European Commission

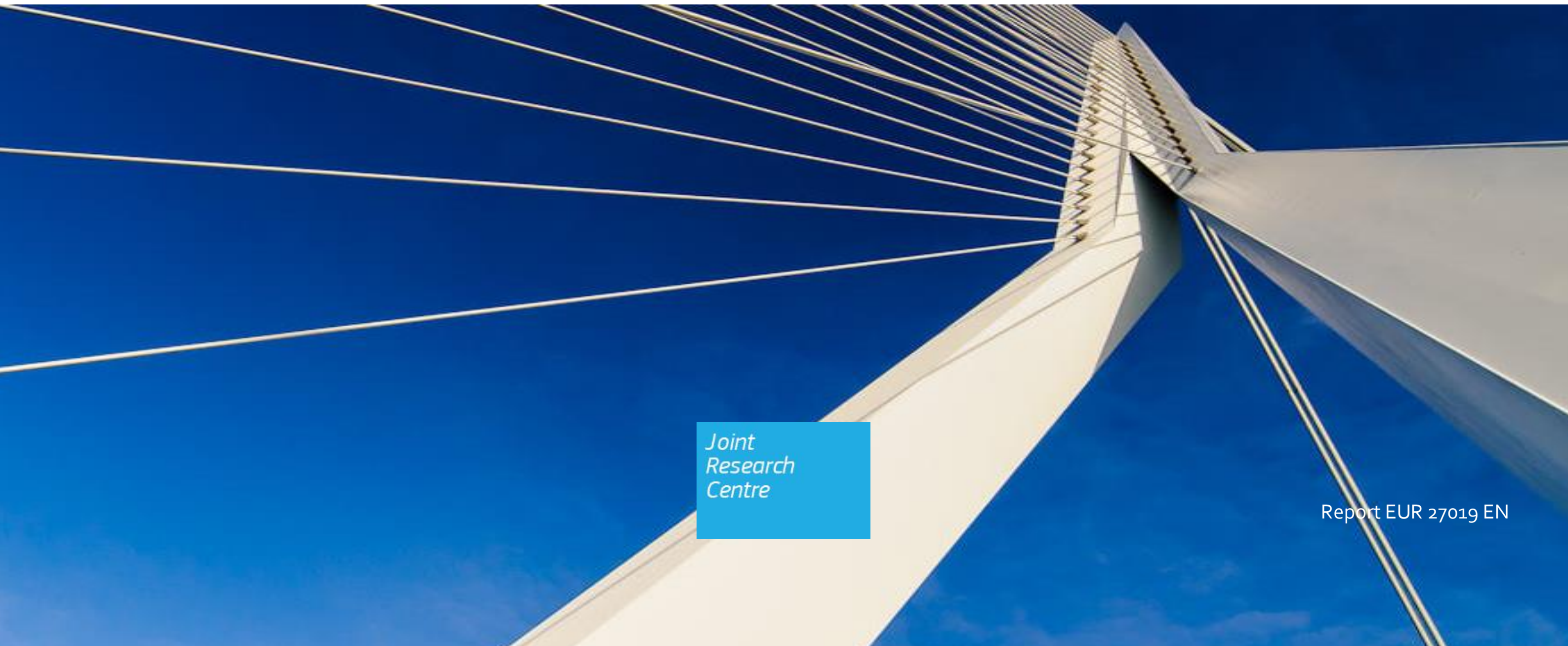
JRC SCIENCE AND POLICY REPORTS

The Reference scenario in the LUISA platform – Updated configuration 2014

Towards a Common Baseline Scenario for EC Impact Assessment procedures

Claudia Baranzelli, Chris Jacobs-Crisioni, Filipe Batista e Silva, Carolina Perpiña Castillo, Ana Barbosa, Juan Arevalo Torres, Carlo Lavalle

2014



Joint Research Centre

Report EUR 27019 EN

European Commission
Joint Research Centre
Institute for Environment and Sustainability

Contact information
Carlo Lavalle
Address: Joint Research Centre, Via Enrico Fermi 2749, TP 272, 21027 Ispra (VA), Italy
E-mail: carlo.lavalle@jrc.ec.europa.eu
Tel.: +39 0332 78 5231

JRC Science Hub
https://ec.europa.eu/jrc

JRC 94069

EUR 27019 EN

ISBN 978-92-79-44702-0 (PDF)

ISSN 1831-9424 (online)

doi: 10.2788/85104

Luxembourg: Publications Office of the European Union, 2015

Abstract
The LUISA land-use modelling framework is used routinely for integrated sustainability assessments of EC policies.. All policy impacts are assessed by comparing policy scenario model results with a reference scenario. This reference scenario is frequently updated to take into account new developments in land-use modelling practice, and to take into account new projections offered by the various sectoral models that supply information to LUISA.. This report details all changes made in 2014 as updates to the EU Reference scenario 2013 with regard to land-use claims and the LUISA spatial allocation mechanism. Finally, new developments related to the reporting and visualization of LUISA model results are highlighted.

TABLE OF CONTENTS

TABLE OF FIGURES

ACRONYMS AND ABBREVIATIONS

CAP	Common Agricultural Policy of the European Union
CAPRI	Common Agricultural Policy Regionalised Impact Modelling System
CLC	Corine Land Cover
DG CLIMA	Directorate-General for Climate Action
DG ECFIN	Directorate-General for Economic and Financial Affairs
DG ENER	Directorate-General for Energy
ECHAM5	European Centre Hamburg Model, version 5
EU	European Union
EUCLIMIT	European Climate Mitigation modelling platform
EUCS100	EuClueScanner 100m resolution
G4M	Global Forest Model
GAEC	Good Agricultural and Environmental Conditions
GDP	Gross Domestic Product
GVA	Gross Value Added
ha	Hectares
HadCM3	Hadley Centre Coupled Model, version 3
HNV	High Nature Value farmland areas
ICS	Industry, commerce and services
IPCC	Intergovernmental Panel on Climate Change
kha	Thousands of hectares
LFA	Less Favoured Areas
LU	Land Use
LUISA	Land Use Integrated Sustainability Assessment platform
LUMP	Land Use Modelling Platform
LAU	Local Administrative Units (LAU-1 – level1; LAU-2 – level2)
MS	Member State
MMU	Minimum Mapping Unit
NUTS	Nomenclature of Territorial Units for Statistics
RED	Renewable Energy Directive
UNFCCC	United Nations Framework Convention on Climate Change

EXECUTIVE SUMMARY

Typical ex-ante evaluations are based on a baseline scenario that projects, as accurately as possible, future states given plausible trends and current policies. Policy impacts are typically modelled as additional effects on that baseline in a separate model variant, so that differences in end state convey information on the impacts of the introduced policy. This working procedure makes the definition of the baseline scenario, in terms of underlying assumptions and included policies, a critical task.

LUISA (the 'Land Use-based Integrated Sustainability Assessment' modelling platform) is a land-function model that is developed by JRC, which is primarily used for the ex-ante evaluation of EC policies that have a direct or indirect territorial impact. At its core is a discrete allocation method that allocates different land uses to most optimal 100m grid cells, given predefined suitability maps, regional land demands and the supply of land in a region. Linked to the allocated land uses are grid cell population counts, which are modelled separately prior to the land-use allocation. The chief outputs that LUISA generates are projected land use, population and accessibility distributions at the 100m grid cell level. Over 50 indicators of land functions are subsequently derived from those chief outputs. Those indicators can inform policy effects on themes as varied as resource efficiency, ecosystem services and accessibility.

This report documents the differences between on the one hand the new EU Reference scenario 2014, which is defined as the baseline scenario in LUISA, and its predecessor, EU Reference scenario 2013. Most changes have been made to more accurately capture intricate relations between the macro-economic drivers of land-use change and regional land demands; to deliver a more comprehensive set of policies incorporated in the scenario's baseline assumptions; to improve consistency with EC policies and, in the case of forest land cover, with formal statistics; and to improve the accuracy of the fine resolution spatial allocation methods that are at the core of LUISA.

For the Reference scenario 2014, land-use distributions are obtained from recently refined CORINE 2006 land cover maps. Population distributions are synthesized from highly detailed census data, the refined land cover maps and soil sealing information. To compute the travel times that inform accessibility, a road network from the Trans-Tools transport model is used. For the Reference scenario 2014 a more sophisticated method has been put in place to model the destinations used in the necessary accessibility computations. Regional land demands are obtained from Eurostat's demographic projections (EUROPOP2010), long-term economic projections by DG ECFIN (EC 2012), and CAPRI models, and in the case of forests, from national reports for UNFCCC. For urban land uses, the NUTS2 regions previously used for the definition of demand have in some cases been up-scaled to allow the model more land supply in often high growth metropolitan areas. For urban and industrial land uses, more sophisticated methods have been put in place to link macro-economic and demographic drivers to land demand, through variable land-use intensities. The previously used G4M model for forest land demands has been replaced by an extrapolation of afforestation and deforestation trends reported in the UNFCCC reports. A wide range of European policies are included

in the Reference scenario 2014 through regional land demands, through local impacts on land suitability and locally restricted land-use conversions. Starting with the Reference scenario 2014, cohesion policy impacts are included, and based on the Commission's Renewable Energy Directive, High Natural Value farmlands are added as an additional criterion important for the allocation of dedicated energy crops. Lastly, an online platform to visualize and explore indicator results interactively is under development.

The Reference scenario 2014 is more consistent and yields more plausible patterns than its predecessor, due to the modelling improvements herein described. Validation exercises are underway to explore the accuracy of its results. A new Reference scenario is planned for the end of 2015. This scenario should take into account the results of the validation exercise and revised economic and demographic projections.

1 INTRODUCTION: CONTEXT AND SCOPE

1.1 *Context and scope*

This report introduces the EU Reference scenario 2014, which essentially consists of updates to the EU reference scenario 2013 (Lavalle et al., 2013). The previous scenario was modelled using the Land Use Modelling Platform (LUMP); following substantial changes in both conceptual and practical modelling approaches, the further developed modelling framework is now referred to as the platform for 'Land-Use-based Integrated Sustainability Assessment' (LUISA). The EU Reference scenario 2014 will be used as a 'Baseline scenario'. Such a baseline scenario is typically defined as the 'situation' (or 'state of affairs' or 'set of conditions') used as the starting point (or 'benchmark') for comparison against alternative scenario(s) reflecting possible policies or in a forecast/projection exercise. In the framework established by the EC Impact Assessment procedure, such a baseline scenario 'provides the basis for comparing policy options' and includes 'national and EU policies in place' (EC, 2013).

To assess policy impacts with possible overlaps or conflicts between sectoral developments and sector-specific policies, a single EC baseline is ideally common between all EC services that would be undertaking an Impact Assessment. Such a common baseline should include the full scope of relevant policies assuring coherence among them, and it should inform on future prospects in all sectoral domains that are affected by EU policies. Because of its benchmark function, the correct definition and implementation of such a baseline scenario is essential to correctly evaluate EC proposals. It would be beneficial for the carrying over of Impact Assessments of legislative and non-legislative proposals, and would also support the tuning (refit) of existing policies. A solid common baseline scenario will also be an essential element for the ex-post evaluation of measures and programmes, since it allows reproducing the processes that are adopted to set targets; and the actual performances can be evaluated with updated information.

1.2 *The Reference scenario 2014: outline and future plans*

The EU Reference scenario 2014, which will be outlined in this report, represents the state of the art of LUISA modelling methods and results. This scenario builds on the previous EU reference scenario 2013 (Lavalle et al., 2013), still within the GeoDMS framework (ObjectVision, 2014), but with substantial improvements in place. The most important improvement considers the inclusion of many indicators that deal with the state of land functions and any changes in those functions, thus steering the previous land-cover oriented framework towards LUISA, with a land-function oriented approach. The improvements to LUISA and the EU Reference scenario 2013 include: a new classification of the modelled land-use types; re-estimation of the suitability functions that drive the spatial allocation of land uses and population; changes in the regionalization of urban land-use claims; more sophisticated methods to compute demand for urban, industrial and forest land cover; a more refined method to approximate the spatial location of destinations that are relevant for the definition of accessibility measures; and technical changes to allow easier adaptation of the model. As noted before, the here presented Reference scenario 2014 is modelled as a reference future state of land use and population patterns in Europe in the LUISA platform. This Reference scenario 2014 will be the reference scenario until the end of 2015. The following Reference 2015 scenario will include, if the necessary data become available, revised population projections (Eurostat 2013), revised economic projections and a new base year based on the soon to be released CORINE 2012 rather than CORINE 2006 land cover data.

LUISA is continuously evolving and developing towards the further dynamic integration of models, methods of assessment and databases, in a coherent framework. Key planned milestones to accomplish such a wholly integrated platform are: modelling an economic rationale in land-use transitions through a net-present value approach; explicitly modelling the local spatial distributions of economic activity; and a further integration of land-use transport interactions, for example by endogenously modelling impacts of congestion on travel-time losses. Furthermore, a validation exercise is initiated to explore the accuracy of the model and information required to potentially improve the model's accuracy.

1.3 This report

All improvements to LUISA and the Reference scenario assumptions that have been made since the EU Reference scenario 2013 will be outlined in this report. Chapter 2 addresses changes in modelling the macro drivers of land-use change and the link between those macro drivers and regional land-use demands. Chapter 3 deals with improvements added to the land-use allocation method. Chapter 4 details policy provisions that are newly modelled in LUISA and integrated in the Reference scenario 2014 as either changes to land-use demands or to the allocation procedure. Chapter 5 introduces the online platform built to visualize and explore the results of LUISA indicators interactively. Finally, chapter 6 offers some preliminary findings obtained with the new Reference scenario 2014. For a full overview of the EUClueScanner100 land-use model that is at the heart of LUISA we refer to (Lavalle et al., 2011); for the Reference scenario 2013 settings we refer to (Lavalle et al., 2013). Many improvements for the Reference scenario 2014 were obtained from modelling exercises done to support the European Commission's sixth report on economic, social and territorial cohesion. For a further description of those modelling exercises, we refer to (Batista e Silva et al., 2013b).

2 DESCRIPTION OF LUISA AND MACRO DRIVERS OF LAND-USE CHANGE

2.1 Integrating top-down and bottom-up dynamics in LUISA

Land use changes are processes that occur at the local level but which depend on both macro drivers and local dynamics and characteristics (Verburg and Overmars, 2009). In the LUISA framework, land use changes are dealt within a multi-scale modelling environment in which top-down and bottom-up dynamics interact to yield likely future land use changes. Figure 1 summarizes how these interactions are conceptualized within LUISA.

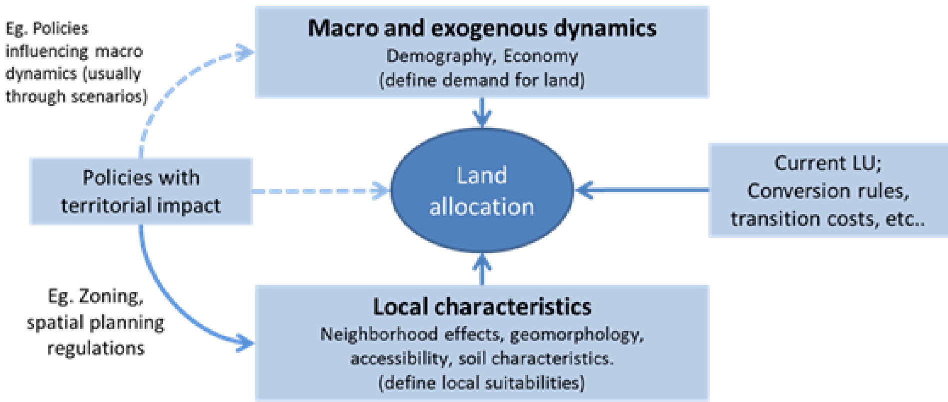


Figure 1. LUISA merges top-down and bottom-up dynamics to simulate land use changes.

The 'top-down' component of the modelling framework reflects the fact that, for example, future demographic growth will entail the development of additional residential built-up to sustain more residents, or that economic activity relies on industrial and commercial land use. These macro-dynamics are addressed in what has been coined the 'demand module' of LUISA (Lavalle et al., 2011), and which is the focus of this section.

The demand module is called after the concept of 'land demand' which, in the land-use modelling community, has been often used to refer to the expected additional land surface required to support future societal and economic activities. In LUISA, land demand is specified for four main groups of land-use classes: urban, industry-commerce, agriculture and forest. 'Urban' land-use comprises built-up used mainly for residential and tourism purposes, comprising also areas of mixed land uses which are commonly found in the cores of urban agglomerations. 'Industry-commerce' land use is a rather heterogeneous group of land uses. It merges manufacturing, energy and storage facilities, logistic centres, large commercial areas, health, education and public administration facilities. The ‘agriculture’ land-use class includes various types of land used for the production of food, feed and fibre, thus comprising arable and pasture land, and permanent crops. Related to the agricultural land-use class is the ‘new energy crops’ class that covers land used to grow crops for the production of energy. Finally, the ‘forest’ class includes all areas dominated by trees, regardless of the actual use. With all its pros and cons, these definitions are directly inherited from the CORINE Land Cover nomenclature (Büttner et al., 2006), which is the only complete and consistent land use/land cover dataset that covers the complete required spatial extent.

In practice, the demand module of LUISA is a set of procedures that capture top-down or macro drivers of land-use change (taken from a set of upstream models) and transform them into actual regional quantities of the modelled land-use types. For example, regional land demands for agricultural commodities are taken from the CAPRI model (Britz and Witzke, 2008), a model that simulates market dynamics using nonlinear regional programming techniques to forecast the consequences of the Common Agricultural Policy. Demographic projections from Eurostat and tourism projections from the United Nations World Tourism Organization (UNWTO) are used to derive future demand for urban areas in each region; land demand for industrial and commercial areas are driven primarily by the economic growth as projected by Directorate-General for Economic and Financial Affairs of the European Commission (DG ECFIN); and the demand for forest is determined by extrapolating observed trends of afforestation and deforestation rates reported under the scheme of the United Nations Framework Convention on Climate Change (UNFCCC). The demand for the different land-use types is ultimately expressed in terms of acreage and defined yearly and regionally (NUTS2).

It is clear that LUISA is linked to several thematic models, and thus it also inherits the scenario configurations and assumptions of those models. Special care is therefore taken when integrating the input data from multiple source models to ensure that inputs are mutually consistent in terms of scenario assumptions. It is also clear that the demand for the various land uses is an exogenous parameter in LUISA: demand is firstly determined for all land-use types, regions and simulated years; only then the ‘allocation module’ of LUISA starts actually determining the optimal spatial arrangement of the land uses for each simulated year according to various local, or bottom-up criteria.

Local characteristics that influence land use changes include both ‘fixed’ and ‘dynamic’ factors. The fixed factors are those which are virtually stable within the time frame of the simulations, comprising soil and terrain characteristics (e.g. elevation, slope, south facing). On the contrary, dynamic factors are those which change over time as a result of the simulations. Neighbourhood (to different land uses, and to population) and accessibility are the two major dynamic factors. These local dynamic factors are endogenous in LUISA, reshaping spatially in each simulated year and thus influencing the land use changes of the subsequent simulated years, in a recursive fashion. In addition to the fixed and dynamic local characteristics, a set of land use conversion rules, costs, and restrictions are either determined by expert knowledge or by policies which are taken into account in each of the scenario setups. All these aspects are all dealt within the ‘allocation module’ of LUISA, which will be further elaborated upon in chapter 3.

LUISA can be configured to project a baseline scenario of land use changes up to 2050, assuming likely socio-economic trends, business as usual urbanization processes, and the effect of established European policies with direct and/or indirect land-use impacts. Variations to that reference scenario may be used to estimate impacts of specific policies, or of alternative macro-assumptions. This highly flexible and customizable structure of LUISA makes it a suitable tool for providing insights to policy-makers in Europe regarding landscape, urban areas, environment and, more broadly, aspects pertaining to sustainability and territorial cohesion.

2.2 Integrating economic and demographic dynamics in LUISA

Overview

Economy and demography are important macro-drivers of land-use change. Figure 2 depicts the workflow currently implemented in LUISA to integrate these two dimensions. Demographic and economic drivers are typically taken from exogenous models with country-level detail. In the Reference scenario 2014, the economic and demographic assumptions are consistent with the 2012 Ageing Report (EC, 2012). The demographic projections, hereinafter referred as EUROPOP2010, were produced by Eurostat, whereas the long-term economic outlook was undertaken by DG ECFIN and the Economic Policy Committee. The actual economic figures used in LUISA were taken from the GEM-E3 model, which modelled the sector composition of future economy (GVA per sector) consistently with the DG ECFIN's projections (EC 2014). Both projections are mutually consistent in terms of scenario assumptions.

Demography and economy are used to drive primarily the demand for 'urban' and 'industry-commerce' land-use types, and that relationship is established, as already evident, within LUISA's demand module. The very first step consists of downscaling national projections (NUTS0) to the regional level (NUTS2). The downscaling assumed regional shares of population from a previous Eurostat projection (EUROPOP 2008) until 2030, and stable from 2030 onwards (see Batista e Silva et al. (2013b) for more details); constant regional shares, as obtained from Eurostat's regional statistics, were assumed to downscale the sector economic projections.

Urban land-use demands are obtained from combining demand for residences and tourist accommodations. The demand for residential urban areas is a function of the future number of households and a land-use intensity parameter that indicates the number of households per hectare of residential urban land. The future number of households is a function of the future regional population and of an average household size that was assumed to converge across European regions. The land-use intensity parameter was extrapolated from observed trends to reflect a business-as-usual approach. The demand for touristic land use is a function of the future number of beds in a region and another land-use intensity parameter that indicates the number of beds in tourist accommodations per hectare of touristic urban land. The future number of beds is a function of the projected number of tourist arrivals, which were obtained from the United Nations World Tourism Organization. Finally, demand for industrial, commercial and services (ICS) land use is a function of economic growth in those three sectors of activity, and, again, a land-use intensity parameter expressing the average gross value added per hectare of ICS land use, which varies per sector and per region (Batista e Silva et al., 2014). Future land-use intensity responds to future GDP per capita because it has been found that economic land-use intensity depends foremost on that factor.

It is worth mentioning that, despite the evidence that urban patterns might be associated with different economic growth rates in the long run (Ahrend and Schumann, 2014), currently in LUISA, future socio-economic conditions are imposed exogenously, thus assuming that future land use patterns will not significantly alter the future regional socio-economic scenario.

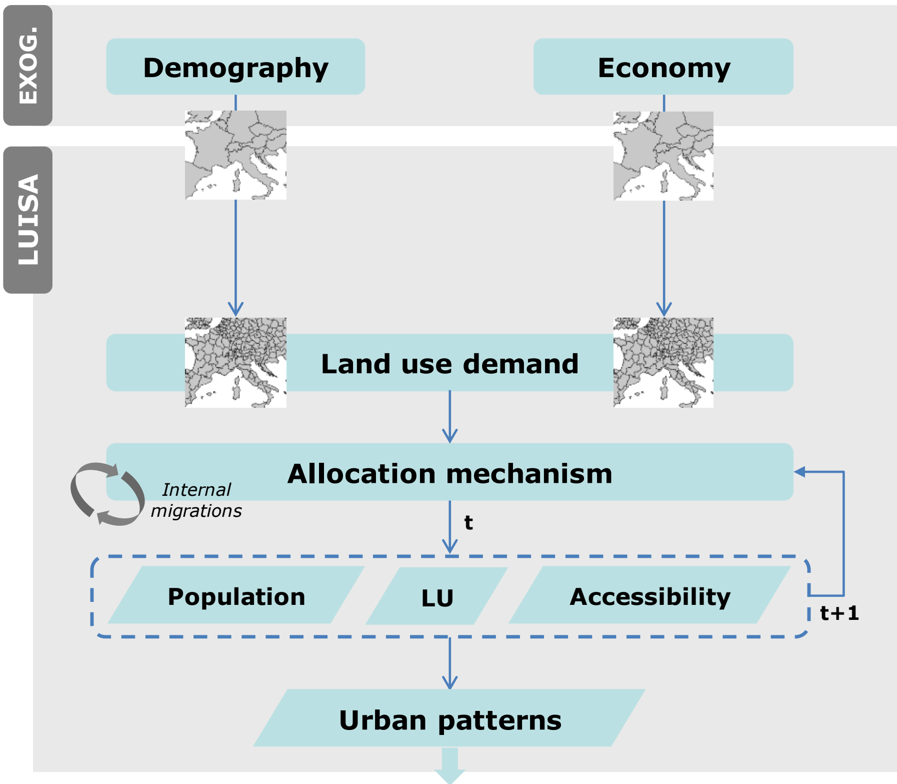


Figure 2. Integrating economy and demography in LUISA.

Estimating demand for urban land use

Demand for urban land use *U* is the sum of the demand for residential land use *R* and tourism land use *T*, in each region *r*, belonging to each country *c*, at each yearly time step *t* (typically the base year 2006) + *n* number of years. Residential land use is primarily driven by projected population *P*, and is sensitive to future average household sizes *H*, and land use intensities *L* which are specific to each sub-land-use type $u \in \{residential, tourism\}$. On the other hand, tourism land use is determined by the projected future number of beds *B*, divided by a land use intensity coefficient which is country-specific and denotes the average number of beds per hectare of touristic land. The formulation can be synthetized as follows:

$$U_{r,t+n} = R_{r,t+n} + T_{r,t+n} \tag{1}$$

$$R_{r,t+n} = \frac{\left(\frac{P_{r,t+n}}{H_{c,t+n}}\right)}{L_{u,r,t+n}} \tag{2}$$

$$T_{r,t+n} = \frac{B_{r,t+n}}{L_{u,c}} \tag{3}$$

The source for projected population is taken from Eurostat with country detail, and then downscaled to regional (NUTS2), as mentioned earlier in this section. The household sizes are recorded at regional level by Eurostat. Future household sizes were then assumed to converge linearly to 1.8 persons per household by 2100. The value 1.8 corresponds to the 1st percentile of the regional average household sizes as observed in 2010. This is in line with the observation that average household sizes have been decreasing and converging over the last decades, and therefore this appears to be a suitable option for the reference scenario. Future refinements of this approach could include explanatory factors of the decline of the average household sizes. Finally, land use intensity is observed for the years 1990, 2000 and 2006, for all regions, whenever land use and population data were available. Future land use intensities are then linearly projected to reflect a business-as-usual approach. In sum, the method to derive demand for additional residential areas makes sure that sensible trends concerning household size and land consumption per household are taken into account. Finally, for some NUTS2 regions the urban land-use projections are summed to larger demand regions that inform the land-use allocation module. This is different from the EU Reference scenario 2013 approach, and is done for those cases were the supply of land within typically metropolitan areas is insufficient for the projected urban growth. Examples of aggregated urban regions are Brussels, London and Prague.

Regarding the tourism component, the future number of beds is estimated using a fitted relationship between yearly arrivals and the number of beds per region constructed with data extracted from Eurostat (see Figure 3). The future yearly arrivals are obtained by applying tourism growth rates projected by UNWTO (2014). The land use intensity specific to the tourism land-use was estimated by using the observed number of beds from Eurostat and estimates of total floor space used by the tourism sector published by the Data Hub for the Energy Performance of Buildings[1]. These land use intensities are estimated at country level and remain constant over time.

Despite the tourism component being an overall small share of the total urban built-up, it does have a relatively large importance in a significant number of European regions where the tourism is the

[1] Data Hub for the Energy Performance of Buildings, http://www.buildingsdata.eu/

main or one of the main sectors of the regional economy. In most regions, and particularly in the latter ones, it is sensible to assume that tourism is a non-negligible driver of built-up pressure. The explicit demand for the tourism sector is a novelty introduced in the Reference scenario 2014.

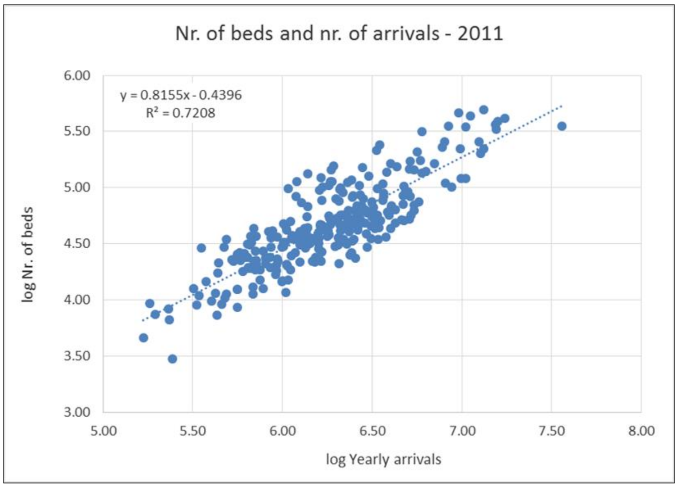


Figure 3. Relationship between yearly arrivals and the number of beds per region.

Estimating demand for industry-commerce land use

Industry-commerce land-use demand is essentially dependent on scenario-based economic outlooks, and it is estimated through a 'land use intensity' approach, as described by Batista e Silva et al. (2014). The land use intensity, or land use productivity, is the ratio between the economic output (GVA) of a given sector *s* in a region *r*, and the land acreage *A* known to be used by sector *s* in a given year *t* (eq. 4):

$$L_{r,s,t} = \frac{GVA_{r,s,t}}{A_{r,s,t}}, with\ s \in \{1\ = \text{industry}, 2\ =\ \text{commerce}, 3\ =\ \text{services}\}, \quad (4)$$

in which the land use intensity parameter *L* measures the economic output per unit of land use, thus reflecting its average productivity. The observed land use intensity per sector can then be used to estimate the total industry-commerce demand for land use for any given time step *t+n* (eq. 5):

$$A_{r,t+n} = \sum_{s=1}^{j} \left(\frac{GVA_{r,s,t+n}}{L_{r,s,t} * w_{r,t+n}} \right), \quad (5)$$

based on regional GVA projections obtained from GEM-E3. The method to compute land demand here is fairly similar to the method used in earlier configurations of LUISA, except that the denominator now includes an additional term (*w*) that essentially makes the land-use intensity of an economic sector dependent on its per-capita regional economic output. It thus reflects that increases in GVA per capita are generally associated with increases in economic output per unit of land used. In practice, this is done by using an econometrically estimated relationship between total GVA per capita and general land-use intensities *L* in *t+n* for each region (see eq. 6):

$$W_{r,t+n} = \exp(1.1509\left[\ln\left(\frac{\sum_{s=1}^{j}(GVA_{r,s,t+n})}{P_{r,t}}\right)\right] - 3.1404) \Bigg/ \left(\frac{\sum_{s=1}^{j}(GVA_{r,s,t})}{\sum_{s=1}^{j}(A_{r,s,t})}\right). \tag{6}$$

The parameters for this function are obtained from an empirical investigation using cross-sectional data for European regions, which showed a strong and highly significant relationship between GVA per capita and land use intensity. Figure 4 clearly shows that regions with higher GVA per capita are more land-use productive.

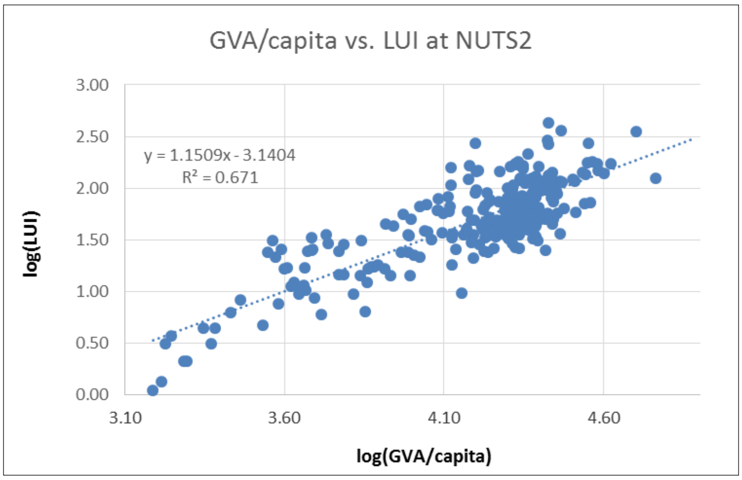


Figure 4. Relationship between GVA per capita and land use intensity.

Three economic sectors are currently considered for the purpose of estimating demand for industry-commerce land-use: industry, commerce and services, as defined in Table 1. The sector GVA for the base year *t* is taken from the Eurostat online database, whereas the sector GVA for *t+n* is derived from the above-mentioned economic projections from the GEM-E3 model. More details regarding the source economic projections used in LUISA can be found in Batista e Silva et al. (2013b).

Table 1. Economic sectors considered in the estimation of industry-commerce land-use demand.

NACE (rev. 1.1) section	Description	Sectors and labels used in LUISA
C + D + E	Mining and quarrying + Manufacturing + Electricity and Gas	Industry
G + H + I	Wholesale and retail trade; repair of motor vehicles, motorcycles and personal	

	and household goods + Hotels and restaurants + Transport and Communications	Commerce and private services (Commerce)
J + K	Financial and Business Services	
L + M + N + O + P	Non-Market Services	Public services and administration (Services)

An empirical exercise conducted for Spain and the Netherlands using detailed national land use datasets for circa 2006 showed that $L_{commerce} > L_{services} > L_{industry}$ consistently for all NUTS2 regions. In fact, on average, it was found that $L_{commerce} = L_{industry} * 27.6$ and that $L_{services} = L_{industry} * 6.7$. These empirical factors allowed us to disaggregate the CORINE Land Cover class 1.2.1 (“industrial and commercial units”) in “industrial areas”, “commercial areas” and “service areas”, thus obtaining, for each region, the term $A_{r,s,t}$ of equation 4.

The predicted demand for industry-commerce land use is driven directly by the predicted changes in the economic output of the respective sectors. This approach is regional and sector specific, and thus sensitive to differences in the economic structure between regions and to changes in the economic structure of each region over time. To illustrate, if the ‘commerce’ sector in a given region is predicted to grow while the ‘services’ and ‘industry’ sectors are predicted to stagnate, the estimated impact on land use will be relatively small due the high intensity of commercial land, or, in other words, due to the low additional land required per unit of economic output. On the other hand, a region, where considerable growth is estimated for the industrial sector, should require a more significant amount of land use, because each additional unit of output requires a large amount of land.

To summarize, the approach used to estimate future industry-commerce demand allows integrating a key driver of industry-commerce land-use change: gains in land use intensity or productivity, which is a function of GVA/capita growth and sector composition. In fact, nearly 72% of the between-regions variability of the land use intensity is explained when GVA/capita and the share of commerce and private services are taken into account (Table 2).

Figure 5 shows projected trends of industry-commerce land-use demand using different approaches. The approach that has been described above, labelled as ‘sector and regional specific with dynamic land use intensity’, provides a more realistic trend of land use demand when compared to other approaches which do not consider increases in land productivity. In fact, such approaches, by projecting infinite expansion of industry-commerce land use do not seem plausible for long-term timeframes. In contrast, the used approach tends to plateau in the future, better reflecting the fact that both growth in absolute production and growth in land productivity influence the future total requirements for industry-commerce land use.

Table 2. Econometric estimation of land use intensity in 2006 at regional level.

	log(land use intensity 2006)	log(land use intensity 2006)
Specification	1	2
N	269	269
Constant	-3.15***	-3.57***
log(GVA/capita 2006)	**1.15*****	**1.095*****
% comm-services (2006)		**1.19*****
R^2-adj	0.671	0.718

*** 99% significance level

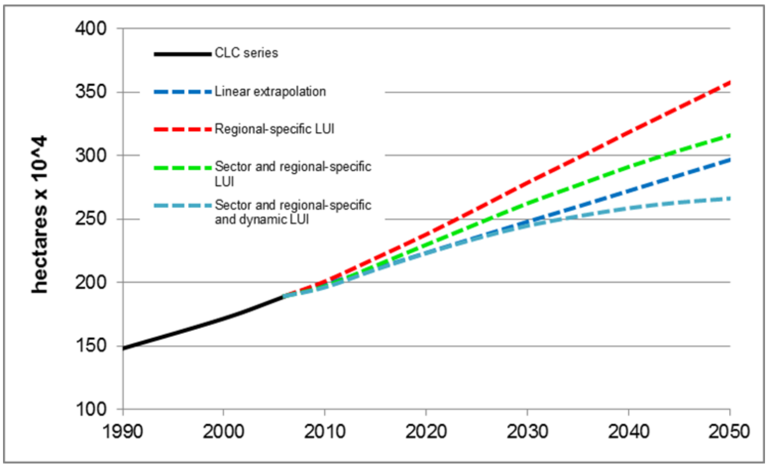


Figure 5. Projected trends of industry-commerce land-use demand using different approaches.

2.3 Updated demand for forest land

In the EU Reference scenario 2013, forest land demand was based on the projections provided by the G4M model (Böttcher et al., 2012), which were originally available at country level and downscaled to regional levels. The simulation results of that model are originally based on the data transmitted by Kyoto protocol countries to the UNFCCC framework. However, when comparing total forest land according to G4M and UNFCCC in the time frame for which both sources provide data, it becomes immediately clear that: 1) there are considerable discrepancies in total area of reported forest land according to those sources; and furthermore, 2) the G4M projections do not evidently follow the trends one may obtain from the UNFCCC reports. As examples, two comparisons of G4M and UNFCCC data are shown for Germany (Figure 6) and Portugal (Figure 7). Note that the background of the chart coloured in yellow indicates the years, from 2000 to 2012, for which both sources provide data.

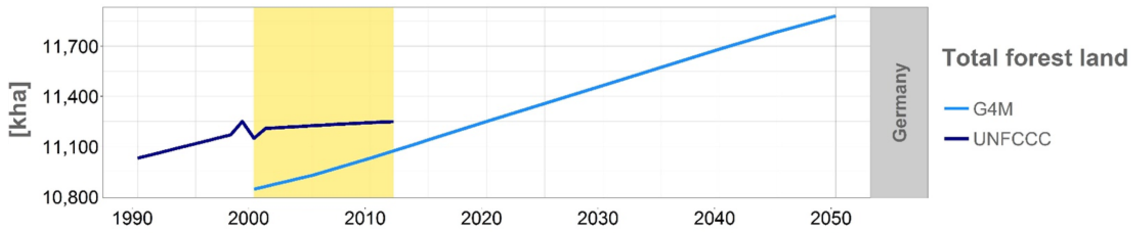


Figure 6. Total forest land in Germany (historical reported data and projected figures), as from the G4M model and according to the national statistics reported under the UNFCCC framework. The yellow layout highlights the years available from both sources.

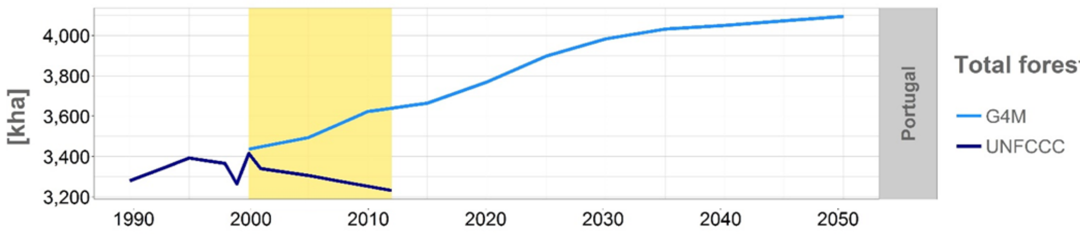


Figure 7. Total forest land in Portugal (historical reported data and projected figures), as from the G4M model and according to the national statistics reported under the UNFCCC framework. The yellow layout highlights the years available from both sources.

An exhaustive comparison between historical trends (EEA, 2014) and the G4M data highlights that, in the majority of the simulated countries, the differences between the two sources, over the common years 2000 – 2012, are substantial. In general, the values reported under the UNFCCC framework are higher than the ones assumed by the G4M model; the opposite case happens only in Portugal and, partially, Slovenia and Romania. The average yearly difference between the two curves is around 10% for countries like Croatia, Latvia, Spain, the Netherlands, the United Kingdom, Estonia, Austria, Italy, Hungary and Sweden. For Denmark, Ireland and France the same difference is greater than 30%. The remaining countries (Romania, Czech Republic, Slovakia, Belgium, Poland, Germany, Luxembourg, Finland, Bulgaria and Lithuania) show moderate differences.

Similarly, the overall change in total forest land over the period 2000 – 2012, can be significantly different between the two sources. For the majority of the countries, the data assumed by G4M leads to a higher change over the period 2000 – 2012. The opposite happens only in Croatia, Czech Republic, Denmark, Finland, Latvia, Luxembourg, Poland, Slovakia, Sweden and the United Kingdom. In few countries (Belgium, Estonia, Portugal and Romania) the two sources report opposite trends. In consequence, the trend in total forest land projected by G4M is, in many countries, significantly different from the trend resulting from the country declarations. Such trends might exacerbate the competition with other land uses and cause, in countries such as Portugal or Slovenia, radical changes in the national and regional landscapes.

To solve the identified problems with the forest land demands that were derived from G4M projections, a new method to compute forest land demands is introduced in the LUISA Reference scenario 2014. This method is fully based on the official figures reported for UNFCCC and the Kyoto protocol. Thus, initially national demands for forest areas in LUISA converge from the area reported in CLC 2006 to the UNFCCC national areas reported for 2012. Subsequently, the national demands for forest areas are obtained from projected trends (2013 - 2050) that are extrapolated from historical annual afforestation and deforestation rates, as reported under the UNFCCC scheme. This method of obtaining forest demands yields results that are consistent with the UNFCCC reports and demonstrate a smaller gap with the land cover data reported in the CLC 2006 maps. Next to the change of source, this change also implies a change in the geographic scale of forest land demands: in the Reference scenario 2013, forest land demands were allocated for each NUTS2; in the Reference scenario 2014, LUISA allocates national land demands.

3 IMPROVEMENTS TO THE ALLOCATION MODULE

The EUClueScanner100 model that is the core of LUISA distributes discrete land uses over 100m pixels given suitability layers that define the attractiveness of a pixel for a certain land-use class and the assumption that land uses compete with each other for most optimal places. An iterative process simulates bidding between land uses, and finally yields a most optimal land-use distribution for any time step. Two constraints are taken into account in this process: first, the procedure obeys to minimum and maximum surfaces, as specified in land-use specific regional demands; second, the procedure cannot allocate more land than is available in a region. With the EU Reference scenario 2013, the land-use allocation procedure has been adapted, so that the model first redistributes people over pixels in the so-called population allocation module, and then allocates urban land uses based on the population distribution and threshold rules. LUISA's land-use allocation procedure is subsequently used to distribute all other land uses over the remaining land. For details of the population allocation module, see Batista e Silva et al. (2013b).

The results of the land-use allocation procedure depend on the previously described regional land-use demand and on specific aspects of the land-use allocation procedure. Most relevant here are the classification of modelled land-use types; the definition of suitabilities, which in the Reference scenario 2014 are defined as the weighted effects of various economic, physical and neighbourhood factors, combined with assumed policy effects; the definition of an 'allow matrix' that governs whether the transition from one land use to another is possible; and the definition of conversion costs, which describe the costs associated with a particular land-use transition and thus adds an element of inertia to modelled land-use transitions. A number of these aspects of the land-use allocation procedure have been reconfigured for the Reference scenario 2014 to improve model accuracy or to model specific scenario assumptions and policy effects.

3.1 An updated classification of modelled land-use types

In the LUISA framework, each LU class belongs to one of the following types: active, passive or fixed. Active classes are those which are fully simulated by the LU model, and for which land demands are determined. Passive classes are LU classes that are allocated by the model, but for which demands are not predefined. These classes expand or shrink depending on pressures exerted by the active classes. The spatial arrangement of both active and passive classes is governed by the previously discussed land allocation mechanism. Lastly, fixed classes are those for which processes, demands and suitability criteria are not known or cannot be modelled with current knowledge and/or data, and thus remain unchanged in terms of both quantity and location. This categorization of LU classes is similar to that adopted in other modelling frameworks (Verburg and Overmars, 2009; Barredo et al., 2003). CLC land-use categories have been grouped in a smaller number of relevant classes for use in LUISA. The classification used in the Reference scenario 2014 can be found in Table 3.

The land-use categorization used for the EU Reference scenario 2013 suffered from small differences in the classification of the semi-natural vegetation class, which caused sharp differences in seemingly continuous land-use patterns on two sides of a national border. With the Reference scenario 2014 this problem has been solved structurally by redefining the land-use classification rules that govern reclassification from CLC 2006: pastures remain a separate class; because transitional woodland shrubs have very different characteristics compared to the other land uses that were previously aggregated into the semi-natural vegetation class, the transitional woodland shrub category is now also modelled as a separate class, while the other previous semi-natural vegetation classes are modelled in the class of scrubs and herbaceous vegetation.

Table 3. Land-use classification used in Reference scenario 2014.

LUISA modelled land-use class	Corresponding class(es) in CLC	Type of simulation
Urban	Urban fabric (11X), built-up component of the sport and leisure facilities (142)	Active
Industry, commerce, services	Industrial or commercial units (121)	Active
Infrastructure	Road and rail networks (122), ports (123), airports (124), mine, dump, and construction sites (13X)	Fixed
Green urban areas	Green urban areas (141), green component of the sport and leisure facilities (142)	Fixed
Arable land	Arable land (21X), heterogeneous agricultural areas (24X, except agro-forestry areas)	Active
Cereals	LUISA specific class	Active
Maize	LUISA specific class	Active
Root crops	LUISA specific class	Active
New energy crops	LUISA specific class	Active
Other arable	LUISA specific class	Active
Permanent crops	Permanent crops (22X), agro-forestry areas (244)	Active
Pasture	Pastures (231)	Active
Forest	Forest (31X)	Active
Transitional woodland shrub	Transitional woodland shrub (324)	Passive
Scrub and/or herbaceous vegetation associations	Natural grasslands (321), moors and heathland (322), Sclerophyllous vegetation (323)	Passive
Other nature	Open spaces with little or no vegetation (33X)	Fixed
Wetlands	Wetlands (4XX)	Fixed
Water bodies	Water bodies (5XX)	Fixed
Abandoned urban	LUISA specific class	Passive
Abandoned industry, commerce, services	LUISA specific class	Passive
Abandoned arable	LUISA specific class	Passive

3.2 Further refinement of CLC 2006

Further study of the CLC 2006 map using in the Reference scenario 2013 has shown two deficits of that map that have been tackled in the preparation of the Reference scenario 2014. These deficits were an underrepresentation of land cover related to transport infrastructure, and an inappropriate classification of built-up tourist infrastructures as green urban areas. Therefore, a further refinement of the CLC 2006 map has been carried out to solve these issues. These changes increase the spatial accuracy of the base data and the LUISA results; improve estimations of total urban area (which now includes both residential, and recreational and tourist built-up); and increase the accuracy of indicators related to urban land, and indicators related to landscape fragmentation as caused by road networks.

To tackle the underrepresentation of land cover related to transport infrastructure, the Minimum Mapping Unit of the CLC 2006 data for roads has been decreased from 25 to 1 hectare. Thus, in any cell where a fixed proportion of a 1 hectare cell is covered by motorways or roads of national importance, the cell is considered to be dedicated to transport infrastructure. Outside urban areas the cell is considered to be urban if at least 10% of the cell is covered by roads; inside urban areas, roads need to cover at least 20%. Road data are obtained from the freely available OpenStreetMap[2] database, downloaded in 2014. Road widths were assumed using an as of yet unpublished book chapter. Finally, roads in tunnels or on bridges were excluded, using a subset of TeleAtlas[3] road network data.

In the original CLC data, buildings that are meant to serve tourists were considered with other facilities such as camping grounds, golf courses and other sports grounds in one land-use class ('sport and leisure facilities'). This causes an underestimation of built-up land and environmental impacts related to built-up land. To tackle these problems, an additional land-use class ('leisure and touristic built-up') has been added to the refined CLC 2006 data used in LUISA. Grid cells have been classified as leisure and touristic built-up if 1) they were classified as sport and leisure facilities; and 2) are highly impervious according to 2006 soil sealing data[4].

3.3 A refined potential accessibility measure driving land-use changes

In the LUISA framework, a potential accessibility measure is computed which in turn acts as an important driving force for population distributions and the suitability of land for industrial land uses. This measure is computed by means of travel times via a road network, between equally distributed origins and a hybrid layer of LAU-1 and LAU-2 zones as destinations (Jacobs-Crisioni et al., 2014). The central point of those destination zones was taken as the precise destination point. During tests for the Reference scenario 2014, it became clear that the geographically central point of a municipality is in several cases not a good approximation of the population centre of such a zone. In exceptional cases, in particular in very large coastal LAU zones, this led to the artefact that the highest accessibility

[2] See http://www.openstreetmap.org

[3] See http://www.tomtom.com/en_gb/licensing/products/maps/multinet/

[4] See http://www.eea.europa.eu/data-and-maps/data/eea-fast-track-service-precursor-on-land-monitoring-degree-of-soil-sealing

levels in a region did not accurately represent the geographic location of population centres, thus stimulating urbanisation in relatively peripheral locations.

To tackle this problem, the method of obtaining destination points for accessibility computations has changed. Instead of selecting the geographic centre of each destination zone, the point in each zone with the highest sum of people in a 15 km radius is selected as the destination point. To do so, first a map of population mass *M* is computed for each grid cell *g* (7):

$$M_g = \sum_{h=1} P_h W_{gh}, \tag{7}$$

based on the population *P* in pixels *h* and spatial weight matrix *W* (8):

$$W_{gh} = \begin{cases} d_{gh} \leq 15\ km\colon\ 1/d_{gh} \\ d_{gh} > 15\ km\colon 0 \end{cases}, \tag{8}$$

which again is based on Euclidean distances *d* between *g* and *h*. The latter matrix essentially observes distances between a grid cell *g* and its neighbours in *h* in such a way that people that are twice as far away have half the effect on *M*. The people in *g* are included in the set *h*. The resulting map represents the amount of people in the neighbourhood and the level of local population-weighted centrality of a grid cell. All grid cells in a zone *i* that meet $M_g = M_i^{max}$ are subsequently preselected, from which one grid cell is randomly selected to be the destination point for zone *i.* This change in the definition of destination points has improved the geographic accuracy of the computed accessibility levels in Europe, and subsequently has increased the accuracy of LUISA's results (see Figure 8).

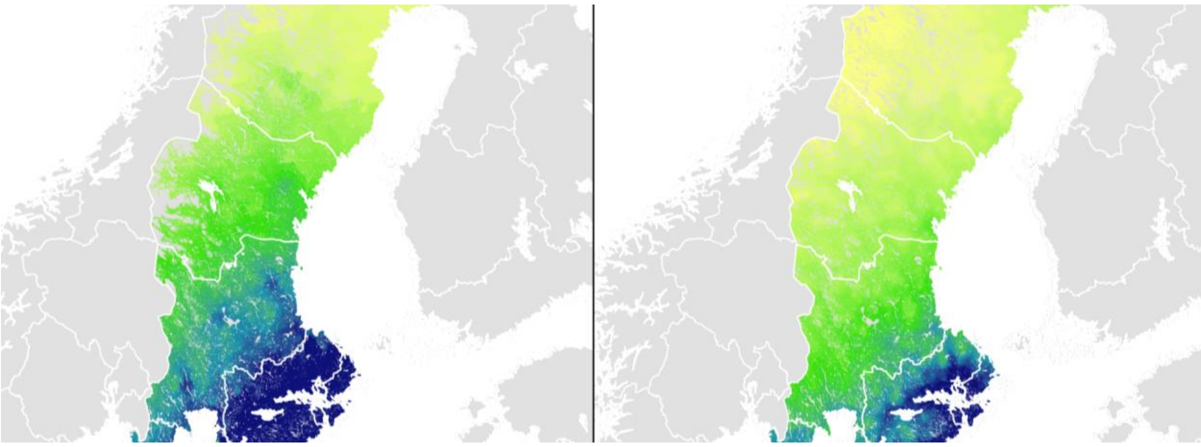


Figure 8. Example of potential accessibility in Sweden, computed with destinations modelled as the geographic centre of municiaplities (left), or as the population weighted centres of municipalities (right). Yellow shades indicate low levels of accessibility, blue shades indicate high levels of accessibility.

3.4 A refined population 2006 map

The population allocation procedure within LUISA uses a gridded map of population in 2006 as its reference point. This map itself is generated with fine spatial resolution census data, a soil sealing map and the refined CLC 2006 map using methods outlined in Batista e Silva et al. (2013a). As a consequence of the updated classification and further refinement of the CLC 2006, as described in section 3.2, the population map had to be regenerated as well. In particular the more accurate inclusion of transport infrastructure has yielded a more plausible spatial distribution of people, particularly within urban areas.

3.5 Estimation of the effect of exogenous variables and neighbourhood effects

One consequence of the reclassification and/or refinement of the CLC 2006, accessibility and population 2006 maps, has been that the effects of exogenous variable and neighbourhood effects on land-use suitabilities and the population potential function had to be re-estimated for the Reference 2014.

For the land-use suitability functions, the selection of variables has not been changed. In general, the estimated effects of the variables on those land-use classes that have not been updated (see section 3.1) are similar to those estimated for the EU Reference scenario 2013. For the population potential function one variable has been added to the explanatory framework, namely a variable that indicates the travel time to the closest town centre. This variable is meant to be used as a proxy for the concentration of local services in towns, which functions as a source of attraction for people. It is meant to complement the potential accessibility measure that was already in use and that approximates large-scale economic opportunities. As previously has been done with the potential accessibility measure (Batista e Silva et al., 2013b), travel times to town centres are obtained for both 2006 and for 2030 within LUISA. Any change in travel times between those years is assumed to have a linear effect on intermediate years.

3.6 An empirically obtained matrix to proxy land-use transition costs

In LUISA, land-use suitabilities are assumed as proxy for the revenues of a given grid cell for each of the modelled land-use classes, if the cell would change into any of those land uses. However, there are also costs involved in any land-use transition. In the LUISA framework those costs are approximated by means of a transition cost matrix. This matrix provides values from 0 (transitions not inhibited) to over 1 (high barriers to transitions), with for example very low costs for transitions from arable land to industrial land, but very high costs for transitions from industrial land to arable land. Previously, the values of the transition costs were filled by means of expert judgement. Ideally, the transition costs are obtained from empirically valuated economic costs that are involved in land use transitions, and by the time of writing this report a project is underway to identify value and underpin those costs. To satisfy the LUISA team's immediate need for a transition cost matrix that is closely tied with land-use change practices, the transition costs have been obtained from recorded land-use transitions. In fact, land-use probabilities have been approximated by the relative occurrences of transitions from one land use to another during the two periods 1990-2000 and 2000-2006, as recorded by CLC data at European level. Those relative occurrences have been rescaled and have been used to inform the land-use allocation procedure for the Reference scenario 2014. An inspection of the land-use allocation results shows more consistent land-use transitions that are more closely linked to observed land-use occurrences.

3.7 Added climate-related layers as inputs to crops allocation

Climate plays an important role in the likeliness of land-use changes, especially the ones involving agricultural land. In particular, climate change in the future may have a considerable impact on the spatial distribution of the revenues of various crops. In order to better assess the potential impacts of climate change, climate-related information has been introduced among the input layers that are used to drive the allocation of the crops groups simulated in LUISA. The results of the ULYSSES[5] project (based upon the methodology developed in AVEMAC[6]) have been used: in particular, the yield change under the A1B Scenario (HadCM3 and ECHAM5 realisations), for the year 2030. Subsequently, the allocation of agricultural commodities in LUISA is influenced only if the yield changes forecasted for the considered agricultural commodities show a reasonable agreement between the considered climatic models. The impacts of climate change on the suitability levels of various crops are shown in Figure 9 to Figure 12.

[5] http://www.fp7-ulysses.eu/

[6] http://mars.jrc.ec.europa.eu/mars/Projects/AVEMAC

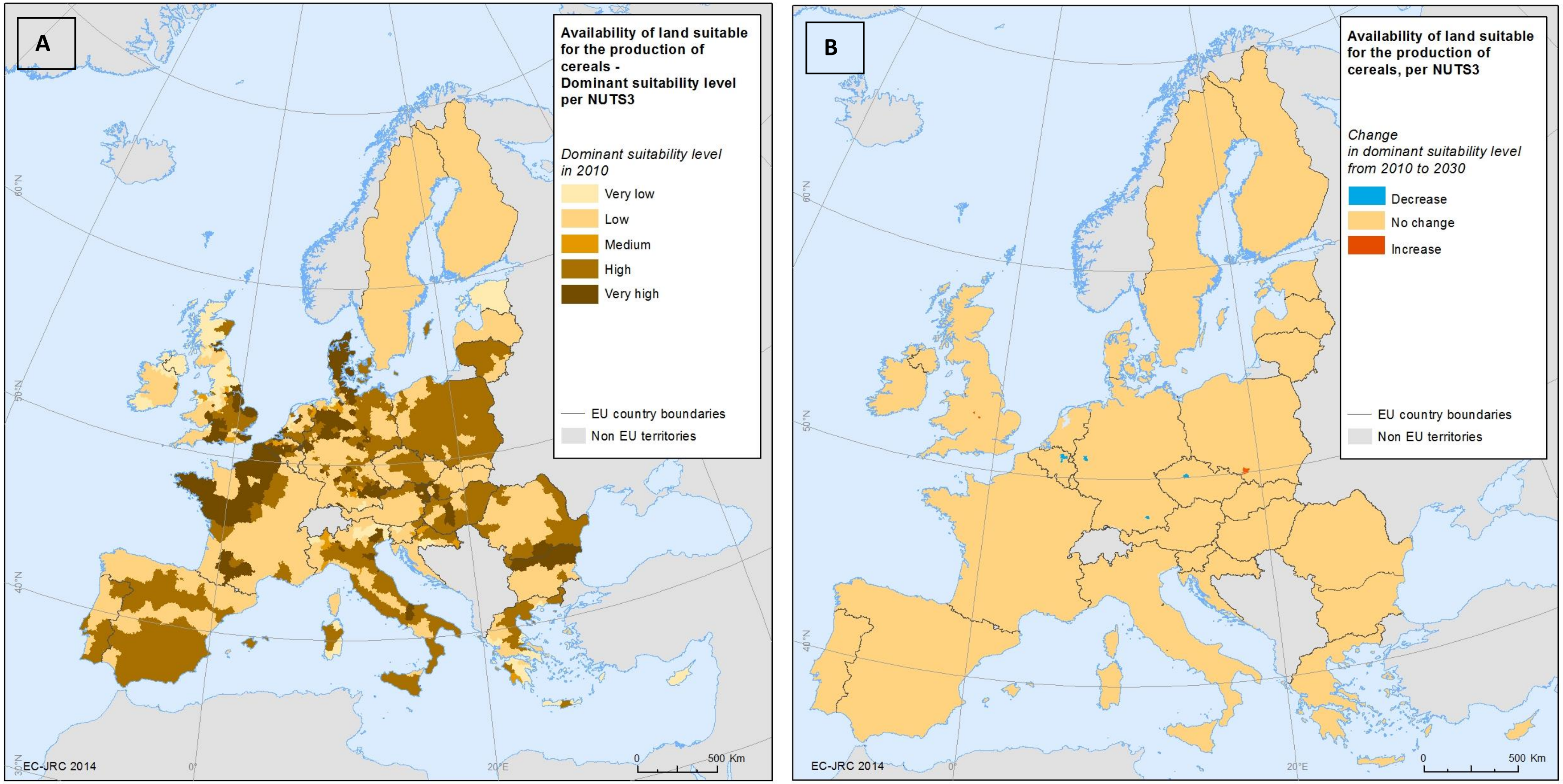


Figure 9. Suitability of land for the production of cereals, as in the year 2010 (frame A) and as it changes in the year 2030 (frame B): per each NUTS3, the most present level (frame A), or its change from 2010 to 2030 (frame B), is represented.

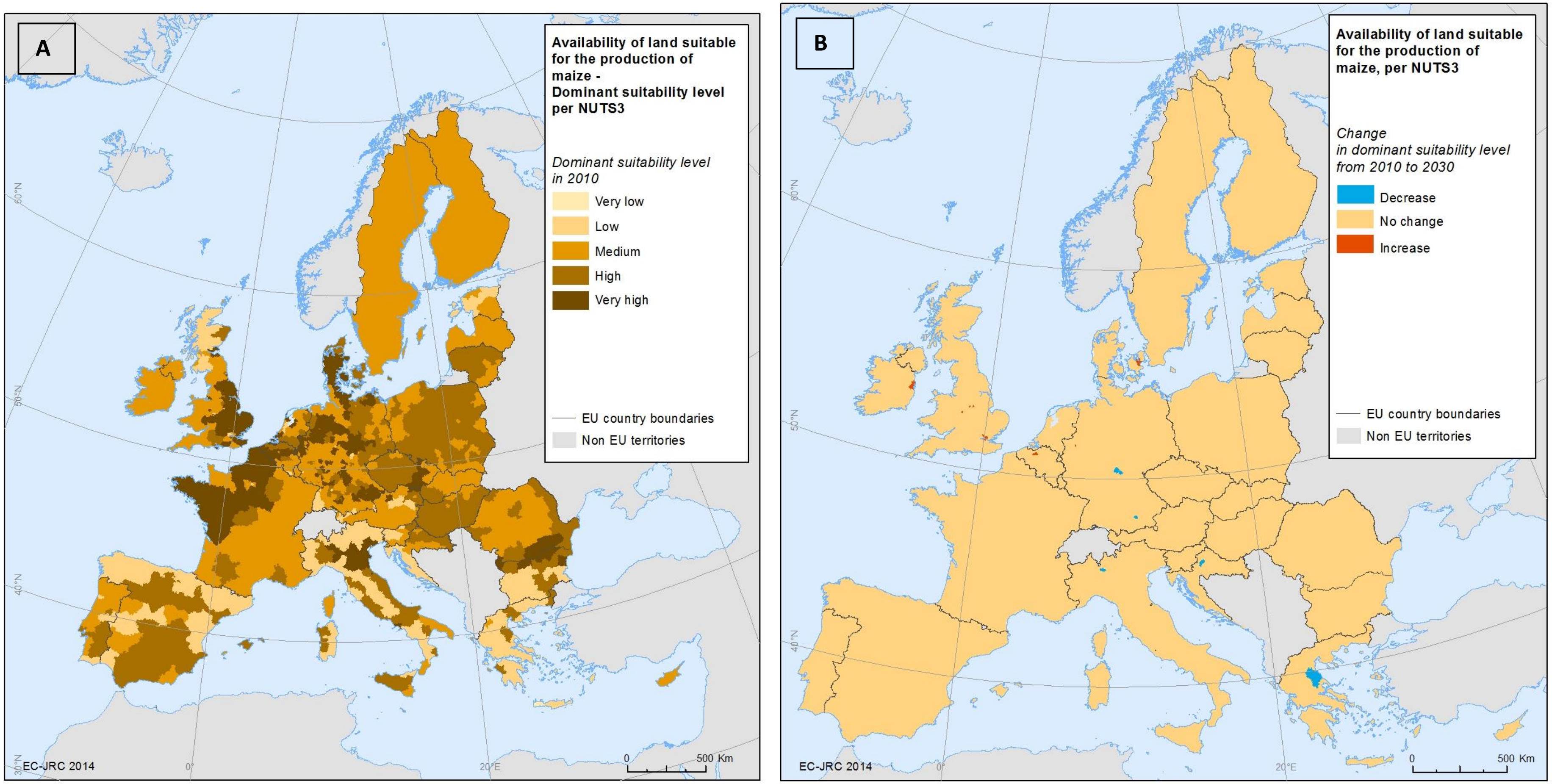


Figure 10. Suitability of land for the production of maize, as in the year 2010 (frame A) and as it changes in the year 2030 (frame B): per each NUTS3, the most present level (frame A), or its change from 2010 to 2030 (frame B), is represented.

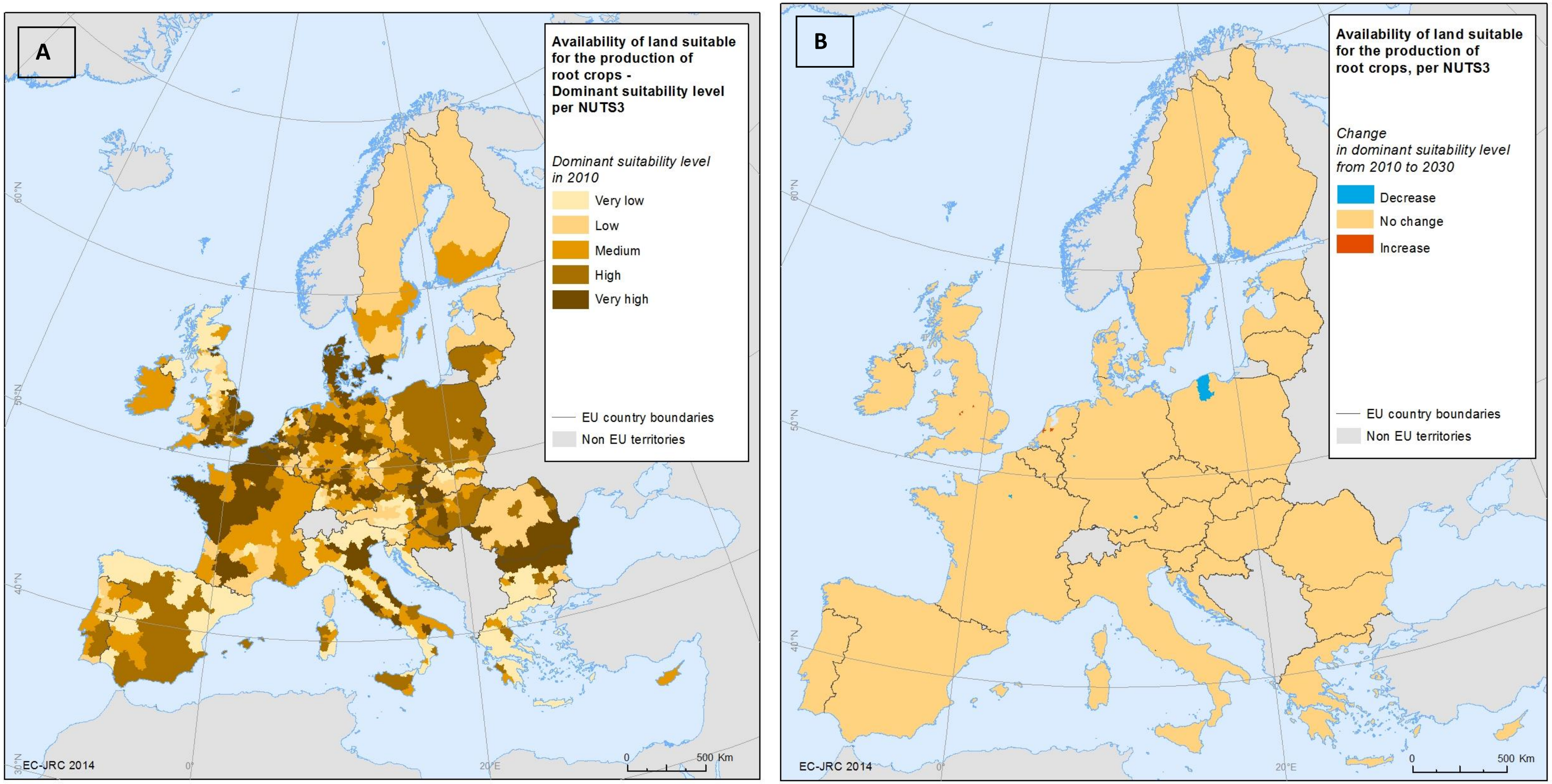


Figure 11. Suitability of land for the production of root crops, as in the year 2010 (frame A) and as it changes in the year 2030 (frame B): per each NUTS3, the most present level (frame A), or its change from 2010 to 2030 (frame B), is represented.

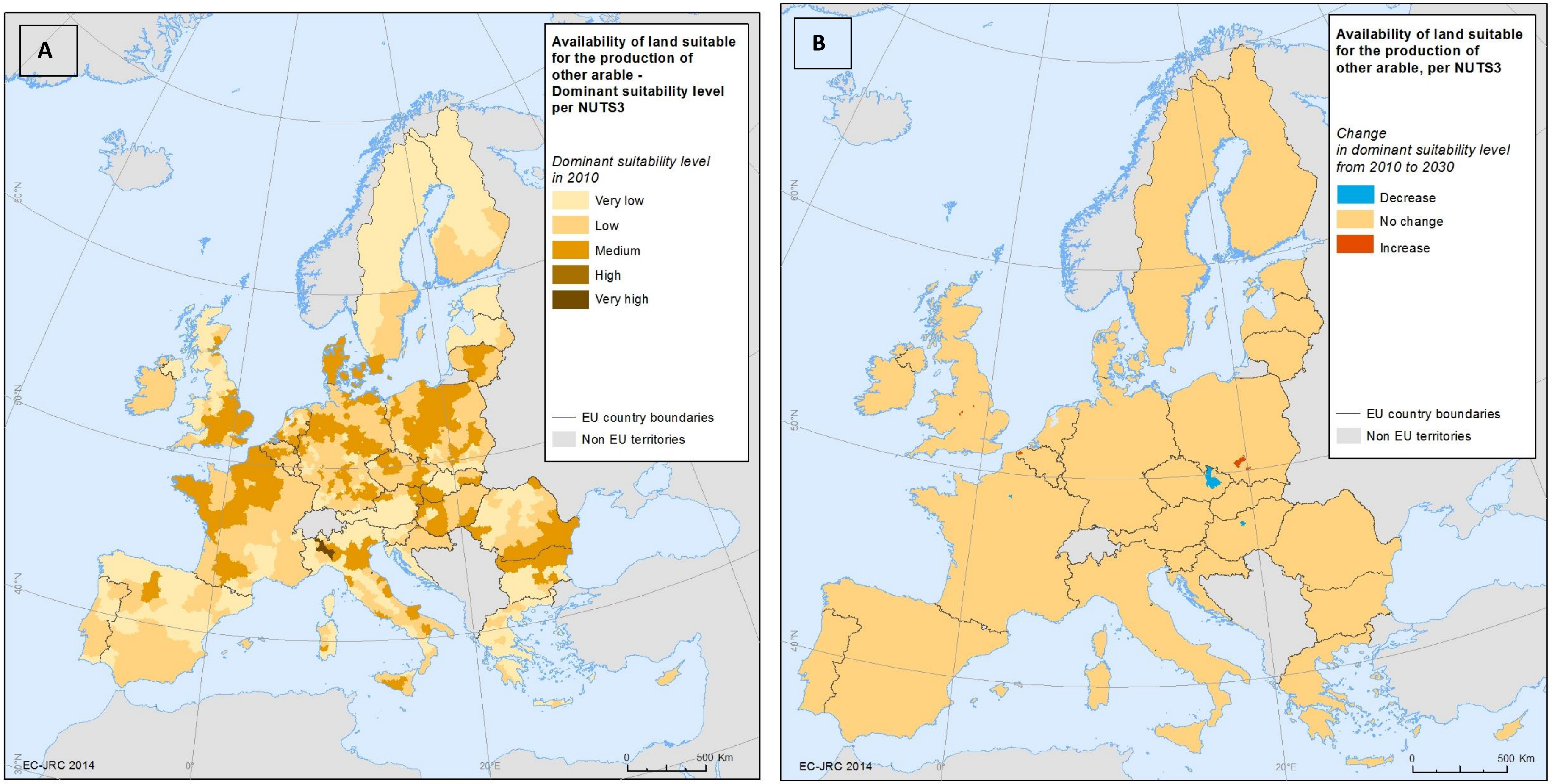


Figure 12. Suitability of land for the production of other arable land, as in the year 2010 (frame A) and as it changes in the year 2030 (frame B): per each NUTS3, the most present level (frame A), or its change from 2010 to 2030 (frame B), is represented.

3.8 Allocation of forest land

Previously, the allocation of forest land was essentially based on calibrated parameters. It is now enriched with high resolution (30m) ancillary data, namely the suite of forest layers recently made available by the University of Maryland (Hansen et al., 2013). The referred set of layers is based on satellite imagery and covers the period spanning from the year 2000 to 2012. In order to include this dataset in the LUISA platform, the layers of forest cover and forest gain have been merged together, in order to obtain the forest cover in the year 2012. The resulting layer has been subsequently resampled from the original 30m to 100m, with each pixel representing the share of crown cover over the 1ha area[7]. This addition of data has enabled much more detailed forest cover patterns than previously available in the CLC data which was based on a MMU of 25 hectares (see Figure 13).

[7] It is worth noting that the validation of the original product, conducted by Hansen (2013), has proved it robust at the 120m pixel scale. The LUISA team is confident that our aggregation to the 100m level provides similarly robust results.

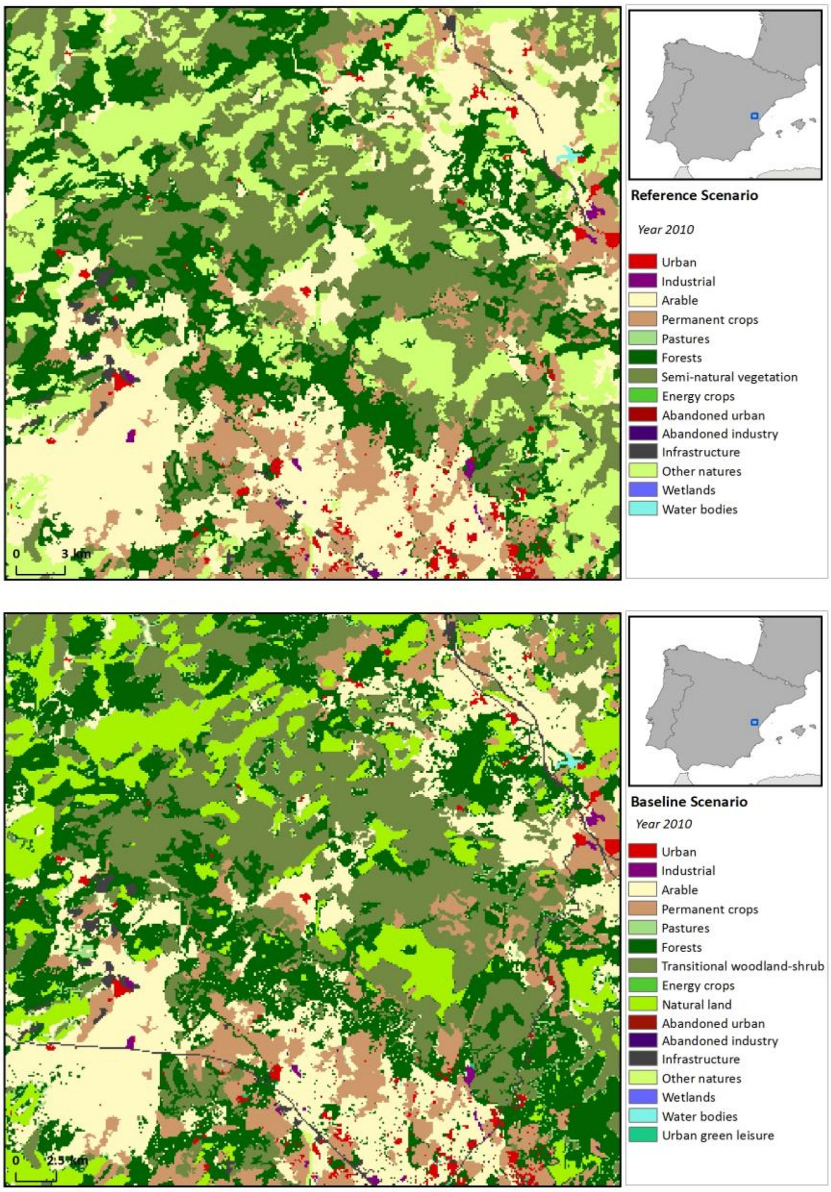


Figure 13. Modelled forest patterns in the EU Reference scenario 2013 (above) and in the EU Reference scenario 2014 (below). Note the differences in spatial detail of the forest patterns in the large patches in the middle.

In addition to more detailed forest patterns, the historical occurrence of forest fires in the recent years and up to 2012 has been taken into account, as reported by the JRC's European Forest Fire Information System (EFFIS)[8]. This has been done to model land-use patterns more accurately, and to make LUISA's base land-use data more consistent with the UNFCCC reported forest areas which take burnt areas into account. In addition, burnt areas as reported in CLC 2006 have been integrated with the data available from EFFIS. Burnt areas as reported from both CLC 2006 and EFFIS were integrated in either

[8] http://forest.jrc.ec.europa.eu/effis/

the base land-use map (2006) or during the simulation (2006-2012), depending on the year of forest fire occurrence. If the forest fire is reported in the forest fires database, the age of the burnt areas depends on the last recorded forest fire in that given grid cell. Once a forest fire occurs, the resulting burnt area is inserted in the map as pertaining to the woodland-shrub land-cover class. This is due to the typically quick recovery from burnt forest to shrubs. Transitions from previously burnt forest to fully grown forest is assumed to take at least 25 years[9], before which they remain classified as woodland-shrub, unless a conversion to agriculture or artificial land uses occurs beforehand.

[9] This lapse of time is set, as first approximation, for all kinds of forest sites across Europe, regardless fire severity, species composition of the forest, fire history (i.e. number of fires that have occurred in the same area), bioclimatic zone, and other site characteristics, such as soil type, that might affect the recovery time after the fire occurred. This average number of years is assumed to be required for the forest to recover to the pre-fire state. The possibility of a human intervention in accelerating the recovery process is not taken into account. Further research is needed in order to refine these assumptions.

4 ADDITIONAL POLICY IMPACTS TAKEN INTO ACCOUNT

As noted before, the LUISA reference scenario tries to take into account all EU policies that have a foreseeable direct or indirect impact on land-use patterns. For the Reference scenario 2014, updates have been made to integrate the effect of regional cohesion policies and to include the impacts of the renewable energy directive.

4.1 The cohesion policies

In 2013, LUISA has been used to assess the impacts of the 2014-2020 cohesion policy program. In order to do so, all funding themes for which funding is reserved within the cohesion policy budget have been scrutinised, in order to identify all themes that have a foreseeable direct or indirect impact on land-use patterns. The selected themes include regional economic growth, transport network improvements, airport improvements, port improvements and urban renewal. A more elaborate account of how cohesion policies were taken into account can be found in Batista e Silva et al. (2013b). The effects of cohesion policies are also modelled in the Reference scenario 2014. Thus, it is expected that cohesion policies affect regional demand for industrial land use. Foreseen road network investments are taken into account through expected improvements in travel time, that subsequently affect accessibility levels, which in turn influence location of residents and activities. Finally, it is expected that the ports and airports in particular regions receive funding, which makes the immediate surroundings of those ports and airports are more attractive for industrial land uses.

4.2 The Renewable Energy Directive

One separate agricultural class modelled in LUISA consists of dedicated energy crops, which essentially are herbaceous lignocellulosic and woody lignocellulosic tree crops that are grown as sources of energy. The Renewable Energy Directive (RED - EC, 2009) provides a list of sustainability criteria that must be taken into account for the production of biomass for energy uses. In particular, these criteria aim at minimising the potential negative impacts that such production might have on environmental (biodiversity, soil, climate change, water, air quality and resource use), social (land competition and labour conditions) and economic aspects (bioenergy costs). According to Article 17 of the RED, biofuels and bioliquids shall not be made from raw material obtained from land with specific characteristics (EC, 2009). Although this directive does not cover solid and gaseous biomass sources directly, it is recommended to follow those sustainability criteria described in the RED also for such sources. The criteria listed in the RED are currently the only legally binding sustainability criteria related to bioenergy which have to be included in the modelling configuration of LUISA, as shown in Table 4.

Table 4. Sustainability criteria and parameters in the field of bioenergy production based on the RED.

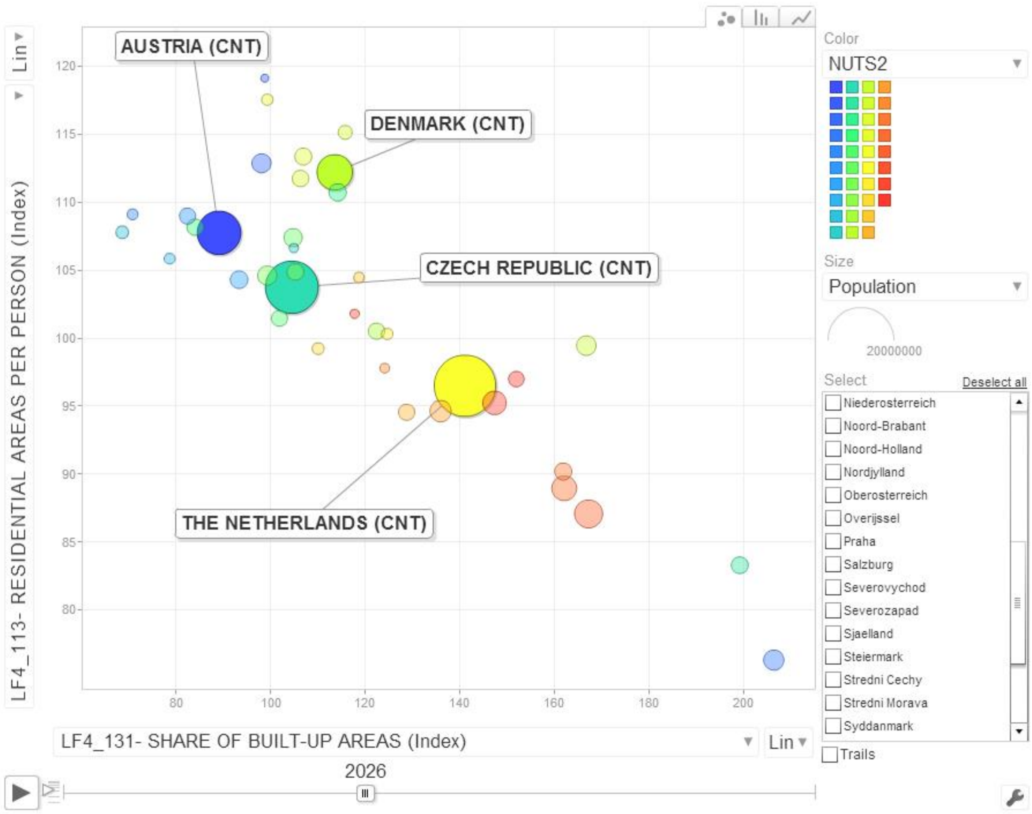
Sustainability Criteria	Parameters
The loss of habitats of high biodiversity value	Natura2000 areas
	Protected areas
	Wetlands and peat lands
Direct land cover changes	Conversion of permanent grassland to arable
	Conversion of continuous forest areas into arable land
Indirect land use changes	Preference of using surplus land
Support agro-biodiversity	Maximum extraction rates for primary agricultural residues
High Nature Value farmland	HNV farmland
Areas with high carbon stocks	Wetlands
	Continuous forest and permanent grassland
Negative impacts on soil	Maximum slope limits for cultivation
	Only perennial crops on sites susceptible to soil erosion
Protect soil quality	Maximum extraction rates for primary agricultural residues
	Adapt crop/trees to local biophysical conditions
Prevent overexploitation of water resources	Adapt crop/trees to local biophysical conditions. If irrigation is considered adapt water consumption to regional resources
Air pollutants emissions	Adapt crop/trees to local biophysical conditions
Avoid competition with food production and biomaterials	Preference of using surplus land

The above listed suitability criteria drive the allocation of energy crops. For the 2014 Reference scenario, High Nature Value (HNV) farmlands have been included as a factor in the determination of energy crop suitability. For this goal, the newly available dataset of HNV farmland has been integrated in the LUISA platform. Subsequently, the suitability for energy crops is restricted in grid cells with high nature value and grid cells that are within Natura 2000 areas or so-called nationally designated areas. All in all, this makes the Reference scenario 2014 fully consistent with the suitability criteria offered by the RED.

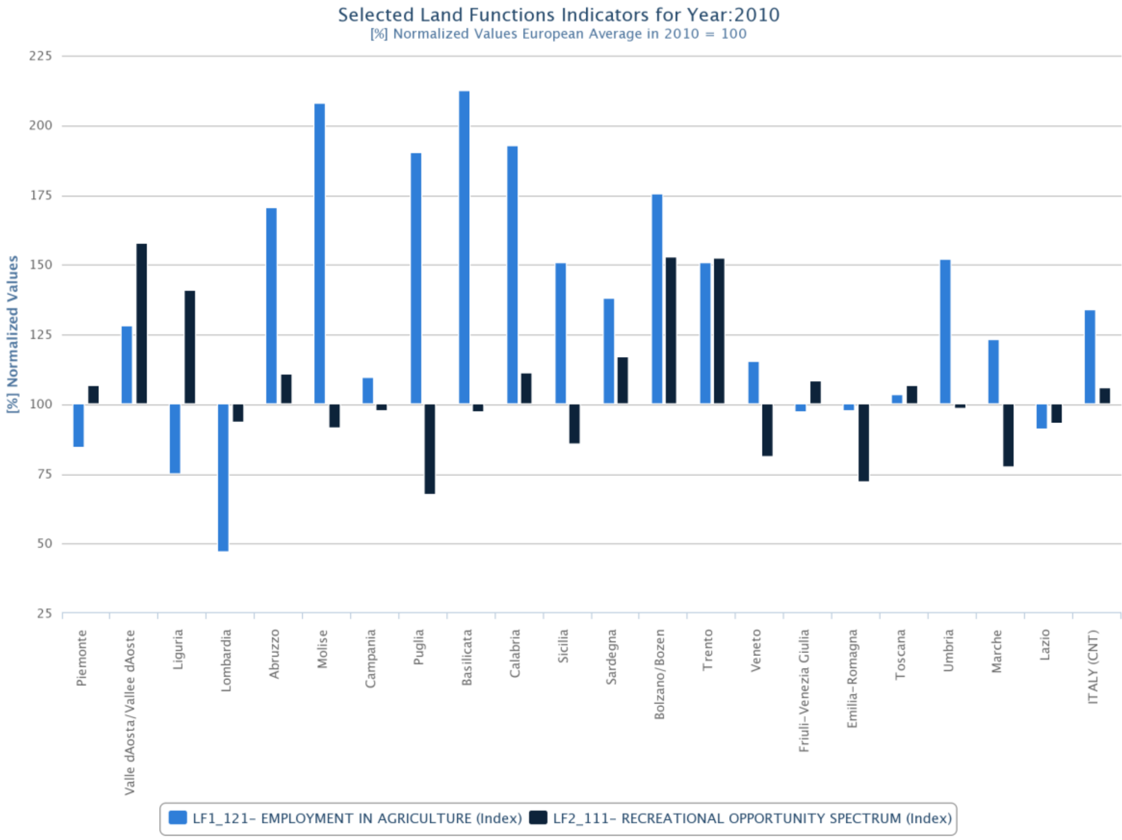
5 INTERACTIVE WEB TOOL FOR DATA VISUALIZATION AND ANALYSIS OF LUISA INDICATORS

The Land Functions Indicators Tool is a Web platform dedicated to explore and analyse data and indicators coming from the LUISA project. The objective of this platform is to present the indicators in an interactive and comprehensive way for informing decision makers, policy makers and other stakeholders. The platform includes 5 different tabs for visualizing and analysing indicators in the form of graphs, tables and maps:

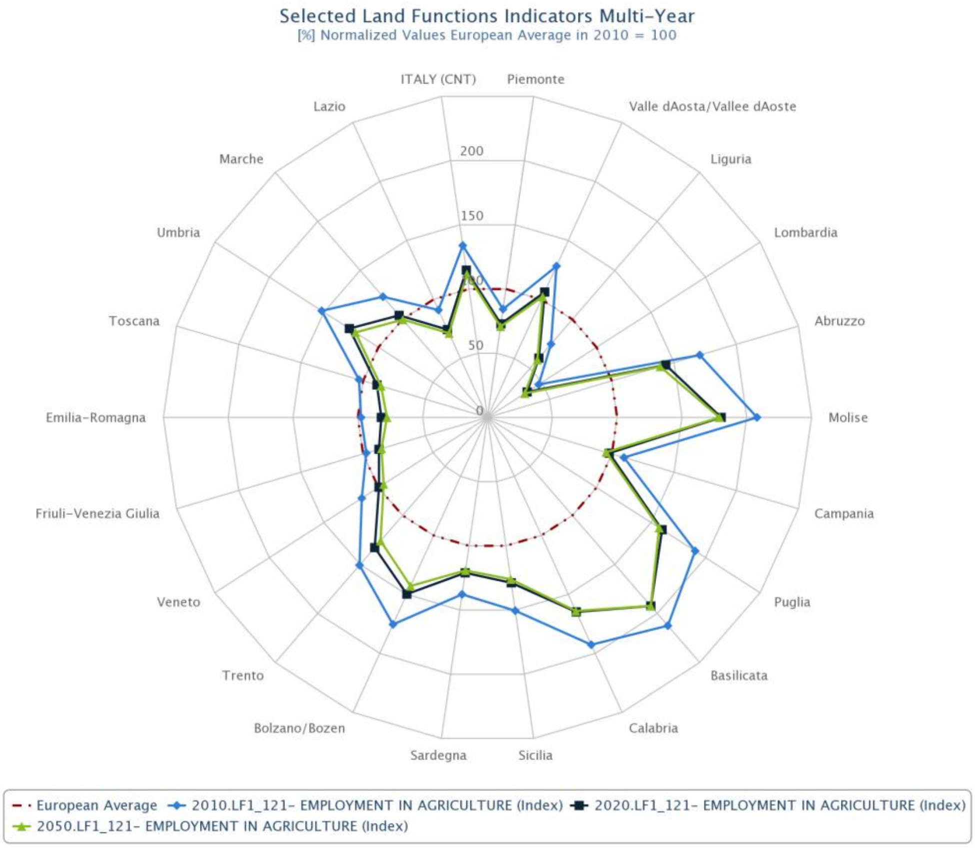
1. *Motion chart:* It consists of a dynamic chart that shows information about LUISA indicators over time. Data can be filtered by country and indicators, and it can be compared across NUTS0 and NUTS2 regions. Annual trends for the different indicators can be visualized by clicking on the play button. The original data can also be downloaded from this tab: after modifications are made to the table, the new information can be uploaded and analysed using the different application tabs.



2. *Annual charts:* This tab provides the user with the possibility to generate interactive radar and horizontal bar charts for visualizing a set of indicators in a specific year. Data can be filtered by country and year of interest (2010, 2020, 2050). Graphs include information for the selected countries and their corresponding NUTS 2. High resolution graphs can be exported in different formats (PNG, JPEG, PDF, SVG).



3. *Multi-year charts:* Similarly to the *annual charts* tab, this feature allows the user to visualize the evolution of a specific indicator for the years 2010, 2020, 2050 in the form of a radar or horizontal bar chart.



4. *Table ranking:* This tab gives the actual numbers for each indicator in table format. Data can be filtered by country, year and indicator of interest. NUTS2 regions are ranked according to the indicator values. There is also the possibility to query the table using different filters, as well as the option to download the table in a CSV format.

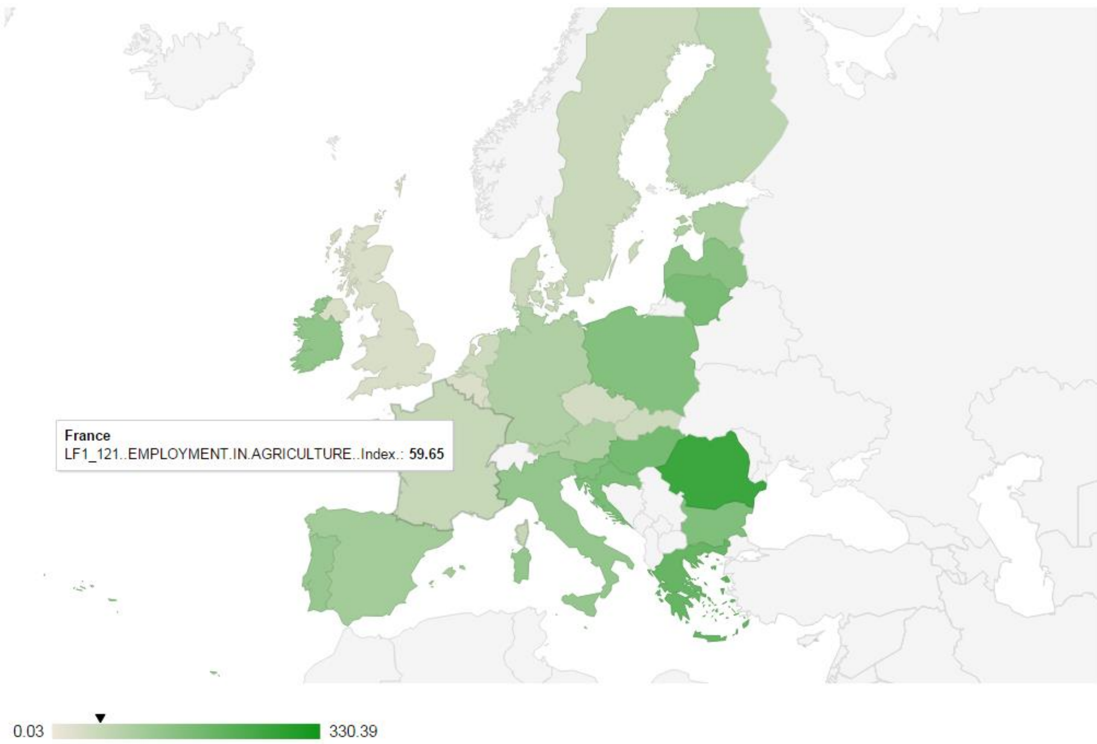
25 records per page   Search:

NUTS2	NUTS2_Name	COUNTRY	Year	LF1_121- EMPLOYMENT IN AGRICULTURE (Index)	Ranking
PT18	Alentejo	Portugal	2010	180.27	1
PT16	Centro (PT)	Portugal	2010	165.59	2
PT11	Norte	Portugal	2010	137.52	3
PT	PORTUGAL (CNT)	Portugal	2010	127.23	4
PT15	Algarve	Portugal	2010	126.79	5
PT17	Lisboa	Portugal	2010	25.98	6
NUTS2	NUTS2_Name	COUNTRY	Year	LF1_121- EMPLOYMENT IN AGRICULT	Ranking

Showing 1 to 6 of 6 entries   ← Previous 1 Next →

Download

5. *Interactive Map:* This tab provides the user with a choropleth map at country level, for a selected indicator. Data can be filtered by country, year and indicator of interest.



Technical details

The prototype of this platform was developed based on R statistical software, using several additional packages: R Shiny, rCharts (Highcharts, JavaScript version library for R) and googleVis.

6 CONCLUSIONS

The LUISA model developed by the JRC is used for the ex-ante evaluation of EC policies that have a direct or indirect territorial impact. Typical ex-ante evaluations are based on a baseline scenario that as accurately as possible projects likely future states given relevant trends and current policies. Policy impacts are typically modelled as additional effects on that baseline in a separate model variant, so that differences in end state convey information on the impacts of the introduced policy. This working procedure makes the definition of the baseline scenario, in terms of underlying assumptions and included policies, a critical task.

This report documents the differences between the new EU Reference scenario 2014 and its predecessor, EU Reference scenario 2013. Most changes for the EU Reference scenario have been made to more accurately capture intricate relations between the macro-economic drivers of land-use change and regional land demands; to deliver a more comprehensive set of policies incorporated in the scenario's baseline assumptions; to improve consistency with EC policies and, in the case of forest land cover, with official statistics; and to improve the accuracy of the fine resolution spatial allocation methods that are at the core of LUISA.

LUISA is continuously developed towards the goal of a fully integrated assessment tool. The strong link with the EU policy settings, together with the use of Europe-wide reference data and outputs from external models, require that the implementation of the Reference Scenario in the LUISA platform undergoes regular updates. These updates are conditional to the availability of new or refined data, and to changes in the EU policy definitions. In particular, the next release of the LUISA Reference Scenario is foreseen for the end of 2015: by that date, updated economic and demographic projections from DG ECFIN and the GEM-E3 model are expected.

BIBLIOGRAPHY

Ahrend R and Schumann A. (2014) Does regional economic growth depend on proximity to urban centres? *OECD Regional Development Working Papers.* OECD Publishing.

Barredo JI, Kasanko M, McCormick N, et al. (2003) Modelling dynamic spatial processes: Simulation of urban future scenarios through cellular automata. *Landscape and Urban Planning* 64: 145-160.

Batista e Silva F, Gallego J and Lavalle C. (2013a) A high-resolution population grid map for Europe. *Journal of Maps* 9: 16-28.

Batista e Silva F, Lavalle C and Koomen E. (2013c) A procedure to obtain a refined European land use/cover map. *Journal of Land Use Science* 8 (3):255-283.

Batista e Silva F, Koomen E, Diogo V, et al. (2014) Estimating demand for industrial and commercial land use given economic forecasts. *PLOS ONE* 9: e91991.

Batista e Silva F, Lavalle C, Jacobs-Crisioni C, et al. (2013b) Direct and indirect land use impacts of the EU cohesion policy.assessment with the Land Use Modelling Platform. Luxembourg: Publications office of the European Union.

Böttcher H, Verkerk PJ, Gusti M, et al. (2012) Projection of the future EU forest CO2 sink as affected by recent bioenergy policies using two advanced forest management models. *Global Change Biology Bioenergy* 4: 773-783.

Britz W and Witzke HP. (2008) Capri model documentation 2008: Version 2. Bonn: Institute for Food and Resource Economicws, University of Bonn.

Büttner G, Feranec G and Jaffrain G. (2006) CORINE land cover nomenclature illustrated guide: Addendum 2006.

EC. (2009) Directive 2009/28/EC of the European Parliament and of the Council on the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.

EC. (2012) The 2012 ageing report: Economic and budgetary projections for the EU27 member states (2010-2060). European Economy 2/2012.

EC. (2013) Assessing territorial impacts: Operational guidance on how to assess regional and local impacts within the Commission Impact Assessment System.

EC (2014) EU Energy, transport and GHG emmissions, trends to 2050 – Reference scenario 2013. Luxembourg: Publications Office of the European Union.

Hansen M C, Potapov P V, Moore R, Hancher M, Turubanova S A, Tyukavina A, Thau D, Stehman S V, Goetz S J, Loveland T R, Kommareddy A, Egorov A, Chini L, Justice C O, Townshend J R G (2013) High-Resolution Global Maps of 21st-Century Forest Cover Change. Science: 342 (6160), 850-853. [DOI:10.1126/science.1244693]

Jacobs-Crisioni C, Batista e Silva F, Lavalle C, et al. (2014) Accessibility and territorial cohesion in a case of transport infrastructure improvements with endogenous population distributions.

Lavalle C, Baranzelli C, Batista e Silva F, et al. (2011) A High Resolution Land use/cover Modelling Framework for Europe: introducing the EU-ClueScanner100 model. In: Murgante B, Gervasi O, Iglesias A, et al. (eds) *Computational Science and Its Applications - ICCSA 2011, Part I, Lecture Notes in Computer Science vol. 6782.* Berlin: Springer-Verlag, 60-75.

Lavalle C, Mubareka S, Perpiña Castillo C, et al. (2013) Configuration of a reference scenario for the land use modelling platform. EUR 26050 EN. Luxembourg: Publications Office of the European Union.

ObjectVision. (2014) *Geo data and model server (GeoDMS)*. Available at: http://objectvision.nl/geodms.

UNWTO. (2014) *Tourism highlights - 2014 edition*. Available at: http://mkt.unwto.org.

Verburg PH and Overmars K. (2009) Combining top-down and bottom-up dynamics in land use modeling: exploring the future of abandoned farmlands in Europe with the Dyna-CLUE model. *Landscape Ecology* 24: 1181.

European Commission
EUR 27019 EN – Joint Research Centre – Institute for Environment and Sustainability

Title: The Reference Scenario in the LUISA platform – Updated configuration 2014

Authors: Claudia Baranzelli, Chris Jacobs-Crisioni, Filipe Batista e Silva, Carolina Perpiña Castillo, Ana Barbosa, Juan Arevalo Torres, Carlo Lavalle

Luxembourg: Publications Office of the European Union

2014 – 42 pp. – 21.0 x 29.7 cm

EUR – Scientific and Technical Research series – ISSN 1831-9424 (online)

ISBN 978-92-79-44702-0 (PDF)

doi: 10.2788/85104

LB-NA-27019-EN-N

JRC Mission

As the Commission's
in-house science service,
the Joint Research Centre's
mission is to provide EU
policies with independent,
evidence-based scientific
and technical support
throughout the whole
policy cycle.

Working in close
cooperation with policy
Directorates-General,
the JRC addresses key
societal challenges while
stimulating innovation
through developing
new methods, tools
and standards, and sharing
its know-how with
the Member States,
the scientific community
and international partners.

Serving society
Stimulating innovation

doi: 10.2788/85104

ISBN 978-92-79-44702-0

Publications Office