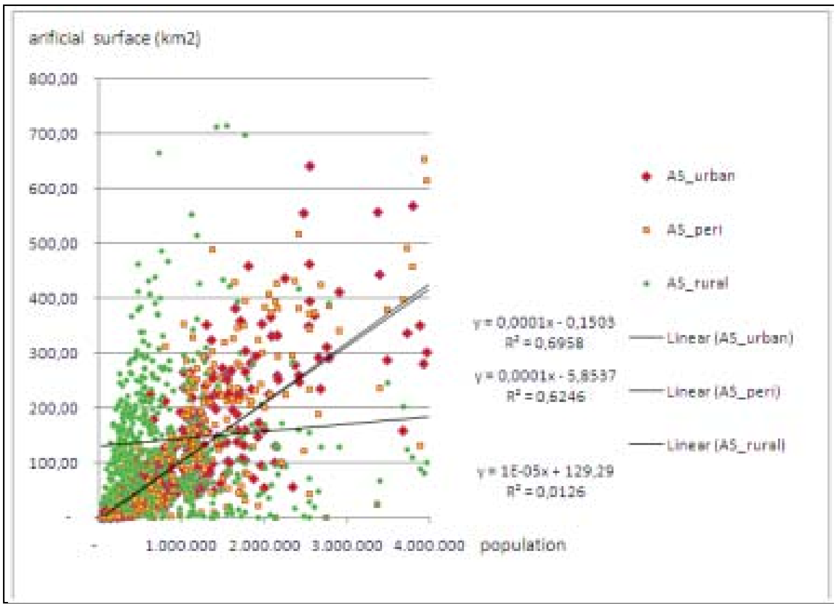

Fig. 3: Artificial surface areas versus population numbers in the sub-regions (AIT)

The regression functions address distinct differences: while the functions for the urban and for the peri-urban artificial surface show the same slope and nearly the same R^2, the regression line for artificial surfaces in rural sub-region shows a certain intercept but an r^2 of around 0, which means there is no linear relation. This can be observed anyway - the rural "data cloud" is scattered in all directions due to missing artificial surface in the rural areas leading to some confusion in the statistics. The population numbers show a distinct correlation with general land consumption in the urban and the peri-urban sub-regions, while the rural population numbers do not match with artificial area volume.

2.3 Relationship: population and open space

Further the open space access and volume has been explored for the population groups in the 3 sub-regions by comparing the amount of open space with the number of inhabitants per sub-region (fig. 4).

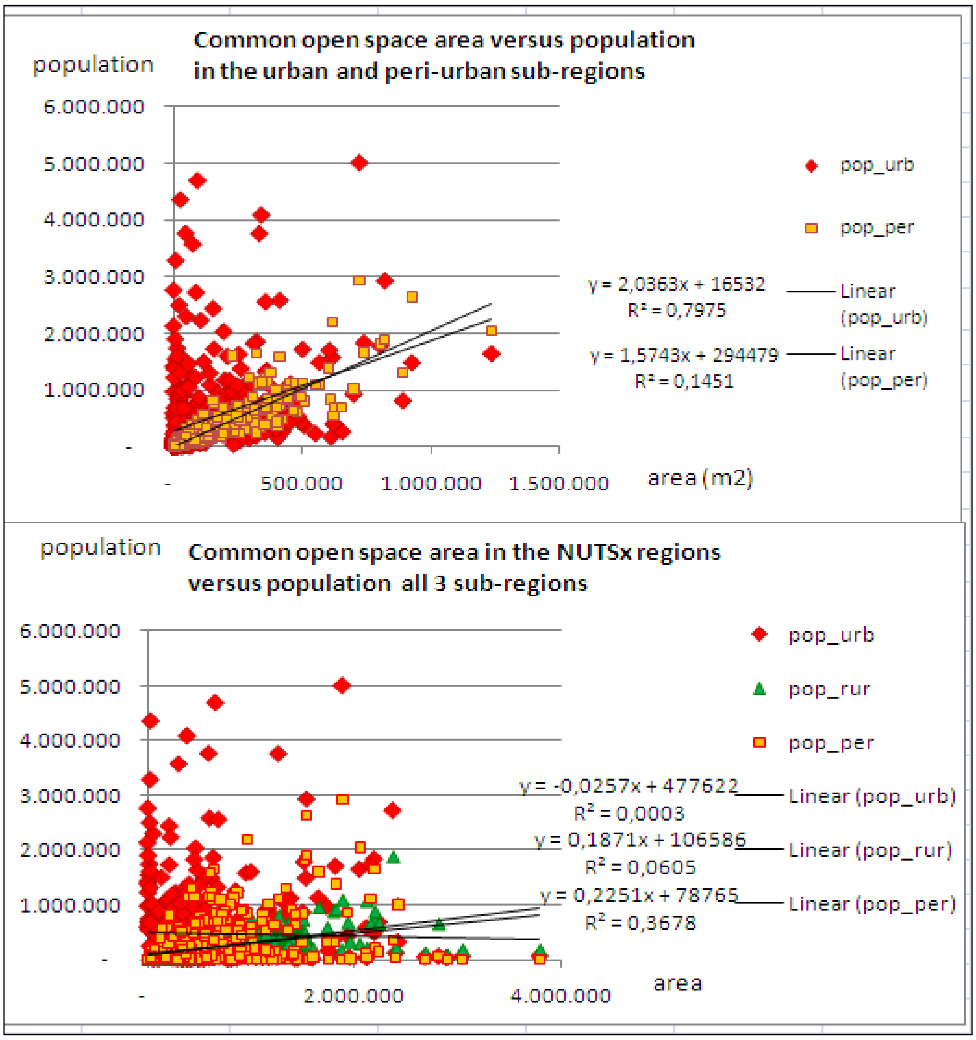

Fig. 4: Open space availability for the inhabitants in the urban, peri-urban and rural sub-regions (AIT)

The top diagram in figure 4 shows the "nearby open space" for the population in the urban and the peri-urban sub-regions. The regression lines are quite similar, but the R^2 for the equation describing the peri-urban population open space availability is small as there is a high variation of population numbers which are sometimes confronted with little open space but partly with larger open space areas. On the other side, the urban sub-region inhabitants show a much more scattered distribution – small population numbers benefit sometimes from large open space volume, but a considerable number of urban NUTSx regions are inhabited by people with little access to open space areas.

The bottom diagram shows the access to near and distant open space. Here the advantage of peri-urban population regarding comfortable open space access is even more distinct: little population numbers of peri-urban dwellings share large amounts of – rather close open space. Many people in large core cities from little open space access and amount in even greater distance.

The open space per capita indicators cannot be presented as meaningful diagrams because of the high variation within the data sets with regions with low per capita numbers and others with very high numbers.

2.4 Relationship: economic performance and land consumption

Additionally the relationship between land consumption (of artificial surface) in the 3 sub-regions and economic performance of the (entire) NUTSx regions had been examined. The equations and regression lines of the urban and the peri-urban sub-regions depicted in figure 5 are nearly identical. The rather high correlation coefficient (R^2=0,6) let expect a high influence of the economic growth within the regions on further artificial surface growth in the urban, as well as peri-urban sub-regions. In the contrary, in the rural sub-regions artificial surface occupation shows no significance regarding interrelations with the regional economic performance.

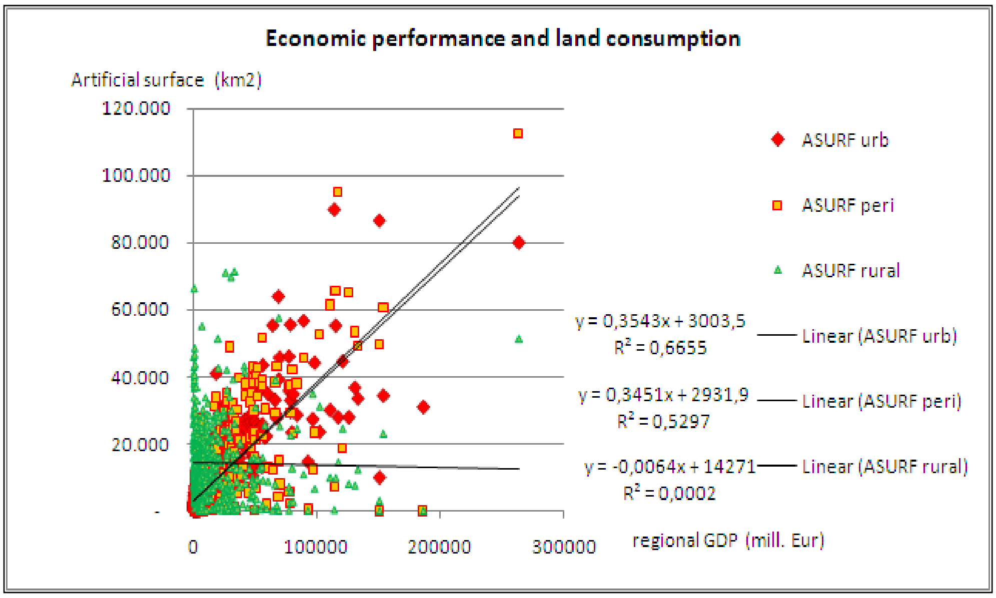

Fig. 5: Economic performance and land consumption in the EU-27 NUTSx regions: GDP versus artificial surface area in the 3 RUR sub-regions

All these results proof a sufficient relationship between population distribution and spatial pattern in terms of urbanisation and peri-urbanisation. Thus population behaviour and structure can be to some extent explained and projected by taking variables characterising land use pattern and land use change. This task will be presented in the following chapter. (The findings above will not be further addressed, as they cannot be integrated into the future scenarios, as required.

3 Response functions to describe population and household structure as reaction on land use change

3.1 Response function estimation

As addressed initially, there is a twofold relation between (a) population and land use regarding urban and peri-urban development – the effects of population development on peri-urbanisation as a trigger of and a pressure on land use change, and (b) the effects of urban and peri-urban development on population and households releasing behaviour of dwellers as a reaction on the evolving urban and peri-urban structures.

In this chapter we estimate some indicators on social structure of the population as a reaction on urbanisation and peri-urbanisation releasing movement of certain population groups and households, attracted by urban areas or peri-urban areas. The here conducted response functions estimate thus effects of land use change on population structure and household structure to quantify future changes in structure as consequence of different future peri-urbanisation trends.

A more detailed exploration of population and household structure would require a broader set of data to allow deeper insights into social structure, age structure, educational aspects their spatial dimensions as well as temporal dimensions. (This was carried out to some extent by the Open Space team (Simon Bell) and the CEMAGREF team (Natalie Bertrand) for case study regions. AIT shall concentrate on the effects and interrelationships of population structure and household structure with land use on a rather coarse European (NUTSx) level to project changes with respect to the PLUREL scenarios. Therefore we have to apply those data, which are available for entire EU27 at NUTSx level for the current situation, as well as for the future situation to be projected till 2025.

Unfortunately the response functions can only make use of a limited set of variables which are available for the PLUREL scenarios and *consider only those effects of land use change* and (to some extent) as effect of economic development, which are depicted by the explanatory data and the spatial pattern of the population related indicators for 2001.

The explaining data for the future are those which had been modelled for the PLUREL scenarios for all NUTSx regions. The data sources for the current situation analysis come from Eurostat (population, GDP) and Univ. Edinburgh, (extracting artificial surface from CORINE land cover data, provided by JRC). The variables are:

- total population (2001) – absolute value
- artificial surface (2000) in urban areas – absolute value
- artificial surface (2000) in peri-urban areas – absolute value
- artificial surface (2000) in rural areas – absolute value
- GDP (total 2001) by NUTSx regions based on GDP per capita numbers (for NUTS2 regions)

The general equation for a certain population-structure related variable y_i, looks finally as follows:

$$y_i = (\beta_1 * \text{total population} + \beta_2 * \text{urban artificial surface} + \beta_3 * \text{peri-urban artificial surface} + \beta_4 * \text{rural artificial surface} + \beta_7 * \text{regional GDP}) * r\_fct$$

where $\beta_{i = 1 \ldots n}$ are the regression coefficients and r_fct is the regional deviation correction factor replacing the (usually additive) error term.

The following table gives an overview of the applied explanatory variables, the related regression coefficients and the correlation coefficients describing the share of the explained variance.

Table 1: Response functions for population structure influenced by land use characteristics

Regression coefficients	Constant	Population total 2001	Artif. Surface urban	Artif. Surface peri-urban	Artif. Surface rural	GDP	R^2
Population with tertiary education	13781,817	-0,005	337,351	-128,773	-9,833	2,332	0,887
Population in 1 person-households	8451,642	0,020	230,945	38,843	38,578	2,171	0,936
Population in 2 person-households	13548,389	0,105	450,267	316,632	13,008	1,639	0,974
Population in 3 person-households	-23674,170	0,244	-289,459	192,112	39,588	0,046	0,969
Population in 4 + person-households	-5624,496	0,647	-502,808	-562,338	-109,866	-4,362	0,972

(own calculation, AIT)

For all response functions the same explanatory variable set has been selected. The explanation quality of the equation is with an R^2 between 0,89 and 0,97 very high. The regression coefficients show some distinct differences between the response functions. For the population in single and two-person households the artificial surface shows general positive influence. For larger households the urban artificial surface show negative influence, for the 4-person households all explanatory variables – except the total population - show negative influence. Population with tertiary education shows highest support from urban artificial surface and GDP, indicating the focus on economically powerful urban centres.

The response functions are a product from statistical analysis, whose reflect the average relationships as delivered by the applied input data. Considering the residuals (the deviations between the modeled and observed results) is essential to include the influence of the respective regions. These deviations have been included by the regional correction factors describing the proportion between modeled and observed results for the analysis year 2001. But even after including a correction factor, the equations could deliver odd results when some of the explaining variables show untypical changes[1]).

3.2 General results – effects of future peri-urbanisation on population and household structure

The explanatory data to project future effects refer to the narrative PLUREL scenarios A1, A2, B1 and B2, following somehow the IPCC scenarios but focusing on the urban and peri-urban issues (J. Ravetz et al., 2008).

The following figure 6 compares the general directions of the 4 scenarios called: A1 Hypertech, A2 Water world, B1 Peak oil and B2 Social fragmentation. The expectations for the scenarios are – with respect to demographic and social aspects - the following:

- Scenario A1 “Hypertech” assumes fast growth, technological development and distinct economic growth, forcing urban migration as well as counter-urbanisation, which may provoke urban sprawl and certain allocation of bigger and wealthier households and more young people.
- Scenario A2 “Waterworld” is fast growing but diverging. It considers certain impacts due to climate change with some areas suffering increased flooding, others suffering from drought. As a result of in-migration cities will show increasing density, attracting smaller households and higher educated people.

[1]) One reason for some, possibly odd results is the region definition: NUTSx regions are administrative entities, which do frequently not match the rural –urban influence sphere, covering the entire urban region extent. Small NUTSx regions, dividing larger urban regions into several entities with either urban or peri-urban areas, may experience changes only in the urban or the peri-urban subsets of artificial surface which would result in implausible population structure changes in the certain NUTSx regions.

- Scenario B1 “Peak oil” expects high energy prices and the high demand for renewable energy, affecting the economy and travel behaviour. High commuting costs will bring people living near their work, leading densification of cities. Urban sprawl will decrease, assuming that the number of children per family will decline due to less economic wealth.
- Scenario B2 “Social fragmentation” assumes processes of decentralisation, increased regional competition, and competition for resources among the generations. The lack of a central driving economy will slow down urban growth. Less economic progress might result into more generation households which will slow down the increase of the average household size.

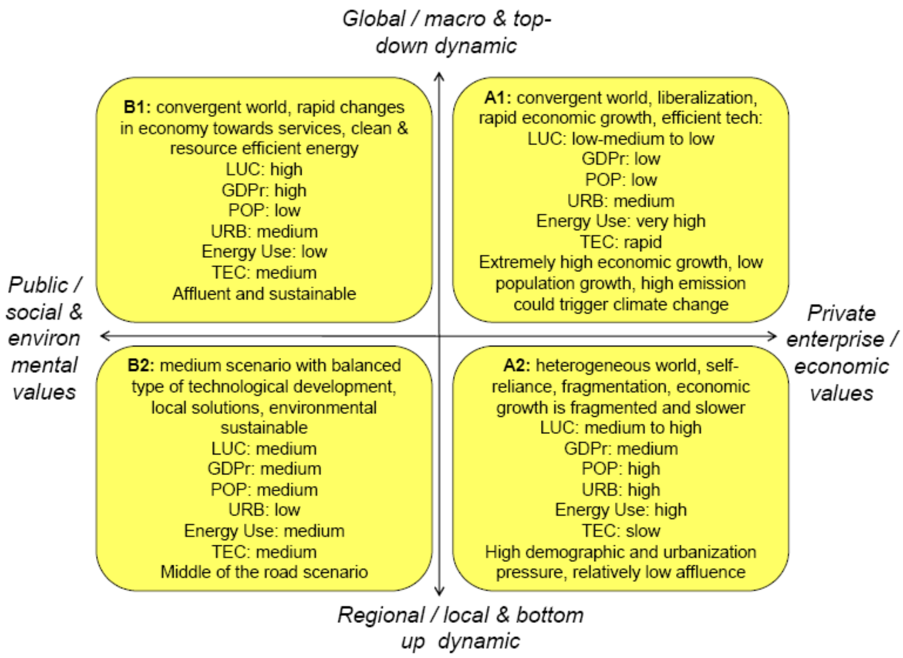

Fig. 6: Driver pressure trends of the 4 PLUREL scenarios (Ravetz et al., 2008)

The response functions are applied to estimate the future social structure changes by taking projected explanatory variables for the PLUREL scenarios for 2015 and 2025. The future projections of the explanatory variables and their further distribution to sub-regions were carried out by different authors:

- Population
    - The general population projection was conducted by IIASA delivering results for NUTS2 regions (V. Skirbekk, 2008).
    - S. Rickebusch (2009) / Univ. Edinburgh had further distributed the population numbers to NUTSx regions.
    - AIT had additionally divided the NUTSx-population into sub-sets, and allocated them to the urban, peri-urban and rural sub-regions (Loibl W, 2010).
- Artificial surface
    - S. Rickebusch (2009) / Univ. Edinburgh has modeled the artificial surface numbers for each of the NUTSx regions.
    - AIT has divided the artificial surface into sub-sets belonging to the urban, peri-urban and rural sub-regions. (Loibl W, 2010)
- GDP
    - The GDP data (for NUTS2) projected for the PLUREL scenarios come from ERASME-group (B. Boitier, 2008).
    - AIT had disaggregated the NUTS2 numbers for NUTSx regions by taking the GDP per capita numbers and the population numbers per NUTSx region.

Before describing the regional variations of future development we present and discuss the general effects for entire Europe on population and household structure, partly released or boosted by peri-urbanisation trends.
The following figures 7 – 9 below show the European-wide trends as expected for the 4 scenarios:

Fig. 7: Expected changes in the EU-wide share of the population by age group ">60years" and "<15 years" as expected for the 4 scenarios (2005 = index 100) (model: IIASA, compilation: AIT)

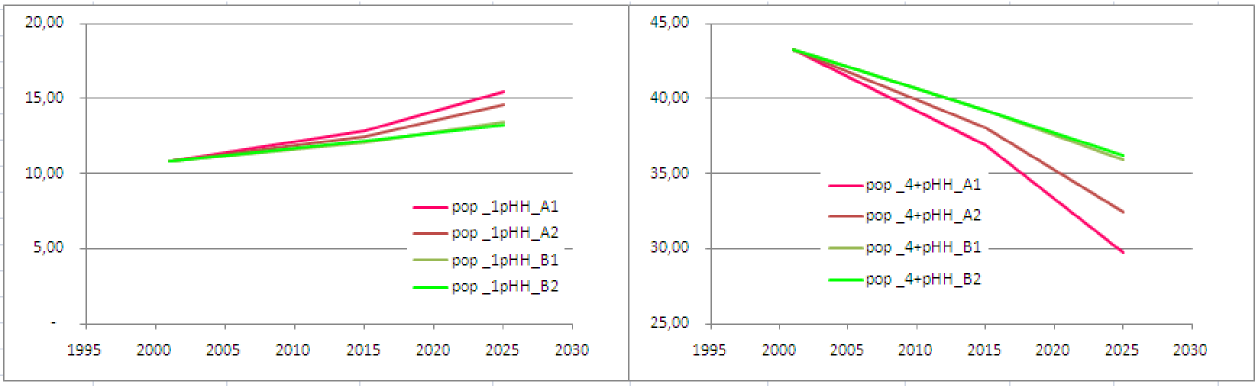

Fig. 8: Expected changes of the EU-wide share of the population living in single and in 4+ people - households for the 4 scenarios (2001 = index 100) (model: AIT, data: EUROSTAT, IIASA, Univ. Edinburgh, and AIT)

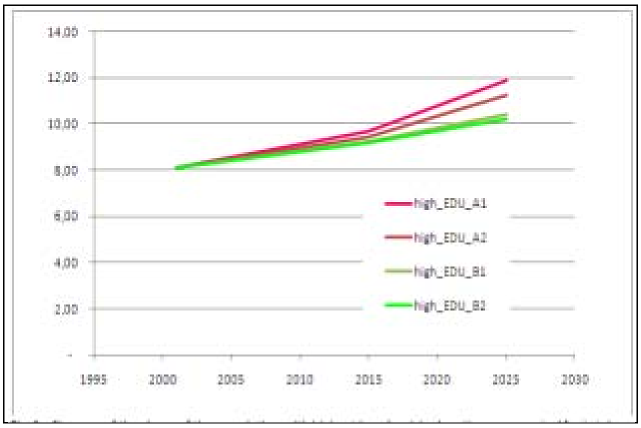

Fig. 9: Changes of the share of the population with highest (academic) education as expected for total EU for the 4 scenarios (2001 = index 100) (model: AIT, data: EUROSTAT, IIASA, Univ. Edinburgh, AIT)

The results are quite pronounced but do not follow totally the expectations for the scenarios:

Age structure (Fig. 7):

The age-structure show similar trends for all 4 PLUREL scenarios:
- Scenarios A and B: The share of the retiree generation will steady increase, while the share of the youngest cohorts experiences an intensive decrease. When comparing the scenarios the differences between A and B remain little.
- Only in scenario B1 the young population share show a more accelerated decline.

(The data are extracted from IIASA projections on assumptions addressing general Europe. They are not triggered by local urbanisation trends, but controlled by economic development and international migration movements).

Household structure (Fig. 8):

The household structure trends are again very distinct, the scenario results, released from the different urbanisation trends, show more differences.
- The A-scenarios let expect a moderate increase of population share, living as single households and a heavy decrease of the share of population living in 4 and more person-households. The A1 scenario proves in both cases slightly steeper increase or decrease trends.
- The B scenarios depict nearly identical trends which are less pronounced: the modest increase of single households is acceptable, the decrease of the population share in 4+ person households is expected to be rather extreme, losing a third of the current share which will increase again the number of smaller households.

High Education (Fig. 9):

High, academic (in the statistics addressed as tertiary) education has been selected as social structure indicator being the only one available , which can be compared throughout Europe. The various other (lower) education indicators by country did not follow common criteria.

A certain effect of urbanisation on education can be observed, although education and general social effects refer more to economic growth. Different urban and sub-urban development patterns will be addressed as criteria pool to decide upon future residential area selection which will release change in educational and thus social structure.
The situation is similar as for the single person households:
- The A-scenarios let expect a high increase, where scenario A1 would experience a higher boost of the share of academic educated population.
- The B-scenarios show a moderate increase, both scenarios let expect identical growth of the share of highly educated people.

Again we must stress that the spatial structure and the urbanisation trends do not directly release changes in population and household structure, but reflect changes in lifestyle evolving an urban lifestyle which on the one hand follows, on the other hand accelerates urbanisation in its different trends. To some extent economic development is a further trigger, building a framework which allows investing in higher education

General:

The spatially explicit results describe the allocation of the different population groups, attracted either by urban or by peri-urban areas (and to some extent by rural areas). Details will be addressed in the following chapter, where regional effects of the scenarios are discussed by comparing the maps.

3.3 Regional trends of the spatial framework conditions

The following figures 10 – 15 depict the base line situation regarding general population distribution, peri-urban population share and peri-urban settlement share and the changes as expected for the PLUREL scenarios –which are the major indicators describing influence factors on population structure. The change patterns for each of the scenario show certain hot spots, where distinct differences can be observed.

Total population: density, change in population numbers (Fig. 10,11)

- The transect ranging from UK, BeNeLux, Germany to Italy shows highest densities in the respective NUTSx regions, indicating the areas with highest population numbers. Further concentration hot spots can be observed in southern Poland, in the Czech Republic and in capital regions (Helsinki, Dublin, Paris, Lyon, Lisboa, Madrid, Barcelona, Vienna, Budapest, Bucuresti, Athens, etc.)

The population changes as expected for the different scenarios show also some hot spots:

- The highest (relative) growth rates are expected in Western Europe: Ireland, UK, France and Spain. Some further regions show growth too: southern Scandinavia, the Netherlands, southern Germany, parts of Austria and Northern Italy.
- A distinct decline is expected for Eastern countries in Europe: the Baltic countries, East Germany, Hungary, and Romania.

The differences between the scenarios are expected from a European view to be rather small:

- The scenarios A2 and B2 show a growth concentration in the Southern regions in France and along the Spanish Mediterranean coast, experiencing distinct acceleration of peri-urbanisation.
- Scenario B1 shows additional growth in scattered NUTSx regions with higher peri-urbanisation ratios in Western and Central France.

Peri-urban population: share, change in the share of peri-urban population (Fig. 12,13)

The changes in the shares show the peri-urban deviations from the overall population dynamics in the NUTSx regions. If the changes remain little the peri-urban population change follows the general population dynamics. If the change is high, the peri-urban dynamics are expected to be more pronounced than the urban or the general population dynamics in the region.

- The transect with the highest change of the shares of peri-urban population ranges from UK till Italy, passing Benelux, Germany and Austria. Further hot spots are a large part of Poland, North Portugal, parts of Greece and NUTSx regions around capitals like Dublin, Paris, Madrid, Budapest, and Bucuresti.
- Low shares of peri-urban population are observed in the scarcely populated Nordic and Baltic areas, in Romania, Spain and the more rural parts of central France, Ireland and Scotland.

The expected peri-urban population share changes for the scenarios show also some hot spots:

The growth and decline patterns in Europe follow the patterns for the total population.

- The highest (relative) growth rates are expected in Western Europe: Ireland, UK, France and Southern Spain. Some further regions with growing peri-urban population are: Southern Scandinavia, the Netherlands, Southern Germany, Austria and Northern Italy.
- A distinct decline is expected for Eastern European countries: the Baltic countries, East Germany, Hungary and Romania.

The differences between the scenarios are - from a European view - expected as small:

- The scenarios A and B2 show a growth concentration along the Mediterranean coast in France and Spain and some moderate growth Southern parts of the Scandinavian countries.

- Scenario B1 shows a slightly diverse trend with less growth in some Scandinavian regions, additional growth in scattered regions in Western France with less pronounced peri-urban growth concentration in Southern coastal France.
- Distinct additional decline is expected for Southern Italy in scenario A2, B1, in Atlantic Spain in scenario B1.

Generally speaking it can be observed that the regions with population decline will experience a shrinking share of peri-urban population – there the population will remain more concentrated in the centres; in dynamic regions there will be an increase of the shares of peri-urban population; in such regions, urban population will move out into the peri-urban areas.

Peri-urban artificial surface: share, change in the share of peri-urban artificial surface (Fig. 14, 15)

The share of peri-urban artificial surface relative to the total artificial surface indicates the importance of suburbanization within the regoins. The overall pattern follows to some extent the population distribution pattern. As the relative shares of peri-urban artificial surface are generally higher than shares of the peri-urban population it can be assumed that the artificial surface always will grow faster than the population.

- A transect with highest shares of peri-urban artificial surface ranges from UK to Northern Italy, passing BeNeLux and Germany. Further hot spots are throughout a large part of Poland and North Portugal. The capital areas addressed before show a different pattern which let assume that those are more affect by sprawl in dispersed settlement, which are not identified as artificial surface.
- Only little growth of the shares of the peri-urban artificial surface is estimated for the Nordic and Baltic regions, in East Germany, in the Czech Republic, Southern Slovakia, Hungary, Romania, in central Spain and in some more scattered regions in central France, further in central Ireland and Northern Scotland.

The changes in the shares show the peri-urban deviations from the overall land use dynamics in the NUTSx regions. If the changes remain little the peri-urban artificial surface change follows the general trend in the region. If the peri-urban artificial surface share is expected to increase, the peri-urban compartment let expect more dynamics than in the overall region.

The expected changes of peri-urban artificial surface in the four PLUREL scenarios let expect somehow different patterns as even in areas in which the population is likely to shrink there is seemingly no decline of the share of peri-urban artificial surface.

- Highest (relative) growth rates are likely in the well known transect: ranging from England, Netherlands, (western) Germany and northern Italy.

The differences between the scenarios are now rather explicit:

- The ”A”- scenarios show similar pictures and let expect the highest increase of peri-urban artificial surface shares (above 10%-points), concentrated in some regions of the transect, addressed above. Some regions around larger urban centres (Krakow, Warszawa, Budapest, Marseilles) show also higher increase (5-10%-points)
- The “B”-scenarios with similar trends show a less pronounced growth of the proportion of the artificial surface in the peri-urban compartments.

These trends are - together with GDP growth - the basis for the projections of changes in population and household structure. The results are in the following presented as maps amended with short interpretations and conclusions.

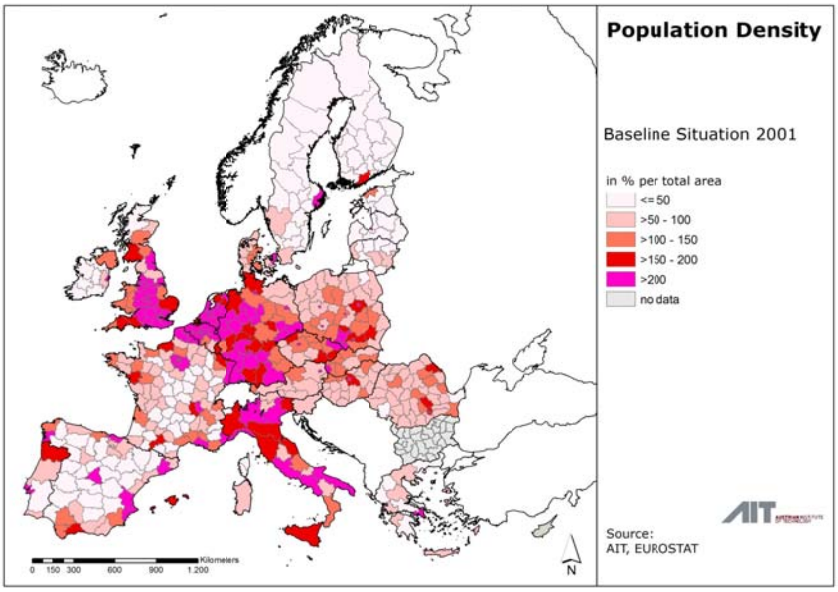

Fig. 10: Population density 2001 (AIT, Eurostat)

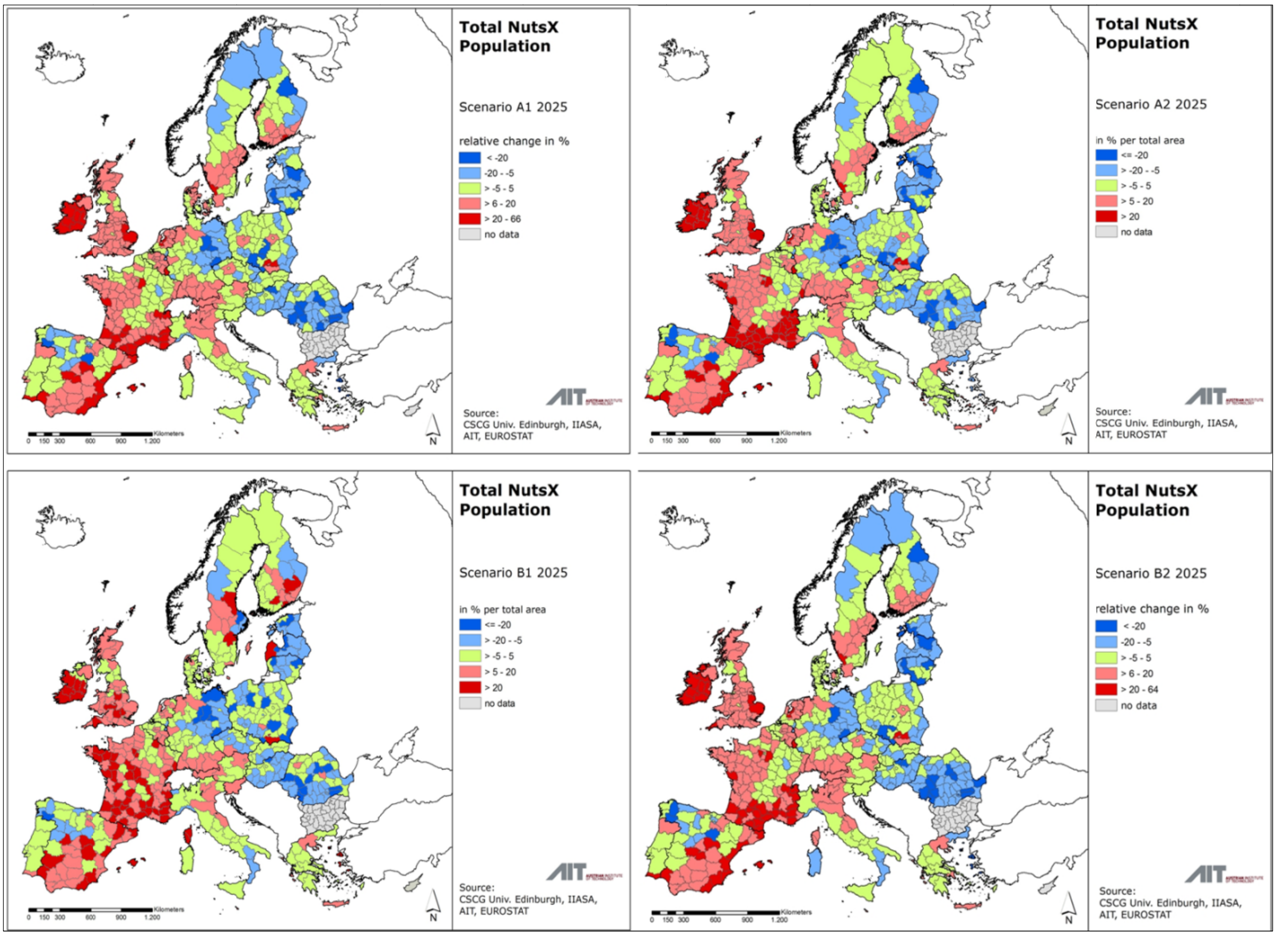

Fig. 11: Change of population numbers 2001- 2025 for the 4 PLUREL scenarios (IIASA, AIT)

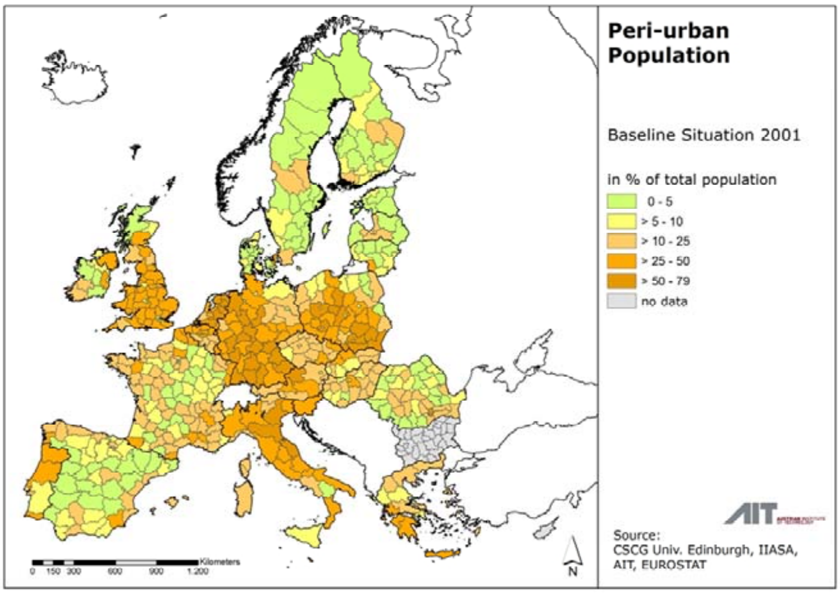

Fig. 12: Share of peri-urban population on the total population per NUTSx region 2001 (AIT, Eurostat)

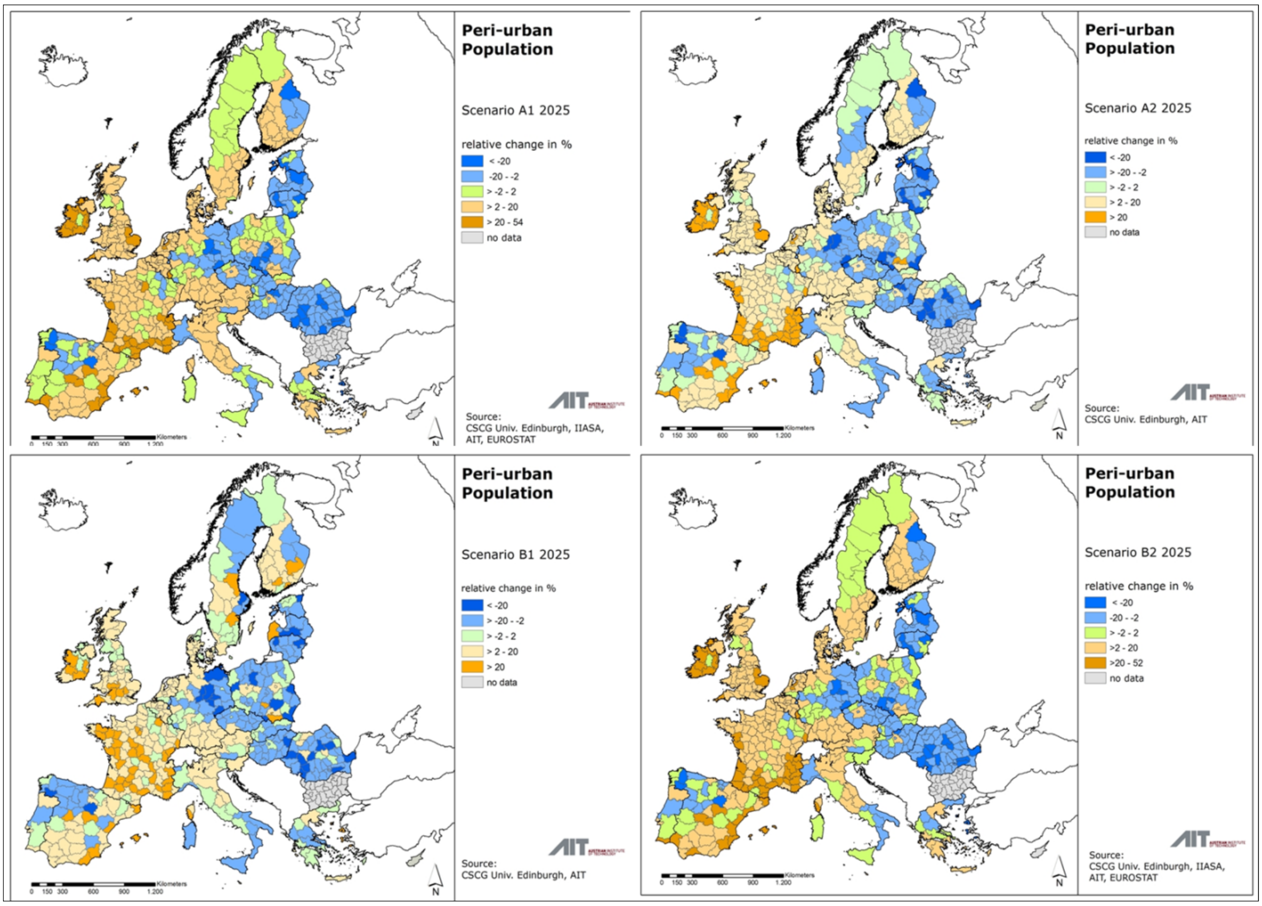

Fig. 13: Change in the share of peri-urban population on total population 2001- 2025 for the 4 PLUREL scenarios (AIT, IIASA, Univ. Edinburgh, Eurostat)

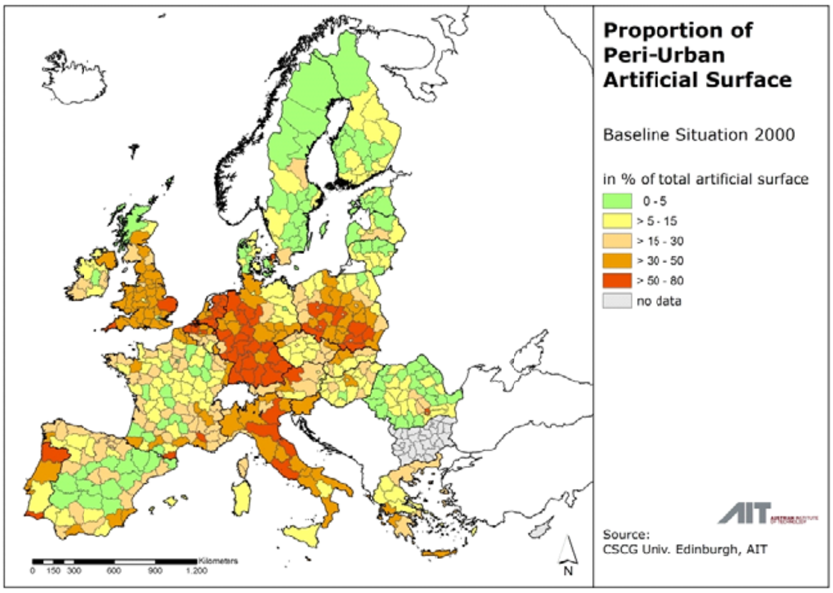

Fig. 14: Share of artificial surface on total artificial surface per NUTSx region 2000 (Univ. Edinburgh, AIT)

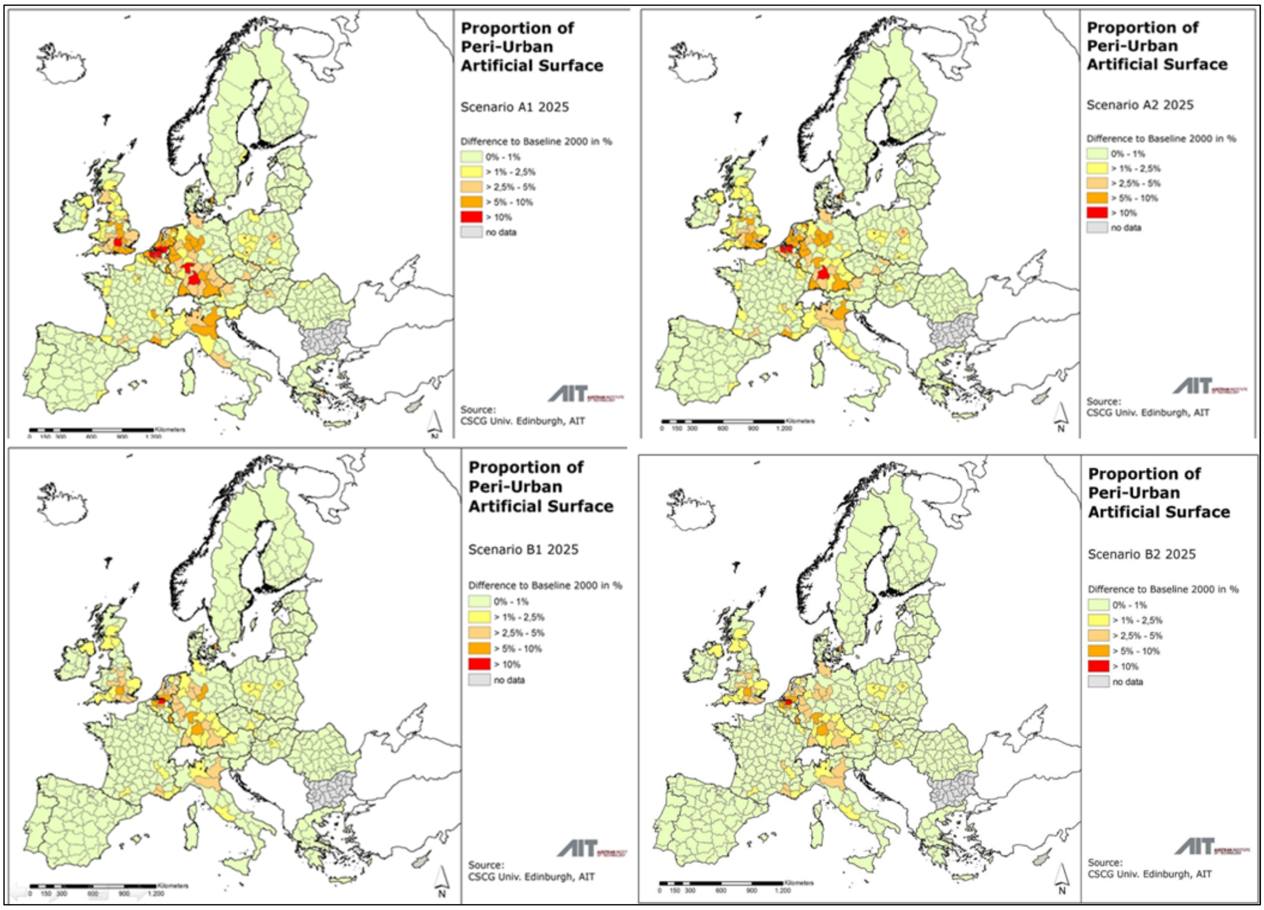

Fig. 15: Change in the share of artificial surface 2000 – 2025 for the 4 PLUREL scenarios (Univ. Edinburgh, AIT)

3.4 Household structure - today and future trends

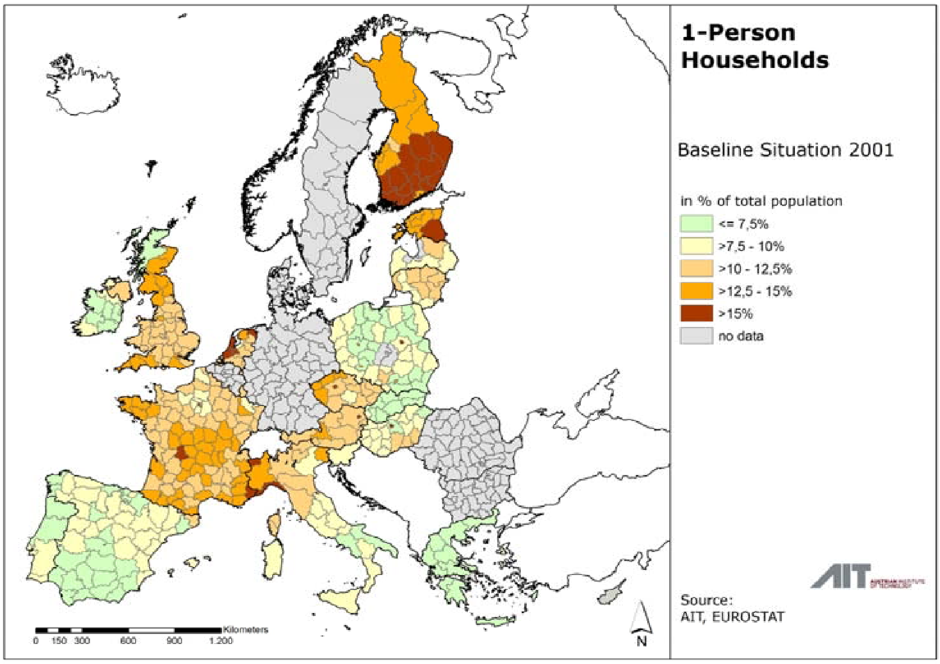

Fig. 16: Share of population in 1 person households on total population per NUTSx region 2001 (AIT, Eurostat)

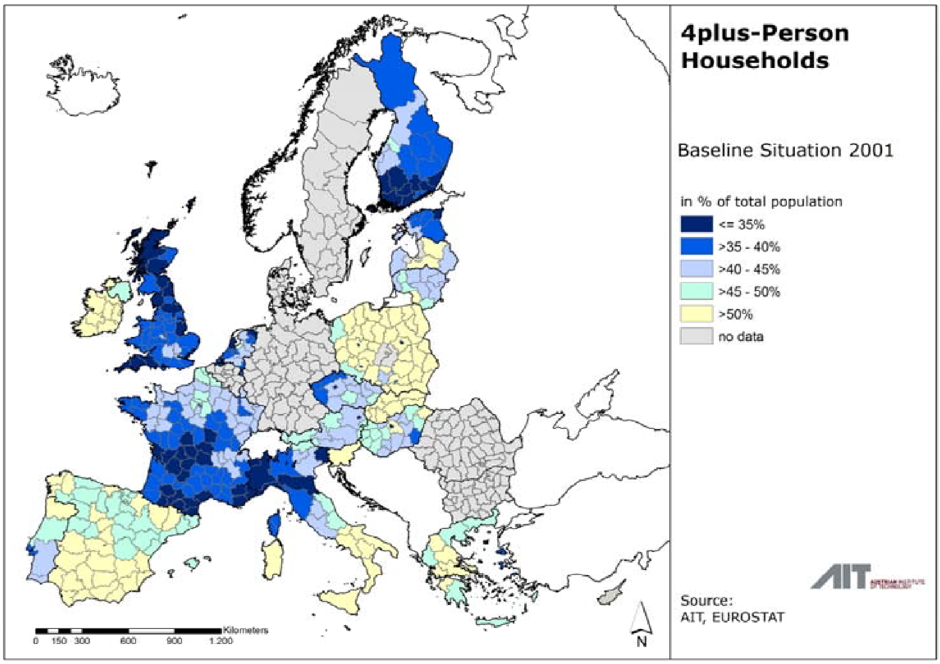

Fig. 17: Share of population in 4+ person households on total population per NUTSx region 2001 (AIT, Eurostat)

Expected changes in the household structure:

The input data come from Eurostat, the projected explanatory variable come from the sources listed earlier. Not for all countries the necessary input data could be made available, to estimate the response functions The reasons are different, either the data are still missing as seen in the baseline map (Germany, Belgium, Sweden, Romania, Bulgaria), or the NUTSx regions had been re-organised and do not match the earlier available data (e.g. Denmark, Scotland) or no GDP data could be provided (Baltic countries). Nevertheless certain trends can be observed and reasons interpreted. We are presenting her only maps for the shares of population living in single person households and in the 4+ person households, showing the trends to smaller households most distinct.

Changes of the share of population in 1 person households on the total NUTSx population:

In all scenarios the shares of single households follow similar trends. In countries with a high single household share, the share will further increase.

- Scenario A1 “Hypertech”: Highest gain is expected in Finland, further in central and Southern Europe (Poland, Czech Republic, Austria, Scotland). Some capital areas (Warszawa, Madrid, show also a high increase of single households. In France some scattered regions show higher increase, but not the capital area. The reason might be migration for rural to urban countries, releasing a saturation of urban lifestyles to new population groups. Southern Spain, Hungary and Slovakia and parts of Ireland shows very little change.

- Scenario A2 “Waterworld”: The increase of the single household percentage is expected to cool down. In southern Spain, in western and central France, in certain areas of various other countries the regions show nearly a stagnation of the single household share. One reason could be in-migration into these Southern areas.

- In scenario B1 “Peak oil” in several regions in France and Spain, there is even a decline of 1 person household shares expected. In most other countries the changes remain little – evolving stagnation. Exceptions are eastern countries Poland, Finland and Czech Republic, which might be caused by ageing.

- In scenario B2 “social fragmentation” the situation is similar as in B1 but there smaller declines of single household shares.

Conclusions regarding urban / peri-urban development:

Speaking generally, the differences in the pattern of the scenarios are coined to a certain extent by differences between countries. But the growth of single household shares is proceeding in all regions. Single person households are expected to be somehow a trigger for further urban development and will release peri-urban development to a lesser extent. (All regression coefficients for the artificial surface variables show high positive values, but those for the urban artificial surface are the highest.)

The differences of the expected future single person household structure between the scenarios are expected to be little. They seem to refer to a lesser extent to differences in urban or peri-urban development. Some other influence factors might be of higher importance:

- Changes in demographic structure in terms of ageing, leading to an increase of the number of old age people living in widow households accelerating single household numbers and thus floor space demand,
- Changes in economic wealth might foster a certain independent lifestyle living as single household.

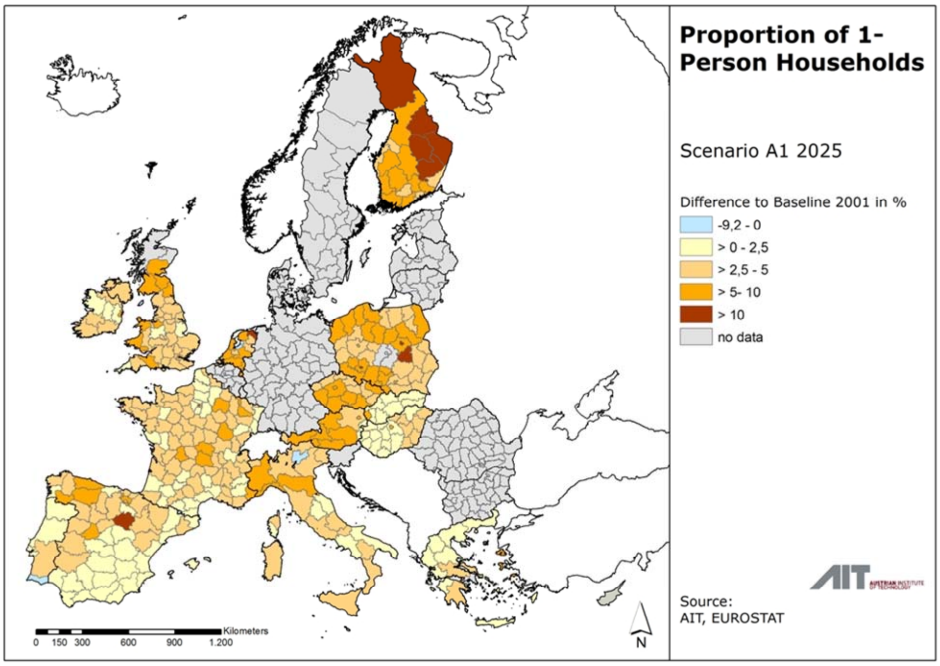

Fig. 18: Change in the share of population in 1 person households on total population 2001- 2025 – Scenario A1 (modelling AIT, with data from IIASA, Univ. Edinburgh, AIT)

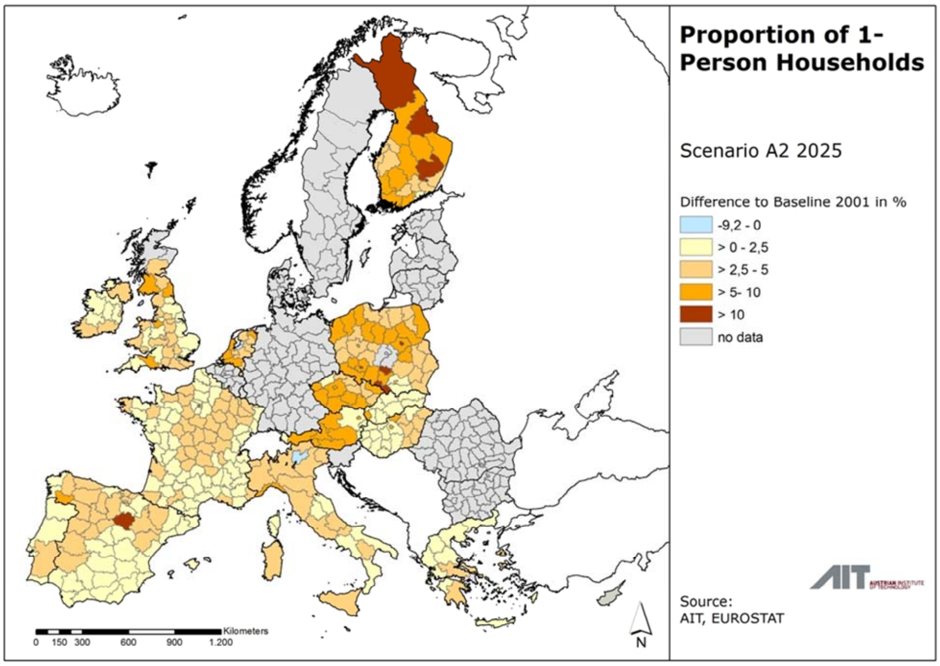

Fig. 19: Change in the share of population in 1 person households on total population 2001- 2025 – Scenario A2 (modelling AIT, with data from IIASA, Univ. Edinburgh, AIT)

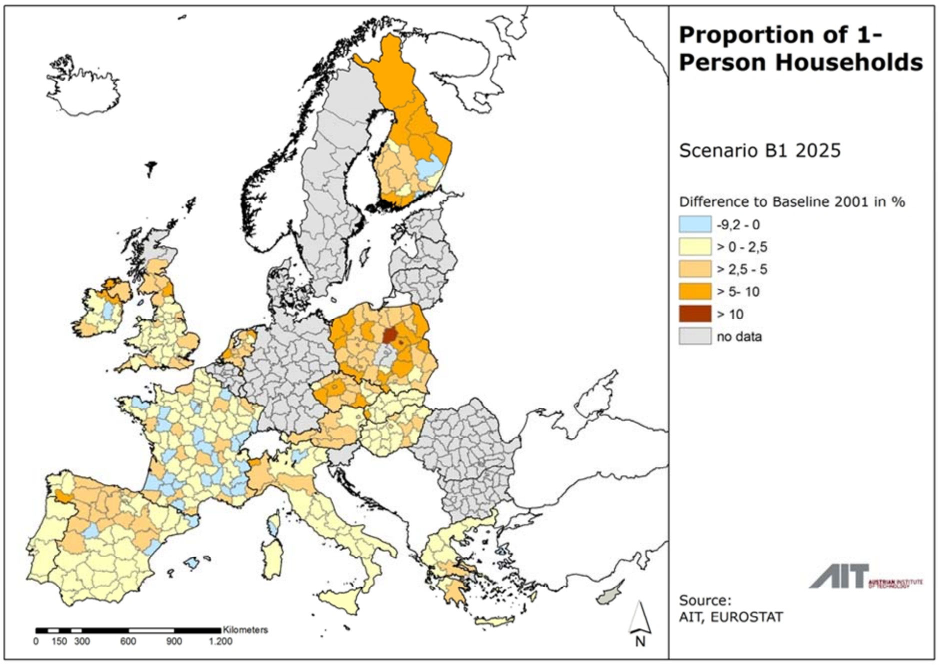

Fig. 20: Change in the share of population in 1 person households on total population 2001- 2025 – Scenario B1 (modelling AIT, with data from IIASA, Univ. Edinburgh, AIT)

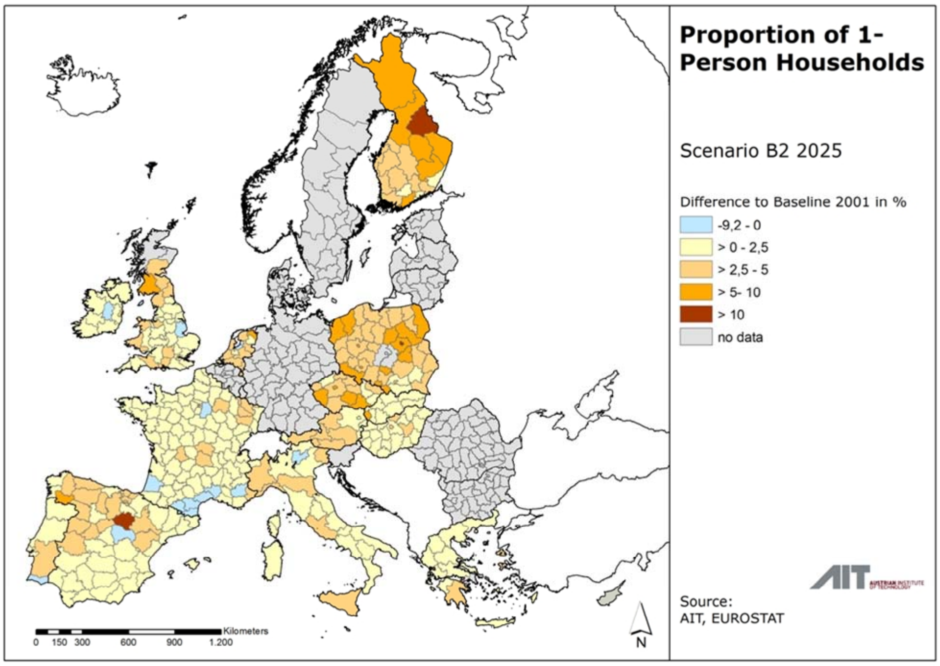

Fig. 21: Change in the share of population in 1 person households on total population 2001- 2025 – Scenario B2 (modelling AIT, with data from IIASA, Univ. Edinburgh, AIT)

Changes of the share of population in 4+ person households on the total NUTSx population:

In all scenarios the share of 4+ households will develop similarly. The trends are the opposite as for 1 person households, in countries with low 4+ household shares, the share will even further decline.

- Scenario A1 “Hypertech”: Nearly all regions (except Hungary) show high decline of the large household shares. Some exceptions can be observed in some coastal regions in France and Spain and around some capital areas – maybe attracted by the peri-urban.

- Scenario A2 “Waterworld”: Here the decline of shares of large households is expected to slow down to some extent. Beside the coastal regions and Hungary further stagnation of the percentages can be expected in regions scattered in Western France, in Southern Spain, the UK, Italy and Poland.

- In scenario B1 “Peak oil” the decline of the shares of the large households remains to a larger extent static: in (Southern) Spain, France, Southern Italy, Greece, Hungary and some regions in central to Eastern Europe. Only Poland and Finland show still a further heavy decline. For some scattered regions in France a slight increase can be expected.

- In scenario B2 “social fragmentation” highest decline is expected in Scotland, in Finland, further in central Europe (Poland, Czech Republic, Austria, Northern Italy), in some scattered regions in France and Spain and Portugal. (Some capital areas might exhibit a slowdown in the decline of the proportion of large households: Warszawa, Madrid, Amsterdam, the Paris region and the Cote Azure regions in France let expect even a slight increase.

Conclusions regarding urban / peri-urban development:

The differences of the expected future 4+ person household share between the scenarios are high, This proves tight relationship with peri-urban dynamics. But the negative regression coefficients for all artificial surface variables let assume that these large households avoid urbanized settlements (neither in the urban nor in the peri-urban settlements) and seem to have an affinity to less densely populated open space areas.

The growth of the share of peri-urban population (which turns out in some areas to be more dynamic than the changes in artificial surface) will lead to less reduction of the share of larger family households as depicted in scenario A2 and even more in both B-scenarios.

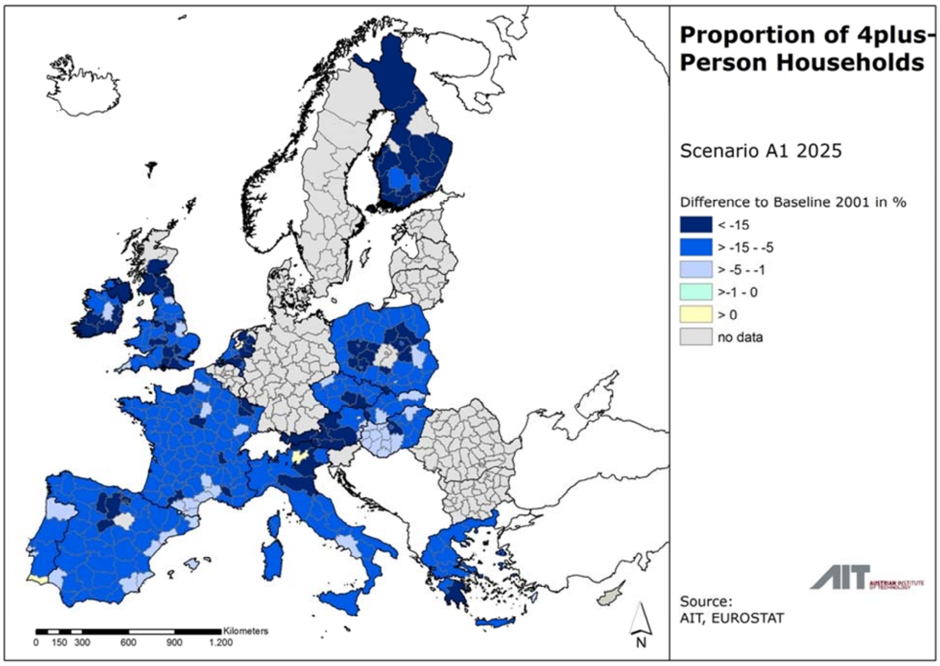

Fig. 22: Change in the share of population in 4+ person households on total population 2001- 2025 – Scenario A1 (AIT, with data from IIASA, Univ. Edinburgh, AIT)

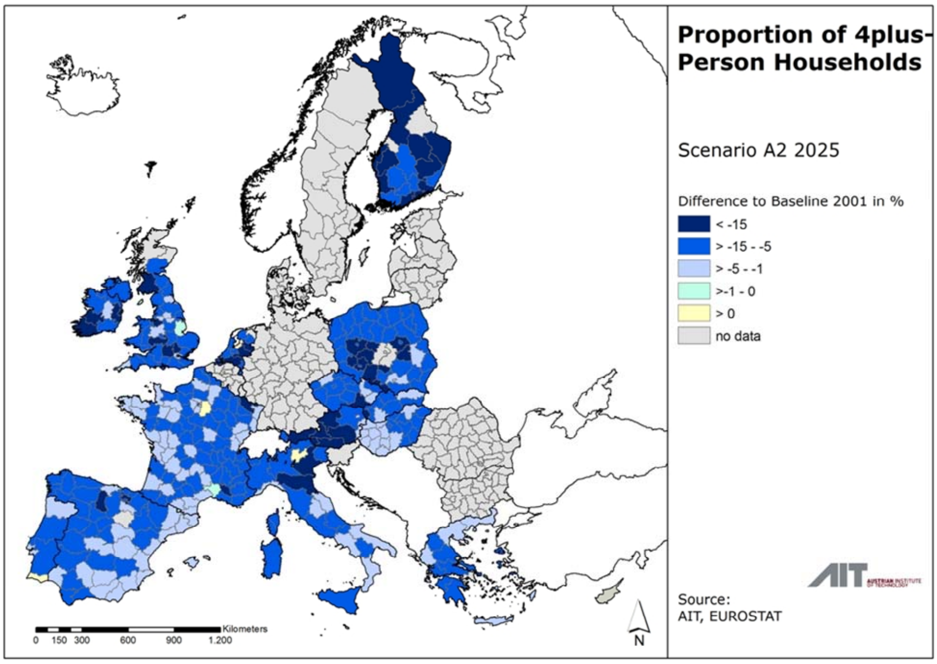

Fig. 23: Change in the share of population in 4+ person households on total population 2001- 2025 – Scenario A2 (AIT, with data from IIASA, Univ. Edinburgh, AIT)

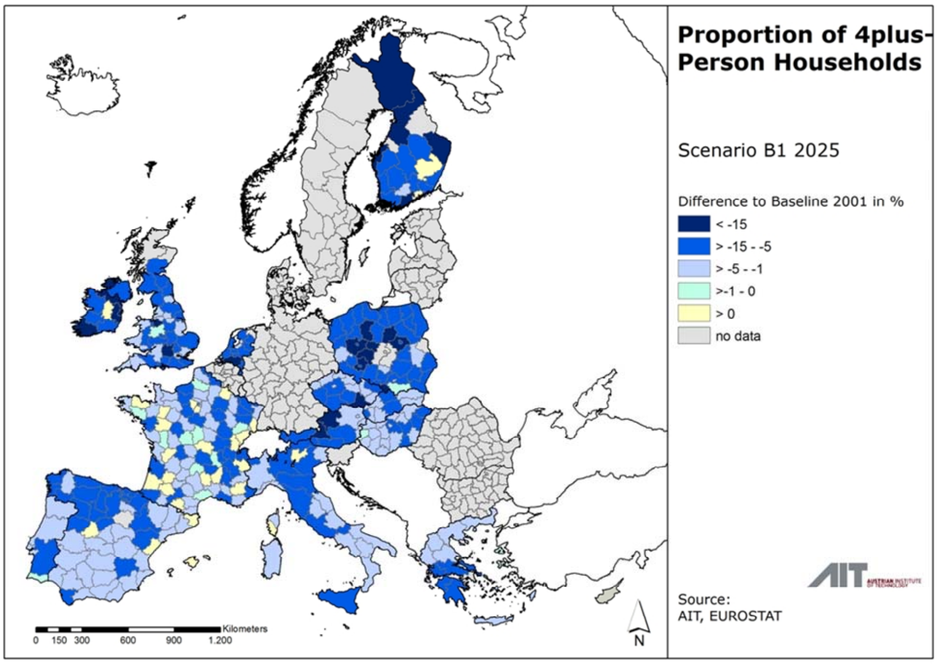

Fig. 24: Change in the share of population in 4+ person households on total population 2001- 2025 – Scenario B1 (AIT, with data from IIASA, Univ. Edinburgh, AIT)

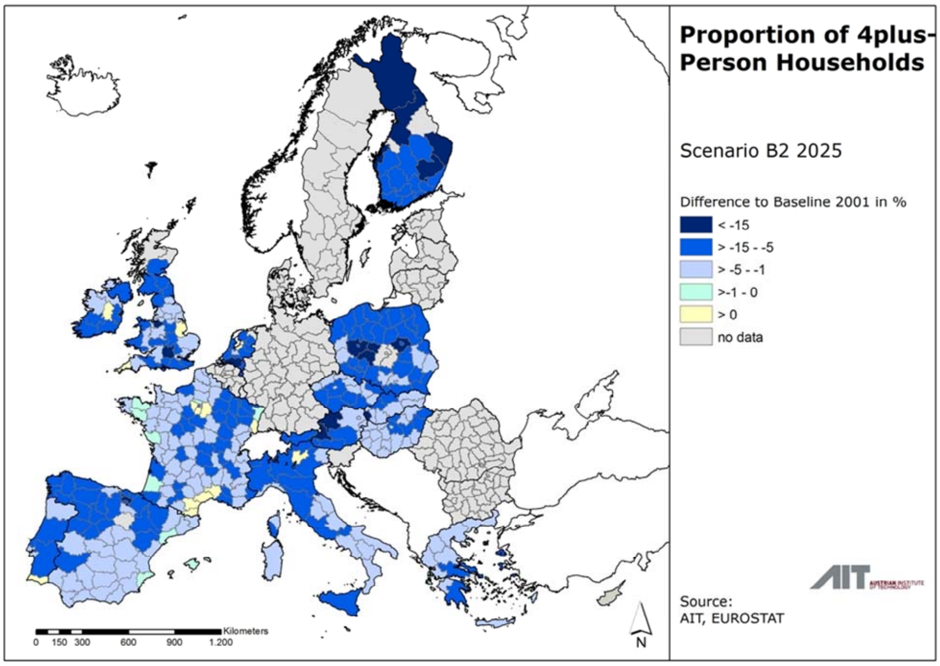

Fig. 25: Change in the share of population in 4+ person households on total population 2001- 2025 – Scenario B2 (AIT, with data from IIASA, Univ. Edinburgh, AIT)

3.5 Age structure - today and future trends

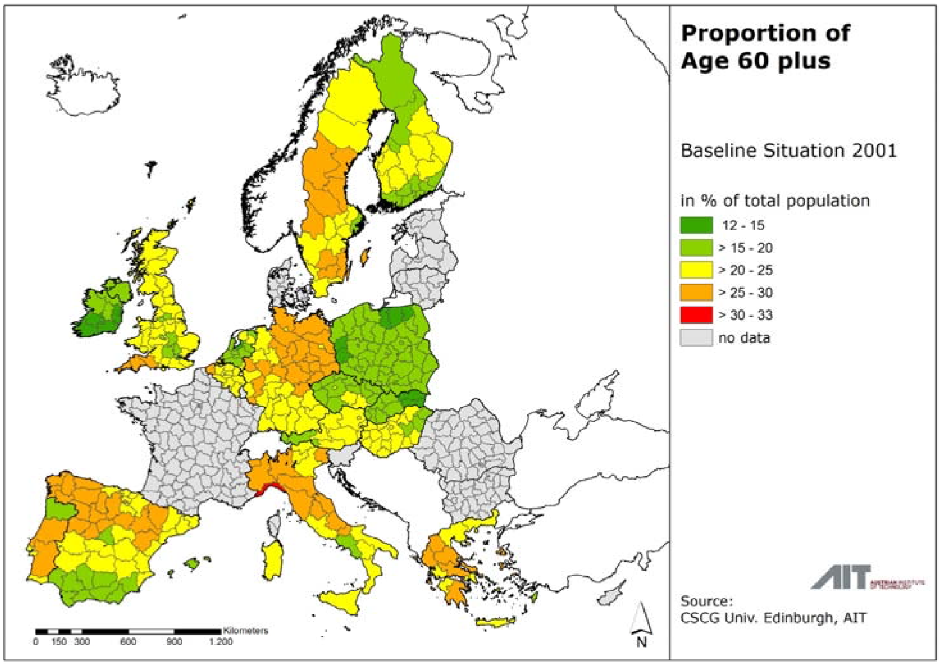

Fig. 26: Share of population of age 60 years and older on total population per NUTSx region 2001 (AIT, Eurostat)

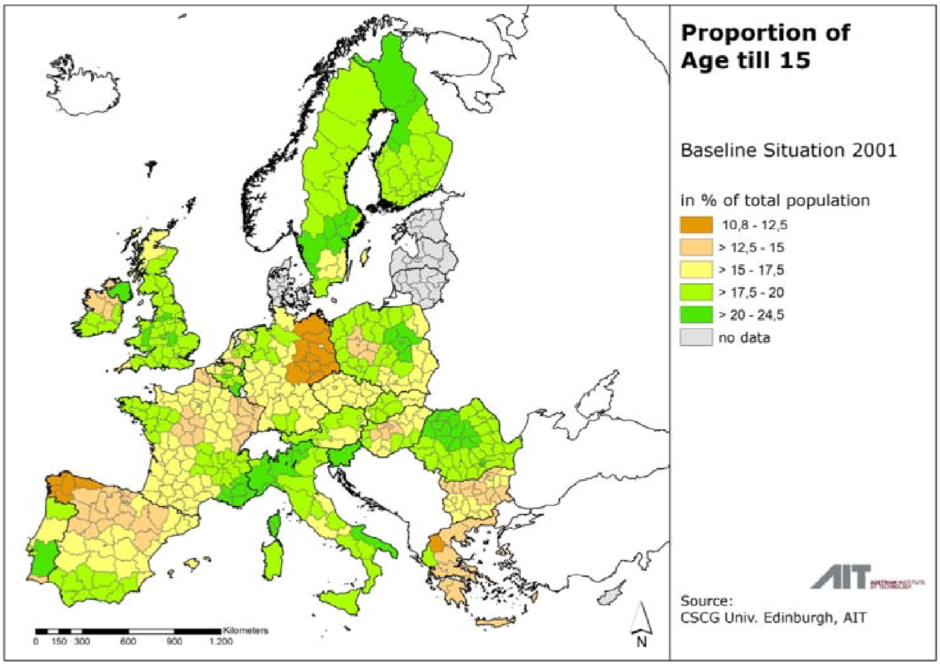

Fig. 27: Share of population of age 15 years and younger on total population per NUTSx region 2001 (AIT, Eurostat)

Expected changes in the age structure:
Instead of describing all age classes, we concentrate on the both “most distant” ones: we have selected the changes in the share of population below 15 years and the share of population above 60 years to explore trends of the coming generation and the ageing one.

Changes of the share of age 60 + population on the total NUTSx population:

The change in the proportion of older age population shows hot spots in various countries depicting today a very different age structure: Ireland, central England, Finland, Poland, the Netherlands, the Czech Republic and Slovakia show low 60+ population shares. Sweden, Eastern Germany, Northern Spain, Portugal, Northern Italy and Greece show a higher share of elder people.

The general future trend is “steadily ageing” – some opposite signals can be explored where urban core regions and their surroundings show less increase of ageing population. This is expected for Leipzig-Halle, Berlin, London, Manchester-Liverpool, and Budapest. Some larger regions, not necessarily capital regions, show also a cease: in Southern Sweden, in parts of Ireland, (in Northern) Italy, in Portugal, in Slovenia, and Northern Romania. In certain areas there is a decrease of the share of older people expected: in Scotland, Northern Ireland and in Greece. The trend is somehow opposite as the current older population shares: Areas with less older population will show an increase of the share, while in countries with today high shares of older population the further increase of the shares is less steep.

The differences between the scenarios are extreme little. A discussion about the assumptions on these changes is not useful.

Conclusions regarding urban / peri-urban development:

The 60+ population exhibits to a lesser extent relationships with changes in urbanisation or peri-urbanisation patterns, as it is depending more on the general age structure. But urban cores turn out as growth poles, attracting more young to middle age people which compensate – in the urban centres - the increasing numbers of older population, living longer: some certain urbanized centre regions show even a decline of the elder population shares.

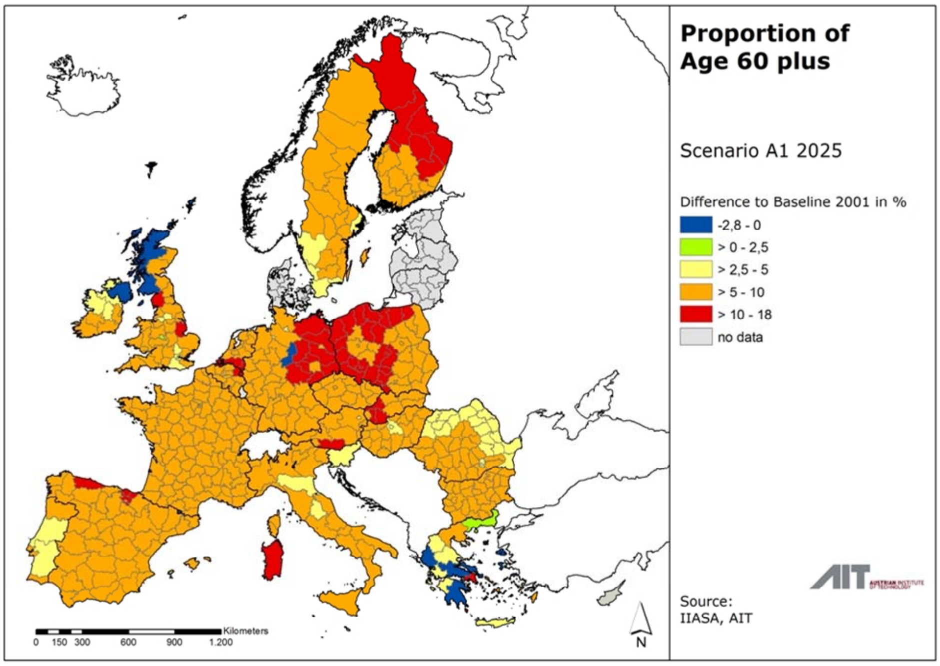

Fig. 28: Change in the share of population of age 60+ on total population 2001- 2025 – Scenario A1 (IIASA AIT)

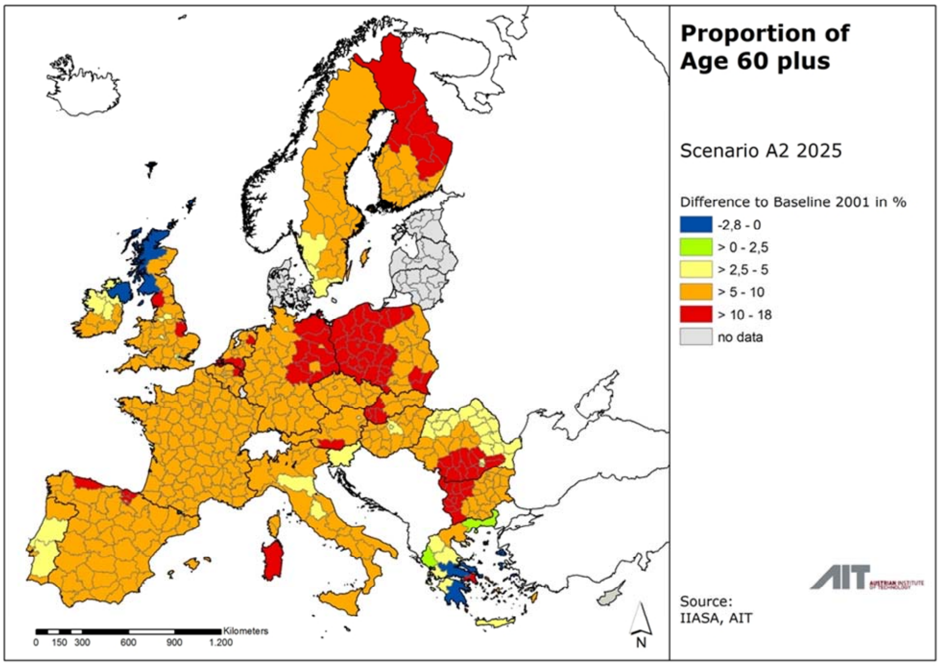

Fig. 29: Change in the share of population of age 60+ on total population 2001- 2025 – Scenario A2 (IIASA,AIT)

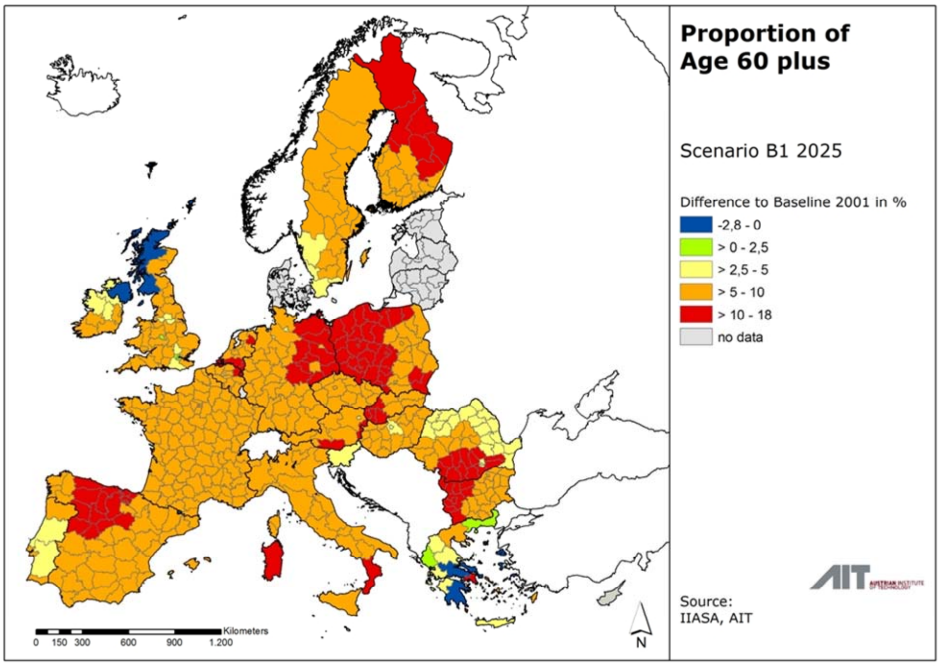

Fig. 30: Change in the share of population of age 60+ on total population 2001- 2025 – Scenario B1 (IIASA, AIT)

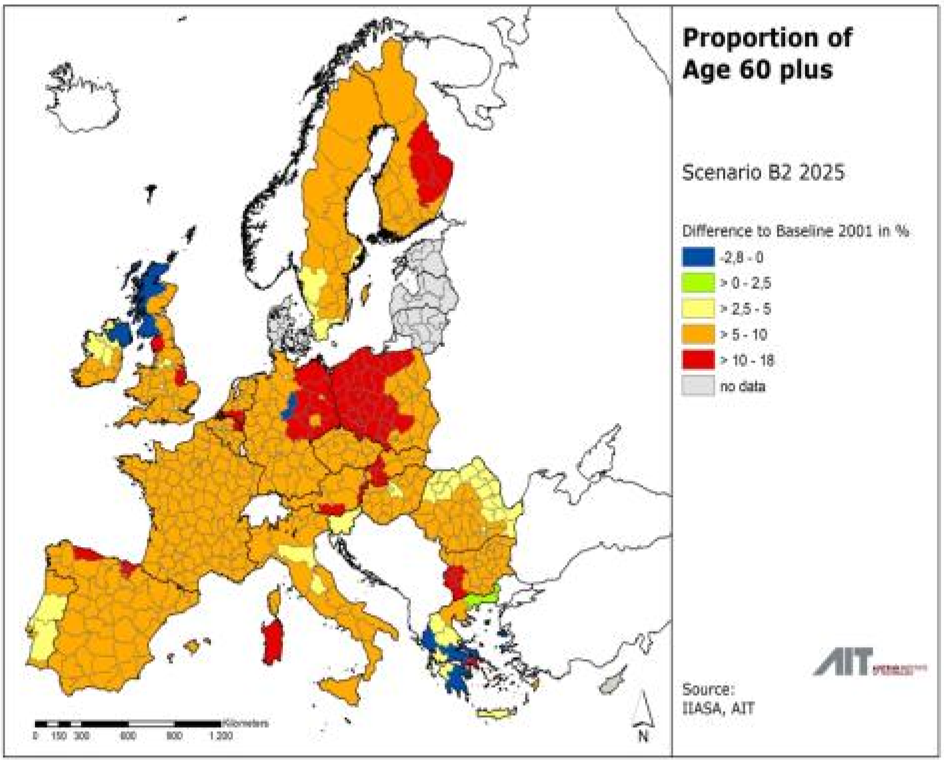

Fig. 31: Change in the share of population of age 60+ on total population 2001- 2025 – Scenario B2 (IIASA, AIT)

PLUREL

Changes in the share of age <15 population on the total NUTSx population:

The current shares of the young population depict somehow the opposite picture as the current share of the older population: high shares can be observed in Scandinavia, in England, Belgium, and in various regions of central to Eastern European countries, additionally Northern Italy and Southern Spain/Portugal. Distinctly little shares are observed in Eastern Germany, in Northern Spain and to some extent in Greece, Romania and central France.

In the 4 scenarios the share of <15 population turn out to show certain differences. The trends are not the opposite as of the 60+ population and are also not the opposite of the current <15 population distribution. This decoupling of the young population cohort from the remaining demographic structure may be caused either by in-migration of younger population or by short term increase of birth rates.

- Scenario A1 "Hypertech": In various regions in central, Europe (Germany, Austria, Hungary, Poland, Romania, Italy, further parts of UK, Ireland and Portugal) let expect a distinct decline of the younger generation. A reduced decline is expected for the Scandinavia, and larger parts of Eastern Europe (with recent ageing population) as well as for France, and Mediterranean Spain.

- Scenario A2 "Waterworld": Central and Eastern Europe (including parts of the UK, of Northern Germany, the Netherlands and parts of Portugal) will show a more distinct decline of the young population share than in scenario A1. A slowing down of the decline is expected for Scandinavia, and parts of France and Spain. Some regions will show a stable proportion of the younger (due to still low recent shares): Sofia, Leipzig, areas in Eastern France.

- Scenario B1 "Peak oil" shows the most severe decline of the younger population: entire Eastern Europe and large parts of central Europe and the Southwest let expect a heavy decline. A reduced decline might be expected in Scandinavia, UK, in parts of Eastern Spain and Northern France, in Eastern Germany, Poland and the Czech Republic. This decline may somehow caused by the also declining economic development

- In scenario B2 "social fragmentation" the decline is slowing down to some extent: heavy decline will be observed in regions scattered mostly over central Europe: Italy, Austria, Germany, Western Poland, Hungary and Bulgaria, but also in UK and large parts of Portugal. Lesser decline might be expected in Scandinavia, eastern Germany, and Western Poland, in large parts in Northern France and in Mediterranean Spain.

Conclusions regarding urban / peri-urban development:

The <15 population exhibits very different change patters when comparing the scenarios, which seem s to show some reaction on spatial development.
Less industrialized regions show less decline of the young population percentage – central France, Spain, Romania, the Scandinavian countries (obviously due to higher birth rates) , while the densely populated peri-urban regions (not necessarily the urban areas within) let expect more decline of the young population share.
This let assume, that the densely populated (peri-urban) areas turn out (again) to be less attractive for younger families and their children.

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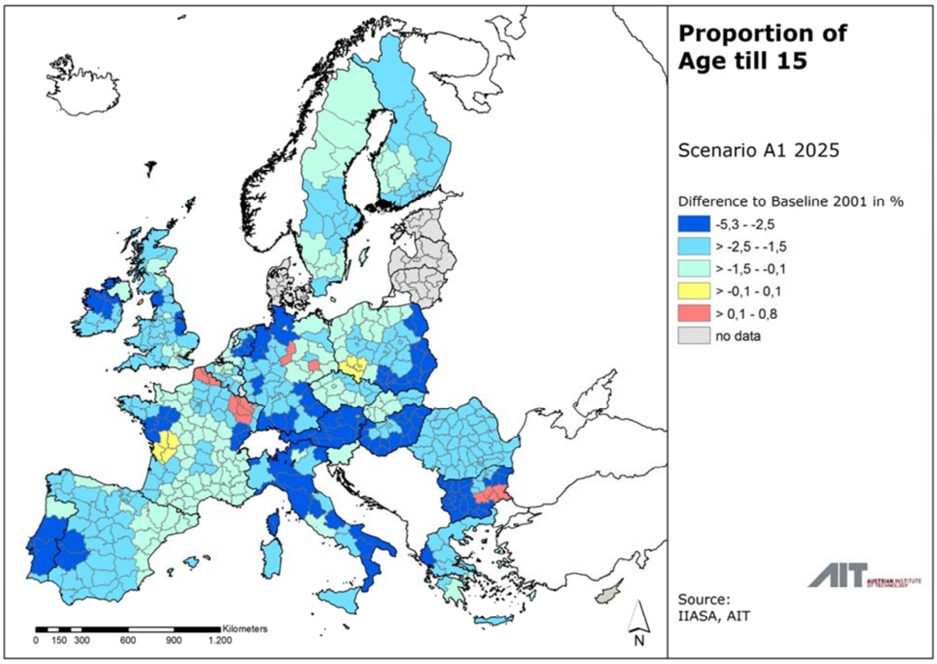

Fig. 31: Change in the share of population of age <15 on total population 2001- 2025 – Scenario A1 (IIASA, AIT)

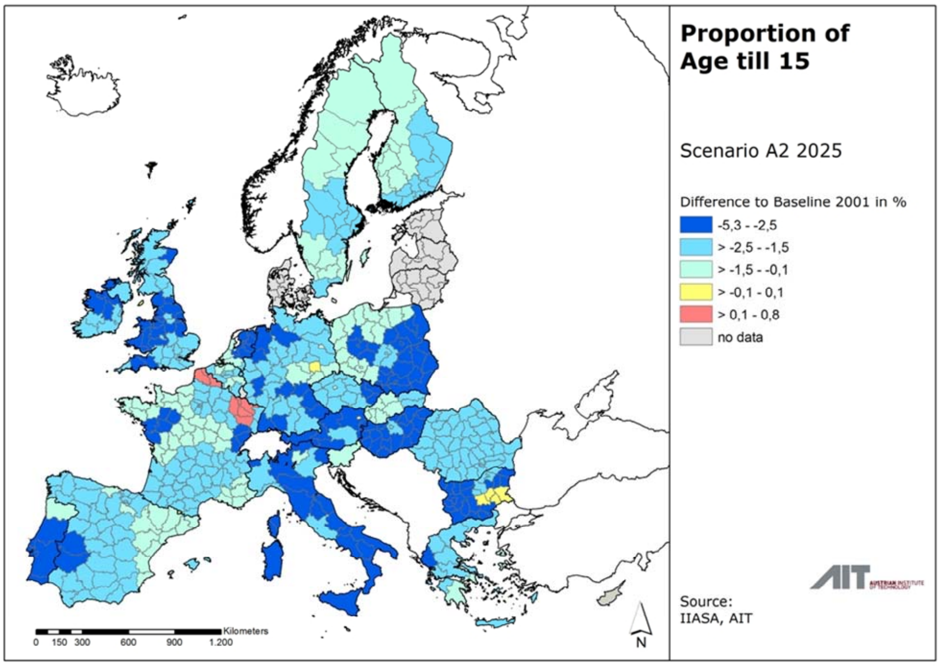

Fig. 32: Change in the share of population of age <15 on total population 2001- 2025 – Scenario A2 (IIASA, AIT)

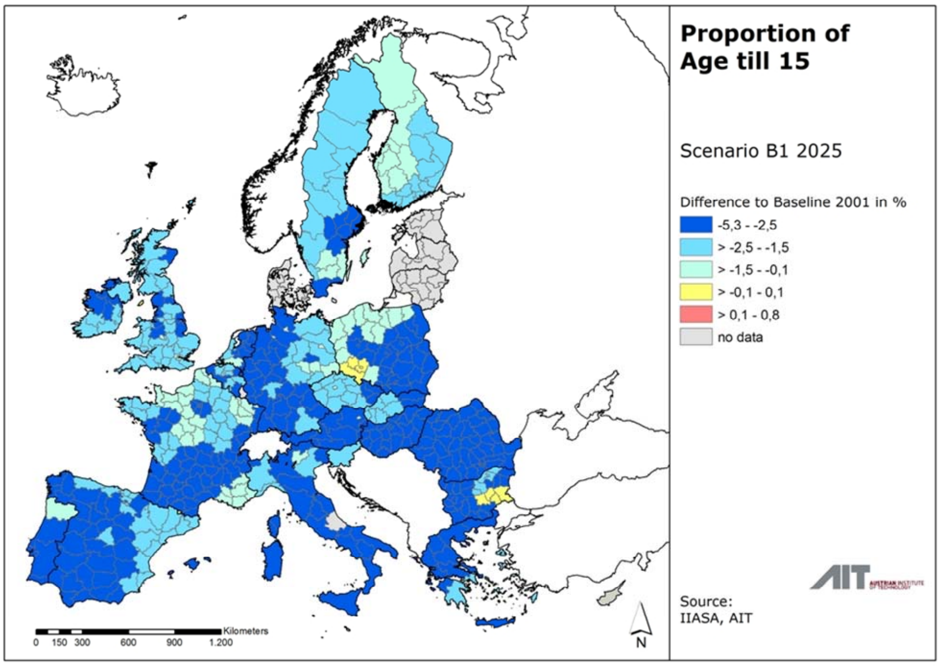

Fig. 33: Change in the share of population of age <15 on total population 2001- 2025 – Scenario B1 (IIASA, AIT)

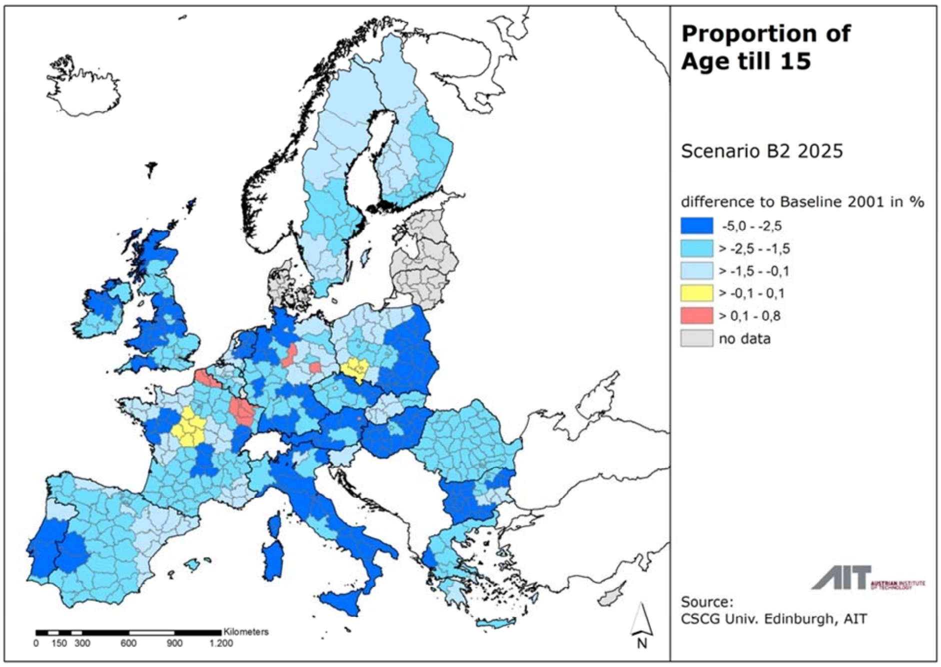

Fig. 34: Change in the share of population of age <15 on total population 2001- 2025 – Scenario B2 (IIASA, AIT)

3.6 Social structure - today and future trends

Tertiary (= academic) education serves as proxy indicator for social structure. No further comparable indicators are available for entire EU27 at NUTS3 scale.

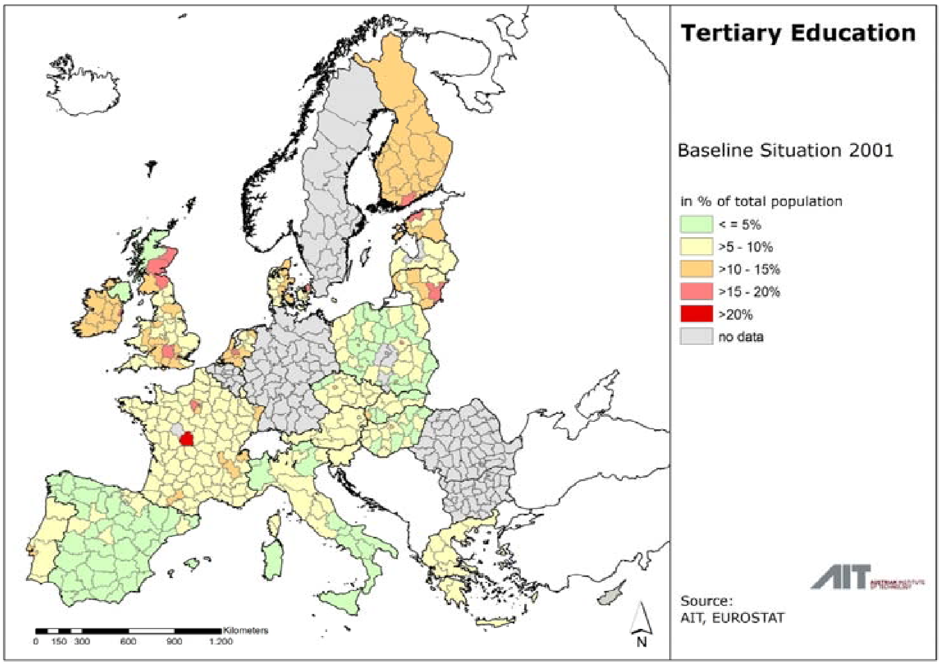

Fig. 35: Share of population with tertiary education on total population 2001 (AIT, Eurostat)

Expected changes in the share of population with tertiary education on the total NUTSx population:

The current shares of the academic population show a certain pattern which exhibits a North to South gradient. In Finland as well as UK and the Baltic countries tertiary education show today the highest shares. Some hot spots show highest shares (partly because of little population number living in small NUTSx regions, with core cities of the NUTSx region with much university personnel: Glasgow, Oxford, London, Paris, Tours (?- maybe an error), Amsterdam, Helsinki, Tallinn, Vilnius, Warszawa. Most regions in Western and central Europe show a moderate share of population with academic education. Regions with the lowest shares can be observed in Spain, Italy, and - to a lesser extent - in Poland and Hungary.

The differences of the changes of shares of academic educated population between the 4 scenarios are expected to be rather little: General y, Poland will show an increase of the share of population with tertiary education. For Finland a further increase of the share of academic population is estimated. Some additional regions will show also an increase above average: regions in the UK and in Ireland, in the Netherlands and further Bratislava.

The differences between the scenarios are neglectable.
All scenarios show for certain regions a slight decline of the tertiary education shares which shows some variation. This seems to be the case, when there is a coincidence of growing peri-urban artificial surface, but missing urban artificial surface. This usually happens when the NUTSx regions do not form a complete urban region but just a part of it – either the urban one or the peri-urban one. A region in Spain with highest expected growth is such an artifact produced due to certain un-usual proportions of urban and peri-urban artificial surface.

Conclusions regarding urban / peri-urban development:

The change in the share of academic population shows differences not between region types in terms of peri-urban characteristics, but more between countries (and their education systems) and certain university regions. More urbanised regions with larger core cities providing more jobs and cultural offerings for highly educated people are expected to be more attractive for those people than more rural areas without or with only few distinct centres showing these characteristics.

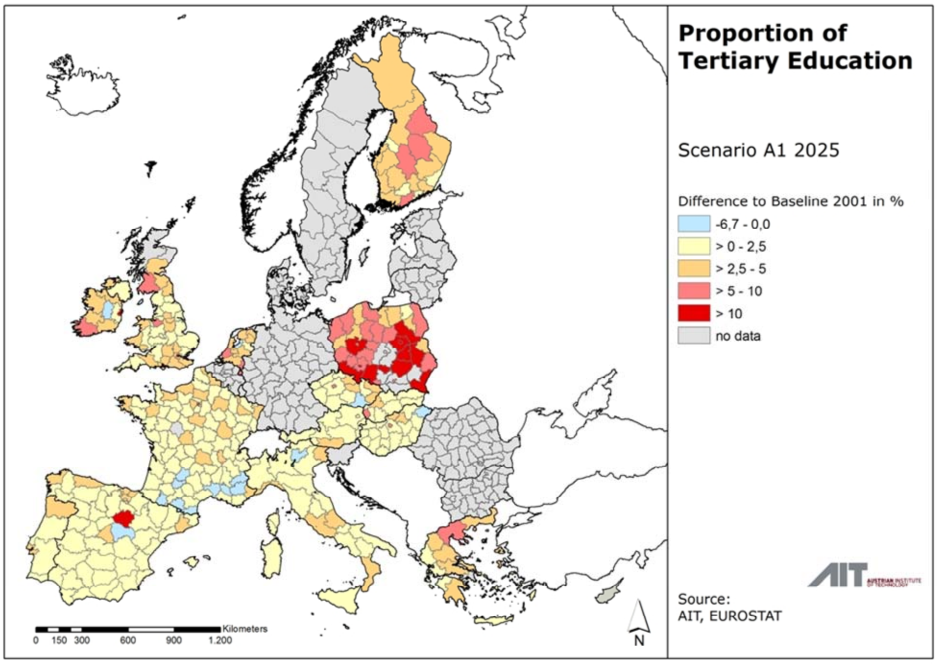

Fig. 36: Change in the share of population with tertiary education on total population 2001- 2025 – Scenario A1 (AIT, with data from Univ. Edinburgh, AIT)

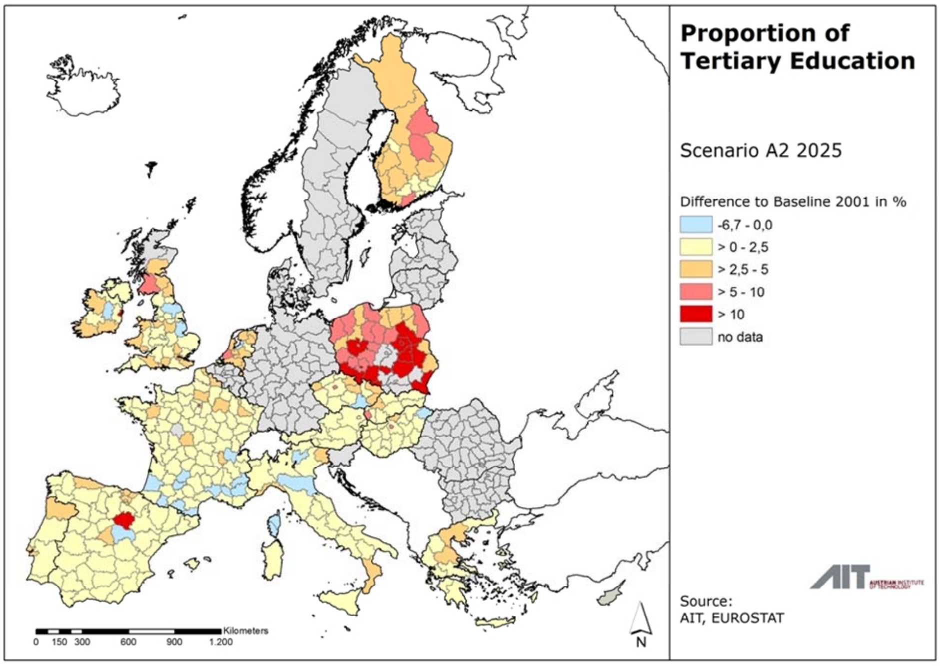

Fig. 37 Change in the share of population with tertiary education on total population 2001- 2025 – Scenario A2 (AIT, with data from Univ. Edinburgh, AIT)

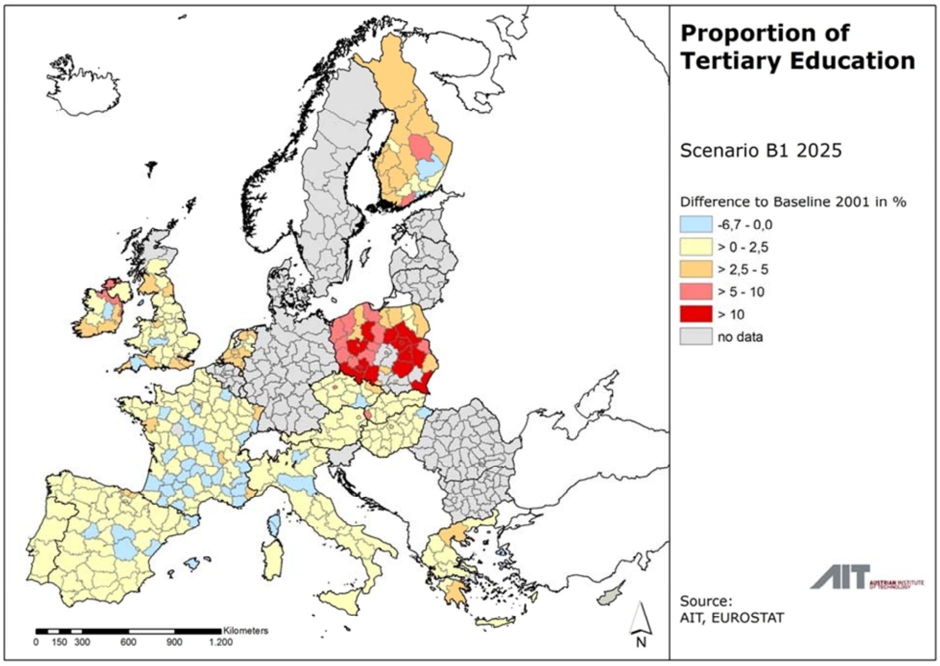

Fig. 38 Change in the share of population with tertiary education on total population 2001- 2025 – Scenario B1 (AIT, with data from Univ. Edinburgh, AIT)

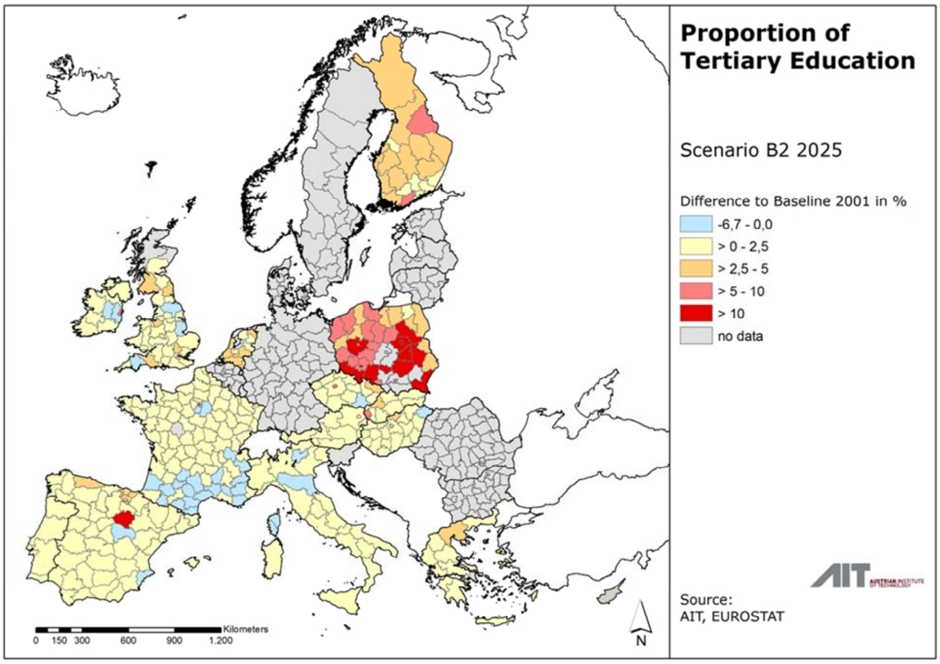

Fig. 39 Change in the share of population with tertiary education on total population 2001- 2025 – Scenario B2 (AIT, with data from Univ. Edinburgh, AIT)

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