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CONFIGURATION OF A REFERENCE SCENARIO FOR THE LAND USE MODELLING PLATFORM

Carlo Lavalle, Sarah Mubareka, Carolina Perpiña Castillo, Christiaan Jacobs-Crisioni, Claudia Baranzelli, Filipe Batista e Silva, Ine Vandecasteele

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Front cover pictures:

Solar power installation in Castilla La Mancha, Spain;
http://ec.europa.eu/regional_policy/projects/stories/index_en.cfm

Shale gas drilling in Grzebowilk, Poland;
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VACCIA - Vulnerability assessment of ecosystem services for climate change impacts and adaptation, Italy (LIFE07 ENV/FIN/000141)

http://www.environment.fi/download.asp?contentid=132156&lan=en

Contents

Executive Summary

A pan-European Land Use Modelling Platform (LUMP) was developed in order to provide projected land use maps at a detailed geographical scale (100m^2, regional or country level), translating policy scenarios into land-use changes such as afforestation and deforestation; pressure on natural areas; abandonment of productive agricultural areas; and urbanization. Furthermore, indirect impacts can be assessed through indicators, such as changes in water-use and landscape morphology. This modelling platform integrates data from sector-specific models in order to resolve what can often be conflicting land use claims. The solution given by the land use model is based on a number of criteria, namely land claimed per sector given by specialized models such as agriculture or energy models; land suitability to host given land use classes; accessibility to transport hubs; policy-driven restrictions and subsidies; as well as planned transport infrastructures.

This document describes the configuration of the Land Use Modelling Platform for the *Reference scenario* as defined in the Energy Trends to 2030 publication by DG ENER and DG CLIMA (EC, 2009a) and the Impact Assessment, annex to the Energy Roadmap 2050 (EC, 2011a), as well as the Roadmap itself (EC, 2011b). This definition specifies full implementation of the Climate and Energy package. The legislation included within the Climate and Energy Package reflects the climate and energy targets for 2020: 20% reduction in EU greenhouse gas emissions from 1990 levels; raising the share of EU energy consumption produced from renewable resources to 20%; and a 20% improvement in the EU's energy efficiency. This scenario assumes that national targets under the Renewables directive (EC, 2009b) and the GHG Effort-sharing decision (EC, 2009c) are achieved. The European Commission regularly assesses projections of EU energy, transport and greenhouse gas (GHG) emission trends. These projections are based on current trends and policies by EU and MS, also using country-specific data. At the time of writing, data from the 2010 Reference Scenario are used within the configuration of LUMP. When data from the 2012 Reference Scenario are made available, these will be integrated.

The configuration of the Land Use Modelling Platform for the *Reference scenario* can be broken down into three main components: 1) editing future forecasts of land claimed per sector to 2050; 2) editing location-specific subsidies and restrictions that influence land use

conversions; 3) implementation of technical aspects such as model calibration, model computation capacity and the implementation of new scenario-specific mechanisms.

Defining future sectorial land claims

The first component involves the quantification of the amount of land required for any given sector, in order to provide essential information to the land-use model. This is what drives land use conversions. The role of the model is then to resolve conflicting land claims within the same geographical or administrative region based on biophysical suitability and policy-related rules.

The data required to model the land use classes usually comes from sector-specific models. In the configuration of the *Reference scenario*, data from the EUCLIMIT modelling framework (http://euclimit.eu/) was used. This framework was designed for the Energy Roadmaps (Low Carbon Economy and Energy) of 2011, to assess the GHG emission trends, mainly for the energy and transport sectors. The EUCLIMIT modelling framework (Figure 1) is used as a basis for the *Reference scenario*.

At the core of the EUCLIMIT modelling framework is the PRIMES Energy model. The models giving data to PRIMES upstream are Prometheus, GAINS and GEM-E3. Prometheus is a world-energy model used to determine fossil-fuel import prices; GAINS is used to estimate non-CO_2 emissions; and GEM-E3 is a general equilibrium macro-economic model used to estimate GDP and other macro-economic variables. The data from GEM-E3 are used directly in the Land Use Modelling Platform. The PRIMES model provides data to specialized models: CAPRI for the agricultural sector; and GLOBIUM/G4M for the forestry sector. CAPRI and GLOBIUM/G4M then provide data directly to the Land Use Modelling Platform for their respective sectors. The EUROPOP-2010 dataset, produced by Eurostat, provides population projections for the EU Member States and EFTA countries. This is used as a reference for future demographic developments, which therefore influences the land required for residential use.

Defining location specific-subsidies and restrictions

The capacity of the land-use model to ingest policy driven, location specific rule sets on a per-land-use basis is at the core of the configuration of the Land Use Modelling Platform. In this way, policies with potential direct and indirect spatial repercussions on EU territory can be

incorporated in the allocation choices made by the model. A significant proportion of relevant legislation is included in the configurations of the upstream models of the EUCLIMIT framework. However, some aspects of European law are missing from these aspatial models. The main policies included in the *Reference scenario* at the spatial level of the land use model are the Renewable Energy Directive, the Common Agricultural Policy (including support schemes and certain elements of cross-compliance), TEN-T transport network, and the 2020 biodiversity strategy.

Technical modifications in the model

In order to make the configuration of the *Reference Scenario* functional, several technical improvements were made to the model. These technical aspects include changes in the modelled classes, the introduction of a dynamic transportation module to assess the impacts of changes in accessibility on the landscape, a mechanism by which the population is distributed over different land use classes, and the implementation of new scenario-specific instruments. These aspects are discussed in detail in this report.

The configuration for the *Reference Scenario* is the benchmark scenario that will be used in LUMP, and is designed as the basis for comparison of alternative scenarios within the EU up to 2050. Ensuring the due consistency in macro-economic and policy assumptions, the results from different time steps (i.e. typically 2020 or 2030) are retained from the simulations. Furthermore other upstream sector-specific models will be tested as part of the modelling exercise, in order to gain knowledge and practice with components of other models run at the JRC such as POLES, CBM and Rhomolo.

LUMP is currently being applied to assess the territorial impacts of regional policies; to evaluate GHG emissions from land use and land cover changes and to quantify the rate of achievement of selected targets of the Resource Efficiency Roadmap. Further applications will cover the formulation of adaptation strategies to climate change in the follow-up of the PESETA project and other policy initiatives such as bio-economy and unconventional energy sources.

1 Introduction

The Land Use Modelling Platform (LUMP[1]) combines various sector-specific models (such as macro-economic[2], hydrology[3], agriculture[4], forestry[5], energy[6], demography[7], transport[8]) together with its core land use model component[9]. This modelling platform provides projected land use maps at a detailed geographical scale (100m^2, regional or country level), translating policy scenarios into land-use related impacts (e.g. shifts in agricultural production, changes in water use and demand, afforestation/deforestation, pressure on natural areas, urbanization, etc.). LUMP takes full and detailed account of competing land use demands between different sectors (e.g. for households, industry and agriculture) and of spatial policy restrictions (e.g. Nationally Designated Areas); as well as planned transport infrastructures. The linkages between LUMP and other bio-physical and macro-econometric models are operational and have been used in the Impact Assessments for the new Common Agricultural Policy[10], the Integrated Coastal Zones Management[11] and the Blueprint to Safeguard Europe's Water Resources[12], among other project applications.

The LUMP has recently been configured to reflect the impacts of current legislation on land use patterns across Europe to 2050, with intermediate time steps typically at 2020 and 2030

[1] http://ies.jrc.ec.europa.eu/our-activities/scientific-achievements/Land-Use-Modelling-Platform.html

[2] IMAGE/LEITAP, GEM-E3, RHOMOLO

[3] LISFLOOD, EPIC

[4] CAPRI

[5] CBM

[6] POLES

[7] Europop2010 (from EUROSTAT and ECFIN)

[8] TRANSTOOLS

[9] EUClueScanner (EUCS100), developed in collaboration with DG ENV

[10] http://ec.europa.eu/environment/enveco/impact_studies/pdf/Final%20CAP_report.pdf

[11] http://ec.europa.eu/environment/enveco/impact_studies/pdf/land_use_modelling%20adaptation_activities_coastal.pdf

[12] http://ec.europa.eu/environment/water/blueprint/

depending on the specific application. The purpose of this modelling exercise is develop a basis upon which to assess the impacts of land management restrictions and subsidies, subject to rules at both EU-level and Member State level under EU directives. This document describes the configuration of a benchmark configuration in the Land Use Modelling Platform, designed as the basis for comparison of alternative policy decisions; configured within LUMP in a second step.

2 Background

The Reference scenario, as configured in LUMP, will be used as a benchmark to test the impacts of policy scenarios on land use within the EU to 2050. The description of the scenarios depends on the political context of the project at hand. The Reference scenario has already been confirmed as a benchmark for assessing impacts of different elements of the Resource Efficiency Roadmap, the Energy Roadmap and an assessment of the Cohesion Policy period 2014-2020.

2.1 Roadmap to a Resource Efficient Europe

The Communication from the Commission on the Roadmap to Resource Efficient Europe (RERM) defines a set of milestones to illustrate what is required to put Europe on a path to resource efficiency and sustainable growth, thus contributing to a global economic transformation. Elements of the Resource Efficiency Roadmap (RERM) relating to *Protecting the Environment*, and in particular on the milestones set to reduce the actual rhythm of land-take, will be assessed using the LUMP. A specific set of indicators has been identified in order to assess the differences among three scenarios: the Reference scenario, described in this document; a "Linear Growth" scenario whereby current land take trends are extrapolated; and a "Target 0" scenario, in which the "no net land-take" milestone is set for 2050. A series of milestones towards the achievement of the RERM are set for year 2020. More details of these scenarios are discussed in Annex I.

2.2 Energy Roadmap 2050

The Energy Roadmap 2050, adopted on December 15, 2011 by the European Commission COM(2011) 885, sets specific targets for emissions reductions, relative to the 1990 values, by

2050. This Roadmap was designed to give a direction to what should follow after the 2020 agenda at a European level. The Roadmap was subject to scenario analysis, for which a modelling suite that is discussed further in this document, was used. A Reference scenario was designed within this framework, in which current trends and long-term projections on economic development and policies adopted by March 2010 (including the 2020 targets for RES share and GHG reductions as well as the Emissions Trading Scheme Directive) are included. LUMP will be used to assess the aspects related to the availability of resources required for renewable energy production, namely water and biomass.

2.3 Cohesion Policy 2014-2020

Specific mechanisms within the LUMP have been prepared for the assessment of impacts of the new Cohesion Policy on ecosystem services and urban-rural systems. Aspects of the Policy that will have a direct impact on the landscape composition of the EU are addressed. The Reference scenario does not include all of the Cohesion Policy and is therefore used as a baseline to which scenarios related to the Cohesion Policy can be compared. The regional macro-economic model Rhomolo pilots most of the policy scenarios for this project. The Rhomolo model was designed to provide insight to the economic implications of the European Cohesion Policy. Developed at JRC-IPTS (Seville), the model provides macro-economic projections for the EU at NUTS-2 level. More details on the scenarios foreseen for this exercise can be read in Annex I.

3 Defining the Reference Scenario

The definition of the Reference scenario, as adopted in the LUMP, is given in the Energy Trends to 2030 publication by DG ENER (2009 update[13]) and the Impact Assessment, annex to the Energy Roadmap 2050[14], as well as the Roadmap itself[15]. At the time of writing, this refers to the 2010 Reference Scenario as used by ENER and CLIMA. This definition specifies full implementation of the Climate and Energy package. The legislation included within the

[13] http://ec.europa.eu/clima/policies/package/docs/trends_to_2030_update_2009_en.pdf

[14] SEC(2011) 1565/2

[15] COM(2011) 885 final

Climate and Energy Package reflects the EU's climate and energy targets for 2020 (20% reduction in EU greenhouse gas emissions from 1990 levels; raising the share of EU energy consumption produced from renewable resources to 20%; a 20% improvement in the EU's energy efficiency). This scenario assumes that national targets under the Renewables directive (2009/28/EC) and the GHG Effort-sharing decision (2009/406/EC) are achieved.

The actual bulk of the configuration of the scenario is done upstream from the LUMP, with the energy model PRIMES. The models giving data to PRIMES upstream are Prometheus, GAINS and GEM-E3. Prometheus is a world-energy model used to determine fossil-fuel import prices; GAINS is used to estimate non-CO_2 emissions; and GEM-E3 is a general equilibrium macro-economic model used to estimate GDP and other macro-economic variables. The modelling chain configuration is under revision by DGs CLIMA, ENER and MOVE while defining the 2012 Reference Scenario. When this data becomes available, it should be implemented in LUMP where possible.

4 Harmonizing assumptions within the modelling framework

The European Commission regularly assesses projections of EU energy, transport and greenhouse gas (GHG) emission trends. These projections are based on current trends and policies by EU and MS, also using country-specific data. To assist in this task, the EUCLIMIT modelling framework[16] was designed for the Energy Roadmaps (Low Carbon Economy and Energy) of 2011. The EUCLIMIT modelling framework (Figure 1) is used as a basis for different "Reference scenarios", in which the main drivers are reflected in the PRIMES model (driven by other models described in the previous section). The latest example is the *2010 Reference scenario*, but the same exercise is being conducted on the revised Reference scenario for PRIMES, referred to as the *2012 Reference scenario* (foreseen for the beginning of 2013).

[16] http://euclimit.eu/

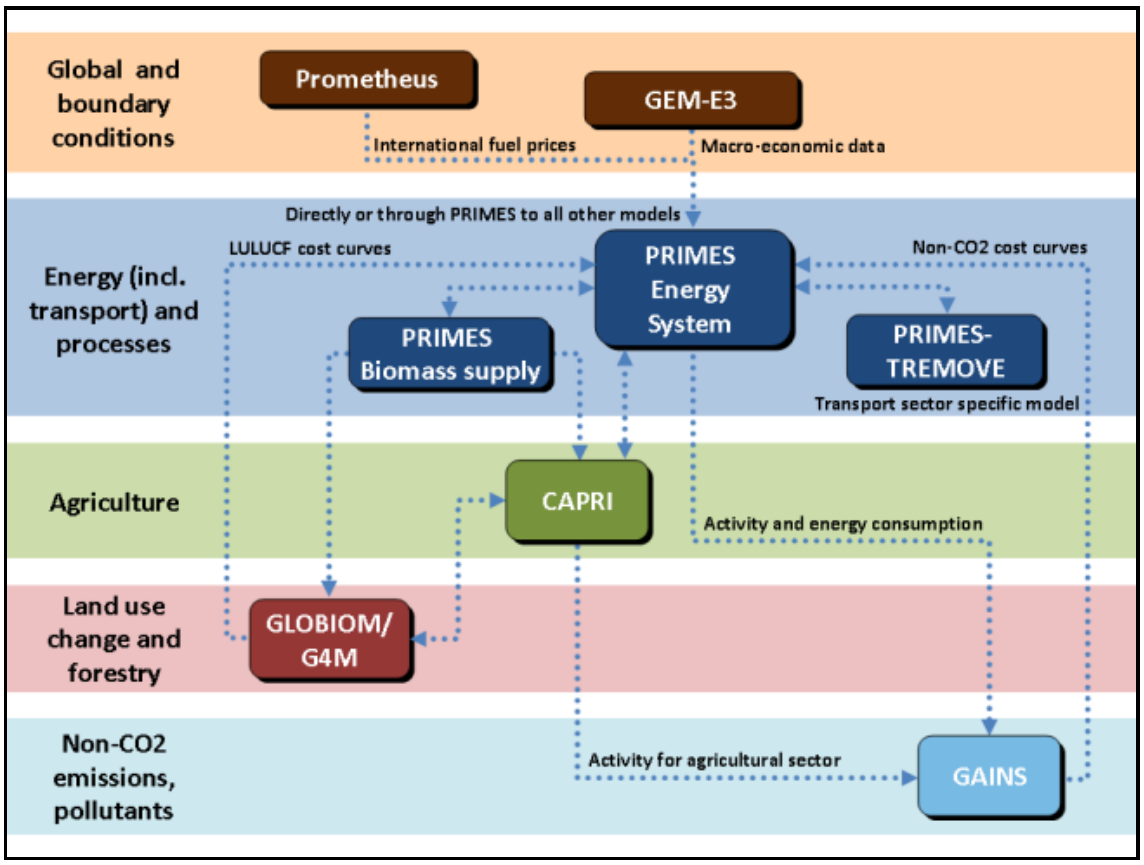

Figure 1. The integrated modelling network in EUCLIMIT (*source: euclimit.eu*)

Each model within the system shown in Figure 1 is specialized. The assumptions behind the specifications of each of these models are followed as closely as possible as they may directly impact the amount of land claimed per economic sector within LUMP. These models are also referred to as "upstream models" within this context when they provide data to LUMP. The upstream models are CAPRI for agricultural commodities, GEM-E3 for industrial and commercial land claims, and G4M/GLOBIUM for forest land. A fourth dataset, EUROPOP-2010, produced by Eurostat, provides population projections for the EU Member States and EFTA countries. This is used as a reference for future demographic developments, which therefore influences the land required for residential use.

4.1 GEM-E3

GEM-E3 (General Equilibrium Model for Energy-Economy-Environment interactions) is a macro-economic general equilibrium model, whose aim is "..to cope with the specific orientation of the policy issues that are actually considered at the level of the European

Commission." (p.10, GEM-E3 user's manual). The model provides projections for multiple sectors and is considered to cover the economy in its entirety. The model is run at country level for the EU27.

The assumptions underlying the LUMP model are coherent with those used within the EUCLIMIT framework to forecast sectorial energy consumption, including household and industrial requirements. The Reference scenario is consistent with recent Eurostat and EPC/ECFIN long term projections on demographic and economic development[17]. The economic projections are used to estimate demand for industrial and commercial land use at regional level (NUTS2). These regional estimates are then spatially allocated. The algorithm estimates the additional industrial and commercial land use based on the Gross Value Added (GVA) per branch of activity. The GVA is used as a proxy for the regional economies and their growth prospects, and is computed by GEM-E3 (version run by the E3M Lab at the National Technical University of Athens). Projections are provided beyond 2010 and up to 2050. In the GEM-E3 run, economic growth rates are taken as targets, specified according to the short and medium term projections by DG ECFIN/Economic Policy Committee and the assumptions used in the Ageing Report 2012.

As depicted in Figure 2, the base year for the land use modelling is 2006. Between 2006 and 2010, the model is driven by the actual sectorial GVA values (in constant prices) as reported by Eurostat. From 2010 onwards, the land use model is driven by the economic projections provided by the GEM-E3 model with national and sectorial detail. In practice, the modelled GVA annual growth rates are used to generate scenario-specific GVA estimates on top of the Eurostat time-series.

[17] P.13 SEC(2011) 1562/2

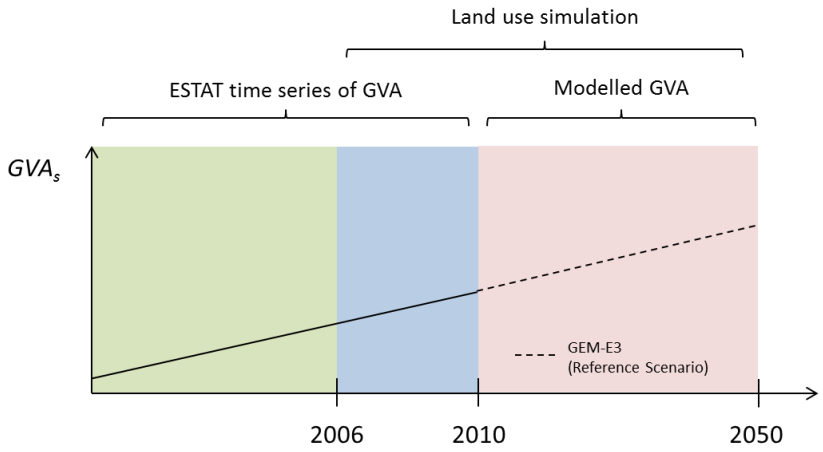

Figure 2. Macro-economic assumptions for the simulation period (2006-2050)

4.2 CAPRI

The 'Common Agricultural Policy Regionalised Impact analysis' (CAPRI) model is a global, comparative static partial equilibrium model for primary and secondary agricultural commodities, designed for impact assessment. The model has a European focus but trade policies from seventy-seven countries, divided into 40 trade blocks, are incorporated through the global, multi-commodity, market module. The agricultural sector for the EU (plus Turkey, Norway and the Western Balkans) is taken into account within the supply module through 280 regional models or 1900 farm-regional models. CAPRI builds upon an analysis of observed historical trends, on expert information for particular issues, and on standard economic modelling.

As described in Blanco et al (2013), CAPRI has a valuable new biofuels estimate module, linking the agricultural and biofuel (energy) markets. This module is fully endogenous to CAPRI in order to allow for the internal computation of the ethanol and biodiesel markets. The outputs from CAPRI are dependent on the PRIMES model, which is used to estimate fuel demand functions. LUMP uses the outputs of CAPRI to drive the agricultural land use allocations in the scenario described in this report. This ensures consistency between the CAP compliant economic and market assumptions, the physical space occupied by the commodities grown in each region and the satisfaction of biofuel requirements as requested by the PRIMES model.

4.3 PRIMES

The energy model PRIMES has been used in the past by the European Commission for the analysis underpinning the 2050 Energy Roadmap, and is foreseen to be used in the development of further energy policy scenarios. As a main output, the model derives the shares of all energy sources under different energy policy scenarios. Energy demands within the model are given per sector (industry, residential, tertiary and transport) and per-fuel type. PRIMES also computes a set of indicators related to GHG emissions. Other indicators are related to energy intensity, use of renewable energy sources, electricity generation and to the transport sector.

The production of renewable energy is directly related to the availability of natural resources, in particular water and biomass. LUMP is able to evaluate the demand of water and biomass according to the level of renewable energy stemming from the energy scenarios, using two dedicated modules:

- The Water-Use Module, developed offline within the framework of the IA for the EU Water Blueprint, provides an advanced tool to evaluate potentiality and vulnerability related to energy production;
- The Biomass-Estimation Module, developed to estimate the land demand for biofuel (in accordance with the CAPRI output) and the verification of the availability of biomass as expected by PRIMES.

These modules are run within LUMP in order to check the consistency between the *needs* for different energy sources results, identified by PRIMES; and the *availability* of natural resources for energy production, given by LUMP. The latter can identify the availability of land for biomass; of water for thermal energy production and hydropower; and biomass-based energy generation, all the while accounting for the competition for these resources with other sectors.

4.4 G4M/GLOBIOM

The Global Forest Model (G4M), developed and run at IIASA, estimates the impact of forestry activities (afforestation, deforestation and forest management) on biomass and carbon stocks. The model can use external information. In particular, it is linked to GLOBIOM, a global model

developed at IIASA to assess competition for land use between the agriculture, bioenergy, and forestry sectors. From GLOBIOM, G4M receives as input prescribed land-use changes (cropland and grassland). G4M covers the entire EU27, providing projections at 5-year time steps. The main outputs are afforestation/deforestation rates and greenhouse gases emissions at country level. The outputs from G4M/GLOBIOM are used to drive the forest land use allocations performed by LUMP for the Reference scenario simulation.

4.5 Climate change assumptions

Climate change will be assumed to be constant within LUMP for the Reference scenario. A critical upstream model, PRIMES, does not include corrections due to climate change (e.g. it assumes static climate condition, reference year 2005) since "degree days" measuring heating and cooling demand are kept constant.

4.6 Temporal window

LUMP is configured to run the Reference scenario from year 2006 to year 2050. The dynamic re-computation of land use potential and allocation is made at annual time-steps. There is no intra-annual dynamic computation of land use allocation.

5 Implemented policy initiatives

This section summarises the policy assumptions with potential direct spatial repercussions on EU landscape (Table 1).

Table 1. Legislation to incorporate into the Reference scenario within LUMP.

Policy	Year	Reference scenario
Renewable Energy Directive	2003	-Restriction of land use conversions of wetlands and peatlands -Restriction of conversions of continuously forested areas (="forest" in CLC) -Restriction of conversions in protected areas (including Nationally Designated Areas)
CAP Health Check	2008	Cross compliance, Rural Development (see sub-sections below)
CAP Health Check GAEC	2008	Inclusion of mandatory GAEC measures on a country-basis where possible

CAP SUPPORT SCHEME Sustainable Agriculture	2008	Identification of areas most likely to have received compensation according to areas under Art 16. (Natura 2000 sites); Art. 18 and Art. 20 areas considered as eligible for subsidies are further refined according to the criteria set by each MS; Art. 19 areas kept intact (i.e. are not refined)
CAP SUPPORT SCHEME Sustainable Forestry	2008	-First afforestation of agricultural land encouraged in marginal lands at risk for abandonment -Short rotation (new energy) crop (2nd generation) plantations also placed as a result of the afforestation measure
Revision of TEN-T	2011	Updates of approved changes in the transportation network
2020 Biodiversity strategy	2011	Location-specific rules are established to restrict or enhance certain land uses according to the strategy and the Habitats and Birds Directives

5.1 Renewable Energy Directive (RED)

Directive 2009/28/EC aims to promote of the use of renewable resources for the energy and transport sector, in order to comply with the Kyoto Protocol to the UN Framework convention on Climate Change. A target of a 20% overall share of energy from renewable sources and a 10% target share of renewables for the transport sector are reiterated[18] as being achievable for the year 2020.

The "energy mix" that would be necessary to achieve the pre-set targets at Member State level is initially taken into account in the energy model PRIMES. The downstream models CAPRI and GEM-E3/GLOBIUM are given information from PRIMES which drives the agricultural and forestry sectors to produce renewables within the different MS from these respective sectors. The Land Use Modelling Platform then incorporates this information into the land allocation module for the distribution of the required land uses within the territory. There is no spill-over effect in terms of land use requirements between countries. The required amount of land to produce renewables from the agricultural and forestry sectors is therefore competing within the Member States and no additional land is made available from

[18] Reiterated from the 2007 Communication on the Renewable Energy Roadmap - Renewable Energies in the 21st century: building a more sustainable future"

neighbouring states. The Land Use Modelling Platform does not yet take other sources of renewable energy into account such as solar, wind or tidal power. Furthermore, many components of the 2009 Directive refer to the innovation and growth of SMEs. These issues and those related to social cohesion and employment and their impacts on land use through the building of new infrastructure (or the renovation of abandoned structures) are addressed in the scenarios built for DG-REGIO. These are therefore not considered within the framework of the Reference Scenario.

5.1.1 Agricultural sector

In the Reference scenario run output, there will be no distinction of crops allocated to biofuels and those allocated to food. All crops, regardless of their destination, will be allocated according to the biophysical characteristics of the land. Production coefficients for agricultural residues (ARES) are computed on a commodity basis, as detailed in Becker and Adenauer (2010). Since these coefficients are expressed in tons, they are not explicitly simulated in LUMP. However the production coefficients for ARES are related to the forecasted demand for agricultural commodities which, in turn, drives the allocation of agricultural land in LUMP. It is therefore possible to estimate the production of ARES through the computation of the actual land available for collection of agricultural residues.

5.1.2 New Energy Crops

New energy crops (NECR), herbaceous and woody lignocellulosic crops, are spatially allocated in the current Reference scenario. Land claimed for NECR are given by the CAPRI model. These figures are exogenously fixed by PRIMES, and are therefore not a product of computation within CAPRI (Becker and Adenauer, 2010). Although the demand share of biofuels produced by NECR are not computed directly by CAPRI, they are taken into consideration by reducing the available agricultural land for the production of other agricultural products in accordance with the yield information collected for NECR (Figure 3).

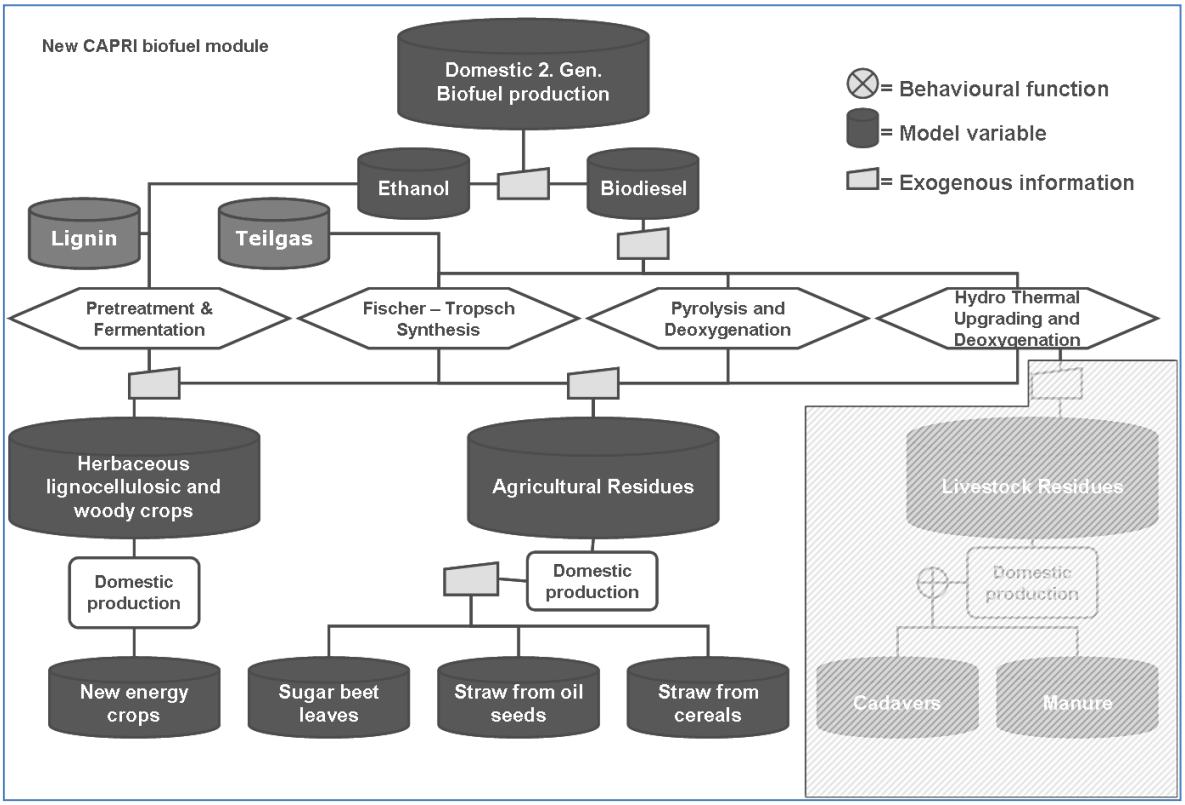

Figure 3. Flow of second generation biofuel production and relative feedstock (source: Becker and Adenauer, 2010; p/4)

Table 2 summarises the salient aspects of the Directive with respect to land use conversions. A green checkmark shows the aspects of this Directive that have been incorporated into LUMP.

Table2. Summary of salient aspects of the Renewable Energy Directive on land use conversions

DIRECTIVE 2009/28/EC	ASPECTS	ARTICLES
	Land use change (direct and/or indirect)	Article 17: **Sustainability criteria for biofuels and bioliquids** **(4)** Biofuels and bioliquids [...] shall not be made from raw material obtained from land with high carbon stock, namely land that had one of the following statuses in January 2008 and no longer has that status: **(a) wetlands**, namely land that is covered with or saturated by water permanently or for a significant part of the year; ✔ **(b) continuously forested areas**, namely land spanning more than one hectare with trees higher than five metres and a canopy cover of more than 30%, or trees able to reach those thresholds in situ; **(c) land spanning more than one hectare with trees higher than five metres and a canopy cover of between 10% and 30%,** or trees able to reach those thresholds in situ. Article 17: **Sustainability criteria for biofuels and bioliquids** **(5)** Biofuel and bioliquids [...] shall not be made from raw materials obtained from land that **was peat** land in January 2008, unless evidence is provided that the

DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL **of 23 April 2009** on the promotion of the use of energy from renewable sources		cultivation and harvesting of that raw material does not involved drainage of previously undrained soil. ✔
	Biodiversity and ecosystem services	**Article 17: Sustainability criteria for biofuels and bioliquids** (3) **(3)** Biofuels and bioliquids [...] **shall not be made from raw material obtained from land with high biodiversity value**, namely land that had one of the following statuses in or after January 2008, whether or not the land continues to have that status:**(a) primary forest** and other **wooded land**, namely forest and other wooded land of native species, where there is no clearly visible indication of human activity and the ecological processes are not significantly disturbed; ✔ **(b) areas designated:** (i) by law or by the relevant competent authority for **nature protection purposes**; ✔ (ii) for **the protection of rare, threatened or endangered ecosystems or species** recognised by international agreements or included in lists drawn up by intergovernmental organisations or the International Union for the Conservation of Nature. ✔ **(c) highly biodiverse grassland that is**: (i) **natural**, namely grassland that would **remain grassland** in the absence of human intervention and which maintains the **natural species composition and ecological characteristics and processes**; or (ii) **non-natural**, namely grassland that would cease to be grassland in the absence of human intervention and which is **species-rich and not degraded**, unless evidence is provided that the harvesting of the raw material is necessary to preserve its grassland status.
	Environmental sustainability	**Article 17: Sustainability criteria for biofuels and bioliquids** **(6)** Agricultural raw materials cultivated in the Community and used for the production of biofuels and bio liquids [...] shall be obtained in accordance with the requirements and standards under the provisions establishing common rules for direct support schemes for farmers under the **Common Agricultural Policy** and establishing certain support schemes for farmers and in accordance with the minimum requirements for good agricultural and environmental condition. **Environment, Annex II of council regulation No 73/2009** - *Council Directive 79/409/EEC on the* ***conservation of wild birds*** - *Council Directive 80/68/EEC on the protection of* ***groundwater against pollution*** *caused by certain dangerous substances* - *Council Directive 86/278/ on the protection of the* ***environment, and in particular of the soil, when sewage sludge is used in agriculture*** -*Council Directive 91/676/ concerning the protection of* ***waters against pollution caused by nitrates from agricultural sources*** -*Council Directive 92/43/ on the* ***conservation of natural habitats and of wild flora and fauna***
	Water/soil/air	Estimated impact of the production of biofuels and bioliquids on, water resources, water quality and soil quality within the Member State; PROTECTION MEASURES

5.2 Common Agricultural Policy

Several changes have been implemented within the LUMP to both accommodate current legislation as accurately as possible, and to represent the energy sector in terms of land

allocation for new energy crops. The following sub-sections describe the implementation of CAP within the LUMP. Details and examples are shown in Annex II.

5.2.1 Health Check 2008

Since the 2003 reform, the CAP has aimed to stabilize farmer's incomes, independently from production. It was furthermore reformed to provide a framework of sustainable development of the rural areas while respecting environmental and other societal needs. The Health Check in 2008 removes set-aside obligations because of the sharp rise in agricultural commodities since 2006 could be exacerbated by supply controls of the CAP (namely dairy quotas and obligatory set-aside).

In order to reflect the health Check in LUMP, support schemes were implemented as described in Annex VI of the Health Check. These refer to Regulation 1698/2005 (natural handicaps, Natura 2000, agri-environmental, afforestation and forest-environment payments); and Less Favoured Areas referred to in Regulation 1257/1999.

5.2.2 GAEC

Article 6 of chapter 1 on Cross Compliance within the Regulation[19], states that Member States shall define minimum requirements at national or regional level based on a specific framework (found in the Annex III of the same regulation). In order to avoid adverse effects of abolishing the compulsory set-aside, the 2008 Health Check introduces requirements for environmental benefits into the Good Agricultural Environmental Conditions requirements. This includes buffer strips along water courses and a more specific definition of landscape features not to be removed. Other provisions include the encouragement to maintain permanent pastures and the protection and management of water (within the context of agricultural activity). Records of the obligations established by the Member States are kept in the JRC GAEC web-database where MS update the definition of the GAEC measures enforced within their country's borders (Figure 4).

[19] Council Regulation (EC) No 73/2009

Figure 4. Screen dump of the MARS portal for GAEC reporting

These MS-specific rule-sets were implemented into LUMP where possible (see Annex I).

5.2.3 Improving the environment and the countryside

Article 36 of the Council Regulation on the support for rural development by the European Agricultural Fund for Rural Development (1698/2005 [20]) ensures measures targeting sustainable use of agricultural land and forestry land. The first set of measures, for agricultural land maintenance, is targeted at encouraging sustainable use of agricultural land and the sustainable use of forestry land. The implementation of these is described in the following sections.

[20] Council Regulation (EC) No 1698/2005, September 2005

5.2.3.1 *Sustainable Agriculture: Less Favoured Areas*

The framework for supporting rural areas (1257/1999[21]) includes several articles on funding of so-called "Less-favoured areas" (LFAs). This Regulation ensures compensation for farmers with a minimum sized holding, in naturally less-favoured areas, in order to ensure the continuation of agricultural activities in these areas. The polygons represent the combination of the art18, art19, art20 and each polygon is labelled as N, P, or T for each of the articles, where

- N = Not belonging to the LFA area
- P = Partially in the LFA area
- T = Totally in the LFA area

In order to reflect the MS definitions of eligible areas for funding, a decision-tree was designed (Figure 5), embedded within LUMP, and run for each MS for the creation of a layer representing location-specific subsidies (*locspecs*). These locspecs layers can potentially be generated for each land use class that is modelled within LUMP. They enhance or discourage the probability of a land-use presence. These layers differ from biophysical layers because they represent the incentives (usually economic, such as cross compliance) for certain land uses to be located in specific areas. In the case of LFAs, where the biophysical qualities of the terrain are not necessarily conducive to agricultural land, subsidies encourage the presence of agriculture nonetheless.

The decision tree represents a generic approach for identifying the LFAs most likely to receive Regional Development Policy funding. The output will be used as a locspec input for agricultural land, forestry and pasture land. The approach shown was applied at Member State level according to MS-based specifications.

[21] Council Regulation (EC) No 1257/1999, May 17, 1999

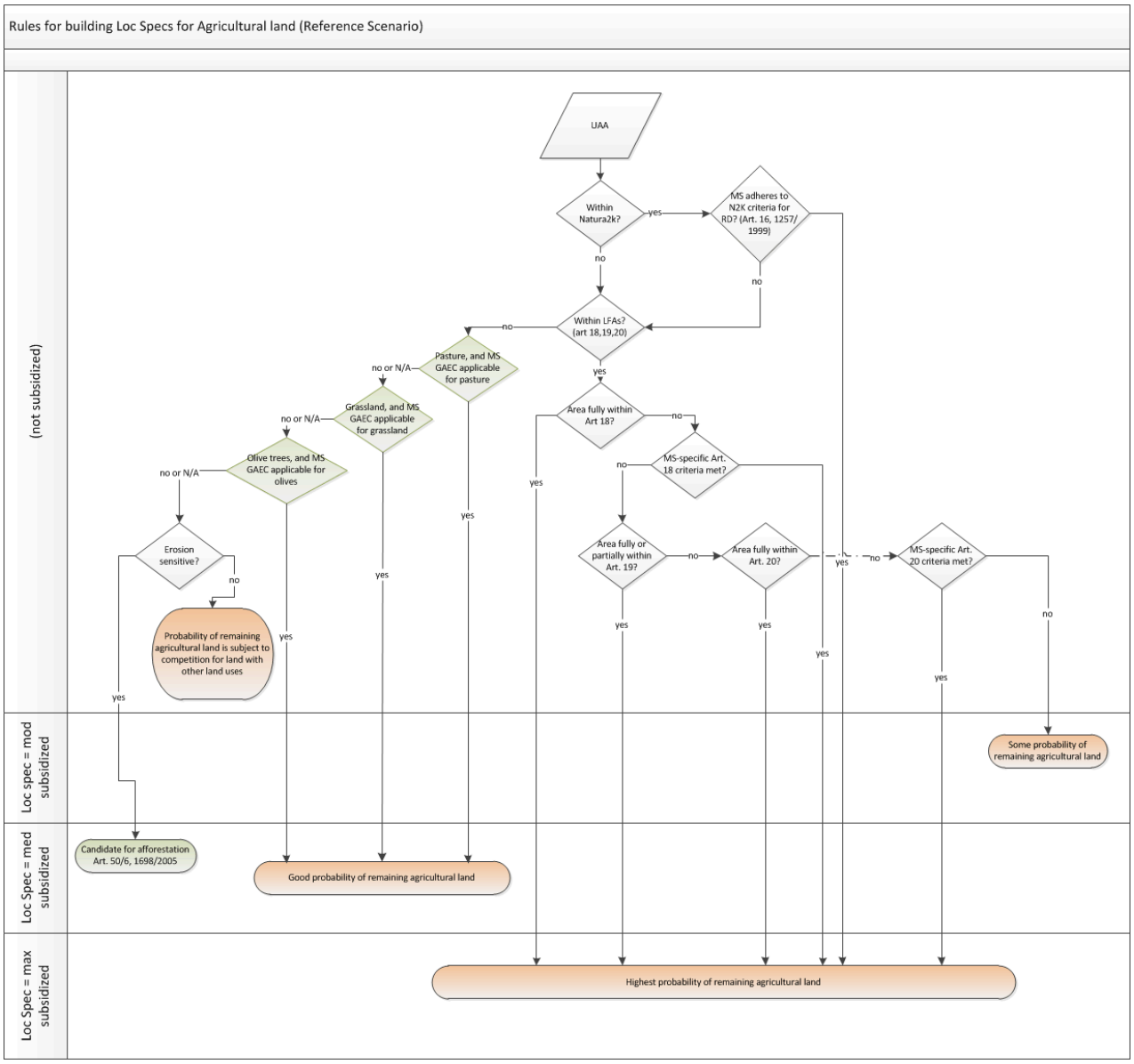

Figure 5. General process to identify different probabilities of land use remaining as agricultural land, given the LFAs and GAECs.

5.2.3.2 Environmental restrictions: configuration of Art. 16

As of 2011, fourteen MS defined eligibility criteria for the LFAs under Article 16. These are Belgium, Czech Republic, Germany, Estonia, Greece, Spain, Italy, Cyprus, Latvia, Lithuania, Hungary, Austria, Portugal, and Slovak Republic[22].

The agricultural land within Natura 2000 areas will remain intact for these countries choosing to incorporate environmental restrictions into their eligibility criteria (see Table A1 in Annex I).

5.2.3.3 Mountainous areas: configuration of Art. 18

This category of LFAs is strictly related to geomorphology (altitude, slope and north of the 62nd parallel). There are specific rules pertaining to these restrictions, given by the MS. These are detailed in the IEEP report for 2006[23]. These criteria are threefold: They can be relative to elevation, slope, or to a third screening for combined elevation and slope. For example, in the Czech Republic, a minimum of 600m asl is described as a criterion, with no minimum slope described. However the combined criteria is 500m asl *and* a minimum slope of 12.3%. Thus all areas above 600m asl are included; and areas between 500 and 599m asl are included only if the slope exceeds 12.3%. This 1 ha-resolution refinement will reduce the overall coverage of LFAs in the municipalities. The delimitation of Art 18 as provided by DG AGRI were refined in the "Partially in the LFA area" polygons only.

5.2.3.4 Other less-favoured areas: Art. 19

This category of LFA can be variable because it depends on areas "in danger of abandonment". In the IEEP 2006 report[24], these areas are defined according to criteria set by the MS. Many criteria are difficult to implement in EUCS. These are typically criteria associated with farmer's age and indices related to annual incomes or productivity and the proportion of the population whose livelihood depends on agriculture. The aspects of Art. 19 that can be used to further refine the current LFA polygons are namely related to population density, however this would be adding uncertainty to the process. The delimitation of Art 19 as provided by DG AGRI were therefore maintained.

[22] http://ec.europa.eu/agriculture/statistics/rural-development/2011/full-text_en.pdf

[23] http://ec.europa.eu/agriculture/eval/reports/lfa/full_annex_en.pdf , pp 8-13

[24] pp. 14-24

5.2.3.5 *Areas affected by specific handicaps: Art. 20*

This Article emphasizes improving, as well as conserving, the environment. The areas included in this Article differ between MS, as described in table 1.3 of the 2006 IEEP report[25]. Most criteria are spatial delimitations related to proximity to restricted areas such as nature parks, riparian areas, erosion-sensitive areas or coastal zones.

The delimitation of Art 20 as provided by DG AGRI was refined in so far as the criteria were clear and it was possible to implement. The implementation was only made in the "Partially in the LFA area" polygons.

5.2.4 *Sustainable use of Forestry land*

Forestry land maintenance targets (a) first afforestation of agricultural land; (b) Natura 2000 payments; (c) forest-environment payments and (d) restoring forestry potential.

The allocation of new energy crops in the CAPRI model is referred to a farming method named short rotation coppice (SRC) for woody crops, with the purpose of producing high yields in terms of generating energy within a short time period. The cycle of harvest and re-growth can be repeated every three years on average, up to an expected life cycle of 25 years[26,27]. Most of the literature focuses on woody species grown in SRC such as poplar, willows, eucalyptus or robinia because they are able to adapt to a wide range of climate and soils conditions. Indeed, an important characteristic of the SRC plantations is that they have good adaptation capabilities in marginal degraded and abandoned lands, where other crops cannot be grown. This is central for its potential in recovering abandoned agricultural lands. Different types of land are targeted for SRC: highly erodible land (erosion-sensitive zones); (2) marginal and degraded lands; (3) contaminated lands; and (4) abandoned land (Fiorese & Guariso,

[25] pp 25-31

[26] Bioenergy: Environmental impact and best practice. Final report, 2007

[27] Report on Energy crops options for Ontario power generation. The research park, London. May 2009

2010),[13,28, 29]. The LUMP was configured to fit NECR to these marginal lands, otherwise not ecologically suited for conventional farming practices.

In order to avoid negative impacts on biodiversity and protected areas due to energy crops plantations, Nature 2000 and nationally designed areas (CDDA) have been included as spatial layers in which NECR are not allowed. Consequently, in the LUMP simulation does not allow the allocation of new energy crops within these areas. Although this configuration is coarse in terms of biodiversity (in particular Target 2 of the Biodiversity Strategy), this modelling system does not have detailed enough information about the type of NECR to be allocated, nor the extent to which their plantations should be restricted. There is therefore room for improvement in this area.

5.3 TEN-T

A portion of the new links and link upgrades that will be funded by TEN-T are already approved and thus known. The impacts of those projects on land use will be modelled in the Reference scenario. To do so, a dedicated transport module is incorporated within the Reference scenario. This transport module computes accessibility measures based on travel-times over current and future transport networks. In the Reference scenario, those transport networks are approximated with the network data that are used in the Europe-wide Trans-tools transport model. Details of the technical implementation of this are given in Section 6.5.

5.4 2020 Biodiversity strategy

The EU2020 Biodiversity Strategy, adopted on 3rd May 2011 focuses on six targets and twenty actions. Target 1 aims at fully implementing the Birds and Habitats Directives, including the need to develop management plans for all Natura 2000 sites (Art. 4 and 6, 92/43/EEC). Key factors for the implementation of the Birds and Habitats Directives (2009/147/EC and 92/43/EEC), including the extent of the Natura 2000 network, are addressed in the LUMP modelling system from a spatial perspective as a constraint, although the current model configuration does not yet incorporate information about the quality of habitats. The Natura

[28] Some ecological and socio-economic considerations for biomass energy crop production(1996)

[29]Best Management Practices Poplar Manual For Agroforestry Applications in Minnesota September/2007

2000 network of protected sites is made up of Special Areas of Conservation (SACs) designated under the Habitats Directive (92/43/EEC) and of Special Protection Areas (SPAs), established under the Birds Directive (2009/147/EC).

The configuration adopted in LUMP is based on the general aim of the Habitats Directive (92/43/EEC, Art. 2) and takes into account the strict protection regime foreseen for protected areas hosting one or more priority natural habitat types (92/43/EEC, Art. 1(d)) and/or priority species (92/43/EEC, Art. 1(h)).Documents consulted from the European Commission are:

- SEC(2011) 1573 final – Commission Staff Working Paper – Financing Natura 2000 – Investing in Natura 2000: Delivering benefits for nature and people;
- EC, Guidance document on Article 6(4) of the 'Habitats Directive' 92/43/EEC, 2007
- EC, Guidance document on the strict protection of animal species of Community interest under the Habitats Directive 92/43/EEC, Final version – February 2007
- EC, Natura 2000 and forests 'Challenges and opportunities' — Interpretation guide, 2003

In addition to the Natura 2000 network, areas designated under national legislation and reported to The European Environment Agency on a voluntary basis are also taken into account (Common Database on Designated Areas - CDDA). Sites included in the CDDA are compliant with the International Union for Conservation of Nature (IUCN) definition of protected area[30] and are classified according to the management categories defined in Dudley, 2008. IUCN Protected Areas Categories System (Table 3).

Table3. IUCN categorization and description of Nationally Designated Areas

IUCN category	Description
Ia Strict Nature Reserve	Strictly protected areas set aside to protect biodiversity and also possibly geological/geomorphologic features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring.
Ib Wilderness Area	Usually large unmodified or slightly modified areas, retaining their natural character and influence without permanent or significant

[30] "A clearly defined geographical space, recognised, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values" (Dudley, 2008).

	human habitation, which are protected and managed so as to preserve their natural condition.
II National Park	Large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible, spiritual, scientific, educational, recreational, and visitor opportunities.
III Natural Monument or Feature	Protected areas set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave, or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.
IV Habitat/Species Management Area	Protected areas aiming to protect particular species or habitats, their management reflects this priority. Many Category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.
V Protected Landscape/Seascape	A protected area where the interaction of people and nature over time has produced an area of distinct character with significant, ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.
VI Protected area with sustainable use of natural resources	Protected areas that conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.

In order to reflect the influence of the management regimes in natural protected areas, three different decision-trees were designed (Figures 6, 7 and 8), and embedded within LUMP for the creation of a layer representing location-specific subsidies/restrictions (*locspecs*). These locspecs layers enhance or discourage the probability of a land-use or population presence.

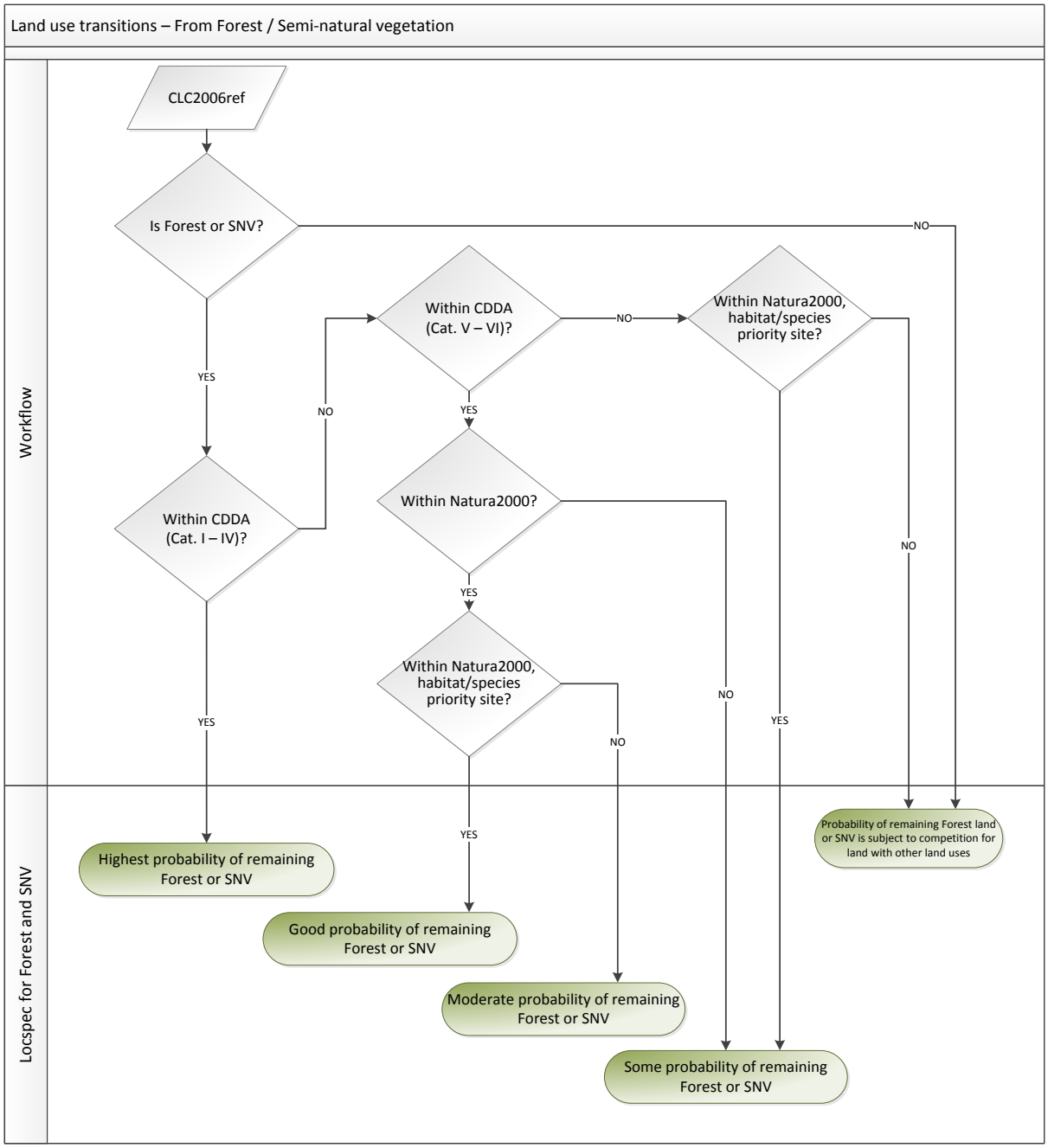

Figure 6. General process to identify different probabilities of land use transitions from forest or semi-natural vegetation, given The Birds and Habitats Directives and the Nationally Designated Areas

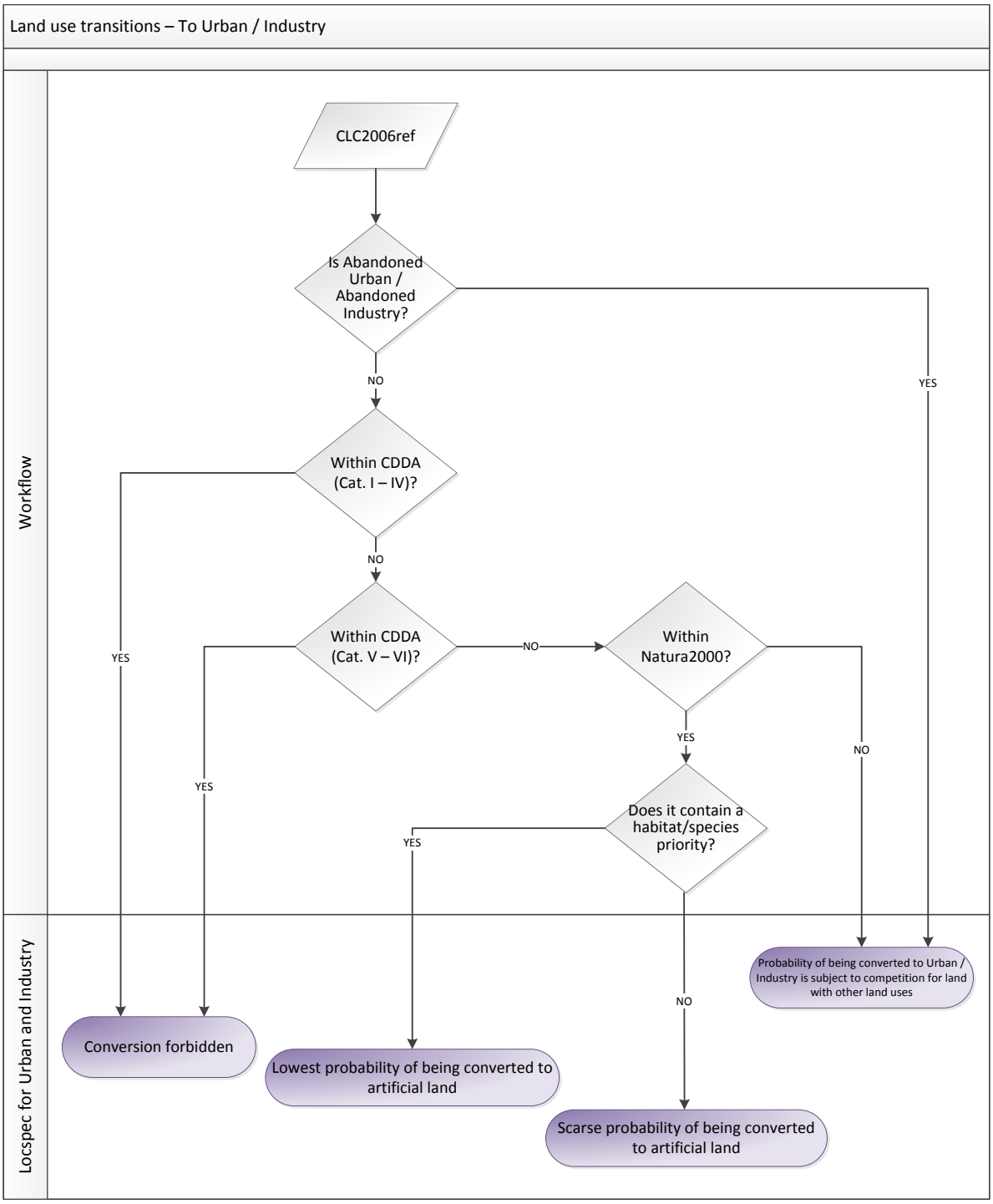

Figure 7. General process to identify different probabilities of land use transitions to industrial land, given The Birds and Habitats Directives and the Nationally Designated Areas.

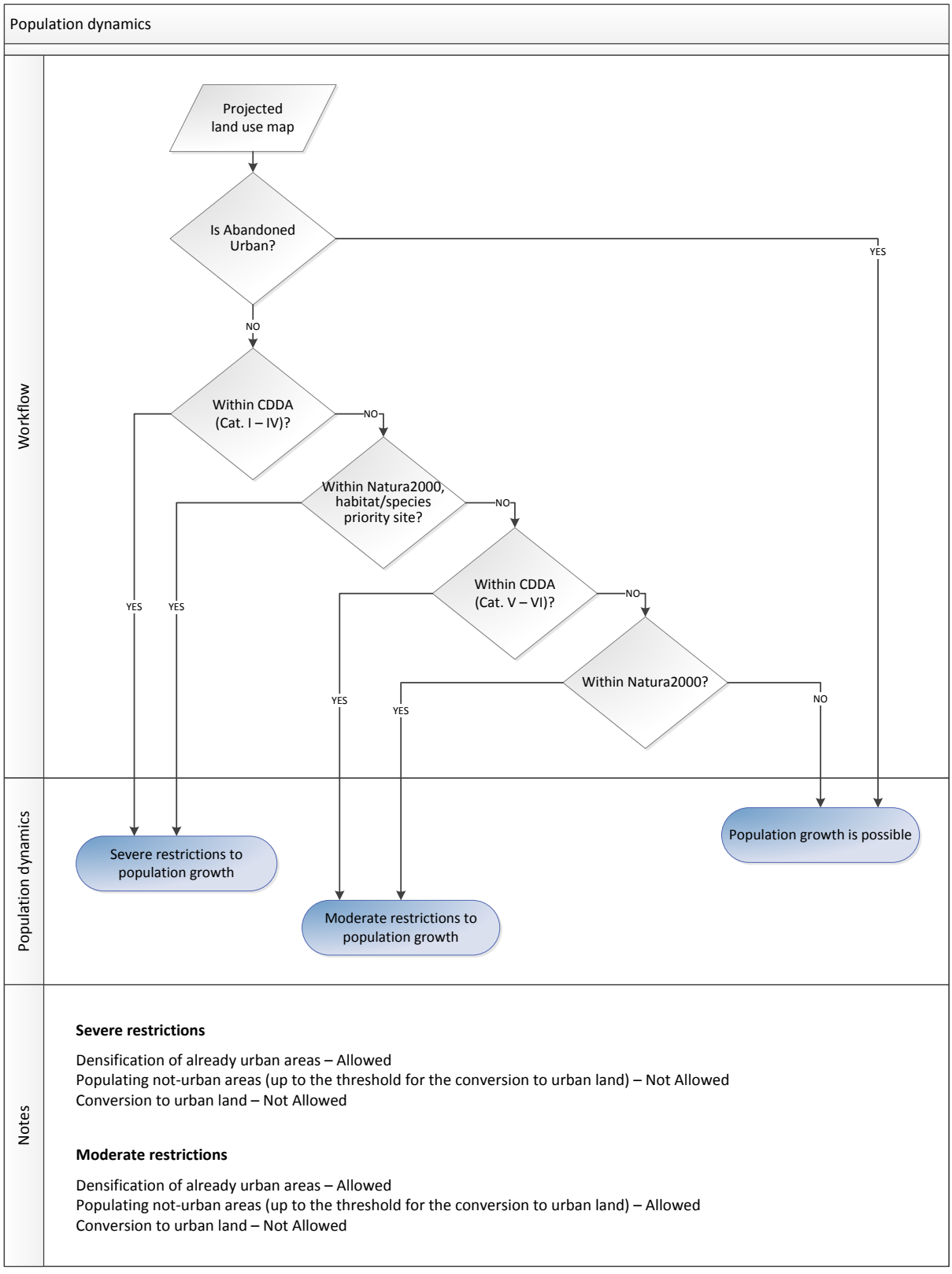

Figure 8. General process to identify different probabilities of population growth, given The Birds and Habitats Directives and the Nationally Designated Areas.

6 Technical changes implemented in LUMP for the Reference scenario runs

Several technical changes were made in order to implement and update the current legislation within LUMP. The following significant technical changes, made to the LUMP for the Reference scenario, are discussed in this chapter:

- Improvement of agricultural crop allocation rules
- Spatial allocation of New Energy Crops
- Densification mechanism of urban land
- Updated transportation module for dynamic calculation of accessibility maps

6.1 Agricultural crop allocation

The agriculture land use allocation depends heavily on the land suitability for specific crops. A new set of agriculture suitability maps have been implemented within the LUMP to improve the spatial distribution of the crop commodities as given by the upstream CAPRI model. Twenty-nine agricultural land uses are distinguished in the original dataset provided by the JRC[31]: barley, citrus fruits, durum wheat, floriculture, permanent grass and grazing, fallow land, fodder on arable land, fruit tree and berry plantations, maize, olive groves, Rape and turnip rape, industrial crops, nurseries, oats, other cereals, potatoes, pulses, rice, rye, sugar beet, soya, sunflower, soft wheat, tomatoes and other vegetables. These classes are aggregated to coincide with the LUMP legend: maize, cereals, permanent crops, root crops and other arable land. The maps, originally at a 1km resolution are resampled to a 100m resolution using a Gaussian smoothing function within LUMP. This product is a highly expressive and reliable dataset. No suitable dataset was found for the allocation of new energy crops. These were therefore newly developed, as described in the next section.

6.2 Spatial allocation of New Energy Crops

The biophysical and environmental information for each energy crop was gathered in order to identify the most suitable location for their development according to their adaptability to climate and geographical areas in Europe. Climate is one of the basic criteria used to

[31] http://afoludata.jrc.ec.europa.eu/DS_Free/AF_Agri.cfm

distinguish the suitability of different areas for different crops. The nature and quality of the soil is a function of soil formation, climate factors, topography, parent material, chemical, structure, and so on[20, 45].Table 4 summarises the pan-European data sources acquired to identify the spatial allocation of NECR.

Table 4. Summary of criteria for NECR crop allocation

Name	Source	Description
Slope	SRTM[32]	Slope in percentage is derived from the elevation at 100m resolution
Erosion-sensitive areas	PESERA[33]	European soil erosion risk map (units: ton/ha/a)
Climate conditions: Temperature and precipitation	EFSA (Europeann Food Safety Authority, Spatial Data Version 1.1) [34]	The mean annual temperature in Celsius degrees and the total mean annual precipitation in mm. Resolution: 1 km
pH soil	EFSA (Europeann Food Safety Authority, Spatial Data Version 1.1)	Map of Topsoil pH whose source is HWSD[35] v1.1. Resolution: 1 km
Soil type	European Soil data Base v2.0 [36]	Raster library of the Soil Geographical Database of Europe and PTRDB (PedoTransfer rules); resolution: 1km
Soil properties: texture, depth, salinity and drainage	SINFO project[37]	Data for the Soil Information System for the MARS Crop Yield Forecasting System based on ESDB
National designated areas	EEA[38]	Nationally protected areas
Length growing period and Frost free days	Global Agro-Ecological Zones[39]	Data from the Agro-climatic resources at global scale (5 arc min). LGP and FFD are measured in days.
Land uses	Corine Land Cover, 2006	Agriculture land and forestry

[32] http://srtm.usgs.gov/

[33] http://eusoils.jrc.ec.europa.eu/library/esdac/Esdac_DetailData2.cfm?id=7

[34] http://eusoils.jrc.ec.europa.eu/library/Data/EFSA/

[35] Harmonised World Data base: http://webarchive.iiasa.ac.at/Research/LUC/External-World-soil-database/HTML/index.html?sb=1

[36] http://eusoils.jrc.ec.europa.eu/ESDB_Archive/ESDB_data_1k_raster_intro/ESDB_1k_raster_data_intro.html

[37] http://eusoils.jrc.ec.europa.eu/library/data/sinfo/

[38] http://www.eea.europa.eu/data-and-maps/data/nationally-designated-areas-national-cdda-7

[39] http://www.gaez.iiasa.ac.at/

Energy crops, belonging to 2nd generation of biofuel, generally fall into two categories: herbaceous and woody crops (ligno-cellulosic). Broadly speaking, **herbaceous energy crops** are mostly perennial grasses. These grasses are usually harvested on a yearly basis. They regrow from their roots and do not require replanting for 15 years or more. The most representative species are:

- Miscanthus (Miscanthus spp.)
- Switchgrass (Panicum virgatum)
- Reed canary (Phalaris arundinacea)
- Giant reed (Arundo donax)
- Cardoom (Cynara cardunculus)

Woody energy crops are typically short rotation coppices (SRC), which are harvested on a 2-5 year cycle. Replanting of SRC is not necessary for 25 years or more (corresponding to around 6 harvests). There are used to produce electricity and/or heat, or can be converted to biofuels[40].

- Willow (Salix spp.)
- Poplar (Populus spp.)
- Eucaliptus (Eucaliptus spp.)

In order to create a suitability map for new energy crops, different criteria (factors and constraints) were established using multicriteria analysis technique. Suitability maps were created to represent the category with the highest probability of presence of aforementioned energy crops. Climate conditions, topography, soil properties, soil type and chemical composition of soil were selected as the most important criteria for each crop (Fischer et al., 2005, De Mastro et al., 2011; Garcia et al.). Table 5 illustrates the example of the Arundo donax crop in which main characteristics of climate, biophysical and environmental catalysts, are identified.

[40] 4FCROPS Future Crops for Food, Feed, Fiber and Fuel. Task 2.1. Choice of the crops. Departimeto di Scienze Agronomiche e delle Produzione animali. Univerita degli Studi di Catania, Italy

Table 5. Summary of biophisical criteria and environmental aspects

	Giant Reed (Arundo donax)
Main characteristics	- Giant reed is native to the Mediterranean area east through India and other subtropical environments. In the United States, giant reed has been reported to grow from California through the southern states to the eastern coast and as far north as Maryland. - Individual plants can tolerate excessive salinity. Giant reed can survive very low temperatures when dormant, but it is subject to serious frost damage after the start of spring growth or while it is still a seedling.
Frost free days	- Requires a minimum of 220 days
Soil properties	- While giant reed prefers well-drained soils where abundant moisture is available. - Giant reed grows on a variety of soil types including coarse sands, gravelly soil, heavy clays, and river sediments. - From heavy clays to sands and gravelly soils, and low quality such as saline ones. - Its growth is most vigorous in well-drained soils where moisture is abundant. - Adapted to Fine Textured Soils, Adapted to Medium Textured Soils. - Root Depth (Minimum): 61 cm
Soil pH	- Arundo donax grows in soils ranging from a pH of 4.8 (extremely acidic ranges from 0 to 5.1) to 8 (neutral ranges from 6.6 to 7.5)
Annual precipitation	- Giant reed occurs in areas with annual precipitation ranging from 300-4,000 mm.
Average temperature	- It is a warm-temperate or subtropical species, and is able to survive very low temperatures when dormant. It has optimum temperature between 24 – 30°C. Minimum temperature -13°C. - The base growth temperature reported for giant reed is 7°C, and a maximum cut-off is at 30°C
Local impact (positive or negative)	- It is also commonly found along roadsides and stream banks. Once established in wetland and riparian habitats, giant reed produces monotypic stands that displace native species. Dead and dry stands can pose a fire hazard. Giant reed also interferes with rivers and lakes by increasing sedimentation and narrowing water channels which leads to flooding and erosion - It typically grows along lakes, streams, drains and other wet sites. It is well adapted for establishment and spread in riparian areas with regular flood cycles. It is most commonly associated with waterways with altered hydrologic regimes (e.g., dams) and/or disturbed riparian vegetation, but can also establish in the understory of native riparian vegetation.

Six suitability classes were used to assign numerical values to each attribute belonging to each of the following eleven factors: temperature, precipitation, growing period length, frost-free days, soil pH, soil texture, soil drainage, soil type, slope and salinity. The attributes were classified as follows within these factor maps: Very suitable (highest adaptability), suitable, moderately suitable, low suitability, very low suitability and not suitable. A qualitative scoring was applied on the individual evaluation for the set of attributes of each factor through value judgement and literature review.

The annual temperature and the annual precipitation is attributed twice the weight in order to reflect the relative importance of these two factors within the context of the study. Consequently, a weighted linear addition is applied in order to obtain the suitability map for each energy crop as the sum of all scores of each factor.

In addition to these factors, several natural and artificial constraints were established. According to the RED, specifically Article 17: Sustainability criteria for biofuels and bioliquids[41], indicates that biofuels and bioliquids shall not be made from raw material obtained from land with specific status. Since not all the suitable land can be converted to energy crops, available land must be identified with the help of current land use data and also taking into account different degraded soils. Land availability for these crops is located within the UAA (Utilizable Agriculture Areas), marginal lands, abandoned lands and contaminated lands. The marginal land category is defined by soil salinity, pH, erosion, soil with mechanical limitations, lack of effective soil layer for rooting depth, water deficit, extremely hot or cold temperatures, steep slopes, etc[42].

All the maps of the biophysical components were elaborated (geo-referenced, processing, visualization, storage, spatial analysis, etc.) in a GIS environment. Finally, the overall suitability map for NECR was obtained as the merger of the eight individual suitability maps. The result is shown in Figure 9.

[41] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=Oj:L:2009:140:0016:0062:en:PDF

[42] 4FCROPS Future Crops for Food, Feed, Fiber and Fuel. Task 2.6. Cropping possibilities. Departimeto di Scienze della produzione agrarie e alimentari. Univerita degli Studi di Catania, Italy

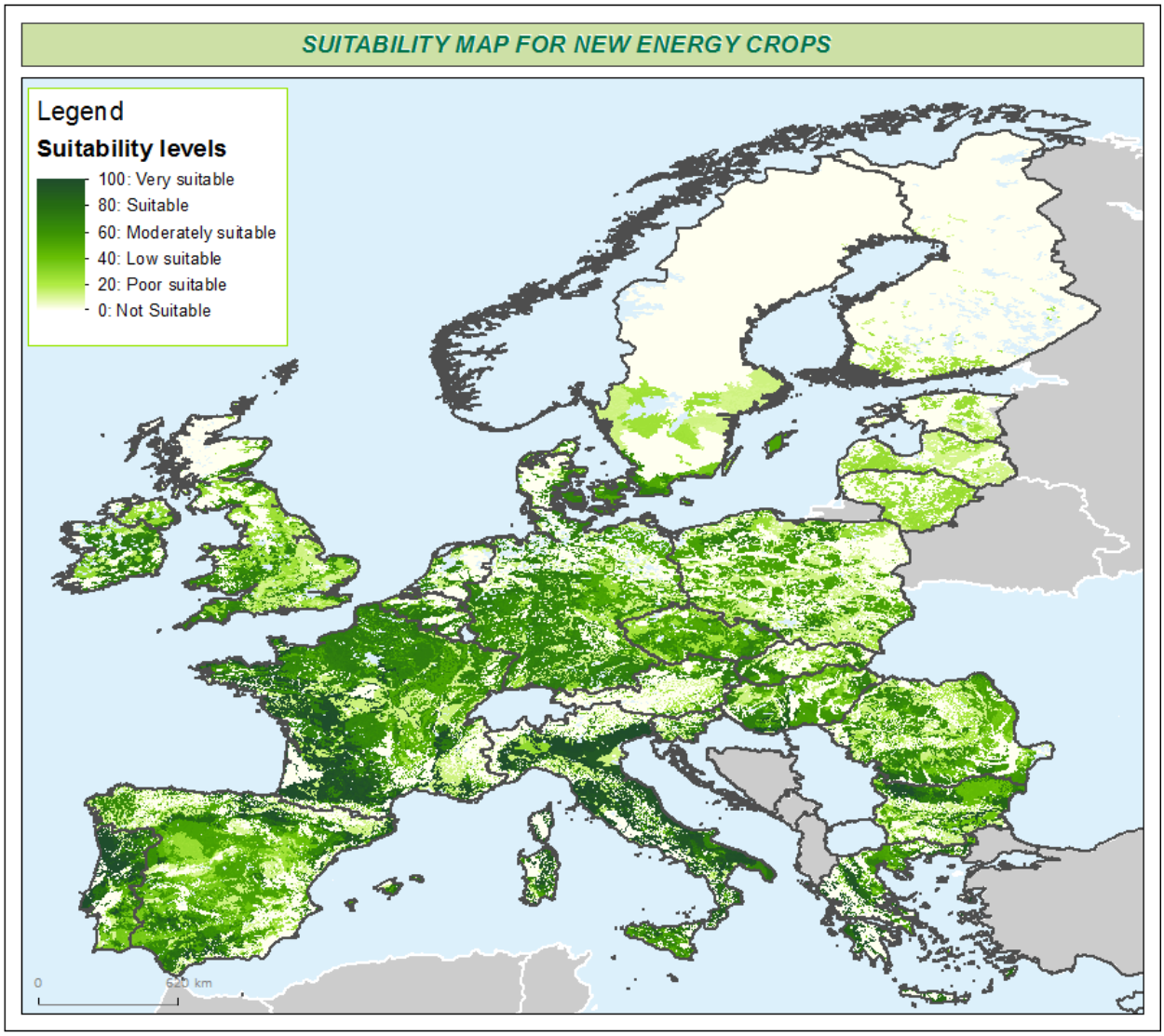

Figure 9. Suitability map for New Energy crops in europe

Although Figure 9 shows the biophysical suitability of land for new energy crops plantations, it does not represent the full area to which LUMP will actually allocate crops. Section 5.1.2 describes the policy-related restrictions implemented within LUMP in order to limit the growth of these crops in all biophysically-suitable areas.

6.3 Densification of urban land

In the former configurations of the LUMP, the new urban land requirements were calculated using a density algorithm whereby each NUTS 2 region is assigned an average density based on the extrapolation of past trends of population density using the Corine Land Cover and Eurostat data sets. Thus, each 1 ha cell represented an average density within each NUTS 2 region. Although this population density fluctuated according to trends, the fluctuating

density was temporal, but not spatial. Thus all built-up cells within the entire NUTS 2 region had the same density, albeit changing from year to year. This methodology produced satisfactory results, however the variability of population density within NUTS 2 regions was not captured for the present, and therefore, nor for the future forecasts. In the new implementation for the Reference scenario, LUMP integrates population density on a per-cell basis in the land use simulation. This provides a more realistic simulation of land required for urban uses as a result of changing population figures given by EUROPOP, and adds the spatial dimension to the already temporal density fluctuations within regions.

The integration of population density calculations within LUMP consists of four steps. First, a map of per-cell population potentials is computed. These population potentials are based on attracting factors, agglomeration benefits captured by population density in the neighbourhood, and the inherent capacities of different land-uses to host people. Although not incorporated in the Reference scenario, the computed population potentials can also depend on policy factors. After the population potentials are established, the amount of people that will be allocated in a region is established. This depends on the projected population change in a region and the assumption that 10% of a region's population will move within the region every year. The resulting sum of projected population change and intraregional movers can be positive or negative. The summed regional population change is scaled over all cells in the region in such a way that the cells with the highest population potential receive the largest population change. Finally, the model defines if a non-urban cell becomes urban land-use (if population in the cell exceeds *6*) or if an urban cell becomes abandoned urban land-use (if population in the urban cell drops below *2*). The outcome of the population allocation mechanism thus consists of per pixel population densities, and urban land uses which depend on the spatial distribution of inhabitants.

6.4 Industrial land claims

The estimation of demand for industrial and commercial areas is done through an 'intensity approach'. The land use intensity is estimated by relating the economic output (GVA) of a given sector s to the land area A known to be used by sector s in t_0 (eq. 1). The observed land use intensity per sector can then be used to estimate the total industrial and commercial land for any given t_1 (eq. 2). Conceptually, this formulation allows the integration of land use

intensities specific to n number of sectors. For the Reference scenario, three sectors are considered: industry, commerce and services. The sectorial GVA for t_0 is taken from the Eurostat online database, whereas the sectorial GVA for t_1 is derived from the GEM-E3 simulations.

$$LUI_{s,t_0} = \frac{GVA_{s,t_0}}{A_{s,t_0}}, with\ s \in \{1 = \text{"industry"}, 2 = \text{"commerce"}, 3 = \text{"services"}\} \quad (1)$$

$$A_{t_1} = \sum_{s=1}^{n} \left(\frac{GVA_{s,t_1}}{LUI_{s,t_0}} \right) + \varepsilon \quad (2)$$

An empirical exercise conducted for Spain and the Netherlands using detailed national land use datasets for circa 2006 showed that $LUI_{commerce} > LUI_{services} > LUI_{industry}$ consistently for all NUTS2 regions. In fact, on average, it was found that $LUI_{commerce} = LUI_{industry} * 27.6$ and that $LUI_{services} = LUI_{industry} * 6.7$. 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 $A_{s,t0}$ of equation 1.

The main assumption of this approach is that the intensity of ICS land, measured in economic terms for a given year in the past, remains unchanged in time. Therefore, the predicted demand for ICS land 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 production structure between regions, as well as to the changes in time in the production structure within each region: if in a given region the "commerce" sector is predicted to grow while the "services" and "industry" sectors are predicted stagnate, the estimated impact on land use will be relatively small due the high intensity of commercial land. On the other hand, a region where considerable growth is estimated for the industrial sector should require a more significant amount of land due to the low land use intensity of the industrial sector as a whole.

This approach can be adapted to incorporate policy and technological aspects. For instance, land use intensities of the industrial sector can be set to increase in time in order to reflect expected technological improvements and/or policy targets.

6.5 Transportation module

Potential interactions with actors such as people, businesses, employers and customers are a considerable influence on the location of urban development. Those potential interactions largely depend on transport supply. Up to now, the interaction opportunities that transport networks provide have been modelled in LUMP by means of static maps that represent travel-times to towns or cities. However, an approach based on such static maps cannot take into account that both transportation networks and the locations and densities of potential actors (such as people, jobs and businesses) may change over time, and as a result of previous land-use developments. In the new transportation module endogenous accessibility measures are computed within LUMP. Those measures are subsequently used to allocate people and land-uses in the LUMP model.

In the transport module, potential accessibility measures Ai are computed by means of:

$$A_i = \sum_{j=1} P_j f(c_{ij}),$$

in which A is accessibility at location i; P is a population count per regional entity *j*; and $f(c_{ij})$ is a function of the travel time between *i* and *j*. A is computed for circa 199,000 points in Europe. The resulting values are spatially interpolated on the 100 x 100 m grid used in LUMP, using an Inverse Distance Weighting method. The population counts *P* are aggregated from the raster of population densities described in Section 6.33, and P is thus wholly endogenous. Because in LUMP countries or sizeable regions are modelled independently, those endogenous population densities are only available within one region (the 'active region') while the model is running. The mentioned regional entities *j* are NUTS3 zones within that active region; and NUTS2 zones (for which population forecasts are produced by EUROPOP) outside of that region. Lastly, the travel-times are obtained from shortest path algorithms that analyse a transport network within LUMP. Currently the Trans-Tools network, and its database of approved network upgrades, is used to obtain current and future travel-times in the Reference scenario. The obtained travel-times are converted using distance decay

function *f,* which is an empirically estimated S-shaped function established by Geurs and Ritsema van Eck (2003).

7 Policy initiatives to be implemented in the future

The configuration of the Reference scenario is a "living" configuration in that it will be updated to follow the changes made within the modelling framework of the DG ENER and DG CLIMA scenarios. This implies updating the Reference scenario within LUMP when changes are made in models upon which LUMP is dependant (CAPRI, PRIMES, GEM-E3 and G4M/GLOBIUM). This chapter is a short summary of upcoming policy initiatives that may be included in the LUMP in the near future.

7.1 2013 CAP reform

A set of regulations describing the legislative framework of the Common Agricultural Policy (CAP) for the Multiannual Financial Framework period 2014-2020, is due to be finalized at the end of 2013. A public debate held in 2010 led to a Communication in 2008 (COM(2010) 672 final)[43] on possible reforms within the CAP. The impacts on land cover of enhanced targeting and greening of direct payments, described within the Integration scenario, were analysed used as the basis for a modelling exercise generated by the LUMP group (Lavalle et al 2011). Following the debate with stakeholders and institutions, a set of legal proposals was presented in October 2011[44]. Although the there is a strong emphasis on the greening aspects of the CAP, and the hint that the Integration scenario is most balances in terms of aligning the CAP with the EU's strategies, the approval of different regulations will only come at the end of 2013 (to be effective January 1, 2014). Thus, the implementation of CAP reform cannot be finalized.

7.2 Floods Directive

Directive 2007/60/EC refers to the assessment and management of flood risks. Member States are required to assess water courses and coastlines for the risk to flooding. Mapping

[43] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0672:FIN:EN:PDF

[44] http://ec.europa.eu/agriculture/cap-post-2013/legal-proposals/index_en.htm

of flood extent and risk for people and assets is required under this Directive. The flood risk maps are only due in 2013, according to the deadlines and milestones described within the Directive. If available on time, these maps could provide a basis for restricted growth of assets, including settlements. The picture will become clearer in 2015, when MS are required to establish flood risk management plans consistent with the river basin management plans required by the Water Framework Directive[45].

The implications of the Floods Directive on the Reference scenario within LUMP will be important once the protection and management plans for flood-prone areas are identified. The Blueprint to Safeguard Europe's Water resources [46] (Communication from the Commission (COM(2012)673) gave several EU-wide recommendations including the limitation of urban and industrial growth in protected areas; and the implementation of Natural Water Retention Measures (NWRM, such as buffer strips, reforestation, and adapted crop practices). If these strategies are enforced in the River Basin Management Plans compiled by the MS they could be included in the Reference scenario in the future.

7.3 Land use, Land use change and forestry and the EU's climate change commitments

According to the UNFCC[47], developed countries should collectively reduce GHG emissions by 80 to 95% with respect to 1990 values. The Communication on Land use, land-use change and forestry (LULUCF), COM(2012) 94[48] was born from this commitment because LULUCF is considered to be an efficient counteraction to GHG emissions from other sectors. This measure would clearly have implications in LUMP if it moves beyond the obligation to report and towards action. Up to now, the LULUCF sector would not be formally included in the EU's emission reduction targets, and will therefore not be included in LULUCF-related current legislation in the LUMP Reference scenario.

7.4 Guidelines on best practice to limit, mitigate or compensate soil sealing

[45] http://ec.europa.eu/environment/water/water-framework/

[46] http://ec.europa.eu/environment/water/blueprint/

[47] Decision 1/CP.16 of the Conference of Parties to the UNFCCC (the "Cancún Agreements"

[48] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2012:0094:FIN:EN:PDF

One of the main causes for soil degradation in Europe is sealing it with impermeable materials. Soil sealing has clearly negative implications in flood risk, among other things, and irreversible landscape conversions. Sealing will be addressed in the Soil Thematic Strategy and proposal for a Soil Framework Directive[49] [50]. Guidelines[51] are native to the Roadmap to a Resource Efficient Europe, to assist in achieving the no net land take milestone for 2050. At the time of writing, no policy provisions are yet available for implementation in LUMP at European level.

7.5 Green Infrastructure and Restoration

Green Infrastructure could become an umbrella tool to fight habitat loss and fragmentation, and thus biodiversity loss in Europe[52], while offering valuable regulatory ecosystem services. Within the Biodiversity Strategy (2011)[53], the development of a GI strategy is foreseen (Action 6) and thus not yet finalized. The reference for Green Infrastructure will be the Biodiversity Strategy until further notice.

[49] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2006:0232:FIN:EN:PDF

[50] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2002:242:0001:0015:EN:PDF

[51] http://ec.europa.eu/environment/soil/pdf/sealing/publication.pdf

[52] http://www.fedenatur.org/docs/docs/583.pdf

[53] http://ec.europa.eu/environment/nature/biodiversity/comm2006/2020.htm

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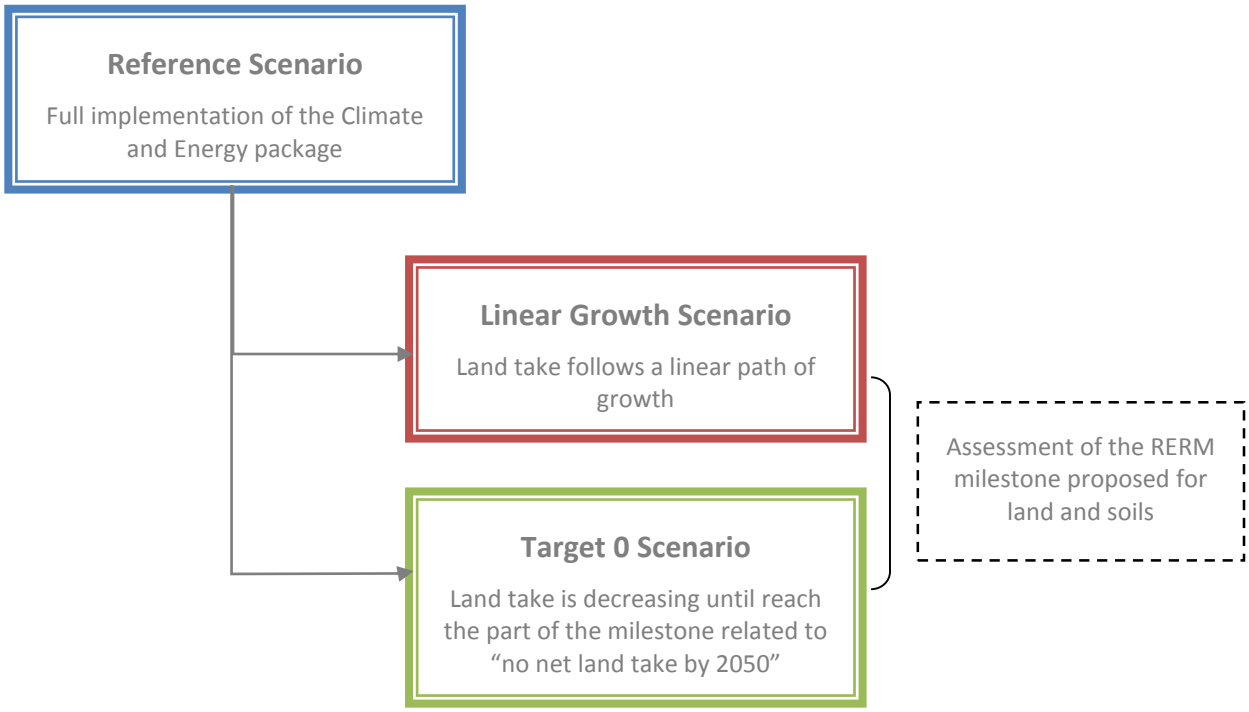
Annex I: Scenarios

Roadmap to a Resource Efficient Europe

The description of the RERM scenarios depends on the milestone regarding land and soils, proposed in the Roadmap. As shown in Figure I1, two scenarios will be evaluated:



"Linear Growth"

For this scenario, it is foreseen that the land take growth will continue following the past trend of growth (2000 and 2006). Small and dispersed settlements dispersed are not discouraged, nor is urban sprawl and the urbanization of suburbs. These growth patterns are only restricted by the pre-existing framework protected areas (Natura 2000 and National Designated Areas). The land claimed to satisfy the requirements from the urban and industry/commerce/services sectors provides an input for the model allocation module, specifying the amount of the land per each active land-use per region. This amount of land claimed will be adjusted in order to fit the expected land take for 2050 for these built-up classes.

"Target 0"

The main goal of the Land Take scenario is to control the urban sprawl and improve land efficiency by implementing a target that constrains the urban development by 2050 "zero land take by 2050". The structure of settlements is more compact, continuous and densely populated in order to reduce the amount of land occupied by the built-up land use classes. This type of landscape can be encouraged mainly through the manipulation of the neighborhood effects. These represent the attractiveness that a certain land use can exert on its neighboring land use classes, as well as on itself. The higher the factor of "self-attractiveness" for new built-up areas, the more compact they will be.

Cohesion Policy

The Policy scenario for DG REGIO is based on the Reference scenario but contains specificities related to the Cohesion Policy for the periods 2007-2013 and 2014-2020. The Policy and the Reference scenarios represent, respectively, a future Europe with and without Cohesion Policy. In order to correctly capture this difference, the actual Reference Scenario used will actually be a spin-off of the one described in this document. In this version of the "Reference Scenario", the effects of the Cohesion policy will be removed, namely the new expected transport infrastructure.

The Policy Scenario for DG REGIO is based on the above mentioned version of the Reference Scenario, and is defined by the following specific components:

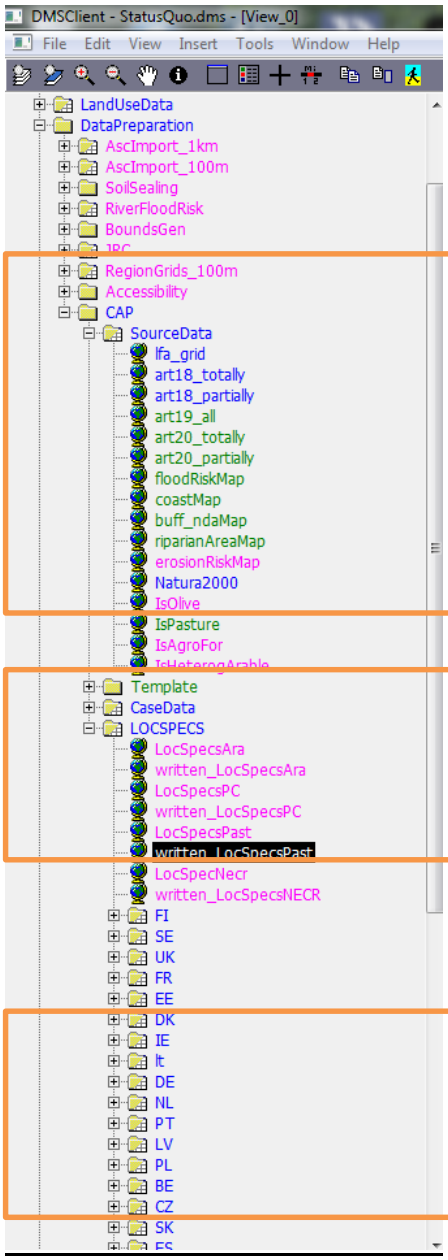
1. Economy: the input from the Rhomolo model;
2. Population projections and urban policies;
3. Implementation of the TEN-T network;
4. The regional and thematic allocation of the cohesion funds (thematic priorities).

The Policy scenario itself will have two branches: a) A branch in which no specific policies for urban development are set; b) including specific policies to encourage compact development, polycentrism and requalification of urban centers, and restricting urban development in sensitive and/or vulnerable areas.

Annex II: Implementation of CAP within LUMP

Figure A1 shows the rule-base as it has been built-in to the land use model graphical user interface. A separate container called “Source Data” has been created to encompass all spatial aspects of the CAP. These spatial layers may be recalled in this container in their original format, for example Natura 2000, or they may have been modified, for example a buffered Nationally Designated Areas map. The Case Data container contains MS-specific criteria regarding Articles 18, 20 and the GAECs. The “LOCSPECS” container is the result of the computation of the individual MS-level rule-sets for four different land uses related to agriculture: Arable land, permanent crops, pasture and new energy crops.

The specific rules applied to the MS are described in Table A1. The first column (green) is relevant to the Natura 2000 site subsidization of agricultural land under Natura 2000 sites. The following four columns (orange) are used to refine the areas that are “partially” within the Article 18 areas. The following 5 columns (blue), are used to refine polygons falling “partially” within the Article 20 LFAs (EROS=erosion; NDA=Nationally designated areas; RIP=Riparian). The final two columns (white), are to account for classes affected by the GAEC. These classes are very difficult to remove from their current state in the countries where they are flagged as “true”. Other classes that were originally isolated to be used in the development of the locspecs as spatial parameters to encourage the continuation of the current land use, are those corresponding to heterogeneous agricultural land (CLC classes 19,20,21). It was not possible to really justify this inclusion however, so the classes were removed as criteria.



Link to relevant source data is in this container for quick access for viewing

Computation of Loc Specs for Arable land, permanent crops, pastures and new energy crops

LocSpecs can also be computed per MS individually

Figure A1. Implementation of CAP-related spatial rules in LUMP

Table A1. MS-specific rules for agricultural land subsidies under the RDR

	N2k	Max Elev	Max Slope	Elev4 Comb	Slope4 Comb	Eros	Flood Risk	Coast	NDA	Rip	Olive	Past
FI	false	x	x	x	x	x	false	false	false	false	false	true
SE	false	x	x	x	x	x	false	false	false	false	false	false
UK	false	x	x	x	x	x	false	false	false	false	false	true
FR	false	800	11	500	9	x	false	false	false	false	true	true
EE	true	x	x	x	x	x	false	true	false	false	false	false
DK	false	x	x	x	x	x	false	false	false	false	false	false
IE	false	x	x	x	x	x	false	false	false	false	false	false
LT	true	x	x	x	x	x	false	false	false	false	false	false
DE	true	800	x	600	10	x	false	true	false	false	false	false
NL	false	x	x	x	x	x	true	false	false	true	false	true
PT	true	750	14	400	9	x	false	false	false	false	false	false
LV	true	x	x	x	x	x	false	false	false	false	false	false
PL	false	500	x	x	x	10	false	false	false	false	false	false
BE	true	x	x	x	x	x	true	false	false	false	false	true
CZ	true	600	x	500	7	x	false	false	false	false	false	true
SK	true	700	11	500	8	x	false	false	false	false	false	true
ES	true	1000	11	600	8	x	false	false	true	false	false	false
AT	true	700	11	500	9	x	true	false	false	false	false	false
HU	true	x	x	x	x	x	true	false	false	false	false	false
RO	false	x	x	x	x	x	false	false	false	false	false	false
IT	true	800	11	600	9	x	true	false	false	false	true	false
SI	false	700	11	500	9	x	true	false	false	false	false	false
GR	true	800	11	600	9	x	false	false	false	false	false	true
BG	false	x	x	x	x	x	false	false	false	false	false	false
MT	false	x	x	x	x	x	false	false	false	false	false	false
CY	true	800	x	500	9	50	false	false	false	false	false	false

7.5.1.1 Data sources

Table A2 summarises the data sources used to define the Article 16, 18, 20 and GAECs.

Table A2. Data sources for delimitation of areas eligible for funding

Name	Source	Description
Natura 2000	EEA, April 2012 download	Polygons delimiting the latest Natural 2000 sites, irrespective of conservation status
Elevation and slope	SRTM[54]	Elevation in meters; slope in degrees is derived from the elevation at 100m resolution
Erosion-sensitive areas	PESERA[55]	European soil erosion risk map (units: ton/ha/a)
Flood risk areas	Alfieri et al (in press)[56]	Flood hazard map for Europe which contains flood extent and water depth based on a 100 year return period event for current climate (spatial resolution 100 x 100 m)
Coastal zones	Lavalle et al 2011[57]	10km buffer from coastline (obtained from administrative boundaries – GISCO); a 2km buffer from aggregation of five Corine Land Cover classes Coastal wetlands (salt marshes, salines, and intertidal flats); Marine waters (coastal lagoons, estuaries)
Nationally designated areas	EEA[58]	Nationally protected areas
Riparian areas	Clerici et al 2011[59]	Map of riparian areas based on biophysical features
Land uses	EEA, Corine Land Cover 2006	Pasture, Grassland, Olives and agro-forestry regions

[54] http://srtm.usgs.gov/

[55] http://eusoils.jrc.ec.europa.eu/library/esdac/Esdac_DetailData2.cfm?id=7

[56] Alfieri L., Salamon P., Bianchi A., Neal J., Bates P., Feyen L. (2013) Advances in pan-European flood hazard mapping. Under preparation for submission to Journal of Hydrology.

[57] http://ec.europa.eu/environment/enveco/impact_studies/pdf/land_use_modelling%20adaptation_activities_coastal.pdf

[58] http://www.eea.europa.eu/data-and-maps/data/nationally-designated-areas-national-cdda-7

[59] http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/16201/1/lb-na-24774-en-c.pdf

7.5.1.2 *Results of CAP implementation*

Figures A2-A4 show some results of the implementation (computed directly within LUMP and exported to Arc Map for display). Northern Germany is highlighted in the first figure of this series, whereby the arable land in the coastal zones and Natura 2000 areas are eligible for subsidies.

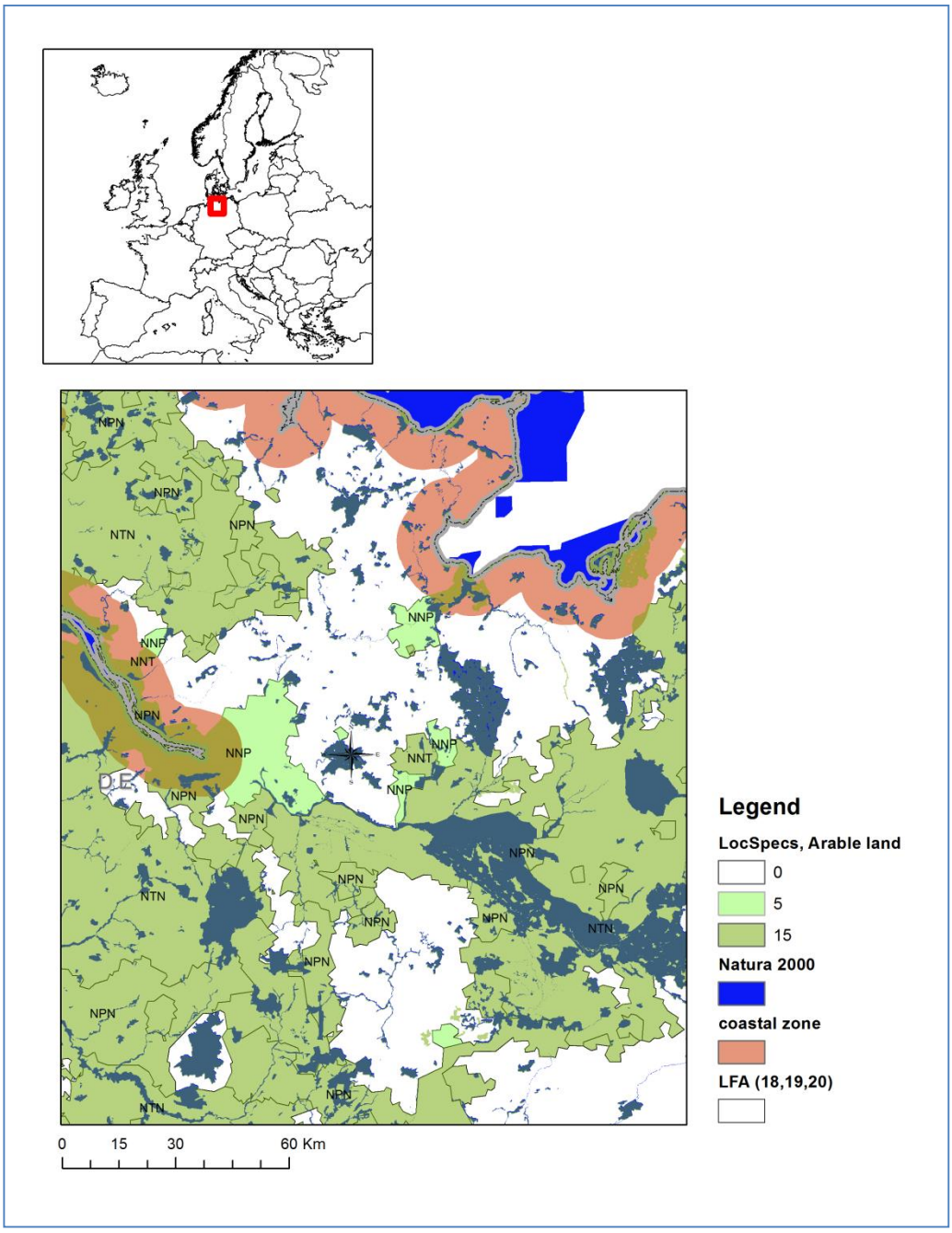


Figure A2. computed Loc specs map for arable land in n. Germany

In the next Figure, a different set of criteria applies. In the Netherlands, Natura 2000 sites were not considered eligible, but flood risk and riparian areas were. The country does not have any areas under articles 18 or 19, and the article 20 areas are all "partially" considered.

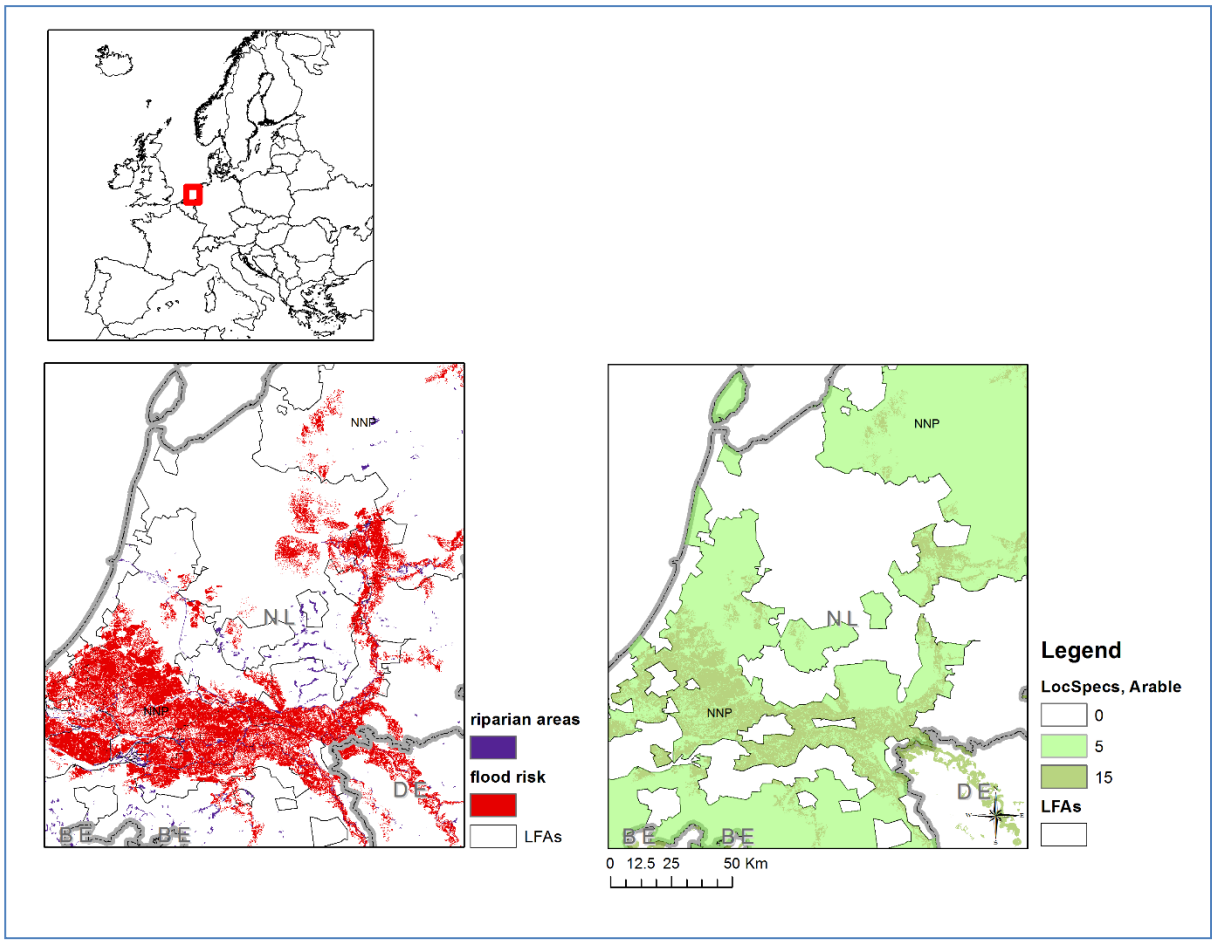


Figure A3. Computed Loc specs map for arable land in the Netherlands

In Slovenia, there are many partial polygons under article 18. The slope and elevation criteria are therefore evident in the refinement of areas falling "partially" within this area.

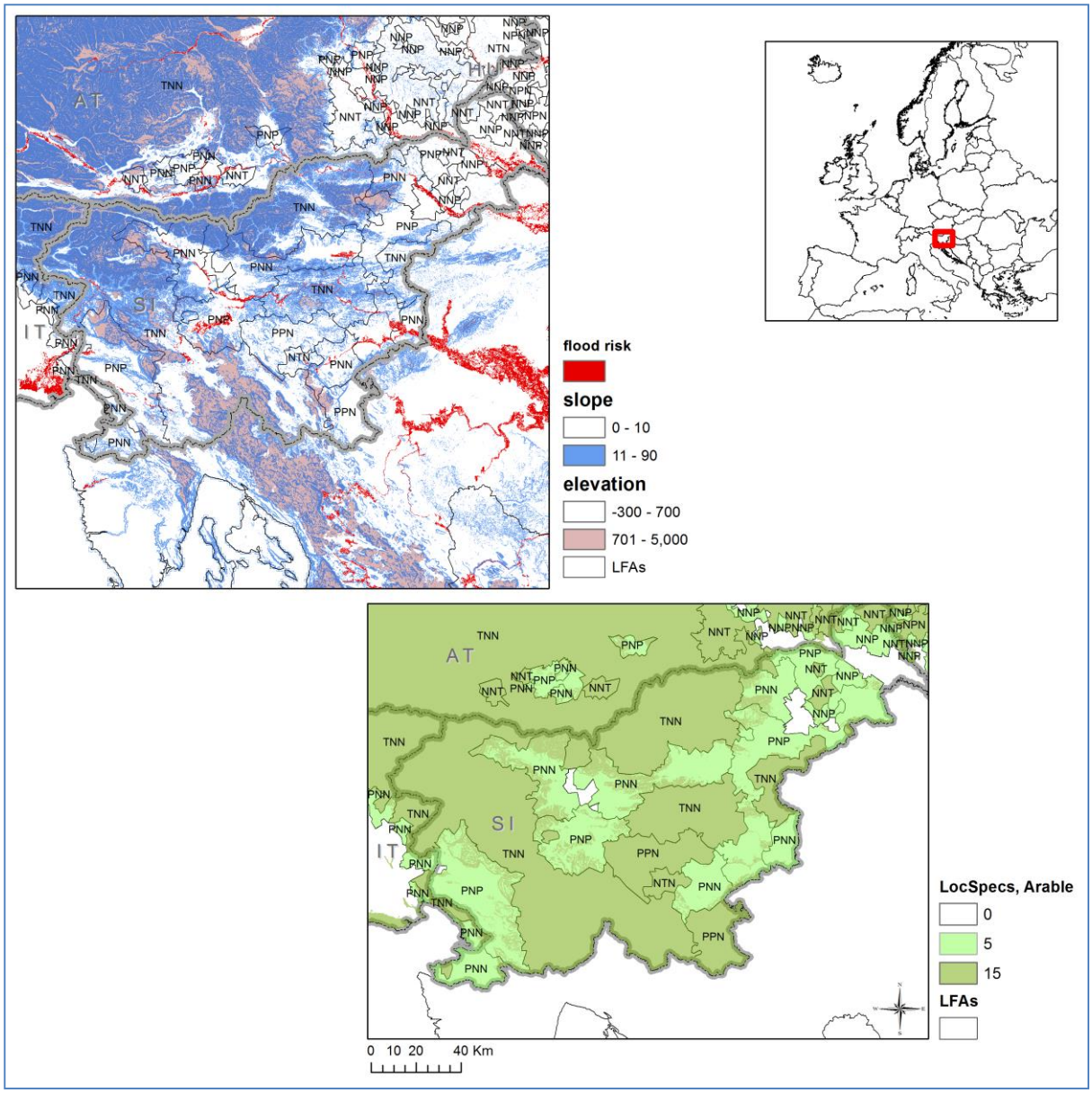


Figure A4.Computed locspecs map for arable land in Slovenia

Annex III: Inventory of legal measures and Community financial support included in a 2050 Reference scenario

Policy assumptions relevant for the elaboration of the PRIMES baseline 2009 and the 2050 Reference scenario, including the implementation of current policies.

1. PRIMES Baseline 2009

The 2009 Baseline includes policies and measures implemented in the Member States by April 2009 and legislative provisions adopted by April 2009 that are defined in such a way that there is almost no uncertainty how they should be implemented in the future:

	Measure		**Adoption**	**How the measure is reflected in PRIMES**
Regulatory measures				
	Energy efficiency			
	Ecodesign implementing measures			
1	Stand-by	Regulation No 1275/2008	2008	Adaptation of modelling parameters for different product groups. As requirements concern only new products, the effect will be gradual (none in 2010; rather small in 2015 and up to full effect by 2030)
2	Simple Set-to boxes	Regulation No 107/2009	2009	
3	Office/street lighting	Regulation No 245/2009	2009	
4	Household lighting	Regulation No 244/2009	2009	

5	External power supplies	Regulation No 278/2009	2009	
6	Labelling Directives	Directive 2003/66/EC	2003	Enhancing the price mechanism mirrored in the model
7	Cogeneration Directive	Directive 2004/8/EC	2004	National measures supporting cogeneration are reflected
8	Directive on end-use energy efficiency and energy services	Directive 2006/32/EC	2006	National implementation measures are reflected
9	Buildings Directive	Directive 2002/91/EC	2002	National measures e.g. on strengthening of building codes and integration of RES are reflected
	Energy markets and power generation			
10	Completion of the internal energy market (including provisions of the 3rd package)	http://ec.europa.eu/energy/gas_electricity/third_legislative_package_en.htm		The model reflects the full implementation of the Second Internal market Package by 2010 and Third Internal Market Package by 2015. It simulates liberalised market regime for electricity and gas (decrease of mark-ups of power generation operators; third party access; regulated tariffs for infrastructure use; producers and suppliers are considered as separate companies).

11	EU ETS directive	Directive 2009/29/EC	2009	Cap for GHGs is respected[60]; additional financing for CCS in the order of several billion euros by 2013 from the New Entrants Reserve is reflected as support to CCS
12	Energy Taxation Directive	Directive 2003/96/EC	2003	Tax rates (EU minimal rates or higher national ones) are kept constant in real term. The modelling reflects the practice of MS to increase tax rates above the minimum rate due to i.a. inflation.
13	Large Combustion Plant directive	Directive 2001/80/EC	2001	Emission limit values laid down in part A of Annexes III to VII in respect of sulphur dioxide, nitrogen oxides and dust are respected; derogations are taken into account
14	IPPC Directive	Directive 2008/1/EC	2008	Costs of filters and other devices necessary for compliance are reflected in the parameters of the model
15	Directive on the geological storage of CO2	Directive 2009/31/EC	2009	Enabling measure allowing economic modelling to determine CCS penetration
16	Directive on national emissions' ceilings for certain pollutants	Directive 2001/81/EC	2001	Checked with RAINS/GAINS modelling regarding classical pollutants (SO2, NOx)

[60] For the allocation regime for allowances in 2010, the current system based on National Allocation Plans and essentially cost-free allowances is assumed, with price effects stemming from different investment and dispatch patterns triggered by need to submit allowances. For the further time periods, in the power sector there will be a gradual introduction of full auctioning, which will be fully applicable from 2020 onwards, in line with the specifications of the amended ETS directive.

For the other sectors (aviation and industry), the baseline follows a conservative approach which reflects the specifications in the directive on the evolution of auctioning shares and the provisions for free allocation for energy intensive sectors based on benchmarking.

17	Water Framework Directive	Directive 2000/60/EC	2000	Hydro power plants in PRIMES respect the European framework for the protection of all water bodies as defined by the Directive
18	Landfill Directive	Directive 99/31/EC	1999	Provisions on waste treatment and energy recovery are reflected
	Transport			
19	Regulation on CO2 from cars	Regulation No 443/2009	2009	Limits on emissions from new cars: 135 gCO2/km in 2015, 115 in 2020, 95 in 2025 – in test cycle
20	Regulation EURO 5 and 6	Regulation No 715/2007	2007	Emissions limits introduced for new cars and light commercial vehicles
21	Fuel Quality Directive	Directive 2009/30/EC	2009	Modelling parameters reflect the Directive, taking into account the uncertainty related to the scope of the Directive addressing also parts of the energy chain outside the area of PRIMES modelling (e.g. oil production outside EU).
22	Biofuels directive	Directive 2003/30/EC	2003	Support to biofuels is reflected in the model
23	Implementation of MARPOL Convention ANNEX VI	2008 amendments - revised Annex VI	2008	Amendment of Annex VI of the MARPOL Convention reduce sulphur content in marine fuels which is reflected in the model by a change in refineries output
Financial support				
24	TEN-E guidelines	Decision No 1364/2006/EC	2006	The model takes into account all TEN-E realised infrastructure projects
25	EEPR (European Energy programme for Recovery)	Regulation No 663/2009	2009	Financial support to CCS demonstration plants; off-shore wind and gas and electricity interconnections is reflected in the model

26	RTD support (7th framework programme-theme 6)	energy research under FP7		Financial support to R&D for innovative technologies such as CCS, RES, nuclear and energy efficiency is reflected by technology learning and economies of scale leading to cost reductions of these technologies
27	State aid Guidelines for Environmental Protection and 2008 Block Exemption Regulation	Community guidelines on state aid for environmental protection	2008	Financial support to R&D for innovative technologies such as CCS, RES, nuclear and energy efficiency is reflected technology learning and economies of scale leading to cost reductions of these technologies
National measures				
28	Strong national RES policies			National policies on e.g. feed-in tariffs and green certificates
29	Nuclear			Nuclear, including the replacement of plants due for retirement, is modelled on its economic merit and in competition with other energy sources for power generation except for MS with legislative provisions on nuclear phase out. Several constraints are put on the model such as decisions of Member States not to use nuclear at all or closure of existing plants in some new Member States according to agreed schedules. Member States experts were invited to provide information on new nuclear investments/programmes and commented on the PRIMES baselines results in spring 2009, which had a significant impact on the modelling results for nuclear capacity.

2. Reference scenario 2050

The Reference scenario, in addition to all measures already reflected in the baseline, includes 4 Eco-design implementing measures; the implementation of the Directive on Labelling of Tyres; the implementation of the Recast of the EPBD and; regulation Euro VI for heavy duty vehicles and the proposal on CO2 from vans. These measures were adopted between April 2009 and March 2010. **It also assumes that national targets under the Renewables directive and the GHG Effort sharing decision are achieved in 2020**.

	Measure		**Adoption**	**How the measure is reflected in PRIMES**
	Ecodesign implementing measures			
1	TVs (+labelling)	Regulation No 642/2009	2009	Adaptation of modelling parameters for different product groups for Ecodesign and decrease of perceived costs by consumers for labelling (which reflects transparency and the effectiveness of price signals for consumer decisions). As requirements and labelling concern only new products, the effect will be gradual (none in 2010; rather small in 2015 up to full effect by 2030)
2	Electric motors	Regulation No 640/2009	2009	
3	Circulators[61]	Regulation No 641/2009	2009	

[61] Circulator is an impeller pump designed for use in heating and cooling systems. Glandless standalone circulators and glandless circulators integrated in products are covered by this regulation.

4	Freezers/refrigerators (+labelling)	Regulation No 643/2009	2009	
5	Recast of the EPBD	Not yet published. Text agreed by the EP and Council in November 2009.	2009	Better thermal integrity of buildings and requirements for new buildings after 2020
6	Labelling directive for tyres	Regulation No 1222/2009	2009	Decrease of perceived costs by consumers for labelling (which reflects transparency and the effectiveness of price signals for consumer decisions)
7	Regulation Euro VI for heavy duty vehicles	Regulation (EC) No 595/2009	2009	Emissions limits introduced for new heavy duty vehicles.
8	Regulation on CO2 from vans[62]	Part of the Integrated	2010/2011	Limits on emissions from new LDV: 181 gCO2/km in 2012, 175 in 2016, 135 in 2025 – in test cycle

[62] On 28 October 2009 the European Commission adopted a new legislative proposal to reduce CO2 emissions from light commercial vehicles (vans). The draft legislation is closely modelled on the legislation on the CO2 emissions from passenger cars (Regulation 443/2009) and it is part of the Integrated Approach taken by the Commission in its revised strategy to reduce CO2 emissions from cars and light commercial vehicles (COM(2007) 19 final). Not including this proposal in the 2050 Reference scenario could lead to an increased bias towards vans, which is not justified given the likelihood of its adoption towards the end of 2010/beginning of 2011.

		Approach to reduce CO2 emissions from cars and light commercial vehicles.		
9	RES directive	Directive 2009/28/EC	2009	Legally binding national targets for RES share in gross final energy consumption are achieved in 2020; 10% target for RES in transport is achieved for EU27; sustainability criteria for biomass and biofuels are respected; cooperation mechanisms according to the RES directive are allowed and respect Member states indications on their "seller" or "buyer" positions
1	GHG Effort Sharing Decision	Decision 406/2009/EC	2009	National targets for non-ETS sectors are achieved in 2020, taking full account of the flexibility provisions such as transfers between Member States. After 2020, stability of the provided policy impulse but no strengthening of targets is assumed.

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Abstract

The definition of the Reference Scenario assumes full implementation of the Climate and Energy package. The legislation included within the Climate and Energy Package is reflective of the legally binding targets to ensure that the EU meets its climate and energy targets for 2020. This scenario assumes that national targets under the Renewables directive (2009/28/EC) and the GHG Effort-sharing decision (2009/406/EC) are achieved.

The purpose of this document is to describe how the Land Use Modelling Platform was configured in order to be consistent with the PRIMES and other upstream models within the integrated modelling chain, including the incorporation of the legally binding objectives, directives and regulations.

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