The EURURALIS study: Technical document

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ABSTRACT

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EURURALIS is developed for policy makers dealing with the future of agriculture and other land use in the enlarged Europe of 25 member states. Expecting that major developments affect the rural areas in Europe pro-active rural policy has to be informed timely and in a targeted and crispy way. A scenario study was launched that built upon : I) recognizable and internationally authorized scenarios encompassing drivers such as global developments like world trade, climate change, demography, II) predicted transformations in land use (area, regions, intensity), III) impacts on the various domains of sustainability (People, Planet, Profit) and IV) possibilities of policy instruments. The study builds upon IPCC and related scenarios, though adapted for our goals, a global economy model (GTAP/LEITAP) linked to an environmental model (IMAGE) and thirdly a land use allocation model (CLUE). Modelling outcomes were generated for 30 years in 10 year time steps; indicators were selected from economical, socio-cultural and environmental/ecological domains respectively. Meta-indicators were added to offer overview. The product is tuned to non-specialists and offers many graphs, maps and texts for easy use in policy, research and education. This background document aims not to deliver the contents of the CD Rom in a hard copy version, but focuses on policy context, leading concepts, methods and data. It also offers discussions on desired improvements and ways to expand the current 1.0 version.

Trefwoorden: scenarios, driving forces, sustainable development, indicators, policy orientation, land use models

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Preface

The EURURALIS study , version 1.0 , "A scenario study on Europe's rural areas to support policy discussion", was carried out in 2004 in about 10 months. A number of 58 people, researchers, data processors, software engineers, designers and various others were involved to cover the complex terrain of scenarios, driving forces in- and outside Europe, modelling in a complicated set of models and presenting results in a crispy, digestible and policy oriented application. Taking into account the time frame and the number of people involved, it reveals that such a project was executed in a pressure cooker atmosphere. The tight time frame had to do with the Dutch presidency of the EU in the latter half of 2004 and more specifically the launching of the CD Rom during the meeting of directors rural development of most of the relevant ministries of all member states of the enlarged EU (EU 15 + EU 10) held in Castle Groeneveld (Baarn). The CD Rom contains the essentials of the project insofar interesting for policy makers and others committed to the future of the rural areas in Europe. So far our impression is that the CD Rom draws due attention and seems to fulfil its goals pretty well for policy makers, colleague researcher and for educational goals.

This background document tries to give technical information in more depth on policy context, conceptual aspects, scenarios chosen, modelling and the question how to connect various models, the choice of indicators and meta-indicators and eventually recommendations for policy makers and further research.

Readers may find the contents rather technical and scientific in nature.We did not bother to compose a very balanced, carefully edited repor. Its primary function is to present basic information on context and concepts, assumptions, modelling specifics and data. It forms the memory of the project. It is advised to interpret this text in direct relationship with the CD Rom, that is more user friendly, visual and colourful.

On behalf of the authors,

The editors,

Jan Klijn

Wies Vullings

Acknowledgements

The initiative to launch the EURURALIS study was taken within the working group Sustainable Development and Systems Innovation, Wageningen University and Research (In Dutch: Werkgroep Duurzame Ontwikkeling en Systeeminnovatie = DOS. Professor Rabbinge and Professor Bouma paved the path within the Ministry of Agriculture, Nature and Food Security that made funds available . Their interest was enforced by the fact that The Netherlands was chairing the EU during the latter half of 2004. On behalf of the Ministry aPolicy Advisory Group (PAG) was installed to give advice on the policy relevance and presentation mode of EURURALIS. The members of the PAG were:

- H.E. van Latesteijn
- S. Mager
- G. Meester
- M.Remmers
- J. Bakker
- T. Breimer
- J.G. Deelen

Next to mention is the Scientific Advisory Group (SAG) giving their contribution in designing the project and helping the team in all other ways. The members of the SAG were:

- J.M. Boussard (INRA-CIRAD, France)
- M. Baranowski (Director UNEP-GRID, Poland)
- J. Bouma (Former professor Wageningen UR): chair
- R. Rabbinge (professor Wageningen UR)
- J. Blom (Deputy director Agricultural Economics Institute (LEI))
- K. van Egmond (director Environmental Assessment Agency (RIVM))

We specially appreciated the effort from Prof. Boussard from France and Dr. Baranowski from Poland to come over to The Netherlands for the meetings helping us to broaden our views.

The project has been carried out by a consortium of Dutch research institutes or groups. Many people contributed directly and indirectly to the contents, the working process and the good atmosphere within the project.

The Netherlands Environmental Assessment Agency (MNP) of the RIVM took part for their own account, were leading in scenario choices and elaborations, the application of the IMAGE model and various thematic topics.

- Land use and climate change: B. Eickhout and T. Kram
- Biodiversity: R. Alkemade, T. Tekelenburg and P. Reidsma
- Data collection and processing: K. Klein Goldewijk and J. Meijer

- Urbanization: L. Crommentuijn
- Nitrogen fluxes: H. Eerens and L. Bouwman
- Demography: H. Hilderink
- Scenarios: J. Bakkes, M. van den Berg and H. Westhoek
- Selftest: T. Aalders

A large portion of the work, especially in the domain of the economy, has been done by the Agricultural Economics Institute (LEI). They contributed by integrating the model LEITAP into the chain of models and were responsible for economic and social parameters.

- H. van Meijl, A. Tabeau, F. van Tongeren, M. Betgen, T. de Kleijn

The Soil Inventarisation and Land Evaluation Group from Wageningen University worked on integrating the model CLUE in the chain of models, the land use chapter of EURURALIS and the hotspot-maps. Moreover many data were centrally stored and processed thanks to their efforts.

- Landscape Level Modelling (CLUE) P. H. Verburg, A. Veldkamp, N. Witte, N. Schulp

The team of Geo-information and Remote Sensing Group, Wageningen University, did work on data processing and the design and supervision of the developing of the CD ROM application.We mention the following persons

- Interface: R. van Lammeren
- Data processing: A. Bergsma, W. ten Haaf

Alterra contributed in specific indicator studies, such as carbon storage, land degradation, biodiversity (together with RIVM), animal diseases (with help from ID lelystad) and agricultural yield. .. The application itself was built by members of the Centre for Geo-Information. Graphical designers were involved in making the CD ROM and booklet.
Alterra was also esponsible for the project coordination.

- Biodiversity: J. Verboom-Vasiljev; R. Reijnen
- Carbon sequestration: G.J. Nabuurs, N. Heidema, T. Helmink, P. Kuikman
- Yield: R. Rötter, K. van Diepen
- Land degradation: J. Stolte, R. Hessel
- Animal disease: M. Perez Soba, I. Gies, T. Hagenaar (ID Lelystad, The Netherlands)
- Data processing: S. Mucher, E. Muller, A. Willemen, J. Clement
- Design booklet and design figures: J.Klijn,M. Jansen, R. Olde Loohuis, C. Onderstal, J. Wiltink
- Editorial advice: J. Luttik, J. Stuiver
- Application development: A. Lamakers, W. de Winter, P. Verwey, T. van de Wal

- Application design: M. Stoker
- Project coordination: J.Klijn, W.Vullings

Jan Banning, David Viner (UK), Dirk Wascher, Lammert Kooistra and Sander Mucher made relevant photos available to Eururalis.

All people involved are gratefully thanked for their contributions on behalf of the

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Bas Eickhout (MNP - RIVM)
Hans van Meijl (LEI)
Ron van Lammeren (WUR)
Teunis van Rheenen (LEI)
Tom Veldkamp (WUR)
Peter Verburg (WUR)
Henk Westhoek (MNP - RIVM)

Summary

1. Introduction

Policy makers on the level of the (enlarged) EU(15+10) as well as on national levels are increasingly apprehensive about future developments in rural areas. These areas occupy 80 % of the total European (EU) area and harbor 105 Million of the total 455 million people (i.e. 23 % of the population). Half of EU 's territory is in agricultural use (fact sheet European Community, 2003).These rural areas are subject to a multitude of transformation processes set in motion by interacting driving forces of various origin (Klijn, 2004). We mention I) the recent enlargement of the EU bringing about a larger internal market and the challenge to bridge socio-economic differences between older and newer member states, II) the ongoing world trade liberalization affecting all economic sectors but especially the agri-food sector that gradually will loose its market protection and export subsidies, III) current or imminent demographic changes (stagnation or even decline in number, aging and/or migration from rural to urban areas) and IV) global change (climate and climate related phenomena; IPCC, 2001; Watson et al., 2000). Other relevant processes (urban and infrastructure developments) act more locally or regionally, but are meaningful (UNEP, 2002).

All these long-term and large scale processes embody threats as well as opportunities for socio-cultural, economic and ecological values in rural areas and their communities. One notices that the full spectrum of sustainable development aspects (People, Planet, Profit) is at stake, including the abundant interactions acting between them. Whereas many processes are long term affairs and often hard to correct by policy measures politicians need to act in an anticipative or "pro-active" manner and from an awareness of the most effective ways to intervene. Therefore they need to be informed timely on what will or could happen and on what could be done to minimize risks and to stimulate promising developments. The role of science is to deliver conceptual support, methods, insights and data. This should include notions of unavoidable uncertainties regarding future developments.

What will happen during the forthcoming three decades set as the time horizon for our study is hard to predict in view of unknown mechanisms and even intrinsic uncertainties. The only scientifically defendable way to support policy makers in discussions and decisions is to sketch what could happen, assuming (changes in) preconditions that differ in nature, course, rate, duration or place. That is where scenario methods come in, helping to depict future situations according to some contrasting world visions and related story lines accompanied by "what - if " questions if a certain course of events is imagined. So-called explorative scenarios help to delineate the margins of the "possible and conceivable". (An example of a scenario study that proved to exert "shock effects" on politicians and stakeholders was the study by the WRR (1992) titled "Ground for choices", indicating that agriculture in Europe could do with an enormously smaller area if practiced at a much higher level of efficiency. It made visible that 40 - 80 % of the cultivated land could become redundant when highly efficient farm management was taken as main entrance!).

The role of contrasting explorative scenarios is to make explicit what the alternative assumptions, beliefs and attitudes are and how they diverge in outcomes. To assess various effects simulation models or sometimes simple "rules of the thumb" are used. Their role is to incorporate cause - effect relationships and interactions in a transparent manner and to deliver outcomes that either can confirm or deny the various expectations or desires. The latter adds to self reflection among participants on their presumptions and fuels debates on policy goals and instruments. That is why we prefer to consider a tool like EURURALIS primarily as a discussion support tool rather than a decision support tool.

The EURURALIS-project was designed against the above background. In the next sections we give some essentials of policy backgrounds, concepts, methods , conclusions and ways to improve or expand its applicability.

2. The policy background.

The EU committed itself to various international treaties or agreements such as made in Rio de Janeiro, Johannesburg, Kyoto, that basically were inspired by the concept of sustainable development. This concept (Brundtland et al., 1987) puts a balanced development of economic, socio-cultural and ecological domains at the forefront, while safeguarding all essential resources for coming generations. Its basics are expressed and visualized in the well-known People, Planet, Profit (3P-) triangle. While committing itself to these general principles the EU has the challenge to tune this with the current bio-physical cultural, social, economic and administrative / political situation. From a recent Policy document on the strategy for sustainable development (European Commission, 2001) we derived the following issues that underline both the general attitude towards sustainable developments as well as the then expected - and in between realized - accession of new member states. We rephrased and classified themes according to the 3 P categories ourselves!

- Climate change (drought, increase in precipitation, flooding, rising sea levels, violent events) =Planet
- Threats to public health (toxic substances, food safety risks, sufficient health services) =People
- Pressure on natural resources (bio-diversity, fish stocks, fresh water, increased amounts of waste) =Planet
- Poverty/social exclusion = People
- Ageing/shrinking labour force = People
- Gap between rich and poor regions (between enlarged EU member states) = People +Profit
- Congestion/pollution related to urban sprawl/ urbanisation; impacts on rural areas related to sub optimal spatial planning = Planet + Profit.

As can be noticed this list focuses at the Planet and People rather than Profit aspects. We can assume that Profit aspects are left somewhat implicit, but still regarded by the EU as crucial for a.o. social development and, sometimes, ecological improvements. We refer to the Lisbon strategy that aims at economic restoration and even a leading position of the EU. Such will affect rural area qualities undoubtedly, though suspicions arise about the safeguarding of Planet and People aspects (EEA, 2004).

In the EURURALIS study items as mentioned above were used to select 3P indicators as elaborated later, adding a few topics such as soil erosion or salinization, carbon sequestration, and animal diseases on the one hand and leaving out some others due to data shortage or insufficient time or money. The final choice as elaborated hereafter was made in close interaction with a Policy Advisory Group and a Scientific Advisory group, both installed by the Dutch Ministry of Agriculture, Nature and Food Quality.

The policy context made it necessary to present data, insights and model results in a user friendly format. This explains the choice of a CD ROM that is easily to approach and to browse (Wageningen University and Research, RIVM, 2004). This tool is made highly visual by a liberal use of possibilities for users to make their own graphs, maps and comparisons of scenarios, countries or periods according to their interest. We tried to build in several levels of detail: I) the level of the simple "take-home" messages (one-liners), II) a second level with some more explanation and III) if necessary more detailed, technical information as background (e.g in PDF format).

3. The main concepts and architecture of the EURURALIS project.

Sustainable development, the explicit policy orientation and the required user friendliness were the main user requirements for the EURURALIS project. We started from the following concepts, methods and architecture of modules (fig. 1):

- the selection of *contrasting scenarios that are scientifically and politically accepted* and fit for the job; therefore we used IPCC/SRES related scenarios or versions that were built upon comparable lines of thought, be it somewhat adapted and made more specific for European rural area issues;
- the identification of *major driving forces* (DF's) considered to be crucial for current or future developments. The idea of DF's causing effects in the state of variables, impacts and possible policy responses fits into the general DPSIR concept (Driver, Pressure, State, Impact, Response) (OECD,1994; EEA,1998; Klijn, 2004);
- due to the nature of currently important driving forces *the inclusion of global processes and data* (e.g. for world economy, population growth, welfare development or global change insofar necessary) was seen as crucial. So we had to throw the net wider than EU 25 countries alone to get relevant data and processes on board, especially on world trade;
- to understand and assess future changes it is necessary to analyse the nature, rate and geography of drivers and effects in *the past*. This helps to underline that all periods differ from each other in some aspects as much as that every

region can differ from the other due to physical, socio-cultural ,economic or political differences;

- the use of *generally accepted and tested core models* that could be linked in order to specify and break down driving forces to the EU25 and to translate their impacts on chosen 3 P parameters. We started with a *global trade model* (GTAP for our goals adapted in LEITAP), linked that to an *environmental model* with mainly national level output (IMAGE) and finally a more detailed - even to kilometre grid-level - land use changes in a *land use model* (CLUE). These models are dealt with elsewhere in this volume (Meijl et al., in press, The impact of different policy environments on land use in Europe, Eickhout et al., in press, Economic and ecological consequences of four European land-use scenarios, and Verburg et al., in press, High-resolution simulations land use changes in European landscapes). Models were lined up in the order of appearance and made interactive. Their combined output was used to assess various effects on indicators in either thematic models or "rules of the thumb";
- *land use change is seen as pivotal* for changes in the 3P domains in rural areas. Land use change can encompass change in total area of a certain land use type (more of type A, less of type B), it can be specified after its precise geographical situation (where) and - when possible (!) - the change in intensity. Logically impacts can result from land use change, spatial characteristics, the change in intensity and/or from driving forces as such (e.g. climate change affecting bio-diversity or farm productivity).
- *spatio-temporal specification*: *temporal scales and related intervals and spatial scales* and related spatial resolution were chosen to fulfil diverging wishes:. For the temporal scales is chosen to give an overview for a period *of 30 years with intervals of 10 years*). For the spatial resolution is chosen to present overviews for the whole of Europe, distinguished for EU 15 respectively EU 10 countries (country level) or lower levels (regions) or when feasible and meaningful even on kilometre grid level.
- *indicators*: as stated above we tried to choose indicators from the 3P domains that were *meaningful* for policy makers as such, *representative* for other related phenomena as much as possible and *based upon sufficient data and scientific insights*. The overall aim was that indicators should be *limited in number* to avoid an overdose of data. In addition we tried to aggregate the results of individual indicators in more *integral or meta-indicators*.

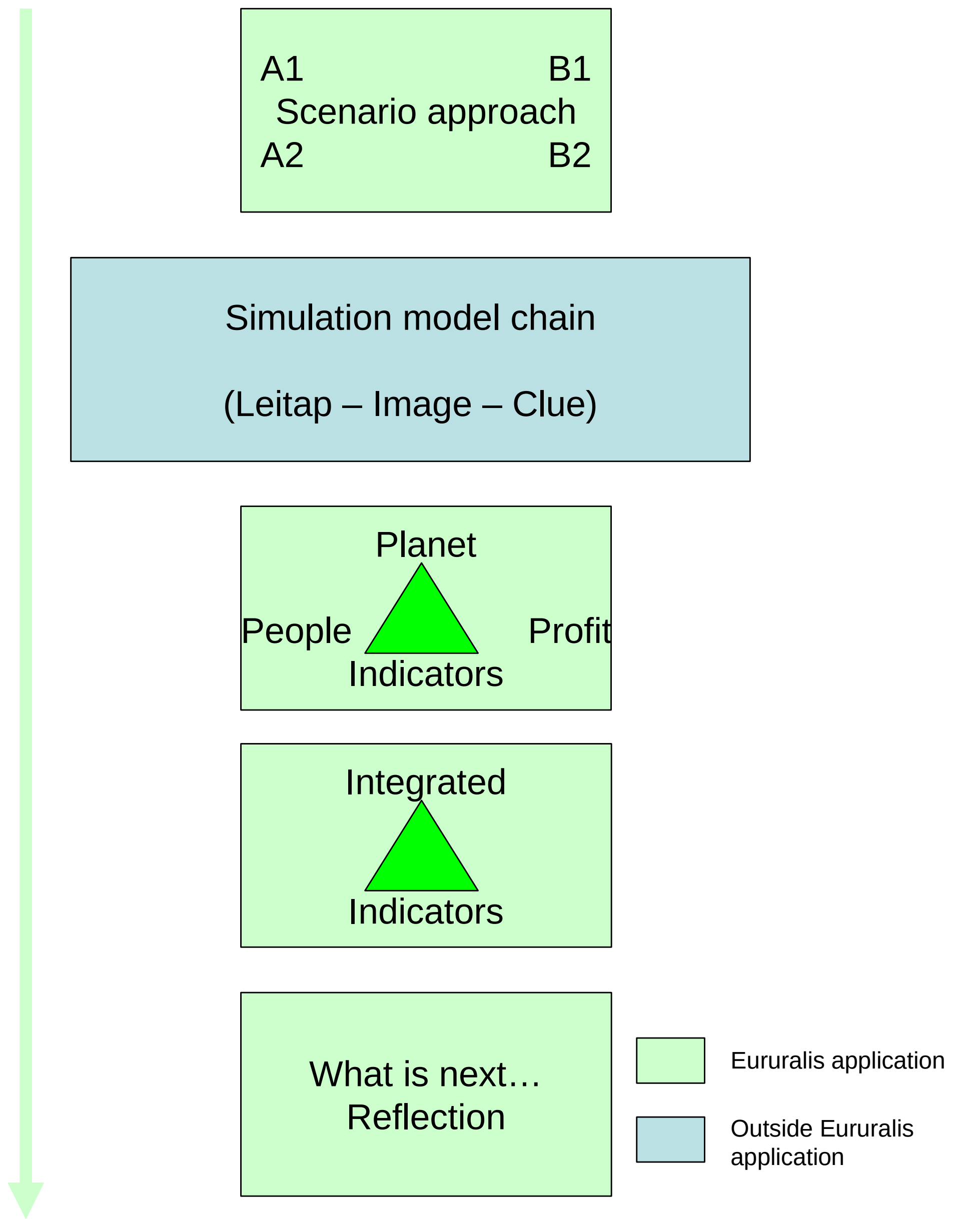


Figure 1: Architecture of EURURALIS project

4. Scenarios

As explained earlier we tried to build on "state of the art" scenarios that were useful for our goals (Europe, long term, large scale (global) processes of various kinds, affecting all aspects of sustainability) and that are politically accepted. The IPCC scenarios and various close relatives (ATEAM, undated ; UNEP, 2002; UNEP/RIVM, 2003; UNEP/RIVM, 2004; Nakicenovic and Swart, 2000; Mooij and Tang, 2003) were used as the fundament. This delivered four familiar scenario-alternatives , in our study titled Global economy(A1), Continental Market (A2), Global Co-operation(B1) and Regional Communities(B2). Their respective positions are determined by two perpendicular axes defining the four quadrants: the assumed role of governments (high versus low regulation, the latter fitting the ideas on the benevolence of a free market) and the scale level of processes and interventions (global versus regional).Necessary specifications were given for EURURALIS to comply with special conditions and requirements for Europe, especially for Common Agricultural Policy issues. We include a figure (fig. 2) showing the most elementary characteristics, extensive information on scenarios is given elsewhere in this volume (Westhoek, et al., in press, Scenario development to explore the future(s) of Europe's rural areas)

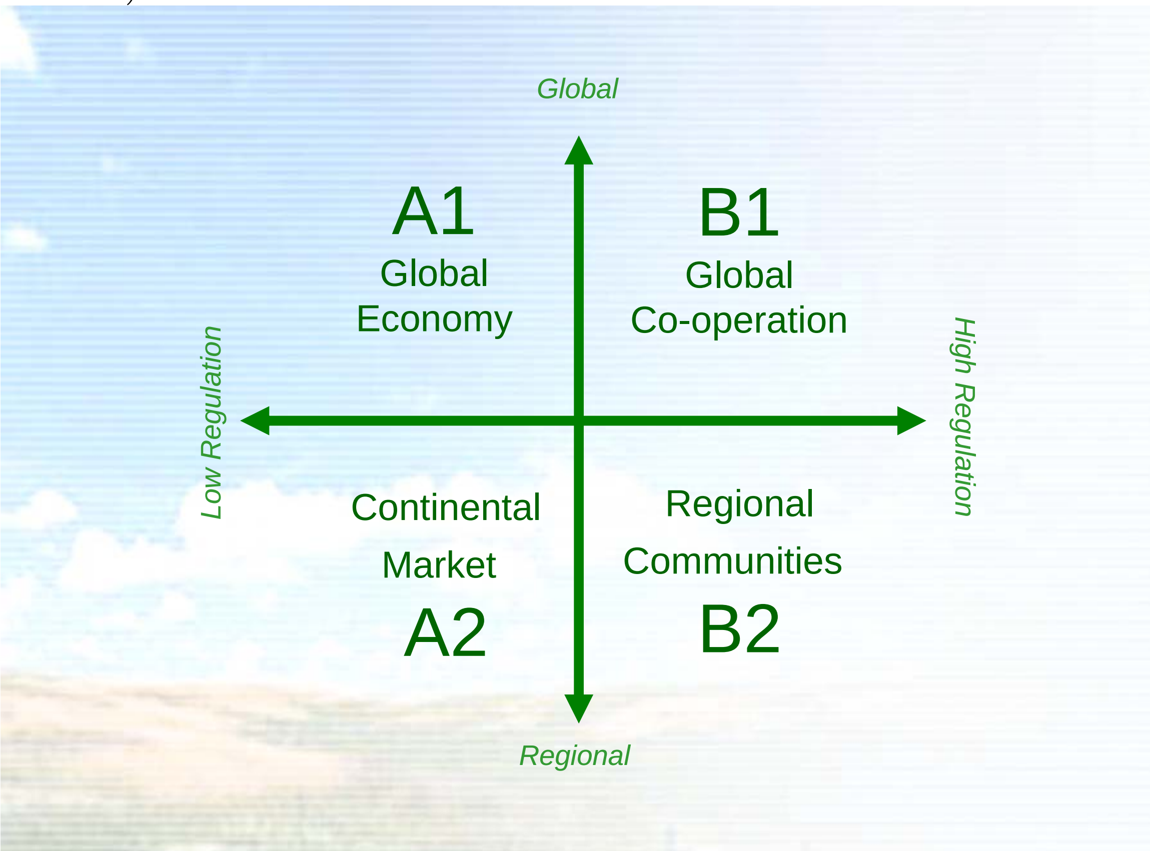


Figure 2: Scenarios in EURURALIS

5. Driving forces

Driving forces (DF's), considered to be relatively autonomous and sometimes literally outside forces affecting processes in rural areas are manifold and not seldom causally interconnected. We identified the following as important: I) demographic developments (growth, decline, ageing, migration) as these determine partly consumption, needs for housing, infrastructure and availability of labour, II) changes in welfare (inside and outside the EU), that determine food demands quantitatively and qualitatively (food quality, diet), III) geopolitical change (e.g. the EU formation, possible further expansion or international agreements and legislation), IV) changes in attitude such as consumer concern (influencing diet preferences of people, their behaviour, societal positions towards animal welfare), V) technological progress (for instance mechanisation, automation on farms, gen-technology and the diffusion of existing techniques) and VI) global change (e.g. climate change affecting regions within Europe in various directions and at various rates). None of these driving forces can be predicted reliably or precisely over 30 years. In EURURALIS we made assumptions as concrete and transparent as possible in the detailed formulation of scenarios (Westhoek, et al., in press, Scenario development to explore the future(s) of Europe's rural areas).

The combined effect of a certain constellation of DF's has been translated to changes in land use. The CLUE model (Verburg et al., 2002, 2004) distinguishes eight (8) land use categories, changing in area and spatial position. Land use change, though not a relatively independent driving force comparable to the above mentioned but a more intermediate shackle in de cause-effect chain, causes effects on e.g. ecology, pollution, erosion hazards, labour, income and others or interacts with other, more autonomously acting forces, such as climate change.

6. Indicators further explained.

Indicators for sustainable development in 3P domains form the alpha and omega of the project. As made clear the "raison d'être" of EURURALIS lies in the choice of policy- relevant indicators that represent 3P domains sufficiently. In view of their central importance we focus on them and explain how we dealt with them or what could be added in later stages. For explanations on the various thematic models and various decisions on rules of the thumb, criteria or classes we must refer to the background document of EURURALIS (Klijn et al, in prep) or the contributions of van de Berg et al. (in press, Impacts of land use change on biodiversity: an assessment for agricultural biodiversity in the European Union) elsewhere in this journal.

6.1. (Single) Indicators.

Generally indicators for use in policy making ought to be I) limited in number, II) comprehensible and policy relevant and III) representative for the 3 P domains. Compared to what was theoretically desired, we had to be practical as not all data were available with sufficient cover over all EU 25 countries. Finally we selected the following list, grouped after the People, Planet and Profit categories:

People :

- *Employment in the agricultural* sector, unemployment relating to poverty or causing migration to cities. Changes in employment in agriculture were calculated and expressed in growth or decline for the sector on country level. Together with other indicators, such as demographical ones, and harder to define aspects such as the level of medical, social and cultural services attainable for inhabitants (un)employment is a measure for the viability of the countryside.
- *Self sufficiency* : considered important by people and governments alike as it symbolises food security, the independence of import of food and other essentials from elsewhere, be it on regional, national or EU level. The importance depends on the world vision and in-built trust in the absence of wars or major disasters and a well-greased trade and transport circumstances. Some scenarios (e.g. A1) disregard such a goal, others take this as an

important issue. Self sufficiency was assessed for the EU level for major categories of products.
- *Animal diseases* : seemingly a peculiar topic to be placed under the heading of People as it has substantial economic aspects (indirect and direct loss of capital) and outbreaks of diseases and patterns of spreading resemble ecological phenomena and could be grouped under Planet aspects. Nevertheless, for EURURALIS the dominant factor is how people are ethically / morally and physically affected and value how official policies (non-vaccination, massive cullings, transport bans, passage prohibited) respond to the outbreak of animal diseases. Predictions of higher or lower risks of outbreaks of diseases were linked to scenarios in which farm size, nearness and some other aspects were used for a qualitative comparison. However, shortage of data and insufficient spatial resolution did not allow more than a qualitative outcome for the EU 15 countries only.

Planet :
- *Bio-diversity in natural areas*: these were explicitly distinguished from bio-diversity in agricultural areas, i.e. largely extensively farmed areas or areas with a mosaic pattern of farmland and natural elements. Natural areas are primarily vulnerable for fragmentation or area reduction, climate change, pollution and disturbance.
- *Bio-diversity in agricultural* areas (mostly related to the continuity in extensive farming and susceptible to change in farming type, scale enlargement, change in farming intensity or land abandonment)
- *Pollution*: for practical reasons we selected Nitrogen pollution (by deposition from the atmosphere) as an example of diffuse pollution of which the effects are relatively well known and well linked to farming intensities as well as other industrial and urban sources.
- *Soil erosion risks*: change in land use (e.g. the conversion from arable land to grassland or to permanent nature) assessed in terms of increased or decreased risks of soil erosion.
- *Salinization risks*: risks for agricultural land related to initial soil salinity, seepage in low lying coastal flats taking into account water deficits. The issue is the more relevant in view of imminent climate change.
- *CO_2 storage*: relevant to the desired control of climate change in view of the KYOTO targets for Europe. The issue of carbon sequestration in rural land use has been selected. A special focus is given to storage in forests, whereas the expansion of natural forest after land abandonment creates opportunities. Other meaningful data related to farm management were not yet included for practical reasons only.

Profit
- *Change in yield* of major agricultural crops has been assessed taking into account I) a gradual increase in productivity and II) especially a more than average increase in Central and Eastern Europe due to the diffusion of more efficient farm management techniques The difference between actual and

potential production levels can be indicated as yield gap. Its size determines possible yield growth.

- *Yields*, *related to assumed climate change* has been assessed to see whether for Europe as a whole or for some regions specific problems could arise. Expert judgement, taking into account predicted change in temperature and precipitation and higher CO_2 levels has helped to assess effects.
- *Income* in agriculture has been assessed, with or without CAP support measure
- *Expenses* in this case for the CAP (Common Agricultural Policy) are connected to the various assumptions or 'a priori's' in the scenarios, varying from abolishment to a continued use of support measures

6.3. Meta - indicators

Even a limited set of scenarios (4) each with a different nature or weight of major drivers, data on land use change (8 land use types, area size, position), single 3P-indicators (12), periods (4) and countries(25) and last but not least a possible specification of agricultural products yields a huge pile of information. The danger for the non-experienced user, is that he/she cannot see the forest for the trees and misses major points. Therefore we tried to aggregate or generalise the output in a more limited manner, while adding some aspects that could be relevant for politicians such as the implications of scenarios and in-built policy measures for developing countries. We addressed these as *meta-indicators* (comprising integrative aspects, aggregations, extra aspects) :

- *overall 3P scores* : tables for the scores in the People, Planet and Profit domains shown for EU 25 countries or specified for EU 15 and EU 10 countries after the 4 scenarios
- *East-west*: Specification EU 10 and EU 15 countries, focused at the question whether or not cohesion between these older and newer member states is furthered by closing the gap in e.g. income or employment
- *North-South*: an expert judgement (!) on the various pro's and con's of scenarios for developing countries
- *Hot-spot areas*: an indication of. those areas where in one or more (up to four) scenarios land use change can be expected. These areas are considered the most interesting for policy makers as they show what different policies can mean in practice and to be warned timely that these areas are prone to changes that often require extra measures to guide these processes orderly (Fig. 7)
- "*Should be* versus *will be differences*": a confrontation of how the various world visions and related expectations within the four scenarios are confirmed or denied by the outcome of the EURURALIS assessments. Often presumptions will be confirmed, though not seldom the opposite is true. The latter are counter-intuitive outcomes. EURURALIS 1.0 offers in the introduction a self test to identify ones personal preference towards world visions.

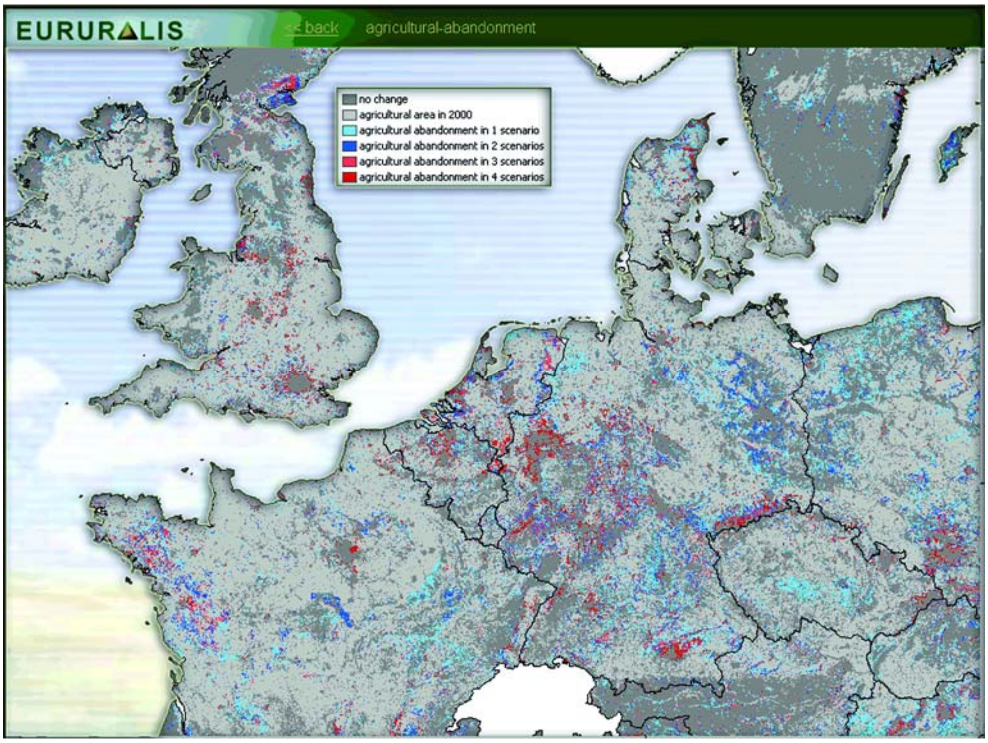


Figure 7: Hotspots map for agricultural abandonment

7. Main conclusions

As stated above a huge number of conclusions can be generated from the EURURALIS project. We present the main conclusions considered policy relevant on EU level;

Rural population : shrinking and ageing more than proportionally

All scenarios yield a strong decrease in rural population: from 100 million people in 2000 to around 75 million in 2030. The ageing of Europe's population as forecasted will be even stronger in rural areas compared to urban areas. Ageing and depopulation will affect the viability of rural communities.

Firm future for farming, also in a global economy

Agriculture, though shrinking in GDP share, employment and in cultivated area will remain the principal player in rural areas in all scenarios. Also in a free market scenario where support measures are abolished. The scenarios encompass quite different agricultural policies, from abolition of Europe's Common Agricultural Policy (tariffs, export subsidies, farm support) to maintenance of the present policy. Most scenarios (except A2) show a decrease of agriculturally used land. Land abandonment could create possibilities for a more sustainable agriculture and nature restoration.

Inescapable climate change asks for adaptive strategies

Climate change will affect all of Europe, more notably the Mediterranean, Alpine and northern regions. Impacts will increase in future decades due to time lag of processes and expected increase of problems caused by economic growth in the 3rd World, especially in the A1 scenario. Next to source oriented policies, adaptive strategies are inevitable, to safeguard bio-diversity, to allocate sustainable agriculture and to avoid risks for people and goods such as flooding. Carbon sequestration by conversion of cropland into forest or by large scale bio-fuel production will have limited contributions to Kyoto targets.

Accession: mutual profits for existing and new countries

The EU enlargement (EU15 + EU10) will bring economic profits to both the EU15 and EU10 countries. The EU 10 countries will be affected most, in economy, in socio-cultural and in ecological sense. Rates of transformations seem to be highest here, especially in free market conditions, having strong impacts in the social and ecological domains as well.

Rural transitions require support for social, cultural, ecological values in marginal areas.

Transitions in rural areas can be fast and massive in certain regions. Most marginal areas will see land abandonment and socio-cultural and economic decline as well as possible landscape deterioration. Areas where agriculture will undergo further intensification, will be affected negatively in environment, biodiversity and landscape qualities. Both transformations demand an adequate strategy to safeguard values by spatial planning and management.

Urbanisation has many effects on rural areas

The tendency in all scenarios is that further urbanisation takes place, having effects on biotope losses, fragmentation of natural areas, environmental stress and larger claims on rural areas for recreation and tourism. Careful planning with respect to existing values and possible future risks due to climate change is required to lead urbanisation processes in a desired manner.

Supranational spatial planning still a missing link?

Many driving forces act on a Europe wide scale, many European level policy responses tend to be thematic (aimed at a certain issue) and at the same time generic (valid everywhere), whereas national policies disregard supranational interests. In view of many problems surpassing national boundaries international spatial strategies for urban and rural areas are required.

Responsibilities for developing countries

In two scenario's (A2, B2) strong trade barriers remain between the EU (in A2 together with the USA + Canada) and other countries (both industrialised and developing countries). In developing countries this will lead to continued poverty of many people, accompanied by high population growth and more land conversion for subsistence agriculture. This affects social and ecological aspects negatively. Dismantling of trade barriers in itself is not enough: effective development aid and the support of good governance in development countries are crucial as well.

Scenarios are just a support to envisage threats and opportunities, no blueprint.

Scenarios as presented serve as a help to envisage alternative futures, not as a simple choice from four meals. The four contrasting scenarios are not intended to suggest an either-or type of choice. Policy makers can, as the present state of policy making may illustrate, make their own choices that are well-considered compromises of policy elements from more than one scenario.

8. Further research

The current EURURALIS 1.0 version results from a 10 months study with practical limitations in time and money. Improvements can be considered on the following points:

- extending the scenario approach by including bottom-up procedures such as developed by the PRELUDE project and/or by including backcasting scenarios that depart from a defined end situation in e.g. 2030;
- adding possibilities to choose policy goals and policy instruments as the primary entrance to assess their effects on indicators;
- by expanding the area studies : e.g. new applicant countries or the new neighbours of the enlarged EU; even other continents could be studied;
- offering more detail for some countries or groups of countries with tailor made specifications;
- adding new topics in the list of indicators: especially attention for water quality and quantity aspects (related to the Water Framework Directive), a more integral approach of greenhouse gases, a consistent inclusion of landscape qualities or certain social or cultural parameters;
- adding more data on intensification or extensification processes within the categories of land use;
- carrying out a more rigid analysis of errors, uncertainties and a sensitivity analysis;
- making the future EURURALIS versions more appropriate for public discussions and/or education purposes.

1 Introduction:

1.1 Background

1.1.1 Europe in space and time: a diverse and dynamic continent

To put the project in its societal context we give some characteristics first.

Europe's rural area harbours economic, ecological and socio-cultural assets. The area - in this study restricted to the EU 25 countries - exhibits many remarkable and attractive regional differences in nature. Both a-biotic diversity (recently addressed as geo-diversity and bio-diversity are determined by a host of different geological and climate conditions, the variety in topography, soils and bio-geographical patterns.Superposed on these natural patterns a millennia long history of land use caused further differentiation and delivered a full spectrum of fully natural to cultural ecosystems.Cultural aspects reflect the wealth of cultures and social conditions found throughout Europe. Rural areas harbour many people, whose social and cultural values and interests are strongly dependent on the course their future could take. Last but not least Europe's rural area is a productive area with a variety of agricultural products and timber, also yielding many other goods and services (water, recreation). Compared to other and larger continents Europe emerges as a physically and culturally very diverse and economically seen wealthy region with a relatively long and intensive interaction of nature, culture (Klijn & Vos, 2000). All these issues require (re-)assessments in view of dominant developments to be expected, of which the majority reflect the importance of globalisation and global change in various respects..

Change as the constant factor
The landscapes of Europe by no means form a static pattern. They were continuously subject to transitions or - stated otherwise - processes of change. These changes differ from region to region and are invariably driven by a combination of processes. History shows major demographic, geopolitical, economic and biophysical as well as socio-cultural driversTheir relative importance and pace changed in time As well as in regions. Some periods are relatively stable, others exhibit sudden and massive transformations driven by forces of various origin. Europe experienced massive migrations in previous millennia, it saw the rise and fall of kingdoms, it witnessed many smaller and greater wars, underwent changes in climate such as the mediaeval Little Optimum later followed by Little Ice Age, devastating diseases like the Black Death, great famines such as observed in Ireland late in the 19th century, it saw the colonisation of the third world from various expansive European countries. More recently the continent underwent large industrial revolutions and urbanisation, a process during which a steadily increased welfare was accompanied by the important increase of Europe’s population size. A recent geopolitical feature is the formation and stepwise expansion of the EU on the one hand and the collapse of the former Soviet Union on the other, creating new socio-economic challenges for East

and West alike. Landscapes were used accordingly to serve the various demands of people and landscapes under sometimes contrasting social, economic and political regimes. It is not only the landscapes that changed due to natural or man-induced causes. People's perception and their valuation of material and immaterial characteristics of the rural environment and its use were equally subject to change: new demands such as a high mobility of people, recreation and tourism, but also an awakened environmental awareness, consumer concerns on food production and animal welfare changed considerably.

All these changes set their stamp on the rural area of Europe in history. Certainly they will do so in future in an equally dynamic manner.

The relationship between driving forces, land use and finally the impact on the rural area and rural communities is the primary subject of our study. Our interest is how rural areas could develop in the coming decades The current study did not approach these issues from an academic point of view .Our primary concern was how policy making could influence the course of processes in a desired direction while avoiding adverse developments. That is why we tried to address threats and opportunities.

1.1.2 Imminent changes: threats and opportunities

Recent and ongoing developments in Europe's rural areas are fast and will have major impacts.

We perceive the recent accession of ten new member states causing an enlargement of the EU from 15 to 25 countries, creating a larger internal market and bringing the challenge to abridge socio-economic differences in order to create more cohesion between East and West.

Furthermore the negotiations within the WTO context will lead to a further opening up of the European market for non European countries. Thirdly, demographic conditions will presumably take quite another course than in preceding centuries. We can witness phenomena like stagnation in population growth or even a decline, ageing and ongoing migration to cities draining the rural areas. Europe, named after the young and attractive maiden EUROPA in Greek mythology, seems to turn into an old lady, demographically spoken (see later in this report dealing with demographic forecasts).

Though uncertain in its precise future the course and impacts of global change (climate, sea-level) will undoubtedly bring about several and sometimes important changes in climatic conditions and related processes. Furthermore we can expect all kinds of other influences such as new technologies (e.g. in agriculture) and changes in attitudes of people (consumer concerns for instance). All these changes and their driving forces are complex and interacting with each other. Effects are hard to fathom as their directions and rates are sometimes highly uncertain.Nevertheless, they can arguably be considered as possibly significant, large scale and affecting a host of values at stake in rural areas. Taking all these processes seriously it always has to be remembered that Europe as a whole is an extremely diverse continent, where regions show remarkable differences in bio-physical conditions, socio-cultural properties and where the direction and rate of changes could differ considerably

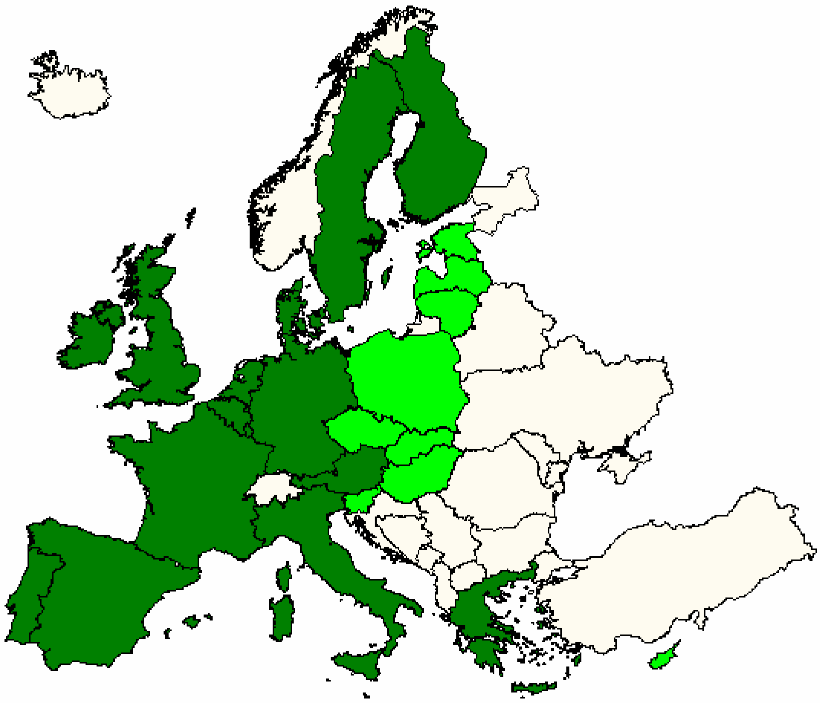


Figure 1.1: EU countries

1.1.3 Policy making and the role of research

Policy making is or at least should try to be congruous to be anticipative and pro-active. This is the more true as many changes respond to forceful drivers that can only be controlled or corrected if policy measures are taken timely and implemented in a powerful manner. Interventions may be of the type that avoids regrettable developments or on the opposite promote promising developments that fit new opportunities. Policy makers, especially at the level of an enlarged EU, should have a clear picture of shared overall goals for coming decades against the background of threats and opportunities. These political goals can be expressed in various levels of detail. On the most general level the internationally shared concept of sustainable development as launched by Brundlandt et al. (1987) , settled in Rio de Janeiro and confirmed in successive agreements (Johannesberg, Kyoto) has been accepted for the EU. The concept implies a dynamic balance between socio-cultural, ecological and economic interests on time scales that span at least the coming generations. The European Union committed itself to these general goals.

The role of research is to inform policy makers on the relevant issues and policy options in an anticipatory, reliable and digestible way. Primary tasks are the ordering concepts and theories, gathering and ordering data, making scenarios explicit and transparant, the identification of the most relevant interactions (interdependencies, cause-effect studies) , making and handling models that enable to predict "what - if " situations and indicating the effect of policy interventions. The predictability of processes over some decades has its limits. Science has to cope with various degrees of uncertainties. Sometimes onecan predict developments within reasonable margins, but in many other cases this is not feasible at all. The most sensible approach is then to identify the margins of what is *conceivable* in the future. Policy makers are thus assisted by delineating the playing field instead of giving them the most probable or profitable course to cross the field.

1.2 Aims, character and steps of the EURURALIS study in short

1.2.1 Discussion support rather than decision support

The general aim was to build a tool that supports discussion on the future of the rural area of Europe (EU25) based upon a scenario-approach addressing the major issues playing in the areas seen from the perspective of sustainable development.We consider discussion support the primary goal to be facilitated by facts, figures and insights, which implicitly means that the tool should be digestable, interactive and policy oriented. It should be based upon the "state of the art" in science. Due to limitations in time and money the study was primarily a desk study, based upon existing and widely acknowledged scenarios, data, models and policy options. Major added value is given by combining various data, insights in interrelationships and by presenting results in a crispy, digestable manner.

1.2.2 EU- 25 coverage; a broad spectrum of issues

Set against the background depicted above the current project has a specific position and role.

Policy makers want to be informed on the possible future developments in the European rural area. The Dutch Ministry for Agriculture, Nature and Food Quality (ANF) commissioned this study from an interest in Europe's future. The Netherlands geographically form a part of a much larger and still enlarging Europe. EU's agricultural policies (CAP) and its agricultural sector have to de defined against the background of a world encompassing market. A special argument to launch the study was the Dutch EU chairmanship in the latter half of 2004. Issues addressed are identified from current policy documents. Europe in 2004 grew to a much larger and more complicated union of countries (15 + 10 !) , whereas it has to cope with a multitude of issues synchronously.To do this in a balanced way is one of the major challenges An overarching goal is to safeguard and enforce sustainable development(see below)

1.2.3 Rural areas at the centre, but not without urban areas

Rural areas, here considered as both natural and cultivated areas,and comprising some 80 % of the total area of Europe, are largely multifunctional Several goals and interests are combined in land use.These relate to economic functions (e.g. agricultural production, mining, water extraction) and an array of social, cultural and ecological values.Rural areas cannot be studied separately from urban or urbanising areas. Urban functions, including housing, infrastructural works, , transport nodes industrial developments , offices etcetera, are powerful in their spatial developments and affecting the rural surroundings in many ways. Therefore, EURURALIS tried to incorporate major developments in urbanisation patterns to assess their effects on rural areas.

1.2.4 Sustainable development as guiding principle

This study is also a product of our time. Political assessments and decisions are no more an outcome of one-sided economic appraisal, as touched upon in the introduction. Choices and decisions will be discussed from a wider perspective as sketched by the generic aims of sustainable development. This approach- later summarized under the heading of the People, Planet, Profit approach, helps to reflect and decide in a more balanced manner than some decades ago when profit dominated our thinking and where quantity (e.g. in housing or in food production) was more important than quality.

1.2.5 Long-term perspective combined with shorter time steps

Many scenario studies define a relatively remote time horizon and the then to be expected or imaginable situations. Our study, while setting the time horizon quite far from now (30 years), tries to include shorter term steps (e.g. per 10 years) as well to enable a view at the various pathways leading to that distant future as well as the effects of interventions in the various stages. This aim roots in the reality of policy making that has to accomplish a change of course in shorter time steps.

1.2.6 Existing data, scenarios and methods : added value in combining data and insights

The present study is an attempt to bring existing knowledge and experience together rather than inventing all possible research modules ourselves.. This applies to the choice of scenarios, in which we chose to follow internationally accepted approaches such as IPCC's/SRES to the use of data and models (authorised data, tested models; see section). We were neither able to develop complete new scenarios or models or gather new data in a short time frame, nor were in favour of that as scientific and political acceptability was more important

1.2.7 Role of an interactive model

The study is not designed as a product of scientists shedding their academic light on interesting issues. Its goal was to build an interactive model, that allows e.g. politicians, to get information and insights in a digestible and comprehensive way.We built in various options to follow personal interest and to get information on various levels of detail. We tried to give answers on questions that are put most often. Interactivity is therefore not complete: many aspects are pre-cooked, for instance the choice of scenario's and indicators. More tailor made information or answers on specific questions cannot be answered by the CD ROM as they require targeted modelling. That however is possible when returning to original data and models and investing more effort and time .

1.2.8 Target Goup Policy makers; policy context

The EURURALIS project contributes by its attempt to include policy aims and measures as background.Main traget groups are policy makers at the EU and national level, commtitted stakeholders and researchers Most relevant for the policy context are the World Trade negotations, the CAP (Common Agricultural Policy and its two pillars) policies and measures regarding the environment (e.g. on the Kyoto agreements on the reduction of greenhouse gases, directives on nutrients or pollutants), Nature conservation (e.g. Natura 2000, Habitat and Bird Directives) , Water management (Water Framework Directive) and European Spatial Planning (ESP) .

1.2.9 EURURALIS in a simple flow diagram

The general framework of the present study is visualised in figure 1.2:

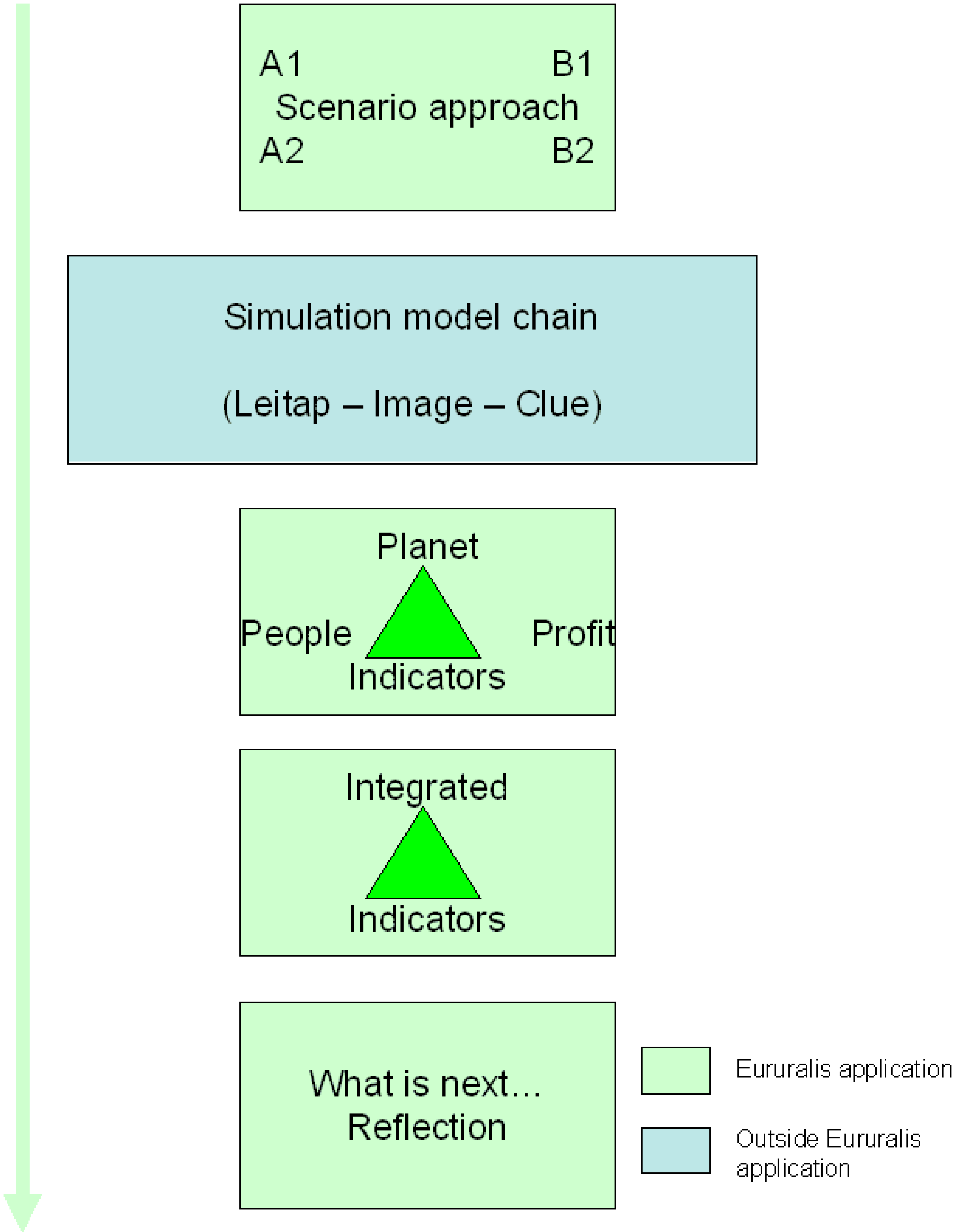


Figure 1.2 General framework for Eururalis project

2 Basic concepts and tools

2.1 Introduction

In EURURALIS we relied upon some central concepts or philosophies such as the DPSIR approach, an explorative scenario-approach, the concept of sustainability (People, Planet, Profit) , the choice of a limited set of indicators to represent the various domains of sustainability, meta-indicators to integrate them, a certain architecture of a chain of core models that enable us to predict and assess assumed changes ("what-if" outcomes) and ways to deliver our findings in an partly interactive, digestable presentation. We elaborate these in the following paragraphs.

2.2 A simple DPSIR approach: The distinction of Driving Forces, Pressures, States, Impacts and Responses (DPSIR)

The DPSIR model shown here (fig 2.1) (see Klijn, 2004; OECD, 1994 ; Wascher, 2004) represents the idea that we can distinguish between *driving forces* (D) (either direct or proximate or indirect or distant) affecting a defined system (ecosystem, agro-system) by so-called *pressures* (P) affecting its *state* (S) This can be seen as the *impact*, which has to be assessed from society's interests (negative or positive, acceptable or unacceptable). This assessment can lead to policy interventions (*Response:R).* These can be targeted at effects (mitigation, compensation) or - more fundamentally - at the direct or indirect drivers. In the current project we emphasised the importance of land use, which is more or less an intermediate entity. Land use is on the one hand the expression of societal needs, interest, economical laws, (Profit), techniques and on the other hand it exerts direct influences on the biophysical en partly socio-cultural values (Planet, People).

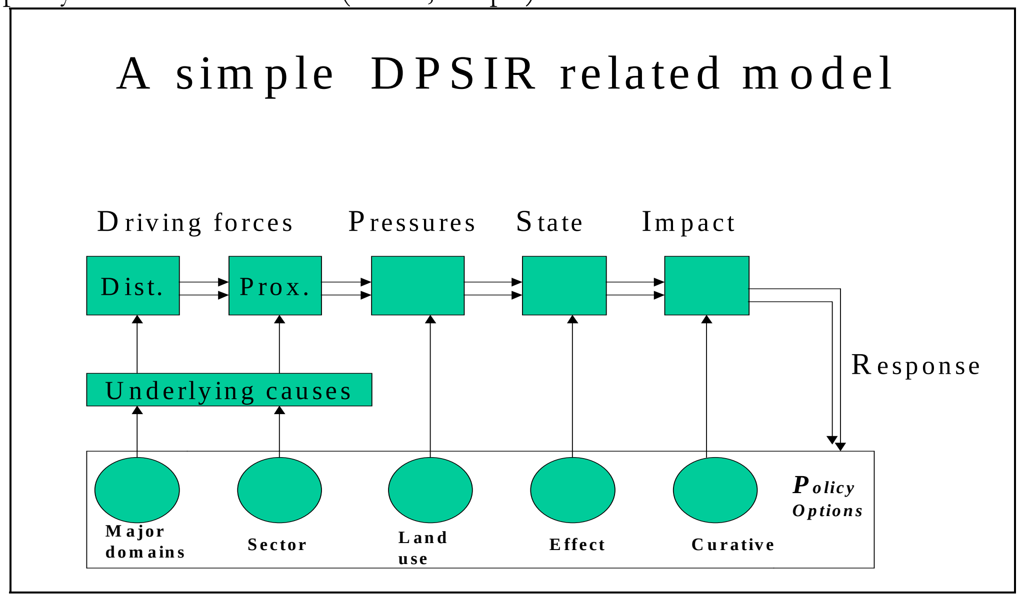


Figure 2.1: DPSIR related model (from Klijn, 2004)

A more targeted specification of the general DPSIR approach is shown in a mental map (fig. 2.2); It shows the major drivers, land use and values or functions in the European rural areas, going from the outward rim to the inner circle of the diagram. Items are indicative, not limitative.

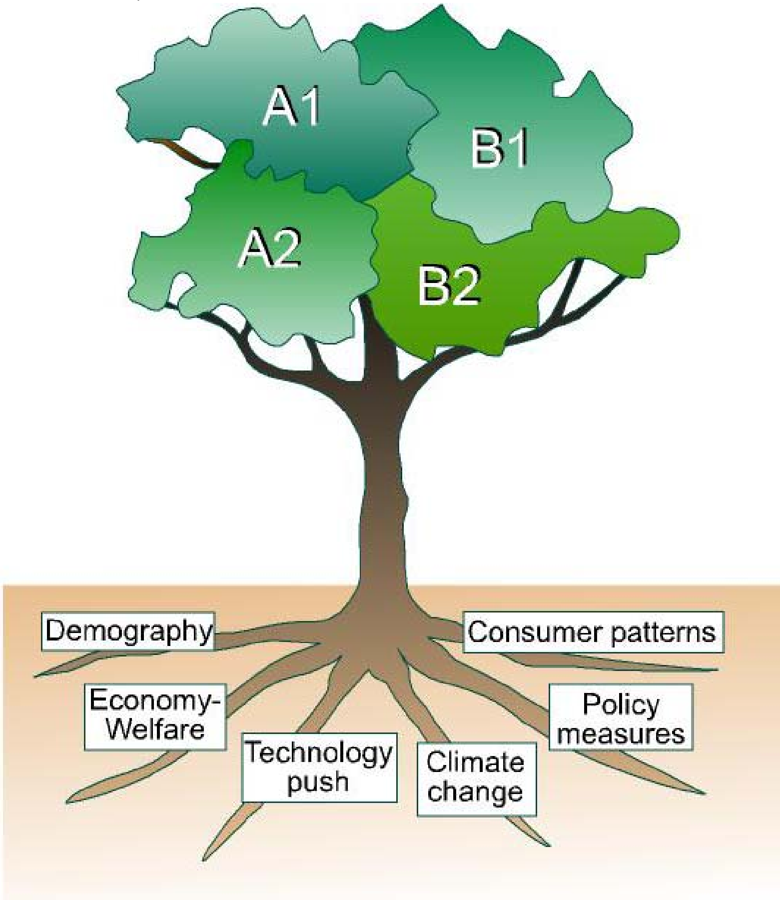


Figure 2.2: DPSIR approach

Referring to the mental map presented in the above diagram we distinguish a number of major driving forces acting both in the past and the future.:

Demography: (expected) growth/decrease of population in (future) member states + (internal) migration between and within states (rural area to cities and /or the other way around) + significant change in age distribution. Specified on the level of countries and/or major regions within countries

Global change: expected (range) of climate change (Summer- and winter temperatures, precipitation and other), change in sea-level according to IPCC scenario studies(not included in effect predictions as such) Specified for zones within Europe and refined based upon topography and other parameters.

Political/ administrative regime: depending on the level of European coordination, legislation and regulations (strong vs. weak). This could enhance Common Agricultural Policy (CAP) measures, specified according to the two pillars. Spatial

Planning of countries regulating land use (urban and industrial development, main infra-structural works, nature protection) and other policies (environmental, nature) as well as other policy domains. Some scenarios assume further enlargement of the EU

Macro-economy/ trade : To be considered as a major driving force, rooted in changes in production and consumption relationships, import and export of goods and services and growth or decline of certain sectors. For agriculture these aspects can be translated in areal demands.

Progress in technology and diffusion of technological findings: Technology and technology diffusion has been documented as an important driver that changes economic and non economic activities in significant manners. Agricultural sector underwent many changes, generally leading to higher production, efficiency and scale increase in farm size.More efficient agricultural production has been incorporated in scenarios.

Change in values in society, consumer concerns and behaviour : for instance related to responsibility for environment and biodiversity; care for food security and quality of production and products; environment, safety respectively specific behaviour (e.g. preference in recreation) .
Not all drivers could be included in EURURALIS explicitly or made quantitive

2.3 Selftest: from personal intentions to scenario comparison

Reflecting upon the future and its various threats and opportunities is a mix of knowledge, more or less justified expectations, personal convictions and sometimes sheer belief or disbelief. Generally people include many explicit and maybe more often im-plicit normative aspects in their way of thinking.

Eururalis offers a test, the so-called Self test, to verify the intentions that drive the personal normative notions. This Self-test is based on the WIN-model of the Dutch Institute TNS NIPO (Hessing et al. 2004). After conducting the test the result shows in which of the eight predefined normative groups the user of Eururalis is classified to.

These groups are Care-takers (Zorgzamen), Conservatives (Behoudenden), Hedonists (Genieters), Well-balanced (Evenwichtigen), Materialists (Luxezoekers), Professionals (Zakelijken), Broadminded (ruimdenkers), Socially minded (Geëngageerden).

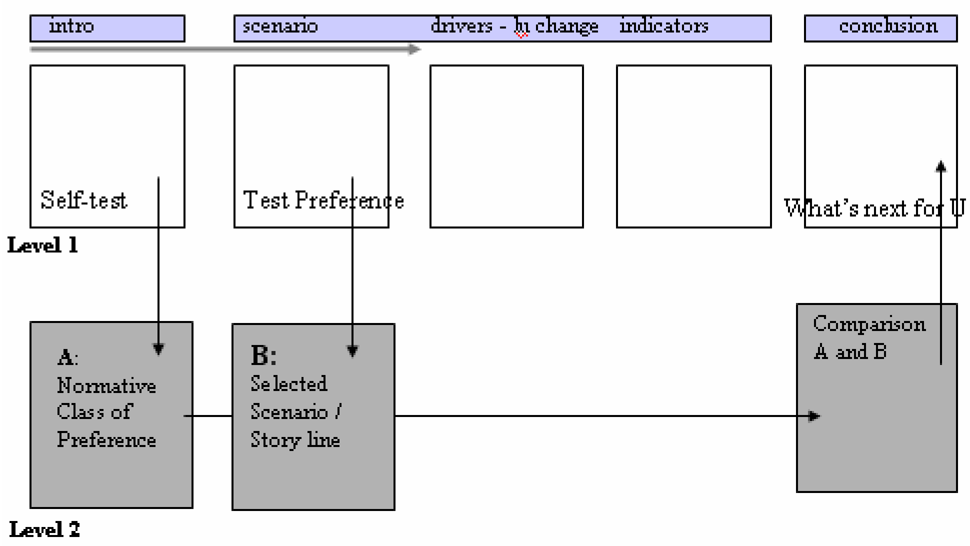


Figure 2.3: Eururalis: from personal intentions into a comparison of scenario preferences

In the Eururalis application (figure 2.3) this Self-test is available by the Intro-Tab (level-1) followed by Self-test Tab (level-2). When the user click subsequently on these Tabs a screen will pop up and asks the user to select one out of 18 human modes of desire, followed by 18 desired end states of existence.

The value systems of respondents are determined according to the WIN-model (Hessing and Reuling, 2002). Each respondent had to rank two lists with 18 values in order of how they desire to be, as developed by Rokeach (1973)1. Rokeach (1973) distinguished the 36 values, which are all social desirable, in 2 groups. One group has 18 instrumental values (modes of conduct) and the other has 18 terminal values (end states of existence) .

[1] Rokeach (1973) defined a value system as an enduring organisation of belief of conduct or end-state of existence along a continuum of relative importance. In a value system values are ordered in priority with respect to other values. Here a value is an enduring belief that a specific mode of conduct or end-state of existence is personally or socially preferable to an opposite or converse mode of conduct or end-state of existence.

Table 2.1 The two lists of 18 values, according to Rokeach (1973)

	Instrumental values (desired modes of conduct)		Terminal values (desired end states of existence)
1.	Ambitious	1.	A comfortable life
2.	Broadminded	2.	A sense of accomplishment
3.	Capable	3.	A world at peace
4.	Cheerful	4.	A world of beauty
5.	Clean	5.	An exiting life
6.	Courageous	6.	Equality
7.	Forgiving	7.	Family security
8.	Helpful	8.	Freedom
9.	Honest	9.	Happiness
10.	Imaginative	10.	Inner harmony
11.	Independent	11.	Mature love
12.	Intellectual	12.	National security
13.	Logical	13.	Pleasure
14.	Loving	14.	Salvation
15.	Obedient	15.	Self-respect
16.	Polite	16.	Social recognition
17.	Responsible	17.	True friendship
18.	Self-controlled	18.	Wisdom

Next a value space is calculated according to Schwartz and Bilsky (1987) by forcing a two-dimension solution of a principal component analysis (PRINCALS). Finally, Hessing and Reuling (2003) made a cluster analysis for the respondents in the value space. They forced an eight-cluster solution and gave names to the value groups, based on their value pattern and other known aspects (figure 2.4). Mind that the names mentioned in figure 2 are not based on the perception of the respondents but given by Hessing and Reuling.

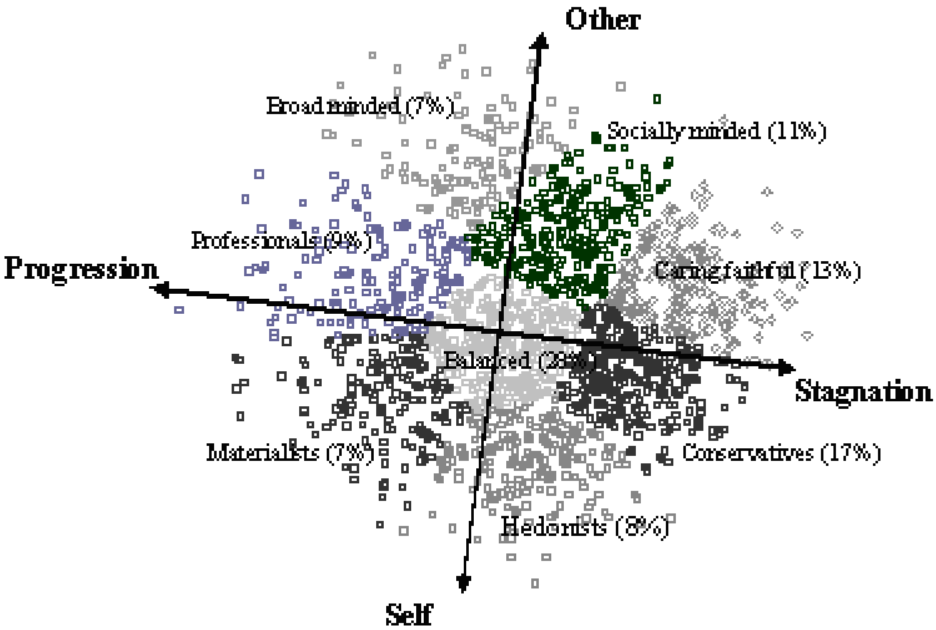


Figure 2.4 Normative groups (Hessing and Reuling (2002))

Figure 2.4 shows the 8 different classes of normative preferences. The percentages reflect the size of the groups in the Dutch population. The last screen of the self-test shows your normative mode.

In the meanwhile this normative mode will be linked to the story line of one of the four scenarios. This link is based on the outcome of previous research of TNS-NIPO and RIVM (MNP-RIVM, 2004) on the relation between normative modes in the Dutch Society and story line preferences. In other words this link is based on a Dutch study and for that reason culture dependent. (figure 2.5).

Figure 3 shows by cross table A the absolute division of the selected representatives of the Dutch Population in normative groups and the scenario preferences. Cross table B shows the relative numbers of this division under the condition that the total population will be 100% and the summation of the preferred scenarios is also 100%. Well-balanced, Socially-minded and Conservatives seem the majority groups. Broadminded, Materialists and Professionals are the minorities.

Cross table C gives a relative overview of the preferred scenarios per normative group. Each group is totalized by 100%. Scenario A1 seems to have the lowest overall priority and the scenarios A2 and B2 will have a preference.

A		A1	2,00 A2	3,00 B1	4,00 B2	
WIN8 rie	1,00 Care-takers	7	67	59	94	227
	2,00 Conservatives	12	125	65	113	315
	3,00 Hedonists	23	97	19	64	203
	4,00 Well-balanced	23	123	56	106	308
	5,00 Materialists	30	71	18	47	166
	6,00 Professionals	26	47	33	52	158
	7,00 Broadminded	4	18	64	44	130
	8,00 Socially minded	8	72	68	129	277
	Total	133	620	382	649	1784

B		A1	A2	B1	B2	Tot. Popula
	1,00 Care-takers	5%	11%	15%	14%	13%
	2,00 Conservatives	9%	20%	17%	17%	18%
	3,00 Hedonists	17%	16%	5%	10%	11%
	4,00 Well-balanced	17%	20%	15%	16%	17%
	5,00 Materialists	23%	11%	5%	7%	9%
	6,00 Professionals	20%	8%	9%	8%	9%
	7,00 Broadminded	3%	3%	17%	7%	7%
	8,00 Socially minded	6%	12%	18%	20%	16%
	Total	100%	100%	100%	100%	100%

C						
	1,00 Care-takers	3%	30%	26%	41%	100%
	2,00 Conservatives	4%	40%	21%	36%	100%
	3,00 Hedonists	11%	48%	9%	32%	100%
	4,00 Well-balanced	7%	40%	18%	34%	100%
	5,00 Materialists	18%	43%	11%	28%	100%
	6,00 Professionals	16%	30%	21%	33%	100%
	7,00 Broadminded	3%	14%	49%	34%	100%
	8,00 Socially minded	3%	26%	25%	47%	100%
	Total Population	7%	35%	21%	36%	100%

Figure 2.5: The link between normative groups and scenario preferences of the Dutch society

The next step is to select by reading the story lines of the scenarios you scenario of preference. First select the Scenario-Tab (Level 1) and afterwards select Your Preference Tab (level 2).

Finally the match between your normative mode (by the linked story line) and the selected story line can be found by the Conclusion-Tab (level 1) followed by the What's next for you-Tab (level 2).

By figure 2 cross table C it turns out that there is not one single preference for a scenario. For example the Caretakers do have preferences for all 4 scenarios, but the scenario B2 scores highest. Analysing the cross table from another perspective it turns out that each normative group has never the highest preference for scenario A1. Even scenario A2 has just once the highest preference (see Broadminded). For the comparison we made a selection of the highest preferences (light grey) and the second highest (dark grey). The highest have been used for comparison by Eururalis conclusion "What's next for you ".

If the user selects View all Maps (level 3) to be reached by the Conclusion-Tab (level 1) then the differences between the drivers, land use changes and indicators of the selected and calculated scenarios could be compared. Knowing that the scenario A1 will never be selected by the Self test it could be of interest to compare the A1 scenario results by the View Map options.

2.4 The scenario-approach

EURURALIS followed a scenario-approach that has been chracterized as an explorative scenario-method in which the focus was on conceivable futures in plural, i.e. the development of story lines, assumptions and ideologies that form a consistent line of reasoning. Generally various contrasting, alternative scenarios are chosen to delineate the intellectual playing field. As an extensive explanation is given in the next chapter we confine us to this short typification.

2.5 Sustainability: PPP-aproach

The idea of sustainability and sustainable development as addresssed by Brundtland et al.(1987) emphasizes a balanced development of various value domains for coming generations. Their ideas are later summarized by the 3P concept (People, Planet,Profit) distinguishing ecological properties and values (Planet), socio-cultural values (People), and values belonging to the economical domain (Profit). The original concept and goals have been endorsed by all countries in the famous Rio Convention, in later conventions (including Johannesburg) and is embraced by the EU and its individual member states.

The current project took sustainable developoment as guiding principal and leading symbol (the well known 3P triangle in fig 2.6.)) and tried to define indicators for all 3P domains involved.

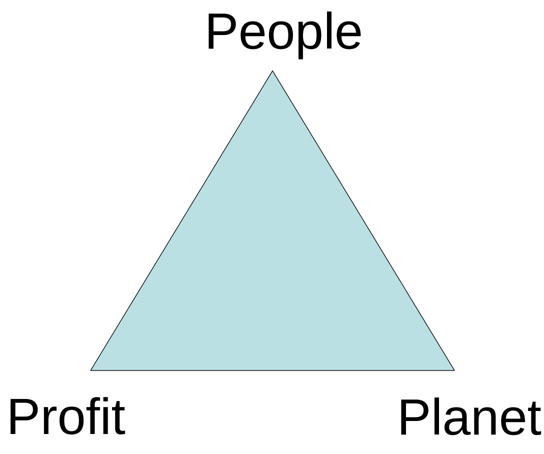


Figure 2.6: 3P representation: People, Profit and Planet

2.6 Choice of Indicators

In Eururalis we followed the above general approach of sustainability domains and tried to select an operational set of indicators

Indicators form the *alpha and omega* of the project. As made clear the "raison d'être " of EURURALIS lies in the choice of policy- relevant indicators that represent 3P domains sufficiently. Scenarios , their various assumptions on driving forces , the choice and necessary adaptation of models, their linking, the gathering of input data, followed by the running and tuning models , finally results in specified outcomes for indicators in future. We made a distinction between single indicators (grouped after their significance for People, profit or Planet domains, and more integrative indicators (see next section).

(Single) Indicators.
Indicators should be limited in number, policy relevant and representative for the 3 P domains. Compared to what was desired in theory , we had to be practical as not all data were available with sufficient cover over all EU 25 countries.
People :

- *Employment in the agricultural* sector, leading to either unemployment and often poverty or the migration to cities. Changes in employment in agriculture were calculated and expressed in growth or decline for the sector on country level. The item is relevant for the policy issue "viability of the countryside".
- *Self sufficiency* : is considered as an item regarded important by people and governments as it symbolises the independence of import of food and other essentials from abroad. Some scenarios seem to disregard such a goal assuming an unimpeded flow of goods and services in an optimally functioning market, others take this as an important issue. Self sufficiency was assessed in EURURALIS for the EU level.
- *Animal diseases* : this seemingly peculiar topic to be placed under the heading People has also substantial economic aspects (indirect and direct loss of capital) and ecological backgrounds as outbreaks of diseases and patterns of spreading represent ecological phenomena. Nevertheless the dominant impact is on people, who are ethically / morally and physically affected by the way official policies (non-vaccination, massive cullings, transport bans, passage prohibited) handled the outbreak of animal diseases. Predictions of higher or lower risks of outbreaks of diseases were linked to scenarios in which farm size, nearness and some other aspects were used for a qualitative comparison. Shortage of data, insufficient spatial resolution did not allow more than a qualitative outcome for the EU 15 countries.

Planet :

- *Bio-diversity in natural areas*: explicitly distinguished from bio-diversity in semi-natural, i.e. largely extensively farmed areas. Natural areas are primarily vulnerable for changes such as fragmentation or areal reduction, climate change, pollution a.s.o.
- *Bio-diversity in semi-natural* areas (mostly related to extensive farming) which is susceptible to change in farming type and intensity or land abandonment

- *Pollution*: for reasons of feasibility we selected Nitrate pollution as a very representative example of diffuse pollution of which the effects in agriculturally influenced areas are well known and well linked to farming intensities.Other pollutants are important as well, but for practical reasons not included.
- *Soil erosion risks* : change in land use (, eg. the conversion from arable land to grassland or to permanent nature) can be assessed in terms of increased or decreased risks of soil erosion.
- *Salinization risks* : this issue is chosen to visualise risks of salinization in agricultural land related to initial soil salinity, seepage in low lying coastal flats etcetera. This issue is the more relevant in view of imminent climate change that leads to larger water deficiencies.
- *CO_2 storage* : also for reasons of control of climate change the issue of carbon sequestration in rural land use has been selected. A special focus is given to the expansion of natural forest where land abandonment creates opportunities to do so.

Profit

- *Yield,* of major agricultural crops has been assessed for the future taking into account a gradual increase in productivity and especially a more than average increase in Central and Eastern Europe.
- *Yields* , *related to assumed climate change* has been assessed to see whether for Europe as a whole or for some regions specific problem s could arise.
- *Income* in agriculture has been assessed as farm income, with or without CAP support measure
- *Expenses* , in this case for the CAP (Common Agricultural Policy) are connected to the various assumptions or a priori's in the scenarios, varying from abolishment to a continued use of support measures

Integrative indicators

Even with a limited set of scenarios (4) , major drivers and their respective values , intermediate data on land use change (8 land use types) , indicators (12) , periods (4) and countries(25) and a number of agricultural products a huge pile of data can be extracted from the EURURALIS system. The danger for the non-experienced user, is that he cannot see the forest for the trees or misses some points. For that reason we tried to aggregate or generalise the output in a more limited and expectantly policy relevant set. We have chosen the following *meta-indicators* (integration or aggregations) :

- *overall 3P scores* : tables for the scores in the People, Planet and Profit domains specified for EU 15 and EU 10 countries showing scores for 4 scenarios
- *East-west*: Specification EU 10 and EU 15 countries, focused at the question whether or not cohesion is furthered by closing the gap in e.g. income or employment
- *North-South* :a expert judgement on the various pro's and con's of scenarios for developing countries

- *Hot -spot areas* : an indication of. those areas where in one or more (up to four) scenarios land use change can be expected. These areas are considered the most interesting for policy makers as they show what different policies can mean in practice and to be warned timely that these areas are prone to changes that often require extra measures to guide these processes orderly
- "*Should be versus will be differences* ": a confrontation of how the various world visions or expectations that were part of the four scenarios are confirmed or not by the outcome of the EURURALIS assessments. Sometimes one will be reassured that his or her vision gave the desired outcome, not seldom the opposite can be true.

2.7 Interface

The original Eururalis project proposal aimed to deliver a computer game like application like the commercial Simcity and Simrural PC games. Main function of such an application should be to challenge the users to find new reasons and manners for land use changes in the EU25.

During the project, it turned out that the three-tier approach (IMAGE, LEITAP and CLUE) needed too much storage and processing capacity to realize such an interactive game within time frame and budgettary posibilities.

For that reason the advisory board advised that possibilities to construct an interesting and foolproof game were to hard to accomplish in the current version. The original ideas of a game were abandoned.

This chapter explains how the Eururalis interface is structured. First the chapter focuses on the different ideas about interfaces and games. Afterwards the interface definition is explained and the possibilities to interact with the application. A description of he technical application follows up and finally some examples of the interface will be shown.

2.7.1 Interfaces

Intentionally the Eururalis application needs to fulfill a number of requirements:

- to present historic facts, figures, maps and pictures of the EU-25
- to present temporary facts, figures, maps and pictures of the EU-25
- to present story lines that will influence the future of the rural areas of the EU25
- to present future facts, figures, maps and pictures of the EU25 based on the four storylines.

In other words text, numbers, pictures and geographical data (maps) have to be visualized and presented in such a way that politicians and their back-benchers could be informed. In other words there are different domains of information to know historical, temporarily, future oriented story lines and future oriented prospects. Being aware that knowledge the Eururalis users about the rural area is very varied and the information that will be delivered by the Eururalis research team is very diverse and dense the application will be based on different levels of information.

Because interaction seems a key item literature offered concepts for the Eururalis interaction. Cartwright (1999) discusses visual metaphors (the story teller, the guide, the sage, the game player, the theatre, the toolbox, the data store and the fact book) that can be used to explore spatial information.

These metaphors can be implemented via different forms of interactions. Based on the relation between cognitive processes and their social use (DiBiase, 1990) MacEachren and Kraak (1997) developed the map use cube (fig. 2.7). The Y-axis of this cube represents the audience (from private to public). The X-axis the level of interaction and the data relations (from unknown (the user decides) to known (the application developer did decide upon).

The box shows that representation of data for a public audience has a low level of interaction and the data relations are completely prepared. On the contrary data exploration will be more individually conducted which means that the data relations are not pre-defined and for that reason the user need some interaction tools the explore.

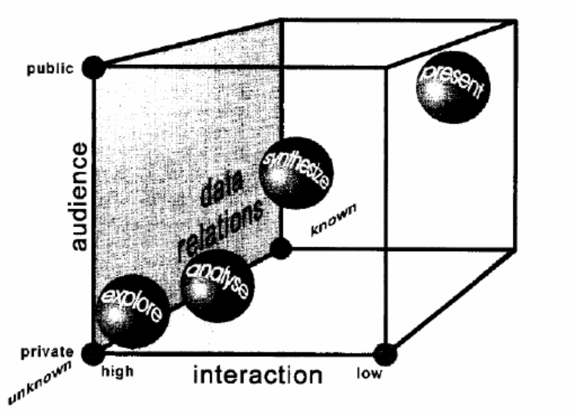


Figure. 2.7 The Map Use cube (McEachren and Kraak, 1997)

In Eururalis users have to explore the data. Consequently the application has to offer interactions to create relations between the different domains and levels of information.

Types of interaction tools that could be linked to visualizations have been categorized by Crampton (2002):

- interactions with data by querying, brushing, filtering and highlighting
- interactions with data representation via lightning, zooming, panning, rescaling, projecting and remapping of symbols

- interaction with the temporal dimension by navigation through time, fly-through, toggling and sorting and querying
- contextualizing interaction via multiple views, combining data layers, window juxtaposition, linking.

In the Eururalis application all types of interactions will be included.

2.7.2 Eururalis interface definition

The definition of the interface is based on the following objectives considering the user requirements:
- the application will be used stand-alone by a single user;
- the user could use the application in two ways; to get a quick overview and to get into more details
- the user must be able to compare the different scenarios by their storylines, but also by their simulated expected impacts
- the user could use texts, maps and graphs to compare.
- the user must be able to play around with the information

The first objective means that the application is developed for CD-ROM. The data extent of a CD-ROM is the limiting factor (app. 700 Mb).
The second objective has been realized to define three levels of information for each of the first level domains. These domains are (see figure 2.8):
- Introduction: What is Eururalis
- Past: from EU7 to EU25
- Future: the future perspectives of EU25
- Conclusions

The future domain has been extended in:
- scenarios: in fact information about the four storylines that determine the type of simulation
- drivers: information about the expected and accepted developments for the next 30 years that have been used as driving factors for the simulations
- land use changes: information about the land use changes based on the outcome of each simulation (via IMAGE, LEITAP and CLUE). The spatial impact is presented via this domain
- indicators: information about some selected items related to People, Planet and Profit indicators. The information is derived via an analysis of the simulation outcomes.
- integration: information about the differences between the story lines intentions and the simulated results (model outcome).

Each of the first-level domains have been extended by a second and a third information level.

The third and four objectives have been realized by offering the users pages with tables or graphs and on the third level with interactive tools to compare maps and graphs. Via two simple tests (see chapter 2.2) users are able to compare their personal intentions with story-lines.

The fifth objective is offered via the interface by which the user can navigate freely through the information levels and the information domains. Other possibilities are created via the interactive graph and map interfaces.

The color green has been chosen to link the graphical definition of the interface to the concept of rural areas. In the lay out of the interface of the application the triangle often used. The triangle represents the mutual interest in People, Profit and Planet. The application shows the information about scenarios, drivers, indicators and integration by reference to the triple-P triangle approach (Slingerland, 2003).

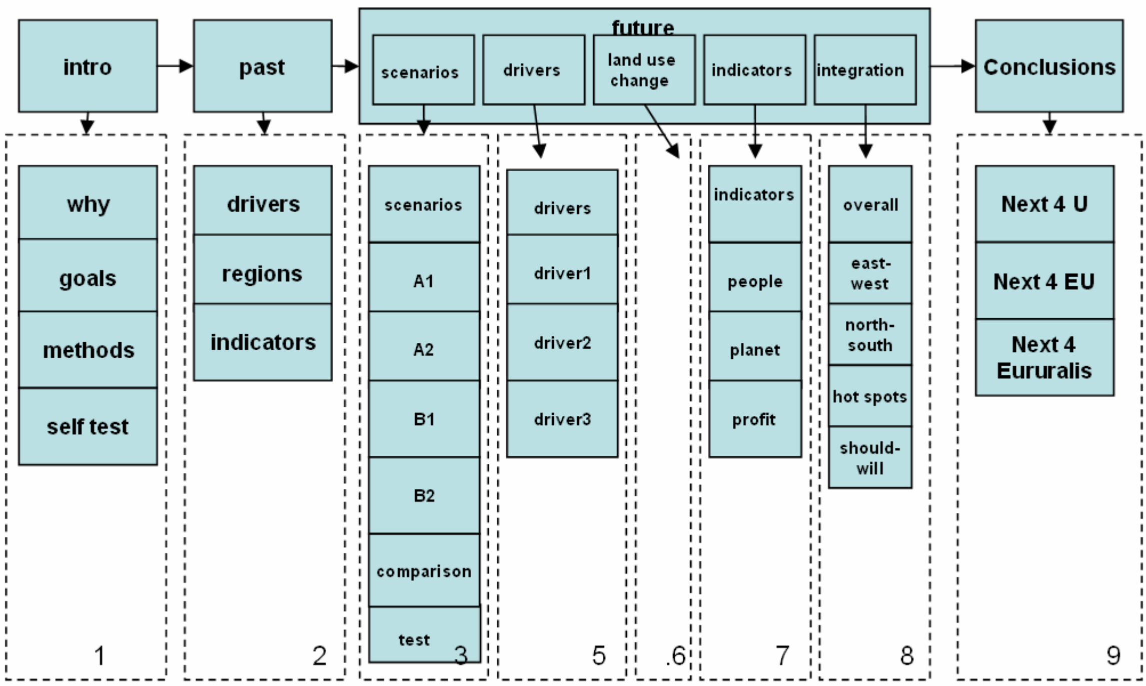


Figure 2.8: conceptual design: information levels 1 and 2 (within dashed boxes) and information domains (each box)

Technical implementation

EURURALIS is implemented in Delphi7 and html. The requirements to use EURURALIS are Windows 98 (or higher) with internet explorer. EURURALIS also uses Adobe Acrobat Reader, which can be freely downloaded from the web. In total EURURALIS contains 90 maps, 875 tables and 157 indicator definitions. Adding new datasets or html pages is no problem. At the moment the data extent of a CD-ROM is the limiting factor (app. 700 Mb), since EURURALIS is not yetan internetapplication.

Interfacing

In the interface three information levels are used. Figure 2.9 and 2.10 show the three levels.

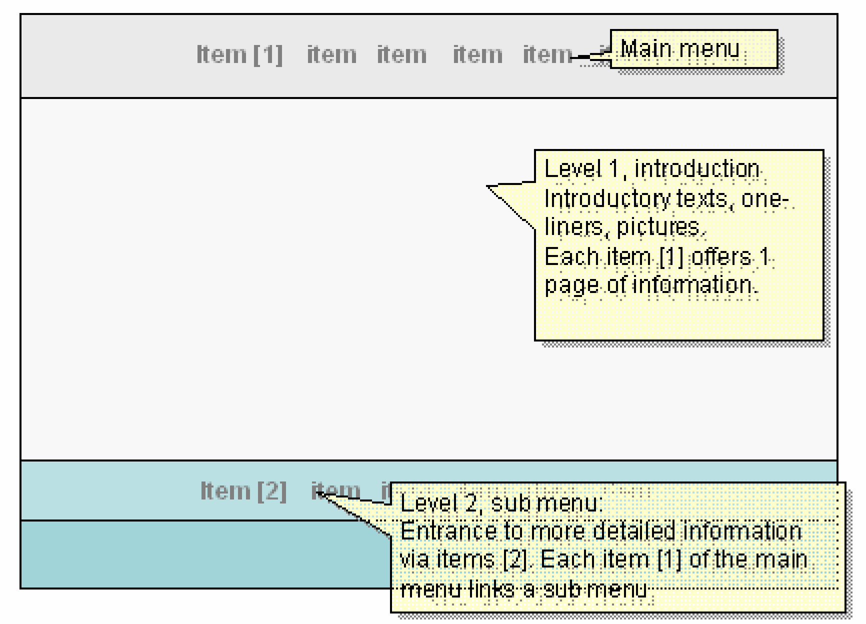


Figure 2.9: main menu and sub menu

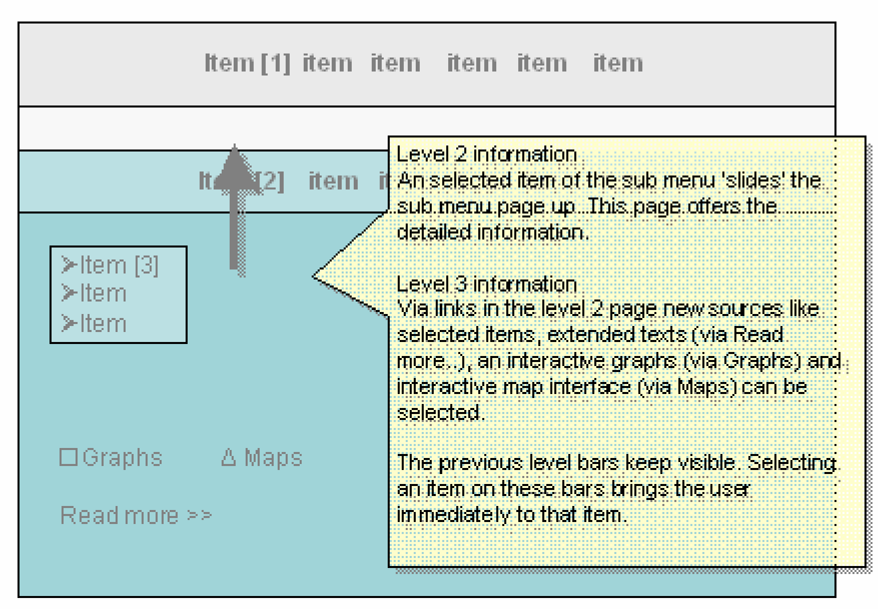


Figure 2.10: sub menu and level 3 items

3 Scenarios

3.1 Eururalis scenario set-up

Scenarios offer possibilities to identify a range of possible futures by defining major processes (driving forces), functional relationships (cause-effect) enabling to identify positive or negative outcomes set against political or societal expectations or desires.

Scenarios should be internally consistent (not contradictory within its own sets of paradigms or assumptions) and - as they fulfil a role in creative thinking and communication - scenarios should be founded on a convincing and crispy storyline that is digestible for users. Scenarios should be contrasting to make discussions meaningful and be limited in number to avoid a too great variety and complexity. Their imaginary playing field should encompass most conceivable situations. Dealing with a future that is inherently unpredictable it is worthwhile to distinguish between degrees of unpredictability. Some processes can be considered as highly certain (gravity, solar movements, incoming radiation), others as "quite certain" (long term demographic trends, climate change, increase and further dissemination of knowledge and technology), others as basically unpredictable for a longer period (new inventions, geopolitical incidents, outbreaks of new diseases such as SARS).

Eururalis scenarios need to cater for analysis in the mid-term as well as the longer term.

Policy makers typically refer to questions within the current policy framework – in the case of the EU with a time horizon of at most 2013, the end date of the Commission's budgetary proposals issued in February 2004. At the same time, a sustainable development perspective requires awareness of the possible consequences of current decision making on future generations; and of new challenges that may arise from autonomous developments. This requires extending the scenario horizon to at least 2030.

Short and medium term analyses commonly use a different approach than long term scenario studies: A baseline-cum-variants set-up is often used for the near and mid-term whereas sets of contrasting (but nonetheless plausible) scenarios seem to be more appropriate for explorations extending further into the future. However, using these different approaches in a single undertaking like Eururalis would lead to confusing discontinuities in assumptions regarding driving forces and the scope of policy response. It would be especially problematic and confusing to present and explain the outcomes in tables or graphs with a continuous time-axis.

Therefore it was decided to develop a set of four contrasting scenarios right from the start. It is recognised that such a scenario set should be of the type geared towards strategic analysis which makes it less suited for detailed questions such as, for example, the consequences of isolated policy measures regarding a single sector. The set of scenarios should enhance discussions linked with today's concerns regarding for example WTO negotiations, further EU enlargement, cohesion policy and the elaboration and implementation of major environmental framework directives. These concerns clearly reflect the (changing) attitudes of societies towards broad issues like globalisation, international solidarity, cultural identity and environmental stewardship which are typically at the roots of long term scenario studies.

3.2 Roots of the scenarios

The Eururalis set of four scenarios is derived from the well-known set of IPCC-SRES scenarios of global coverage (Nakicenovic and Swart, 2000). IPCC-SRES initiated a set of four scenarios, which have been widely adopted and used in other studies, usually modified or specified to serve a certain purpose. Also in the Eururalis study modifications to this core set have been made. The EURURALIS-study could build on previous work done in other studies, making a quick start of the work possible. These studies were GEO-3 (UNEP, 2002 , UNEP and RIVM, 2003, UNEP/RIVM, 2004), the study Four Futures of Europe by the Dutch CPB Economic Assessment Bureau (Mooij and Tang, 2003) and the work of RIVM and LEI for MNP-RIVM's forthcoming Sustainability Outlook (Eickhout et al., in prep.).

The quantative base of the scenarios was taken from the Four Futures of Europe study which itself used the Worldscan model, in which assumptions have been made regarding macro-economic growth, not only in Europe but in other continents as well. Other important driving forces taken from this study were demographic development and labour force projections.

Concerning trade in agricultural and other products, scenario assumptions have been elaborated and quantified by LEI (with GTAP-based modelling) and RIVM (with IMAGE) and cover the EU-25 in a global regionalized context. The present study was inspired by this approach but had to adapt and refine it to the national levels. Therefor all data were recalculated. Climate policies, which are not part of the original SRES scenarios, can be derived from subsequent 'mitigation scenarios' as elaborated in IMAGE (Bollen et al., 2004).

In addition, many other specifications were added by the project team – for example regarding EU agricultural policy and regarding biodiversity in the four scenarios.

3.2.1 The overall view

In order to deal with different uncertainties, four contrasting scenarios have been developed, like in the SRES approach. One axis distinguishes a world being further globalized versus a regionalized world. The second axis represents the dominant steering philosophy, one being a world with low governmental intervention and the other being a world with a high(er) degree of governmental intervention. In that way four scenarios are distinguished. The scenarios are called Global economy (A1), Global co-operation (B1), Continental markets (A2) and Regional communities (B2) (fig 3.1). The indications A1 to B2 refer to the SRES-indication. The names for B1 and A2 differ from the names being used by the CPB.

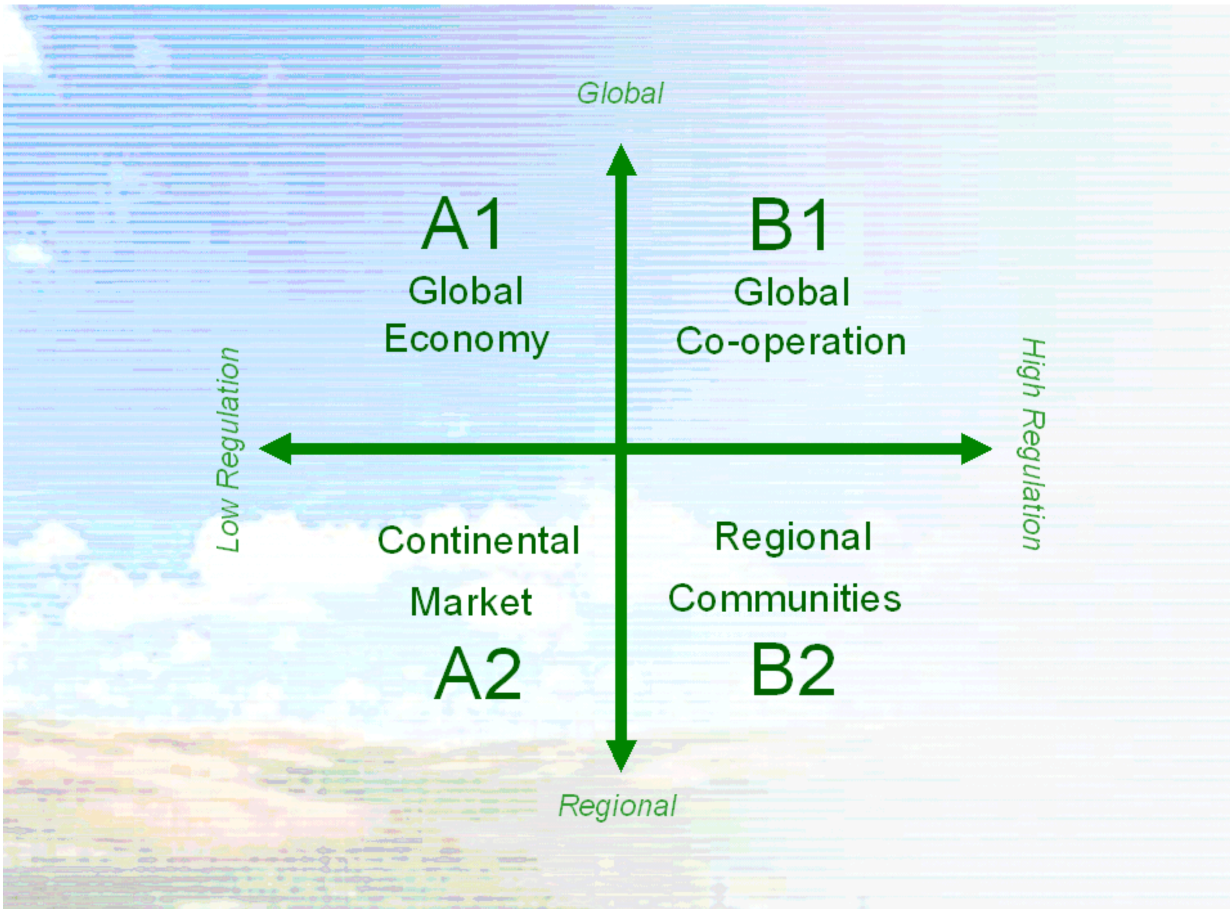


Figure 3.1: Four contrasting scenarios

3.2.2 Short story lines per scenario

In this section the storylines are presented for the four scenarios. The storylines are however kept short, in order to be able to maintain the overview. The assumptions per scenario are worked out more in detail per subject in appendix 1.

Global economy (A1)
The **Global Economy** scenario assumes multilateral cooperation on economic issues, including successful WTO negotiations leading to elimination of almost all trade barriers. CAP subsidies and cohesion policy are phased out by 2030. Societies are predominantly driven by market-based solutions, resulting in high economic growth rates, particularly for poorer countries. There is a strong technology development. The role of the government is limited to core responsibilities, like basic education, security, major infrastructure ensuring conditions for competitive markets, law enforcement.

Turkey, Romania, Bulgaria as well as some Balkan countries, Ukraine and some smaller countries have joined the EU. There is a flexible policy regarding migration. Maintenance (and extension) of nature preserves is not seen as a priority for the government and is mainly depending on private initiatives.

Global co-operation (B1)

The **Global Co-operation** scenario assumes multilateral cooperation on many issues, aiming at a fair distribution of wealth, social justice and environmental stewardship. Trade barriers are gradually removed. Developing regions (inside and outside the EU) are supported to eliminate poverty. The level of CAP subsidies is reduced, with domestic support specifically targeted at environmental sustainability and to catalyse rural development (2nd pillar of CAP). The economic growth rate in the EU and other OECD countries is strong, but less then in Global Economy. The economic growth in other regions is slightly higher than in Global economy. There is a strong technological development, partly focussed on environmentally friendly production methods. Turkey, Romania and Bulgaria have joined the EU. There is a flexible policy regarding international mobility of people from outside the EU. No limitation for migration among member countries. Maintenance (and acquisition) of natural and cultural heritage are mainly publicly funded.

Continental markets (A2)

The **Continental Markets** scenario assumes a view that social and cultural values can best be preserved in regional political alliances, within which nation states should keep as much sovereignty as possible. Therefore protection measures remain in place. Within this constrained, the society prefers market-based solutions. The EU will form a single market with the US and Canada. No further enlargement of the EU will take place. The policy regarding the international mobility of people from third countries is restrictive. Cohesion policy is not seen as a priority. The overall economic growth rate is lower then in A1 and B1, especially in the Central and Eastern European countries as well as in developing countries. The technology development is also lower then in the other two scenarios.

Regional communities (B2)

The **Regional communities** scenario assumes that social and cultural values can best be preserved at the community level. Resource allocation cannot be left to the market. Self-reliance, ecological stewardship and equity are the keys to sustainability. Government intervention is necessary to facilitate negotiations between stakeholders and enforce decisions, rather than to impose regulations. International co-operation is necessary to obtain sustainable development at global level. Agricultural markets protected against competing products to avoid cheap import surges, disrupting EU agriculture. Strong attention to non-trade concerns regarding imports form third countries. Production standards of imports regarding health, environment and animal welfare should be at least as high as EU. High environmental standards are agreed at national and EU level, e.g. the Water Framework Directive is fully implemented. Maintenance (and acquisition) of natural and cultural heritage is a priority. Requests for funding by EU and national governments are prepared by local communities. Hotspots of biodiversity are protected by EU regulations. There is an increase in area as compared to 2000 situation, but an Ecological Main Structure is difficult to achieve due to lack of co-ordination.

3.3 Characteristics

3.3.1 Time paths

The aforementioned studies either assume the implementation of a complete package of contrasting policy measures right from the start or do not provide time paths at all. Given the scope and objectives of EURURALIS, considerable efforts were invested to elaborate consistent time-paths along which more or less autonomous developments occur. The land use allocation module used in EURURALIS (CLUE) is particularly designed to take account of key path-dependencies.

3.3.2 Not a la carte policy choices

Policy interventions will have a different effectiveness in the different scenarios. This is because certain interventions will 'go with the flow' in certain scenarios, while others will not. For example, drastic reform of subsidies will relatively easily and quickly be adopted in a scenario where free-market thinking is generally embraced. In contrast, a policy strategy of ambitious zoning (spatial planning) will run into headwind in such a scenario. This needs to be incorporated in the mechanics of any interactive presentation and explained to the user.

3.3.3 Careful presentation

Obviously, the proposed pragmatic combination of pre-existing elements may be optimal in terms of available time but will suffer from issues of internal consistency, unbalanced depth of analysis and other problems. Thus it will be vulnerable to criticism. Therefore, the scenarios must be presented as:

- a first exploration of scenarios for rural development in the expanding EU
- members of the four 'scenario families' that figure in SRES – having genes in common but not necessarily being identical.

In particular, the CPB interpretation of the four scenarios is clearly biased towards free-market scenarios and only just related enough to pass for an elaboration of IPCC SRES.

By way of conclusion, Figure 3.2 illustrates the way we pragmatically derived relevant scenarios for Eururalis.

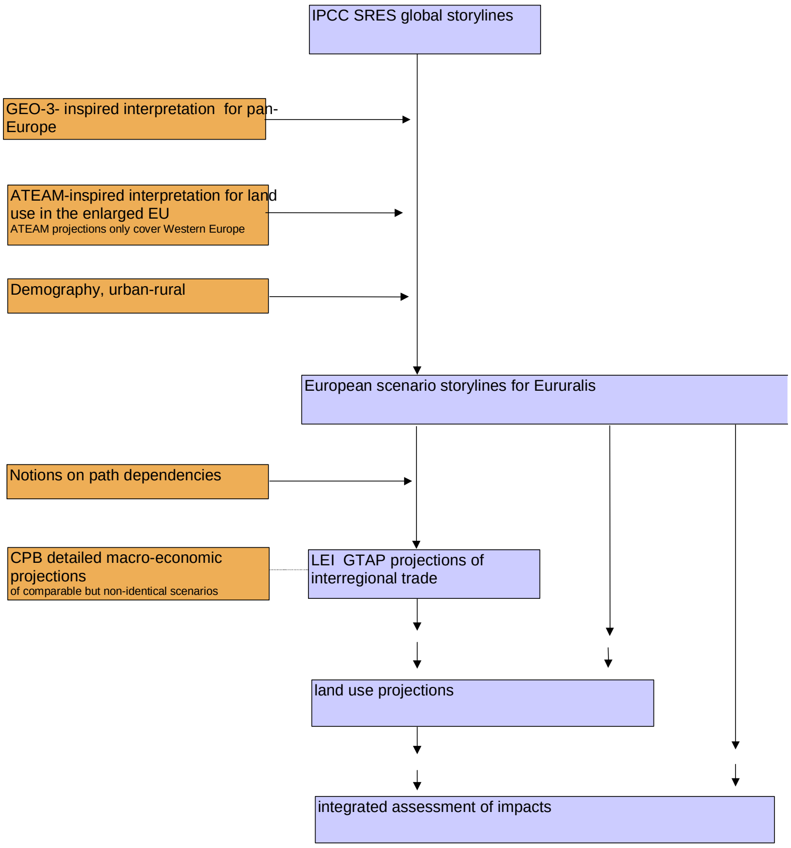


Figure 3.2. Derivation of Eururalis scenarios

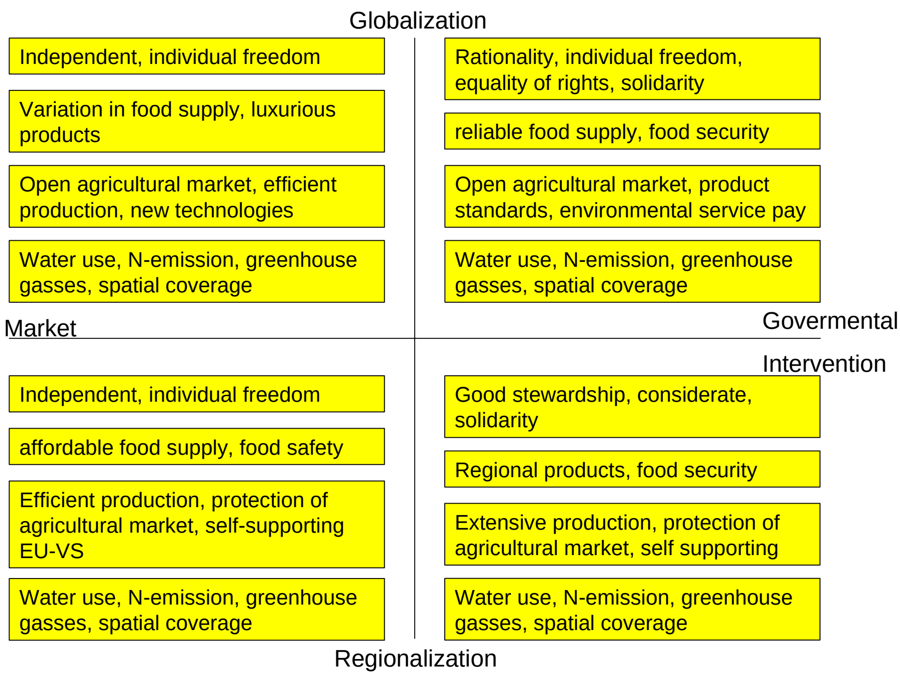


Figure 3.3:Preferences in society, summary of assumptions in the four scenarios

3.4 Further elaboration of the scenarios

The next stage was that these storylines were specified for the topics at stake in EURURALIS. These are included in this document in the Annex 1. These are still rather qualitative. In order to translate these in concrete and if necessary in quantified information to serve as input for modelling and predictions we added information in extended tables. These tables are added in appendix 1.

The main policy fields considered are the Common Agricultural Policy (farm payments, export subsidies, tariffs, specific arrangements with (groups of) countries, production quota, less favoured areas, etc.), incentives for organic farming, nature conservation, urban planning etc. Table x.x gives a summary of the assumptions per scenario. Furthermore, a number of important driving forces were quantified. These driving forces are therefore exogenous variables for the models which have been used. These driving forces and their quantification are described in Chapter 2.1.

Table 3.1 Summary of policy assumptions per scenario

	Global Economy (A1)	Continental Markets (A2)	Global Co-operation (B1)	Regional Communities (B2)
EU	Turkey enters EU in 2020	Turkey outside EU-27	Turkey enters EU in 2010	Turkey outside EU-27
Common Agricultural Policy	Export subsidies and import tariffs: abolished in 2030 (after stepwise reduction) Product quota abolished in 2020 Coupled and decoupled payments abolished in 2030	Export subsidies: kept in place Import tariffs: kept in place Product quota remain,; aiming at self-sufficiency Coupled farm payments remain at 2003 level Decoupled payments remain	Export subsidies and import tariffs: abolished in 2030 (after stepwise reduction) Product quota abolished in 2020 Coupled payments incorporated in single farm payment Decoupled payments remain, but -50%	Export subsidies: abolished in 2020 Increase in non-tariff barriers Product quota remain,; aiming at self-sufficiency Coupled farm payments remain at 2003 level Decoupled payments remain, but -20%
Nature conservation	Existing areas within Natura 2000 protected	Existing areas protected	Existing areas protected; Abandoned agricultural areas in Natura 2000 network managed for nature development	Existing areas protected; 50% of abandoned agricultural areas managed for nature development
Urban planning	No restrictions	No restrictions	Restriction on growth of large cities	Restriction on growth of large cities

3.5 Different views on sustainability

The text is this paragraph mainly consists of an adaption of the English summary of the RIVM-publication Quality and the future: Sustainability outlook (RIVM, 2005)

In essence, sustainability is about the quality of life and the possibilities for maintaining this quality in future. What sustainability is, therefore, depends on:

- the public opinion about the quality of life,
- the distribution of this quality of life across the globe, and
- the scientific understanding of the functioning of humans and natural systems.

Is inequality in the world seen as a problem? Are the available collective resources sufficient? Should they be allocated fairly via the public sector, or on the basis of efficiency via the market? Scientific knowledge on the availability of resources can be used to estimate the future risks associated with maintaining this quality. Sustainability, therefore, is as much about social values as scientific insights.

A survey conducted in the Netherlands indicated that both the choice for a certain quality of life and people's opinions on how this quality should be allocated were derived from the same value orientations. Those who rate performance highly are more likely to prefer free trade. Those who consider equity and world peace to be the highest goals are more likely to support strong international governance. The chosen quality of life, the way it should be realised and on what scale can, therefore, be combined. These combinations can be seen as world views. In order to confront the user of the EURURALIS CD with this principle, a self test is included. Users can test themselves in a simple test, to determine which world view fits them.

In line with the four scenario's, we distinguish between four world views. The world views differ primarily in the degree to which activities have international interlinkages, i.e. globalisation versus more regional development (vertical axis) and in the balance between efficiency and solidarity (horizontal axis). The horizontal axis is strongly associated with the choice between market forces and government coordination. Each world view represents a different specific quality of life; in other words, a specific idea about goals and means.

The question 'How are we doing?' has more than one answer
In general, sustainability is measured through a set of indicators. Indicators are the lenses through which we examine the actual trends in sustainability from the perspective of the different world views. In the A1 world view, for example, great significance is attached to the size of the national debt, while in B2 this is unimportant. In B1 great importance is attached to hunger in the world and to human rights. In other words, what sustainability is depends to great extent on which world view is adopted.

On the EURURALIS CD we therefore choose to show a number of indicators, in all three domains of People –Planet – Profit. It is up to the user to find a balance between the 3 P's.

4 Models and data

4.1 General framework

Models enable to answer "what if?" questions. The impact of changes in driving forces such as climate and policy on land use can be assessed. The EURURALIS project uses three important core –models:

- LEITAP, which is an adapted version of the modelling framework developed for the Global Trade Analysis Project (GTAP, Hertel, 1997);
- the Integrated Model to Assess the Global Environment (IMAGE; Alcamo et al., 1998; IMAGE Team, 2001) is a dynamic integrated assessment modelling framework for global change;
- the CLUE modelling framework (the Conversion of Land Use and its Effects) which allocates national level changes in land use to different locations within the 25 countries considered.

The main architecture and relationships of these three models and their interactions is visualised in Fig. 4.1. A characterization of each of the models will be given below. Next to the core models GTAP, IMAGE and CLUE various thematic models were used to evaluate the effects of changes in landuse on the selected indicators.

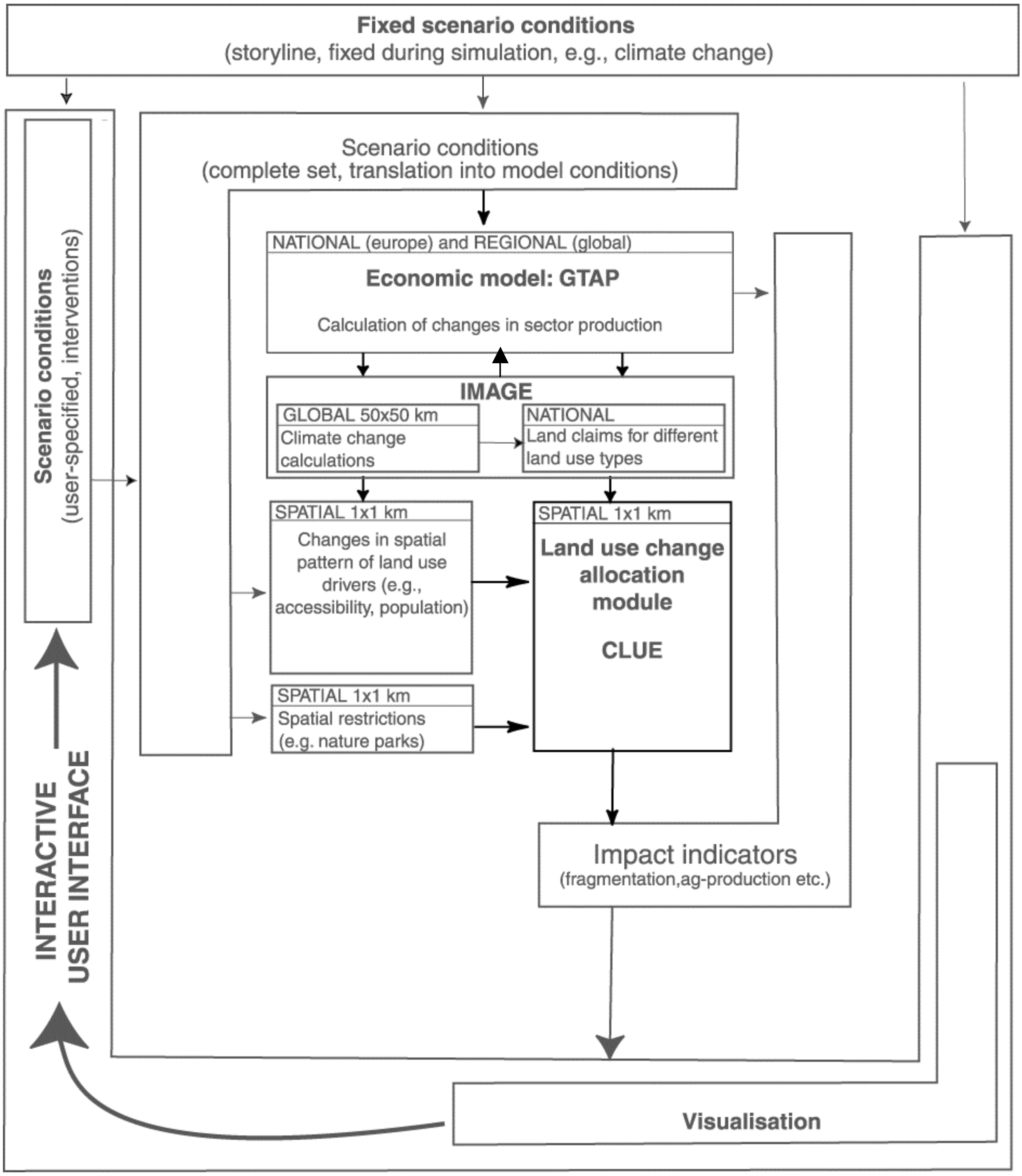


Figure 4.1: Relationschp between GTAP, IMAGE and CLUE)

4.2 LEITAP (adapted version from GTAP)

The analysis is carried out with an adapted version of the general equilibrium model of the Global Trade Analysis Project (GTAP, Hertel, 1997). The first part of this section provides a brief overview of the standard GTAP model and the second part we focus on extensions. The standard model was improved with a new land allocation method that takes into account that the degree of substitutability between different types of land use (Section 4.2.2). A new land supply curve allowing for conversion and abandonment of land is described in Section 4.2.2. The linkage of the adapted economic model to the IMAGE framework in order to model yields and feed efficiency rates is described in Section 4.2.2. Additionally, we used information from the OECDs Policy Evaluation Model (PEM) to improve the production structure and introduced an endogenous quota mechanism. In section 4.2.3 we describe the projection methodology and in section 4.2.4 we discuss the data. Finally, in section 4.2.5 policy assumptions and their implementation aredescribed.

4.2.1 Global Trade Analyses Project: The standard Model

GTAP was initiated with the goal of supporting high-level quantitative analysis of international trade, resource, and environmental issues in an economy wide context. The GTAP project is supported by the leading international agencies (e.g. WTO, Worldbank, OECD, UNCTAD) in trade and development policy, as well as a number of national agencies with active research programs on these issues. The GTAP project develops and maintains a database, a multi-region multi-sector general equilibrium model. It also provides training courses and organizes an annual conference on global economic analysis. This project has grown rapidly since its inception in 1993. There is no doubt that the GTAP database and its associated modelling efforts represent a major achievement for advancing quantitative analysis of international trade, resource and environmental issues. The success of this approach is reflected in a high degree of academic recognition as well as the increasing usage for policy analysis by international and national agencies.

Standard model characteristics
There are basically two strands of quantitative modelling in policy analysis. One approach is to build issue-specific models, depending on the question at hand. These models will usually be capable of capturing many relevant aspects of one specific policy question, but are of less use in a different policy context. The other approach sets out to construct more general and flexible models, which do not necessarily attempt to capture all detail but are flexible enough to allow elaborations in face of specific policy questions. The Global Trade Analysis Project (GTAP) provides such a modelling framework.

The standard GTAP model2 is a comparative static multi-regional general equilibrium model. In its standard version constant returns to scale and perfect competition are assumed in all markets for outputs and inputs. A detailed discussion of the basic algebraic model structure of the GTAP model can be found in Hertel

[2] We deliberately refer to the ‘standard GTAP model’ as the model version that is supported by the GTAP consortium. GTAP users have developed numerous variations on the standard model. In this study we also make some modifications to the standard model. These are discussed more extensively in subsequent chapters

and Tsigas (1997)3. In the GTAP model each country or region is depicted within the same structural model.

The general conceptual structure of a regional economy in the model is represented in Figure 4.2. Within each region, firms produce output, employing land, labour, capital, and natural resources and combining these with intermediate inputs. Firm output is purchased by consumers, government, the investment sector, and by other firms. Firm output can also be sold for export. Land is only employed in the agricultural sectors, while capital and labour (both skilled and unskilled) are mobile between all production sectors.

The model is characterized by an input-output structure (based on regional and national input-output tables) that explicitly links industries in a value added chain from primary goods, over continuously higher stages of intermediate processing, to the final assembling of goods and services for consumption. Inter-sectoral linkages are direct, like the input of steel in the production of transport equipment, and indirect, via intermediate use in other sectors. The model captures these linkages by modelling firms' use of factors and intermediate inputs. The most important aspects of the model can be summarized as follows: (i) it covers all world trade and production; (ii) it includes intermediate linkages between sectors;

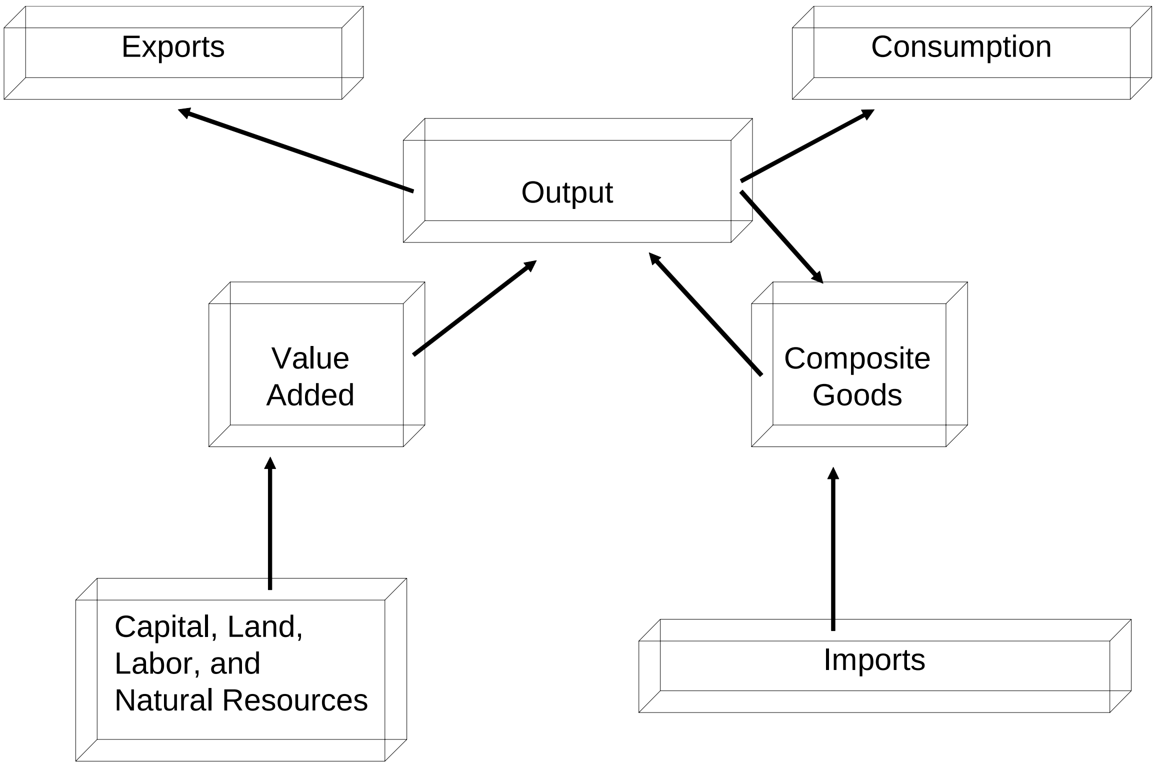


Figure 4.2: the flow of production

The consumer side is represented by the regional household to which the income of factors, tariff revenues and taxes are assigned. The regional household allocates its

[3] Or in the internet http://www.agecon.purdue.edu/gtap/model/chap2.pdf

income to three expenditure categories: private household expenditures, government expenditures and savings. For the consumption of the private household, the non-homothetic Constant Difference of Elasticities (CDE) function is applied.

In the model, a representative producer for each sector of a country or region makes production decisions to maximize a profit function by choosing inputs of labor, capital, and intermediates to produce a single sectoral output. In the case of crop production, farmers also make decisions on land allocation. Intermediate inputs are produced domestically or imported, while primary factors cannot move across countries. Markets are typically assumed to be competitive. When making production decision, farmers and firms treat prices for output and input as given. Primary production factors land and capital are fully employed within each economy, and hence returns to land and capital are endogenously determined at the equilibrium, i.e., the aggregate supply of each factor equals its demand.

The production structure is depicted with a production tree with four nests (Figure 4.3). The Leontief and the Constant Elasticity of Substitution (CES) functional forms are used to model the substitution relations between the inputs of the production process. In the output nest, the mix of factors and intermediate inputs are assembled together, forming the sectoral output. The functional form can be Leontief (fixed proportions) or CES. The substitution relations within the value added nest are depicted by the CES function. While labor and capital are considered mobile across sectors the Constant Elasticity of Transformation (CET) function is used to represent the sluggish adjustment of the factor land. That is, land can only imperfectly move between alternative crop uses. The CES function is applied in the composite intermediate nest depicting the substitution between domestic and imported products. The last nest illustrates the relation between imports of the same good from different regions. The Armington approach treats products from different regions as imperfect substitutes.

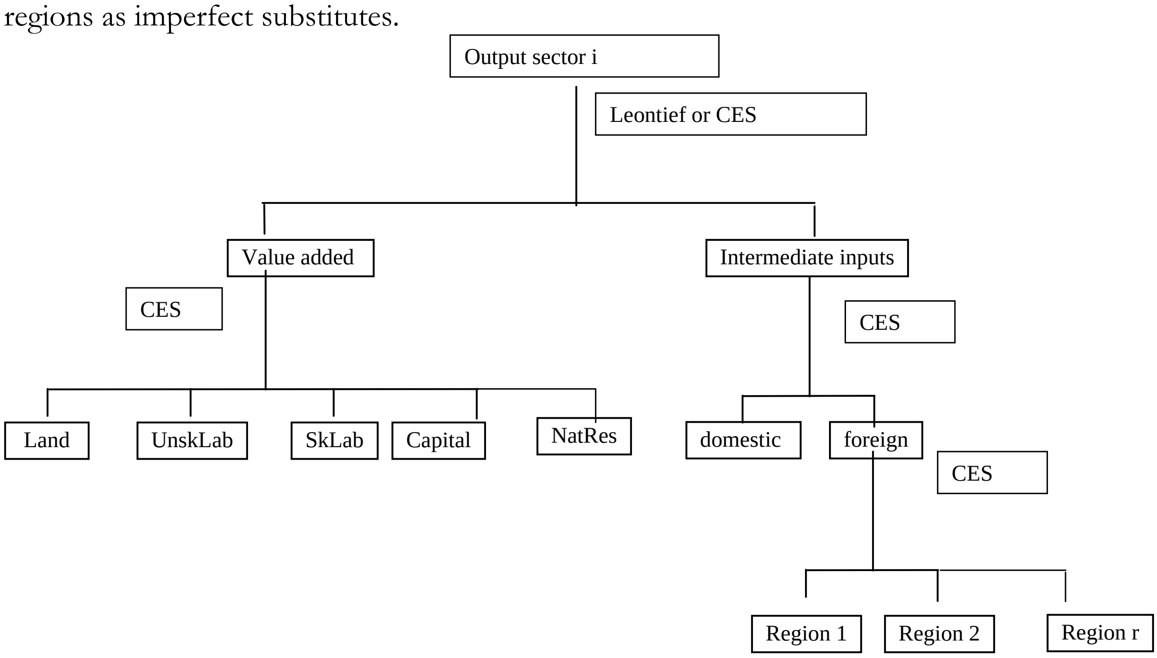


Figure 4.3: Production tree (Source: Hertel and Tsigas (1997)).

Prices on goods and factors adjust until all markets are simultaneously in (general) equilibrium. This means that we solve for equilibria in which all markets clear. While we model changes in gross trade flows, we do not model changes in net international capital flows. Rather our capital market closure involves fixed net capital inflows and outflows. (This does not preclude changes in gross capital flows). To summarize, factor markets are competitive, and labor and capital are mobile between sectors but not between regions.

The GTAP model includes two global institutions. All transport between regions is carried out by the international transport sector. The trading costs reflect the transaction costs involved in international trade, as well as the physical activity of transportation itself. Using transport inputs from all regions the international transport sector minimizes its costs under the Cobb-Douglas technology. The second global institution is the global bank, which takes the savings from all regions and purchases investment goods in all regions depending on the expected rates of return. The global bank guarantees that global savings are equal to global investments. With the standard closure, the model determines the trade balance in each region endogenously, and hence foreign capital inflows may supplement domestic savings. The model does not have an exchange rate variable. However, by choosing as a numeraire an index of global factor prices, each region's change of factor prices relative to the numeraire directly reflects a change in the purchasing power of the region's factor incomes on the world market. This is can be directly interpreted as a change in the real exchange rate.

The welfare changes are measured by the equivalent variation, which can be computed from each region's household expenditure function.

Taxes and other policy measures are included in the theory of the model at several levels. All policy instruments are represented as ad valorem tax equivalents. These create wedges between the undistorted prices and the policy-inclusive prices. Production taxes are placed on intermediate or primary inputs, or on output. Trade policy instruments include applied most-favored nation tariffs, antidumping duties, countervailing duties, price undertakings, export quotas, and other trade restrictions. Additional internal taxes can be placed on domestic or imported intermediate inputs, and may be applied at differential rates that discriminate against imports. Where relevant, taxes are also placed on exports, and on primary factor income. Finally, where relevant (as indicated by social accounting data) taxes are placed on final consumption, and can be applied differentially to consumption of domestic and imported goods.

The GTAP model is implemented in GEMPACK - a software package designed for solving large applied general equilibrium models. A description of Gempack can be found in Harrison and Pearson (2002)4.

[4] More information can be obtained at www.monash.edu.au.policy/gempack.htm

Various GTAP users have developed adaptations of the standard model. Such elaboration's, include increasing returns to scale and imperfect competition, dynamic equilibrium formulations and incorporation of non-continuous policy instruments such as Tariff rate quota that resulted from GATT Uruguay round, or production quota as applied in the European milk and sugar sectors. For a model version that uses both increasing returns and production quota, see Francois et al. (2003) and Francois et al. (2005).

4.2.2 Extensions to the standard GTAP model:

For the purpose of the EURURALIS study, we have constructed a special purpose version of the GTAP database and model, designed to make it more appropriate for the analyses of the agricultural sector. We use information from the OECDs Policy Evaluation Model (PEM) to improve the production structure.

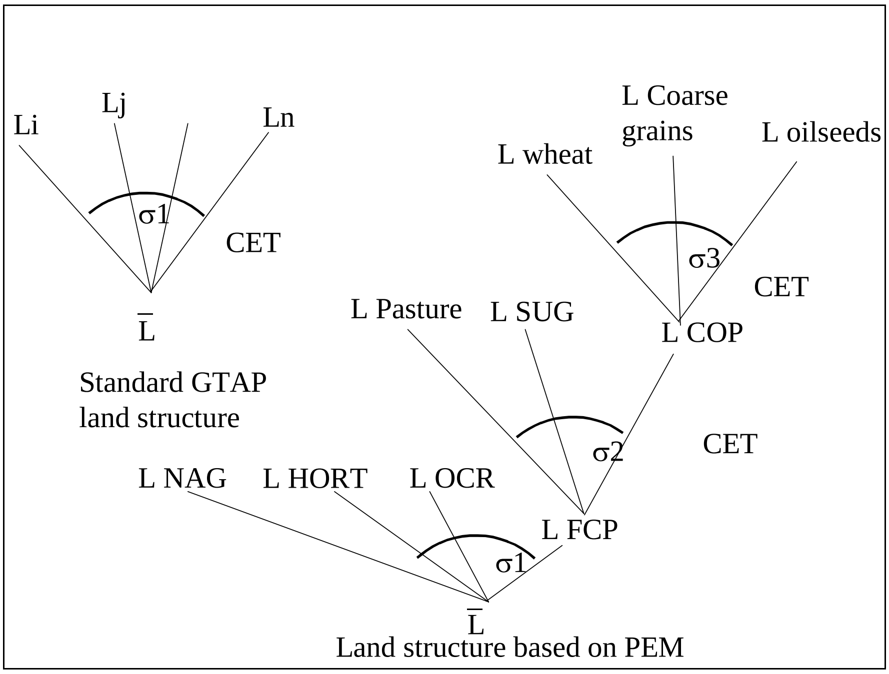


Figure 4.4: Land allocation 'tree'

4.2.2.1 Land allocation under the heterogeneity of land assumption:

The base version of GTAP represents land allocation in a CET structure (see left part of Figure 4.4). It is assumed that the various types of land use are imperfectly substitutable, but the substitutability is equal among all land use types. We extended the land use allocation structure by taking into account that the degree of substitutability of types of land differs between types (Huang et al. 2003). We use the OECDs Policy Evaluation Model (OECD, 2003) structure, as it has more detail. It distinguishes different types of land in a nested 3-level CET structure. The model covers several types of land use more or less suited to various crops (i.e. cereal grains, oilseeds, sugar cane/sugar beet and other agricultural uses). The lower nest assumes a constant elasticity of transformation between 'vegetable fruit and nuts' (HORT), 'other crops' (e.g. rice, plant based fibres; OCR), the group of 'Field Crops and Pastures' (FCP, and non-agricultural land (NAG)5. The transformation is governed by the elasticity of transformation σ1. The FCP- group is itself a CET aggregate of Cattle and Raw Milk (both Pasture), 'Sugarcane and Beet' (SUG), and the group of 'Cereal, Oilseed and Protein crops' (COP). Here the elasticity of transformation is σ2. Finally, the transformation of land within the upper nest, the COP-group, is modeled with an elasticity σ3.

In this way the degree of substitutability of types of land can be varied between the nests. It captures to some extent agronomic features. In general it is assumed that σ3> σ2 >σ1. This means that it is easier to change the allocation of land within the COP group, while it is more difficult to move land out of COP production into, say, vegetables. The values of the elasticities are taken from PEM (OECD, 2003).

4.2.2.2 Variability of total area

In the standard GTAP model, the total land supply is exogenous. In the version of the model the total agricultural land supply is modeled using a land supply curve which specifies the relation between land supply and a rental rate (Abler, 2003). Land supply to agriculture as whole can be adjusted as a result of idling of agricultural land, conversion of non-agricultural land to agriculture, conversion of agricultural land to urban use and agricultural land abandonment.

The general idea is that when there is enough agricultural land available increases in demand for agricultural purposes will lead to land conversion to agricultural land and a modest increase in rental rates (see, left part of Fig. 4). However, if almost all agricultural land is in use then increases in demand will lead to increases in rental rates (land becomes scarce, see right part of Fig. 4).When land conversion and abandonment possibilities are low the elasticity of land supply in respect to land rental rates are low and land supply curve is steep.

[5] The non-agricultural commodities do not use land in the current GTAP model version. However, since land allocation in GTAP is defined over all commodities we add the non-agricultural land to the land allocation tree.

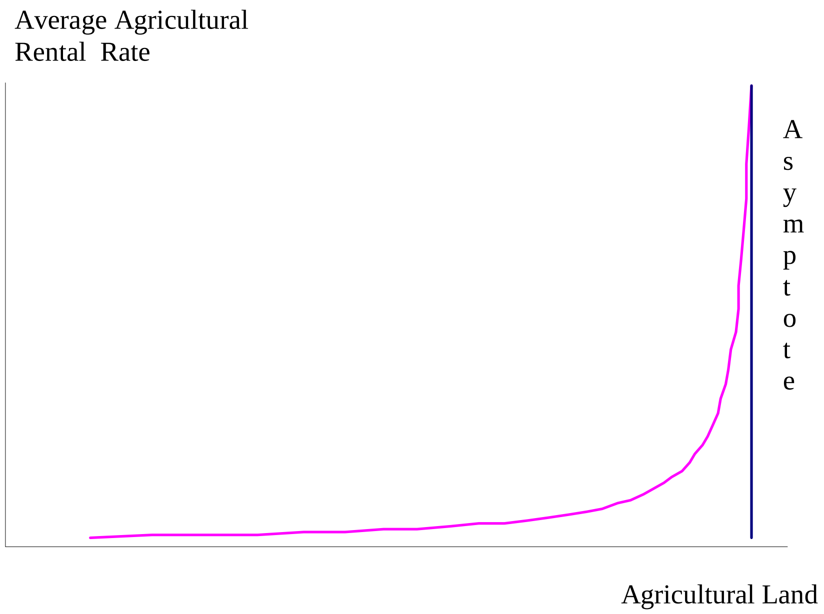


Figure 4.5: Land supply curve: land conversion and abandonment

We have assumed the following land supply function:

$$\text{Land supply} = a - b/\text{real land price} \qquad (1)$$

where: a (>) is an asymptote, b is a positive parameter and the land supply elasticity E in respect of the land price is equal to

$$E = b/(a \cdot \text{real land price} - b) \qquad (2)$$

We have calibrated the parameters a and b of the land supply function in such a way that it reproduces the GTAP land data for 2001. We have assumed the available agricultural land expressed by asymptote a is a sum of the agricultural land used currently is the production process and abounded agricultural land. We have used predicted by FAO agricultural land changes per region for 2030 as indicators of agricultural land availability. In general, we have assumed that higher predicted increase of the agricultural land means higher availability of abounded agricultural land in the region. If the decrease of the agricultural land was predicted, we have assumed the scarcity of the agricultural land. Base on these consideration, we set the asymptote a.

Having asymptote a, we have used GTAP land use data for 2001 as the land supply and observation for 2001 the initial GTAP real land prices equal to one to calculate the parameter b of the land supply function from the formula:

$$b = a - \text{Land supply} \qquad (3).$$

and the land supply elasticity E in respect of the land price from formula (2).

4.2.2.3 Yield and feed conversion: Linkage with IMAGE[6]

Section 3.1 showed that yields are only dealt with implicitly and that the feed livestock linkage in the GTAP is calculated using input-output coefficients. To improve the treatment of these issues the adjusted GTAP model was linked with the IMAGE model (Alcamo *et al.*, 1998; IMAGE Team, 2001[7]). The objective of IMAGE 2.2 is to explore the long-term dynamics of global environmental change. Ecosystem, crop and land-use models are used to compute land use on the basis of regional production of food, animal products and timber, and local climatic and terrain properties. The production of food and animal products come from the adjusted GTAP model. The coinciding land-use change and greenhouse gas emissions are determined. The atmospheric and ocean models calculate changes in atmospheric composition by employing the emissions and by taking oceanic CO_2 uptake and atmospheric chemistry into consideration. Subsequently, changes in climatic properties are computed by resolving oceanic heat transport and the changes in radiative forcing by greenhouse gases and aerosols. The impact models involve specific models for sea-level rise and land degradation risk and make use of specific features of the ecosystem and crop models to depict impacts on vegetation and crop growth (Leemans and Eickhout, 2004). Since the IMAGE model performs its calculations on a grid scale (of 0.5 by 0.5 degrees) the heterogeneity of the land is taken into consideration (Leemans et al., 2002).

Yields

In the adjusted GTAP model yield is only dependent on a trend factor and dependent on prices. The production structure used in this model implies that there are substitution possibilities among factors. If land gets more expensive, the producer uses less land and more other production factors such as capital. The impact is that land productivity or yields will increase. Consequently, yield is dependent on an exogenous part (the "trend" component) and on an endogenous part with relative factor prices (the "management factor" component).

First, the exogenous trend of the yield is taken from the FAO study 'Agriculture towards 2030' (FAO, 2003), in which they combined macro-economic prospects with local expert knowledge. This approach led to best-guesses of the technological change for each country for the coming 30 years. Given the scientific status of the FAO-work these data are used as exogenous input for a first model run with the adjusted GTAP model. However, many studies indicated this change in productivity

[6] This section concentrates on GTAP-IMAGE link concerning yield calculation. More about GTAP-IMAGE link, reader can find in the section 5.1.5.

[7] In this paper we focus on the yield and feed efficiency linkage and the environmental consequences are described in Eickhout *et al.* (2004).

will be enhanced or reduced by other external factors, of which climate change is mentioned most often (Rosenzweig et al., 1995; Fischer et al., 2002). These studies indicated increasing adverse global impacts because of climate change will be encountered with temperature increases above 3 to 4 °C compared to pre-industrial levels. These productivity changes need to be included in a global study. Moreover, the amount of land expansion or land abandonment will have an additional impact on productivity changes, since land productivity is not homogenously distributed over each region.

In our approach, the exogenous part of the yield is updated in an iterative process with the IMAGE model (see Figure 5). The output of GTAP used for the IMAGE-iteration is sectoral production growth rates and a management factor describing the degree of land intensification. Next, the IMAGE model calculates the yields, the demand for land and the environmental consequences on crop growth productivity. IMAGE simulates global land-use and land-cover changes by reconciling the land-use demand with the land potential. The basic idea is to allocate gridded land cover within different world regions until the total demands for this region are satisfied. The results depend on changes in the demand for food and feed and a management factor as computed by GTAP. Crop productivity is also affected by climate change. The allocation of land-use types is done at grid cell level on the basis of specific land allocation rules like crop productivity, distance to existing agricultural land, distance to water bodies and a random factor (Alcamo et al., 1998). This procedure delivers additional changes in yields, which are given back to GTAP. A general feature is that yields decline if large land expansions occur since marginal lands are taken into production.

4.2.2.4 Feed conversion in livestock

The intensification of livestock production systems also influences the composition of the animal feed required by livestock production systems. In general, intensification is accompanied by decreasing dependence on open range feeding and increasing use of concentrate feeds, mainly feed grains, to supplement other fodder. At the same time improved and balanced feeding practices and improved breeds in ruminant systems enabled more of the feed to go to meat and milk production rather than to maintenance of the animals. This has led to increasing overall feed conversion efficiency (Seré and Steinfeld, 1996). In the IMAGE model, the production of animal products is used as input to model the number of animals required for this production. For this conversion, the animal productivity is taken from FAO (2003) including the future developments until 2030. Based on the animal diets, the intake of crops and grass/fodder are calculated to feed the animals. The feed composition in 2000 is taken from FAO (2003). Future shifts in feed composition are assumed to follow the intensification or extensification coming from GTAP. Intensification will lead to a shift towards more concentrate feeds (maize and soy beans). On the basis of these feed diets the demand for grass and fodder is calculated, assuming that grazing animals such as cattle, goats and sheep depend mainly on pasture and fodder species, while pigs and poultry rely primarily on crops.

After 1995 the feed mix is scenario-driven. We assumed the importance of food crops in the animal diet increases at the cost of pasture and fodder species and crop residues, along with increasing intensity of production on the basis of recent trends observed. More details of the IMAGE grazing simulation are described in Bouwman *et al.* (2005). This procedure delivers feed conversion or efficiency rates for the livestock sectors, that are fed back to the GTAP modeling framework.

4.2.2.5 Feed demand in food processing industry

Developments in livestock are important for the demand for feed crops. In many countries feed crops are delivered to the feed-processing industry and this sector adds value and delivers it to the livestock sectors. The feed-processing sector in GTAP is a part of a very heterogeneous food processing sector which causes the problem that feed demand is determined by the growth of this larger food processing sector and only indirectly by the growth of the livestock sectors.[8] Given the importance of crop feed demand for land use we adjust this aggregation issue by creating a direct link between feed demand in agro-food processing sector (“agro”) and the growth of the livestock complex. Demand for feed crops in food processing sector is a sales weighted average of growth of livestock sectors:

$$qf(i,"agro"r) = \sum_{k=livestock} \frac{VFA("agro",k,r)}{\sum_{m=livestock} VFA("agro",m,r)} * \left(qo(k,r) - af(i,k,r)\right)$$

where
qf (i, “agro”, r) industry demands in food processing sector (agro) for intermediate feed crop input i in region r, VFA (“agro”,k,r) is producer expenditure of k industry on sales from food processing industry (agro) in region r, qo(k,r) is production growth in sector k in region r, sector k is a livestock sector, and af(i,k,r) is the feed efficiency rate in livestock sector k in region r. This efficiency rate af(i,k,r) is provided by IMAGE.

4.2.2.6 Segmentation of factor markets and endogenous production quota

If labor were perfectly mobile across domestic sectors, we would observe equalized wages throughout the economy for workers with comparable endowments. This is clearly not supported by evidence. Wage differentials between agriculture and non-agriculture can be sustained in many countries (especially developing countries) through limited off-farm labor migration (De Janvry 1991). Returns to assets invested in agriculture also tend to diverge from returns of investment in other activities.

[8] In the aggregation used in this paper the problem is more serious because it separates only a very aggregated food-processing sector where the feed processing industry is only a minor part.

To capture these stylized facts, we incorporate segmented factor markets for labor and capital by specifying a CET structure that transforms agricultural labor (and capital) into non-agricultural labor (and capital) (Hertel and Keening, 2003). This specification has the advantage that it can be calibrated to available estimates of agricultural labor supply response. In order to have separate market clearing conditions for agriculture and non-agriculture, we need to segment these factor markets, with a finite elasticity of transformation. We also have separate market prices for each of these sets of endowments. The economy-wide endowment of labor (and capital) remains fixed, so that any increase in supply of labor (capital) to manufacturing labor (capital) has to be withdrawn from agriculture, and the economy-wide resources constraint remains satisfied. The elasticities of transformation can be calibrated to fit estimates of the elasticity of labor supply from OECD (2001).

4.2.2.7 Agricultural production quotas

An output quota places a restriction on the volume of production. If such a supply restriction is binding, it implies that consumers will pay a higher price than they would pay in case of an unrestricted interplay of demand and supply. A wedge is created between the prices that consumers pay and the marginal cost for the producer. The difference between the consumer price and the marginal costs is known as the tax equivalent of the quota rent.

In our model both the EU milk quota and the sugar quota are implemented at the national level. Technically, this is achieved by formulating the quota as a complementarity problem. This formulation allows for endogenous regime switches from a state when the output quota is binding to a state when the quota becomes non-binding. In addition, changes in the value of the quota rent are endogenously determined. If t denotes the tax equivalent of the quota rent, and r denotes the difference between the output quota $\bar{q}$ and output q, then the complementary problem can be written as:

$$r = \bar{q} - q$$

and

either $t > 0$ and $r = 0$ the quota is binding
or $t = 0$ and $r = \geq 0$ the quota is not binding.

4.2.3 Projection methodology

Figure 4.6 shows the projection methodology. The four analyzed scenarios differ by macroeconomic assumptions concerning the GDP, population and employment growth and productivity development in agricultural sector. The economic consequences for the agricultural system, on the basis of the scenario assumptions outlined in the section 2 are calculated by GTAP. The output of GTAP is, among others, sectoral production growth rates, land use, and a management factor describing the degree of land intensification. These are in turn used by IMAGE model to calculate yields, the demand for land, feed efficiency rates and environmental indicators. This procedure delivers new yields, which are given back to GTAP. The iteration process stops when land use is the same in both models.

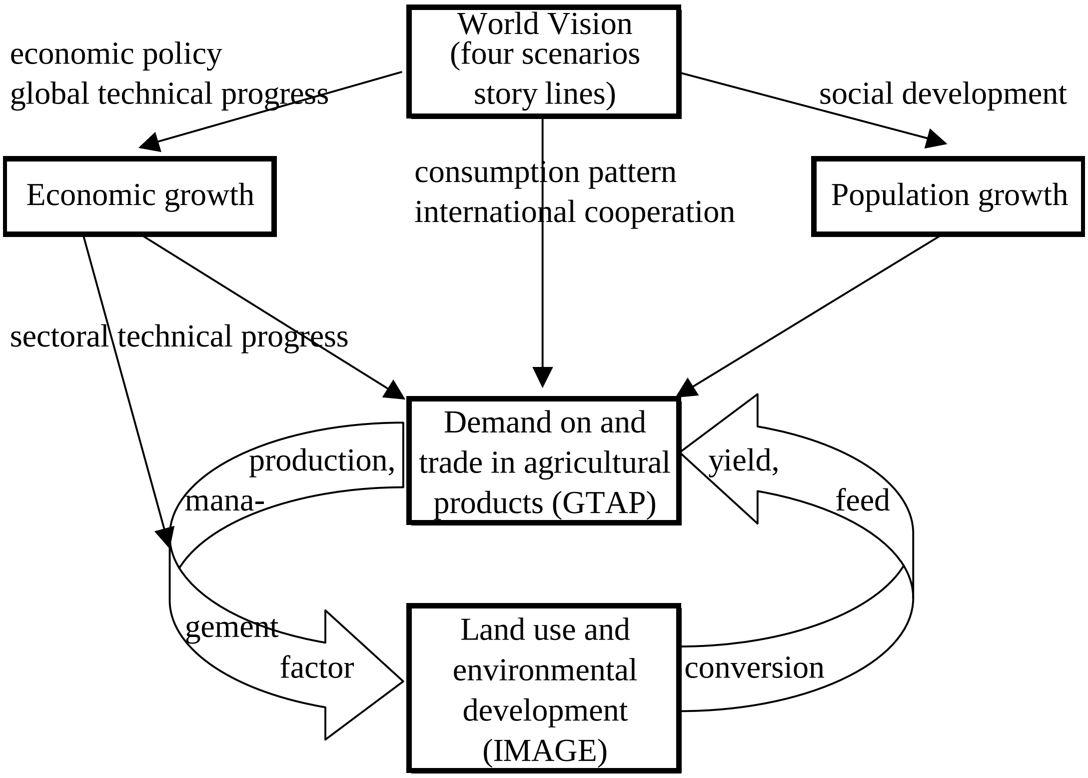


Figure 4.6: The modeling framework of GTAP and IMAGE

The quantification of these assumptions is based on CPB and FAO simulations that were adapted to the sectoral and regional aggregation use in this research in the EURURALIS project framework9. The scenarios are constructed through recursive updating of the database for three consecutive time steps, 2001 – 2010, 2010 – 2020 and 2020 – 2030 such that exogenous GDP targets are met and given exogenous estimates on factor endowments -skilled labor, unskilled labor, capital and natural resources- and population. Therefore, scenario assumptions are made for each period separately.

The procedure implies that technological change is endogenously determined within the model (see also Hertel et al. 1999). In line with CPB, we assumed common trends for relative sectoral total factor productivity (TFP) growth (CPB, 2003). CPB assumed that all inputs achieve the same level of technical progress within a sector (i.e. Hicks neutral technical change). We deviate from this approach by using additional information on yields and feed conversion or efficiency rates from FAO

[9] The exact numbers are available from authors on request.

and the IMAGE model. For the land-using sectors yields are exogenous and obtained in the base run from scenario specific assumptions based on deviations (see annex Table A3) of the FAO yield projections (FAO, 2003). In the iteration process yields are obtained from the IMAGE model. For the livestock sectors (cattle, pigs and poultry, dairy) we obtain in addition feed conversion or feed efficiency rates from the IMAGE model. Within the heterogeneous food processing sector feed input augmenting technical change is endogenous (see section 3.4.5). For the non-land using sectors we assume Hicks neutral technical change.

4.2.4 Data

Version 6.2 of the GTAP data for simulation experiments was used. The GTAP database contains detailed bilateral trade, transport and protection data characterizing economic linkages among regions, linked together with individual country input-output databases which account for intersectoral linkages. All monetary values of the data are in $US millions and the base year for version 6 is 2001. This version of the database divides the world into 88 regions. An additional interesting feature of version 6 is the distinction of the 25 individual EU member states. The database distinguishes 57 sectors in each of the regions. That is, for each of the 65 regions there are input-output tables with 57 sectors that depict the backward and forward linkages amongst activities. The database provides quite a great detail on agriculture, with 14 primary agricultural sectors and seven agricultural processing sectors (such as dairy, meat products and further processing sectors).

The social accounting data were aggregated to 13 sectors and 37 regions (see Annex Table A1 and A2). The sectoral aggregation distinguishes agricultural sectors that use land and sectors engaged in the Common agricultural policy (CAP). The regional aggregation includes all EU 15 countries (with Belgium and Luxembourg as an one region) and all EU 10 countries (with Baltic regions aggregated to an one region and with Malta and Cyprus included in one region) and the most important countries and regions outside EU.

The initial quota rents level are set base on aster set base on SEC, 2003 for sugar and Jensen et al., 2004 and Kleinhanß, et al., 2001 for milk for the EU 15. Since milk deliveries in EU10 counties are far bellow the quota level we assume that the quota rent and production in these countries are exogenous in the model and there is a low quota rent for these counties.

A key aspect of the land cover model of IMAGE is that it uses a crop- and regionally-specific management factor (MF) to represent the gap between the theoretically feasible crop yields simulated by the crop production model, and the actual crop yield which is limited by less than optimal management practices, technology and know-how. Regional management factors are used to calibrate the model to regional estimates of crop yields and land-cover for the period 1970-1995 from FAO. For years after 1995 the management factor is a scenario variable, which is generally assumed to increase with time as an indication of the influence of technological development on crop yields. In this analysis we used the same estimates of the productivity increases from FAO as was used in the GTAP calculations (FAO, 2003). In the four scenarios we deviated from these productivity growth estimates on the basis of regional GDP growth. Other data are used within IMAGE for the 1765-1995 period to initialize the carbon cycle and climate system. After 1995, GTAP results are used for the terrestrial system of IMAGE and CPB/RIVM prognoses for the energy system (Bollen et al., 2004).

4.2.5 Policy assumptions and their implementation

4.2.5.1 Enlargement and Free Trade Areas (FTAs)

The enlargement of the EU is implemented by elimination of all import tariffs and export subsidies as between the EU15 countries and ten new members (EU10) countries. At the same time all (EU10) counties get the same level of protection against third countries as EU15 before enlargement This is implemented by setting EU10 import tariffs and export subsidies on the average level of EU15 tariffs and subsidies. In case of FTAs only A1 bilateral import tariffs and export subsidies are eliminated.

4.2.5.2 Decoupled payments implementation

Decoupling of domestic support is one of the key features of the Mid Term Review (MTR). The different mechanisms through which decoupled payments may affect production are discussed in Westcott and Young (2003). Francois et al. (2005) model decoupling of payments by converting all kinds of payments including output, intermediate input and factor payments and subsidies into uniform land payments. This is also known as full decoupling. This approach can be interpreted as per hectare payment. Alternatively, decoupling of payments can be approached by converting all kinds of payments to homogenous payment for all factors, which can be interpreted as farm payments (premium). In this study, the two above approaches are combined10. The payments are assumed to stay partially coupled because the payments still have production effects and because countries have the opportunity to keep part of the payments coupled.

For EU-15 countries, we assume uniform land subsidy rates for all cereals and oilseeds equal 0.75 and uniform land subsidy rate sectors equal 0.5 for sugar, other crops, beef and milk sectors. The 0.25 difference between these rates depicts the possibility of coupling of 25% hectare payments for cereals and oilseeds agreed in MTR proposal. All remaining factor payments we distributed equally among other than land production factors. Since, we treated the milk sector related payments as partially coupled to the sector, the milk and not-milk sectors have different subsidy rates for others than land production factors.

For EU10 counties we model decoupled payments as farm payments. The total amount of payments was calculated using European Commission estimates.

[10] See Britz, 2004 for similar approach.

4.3 The IMAGE model

4.3.1 Introduction

To assess the consequences of population change, agricultural production levels and climate change on the desired agricultural land area, the IMAGE model was used. The Integrated Model to Assess the Global Environment (IMAGE; Alcamo et al., 1998; IMAGE Team, 2001) is a dynamic integrated assessment modelling framework for global change. The main objective of IMAGE is to support decision-making by quantifying the relative importance of major processes and interactions in the society-biosphere-climate system. The consequences of global processes on the European land-use can be indicated by the IMAGE model, after which the CLUE framework can provide more details in local land-use changes. After a short description of the IMAGE model in Section 4.3.2, the linkage between LEITAP and IMAGE is explained in more detail. This Chapter is concluded with Section 2.3, in which the linkage with the CLUE framework is described.

4.3.2 Background of the IMAGE model

In the IMAGE 2.2 framework the general equilibrium economy model, WorldScan, and the population model, PHOENIX, feed the basic information on economic and demographic developments for 17 world regions (see Figure 4.7) into three linked subsystems (see Figure 4.8):

The Energy-Industry System (EIS), which calculates regional energy consumption, energy efficiency improvements, fuel substitution, supply and trade of fossil fuels and renewable energy technologies. On the basis of energy use and industrial production, EIS computes emissions of greenhouse gases (GHG), ozone precursors and acidifying compounds.

The Terrestrial Environment System (TES), which computes land-use changes on the basis of regional consumption, production and trading of food, animal feed, fodder, grass and timber, with consideration of local climatic and terrain properties. TES computes emissions from land-use changes, natural ecosystems and agricultural production systems, and the exchange of CO2 between terrestrial ecosystems and the atmosphere.

The Atmospheric Ocean System (AOS) calculates changes in atmospheric composition using the emissions and other factors in the EIS and TES, and by taking oceanic CO2 uptake and atmospheric chemistry into consideration. Subsequently, AOS computes changes in climatic properties by resolving the changes in radiative forcing caused by greenhouse gases, aerosols and oceanic heat transport.

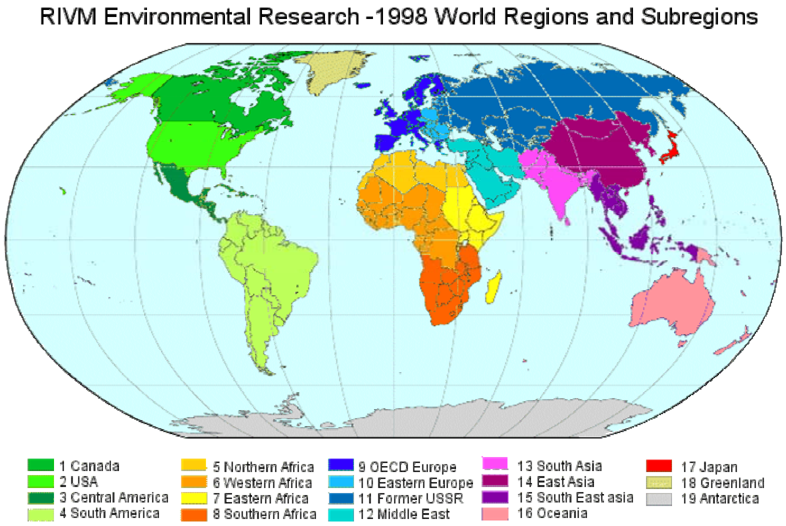


Figure 4.7: The 17 world regions plus Greenland and Antarctica in the IMAGE model

4.3.3 Link with scenarios

The four scenarios that have been used in this exercise are an elaboration of the four emission scenarios of the Intergovernmental Panel on Climate Change (IPCC), as published in its Special Report on Emission Scenarios (SRES; Nakicenovic et al., 2000) (see chapter 3). To enhance our understanding of possible outcomes of future trade policies, the rationale of these four storylines have been used to develop four different trade liberalisation scenarios. In the analyses the population numbers are taken from IPCC (Table 12; Nakicenovic et al., 2000). The global GDP numbers are taken from the report "Four Futures of Europe" (Table 12; CPB, 2003), where the same four narratives have been used as by the IPCC. However, in this CPB report more attention has been paid to the economic consequences of different trade blocks and different formations of the European Union.

The developments in the energy market, of importance for the development of the global greenhouse gas emission profiles, is taken from the latest energy study of CPB and RIVM, which used similar trends in population and economy as described above (Bollen et al., 2004). Assumptions in the agricultural sector are based on a previous study of LEITAP and IMAGE (Eickhout et al., 2004).

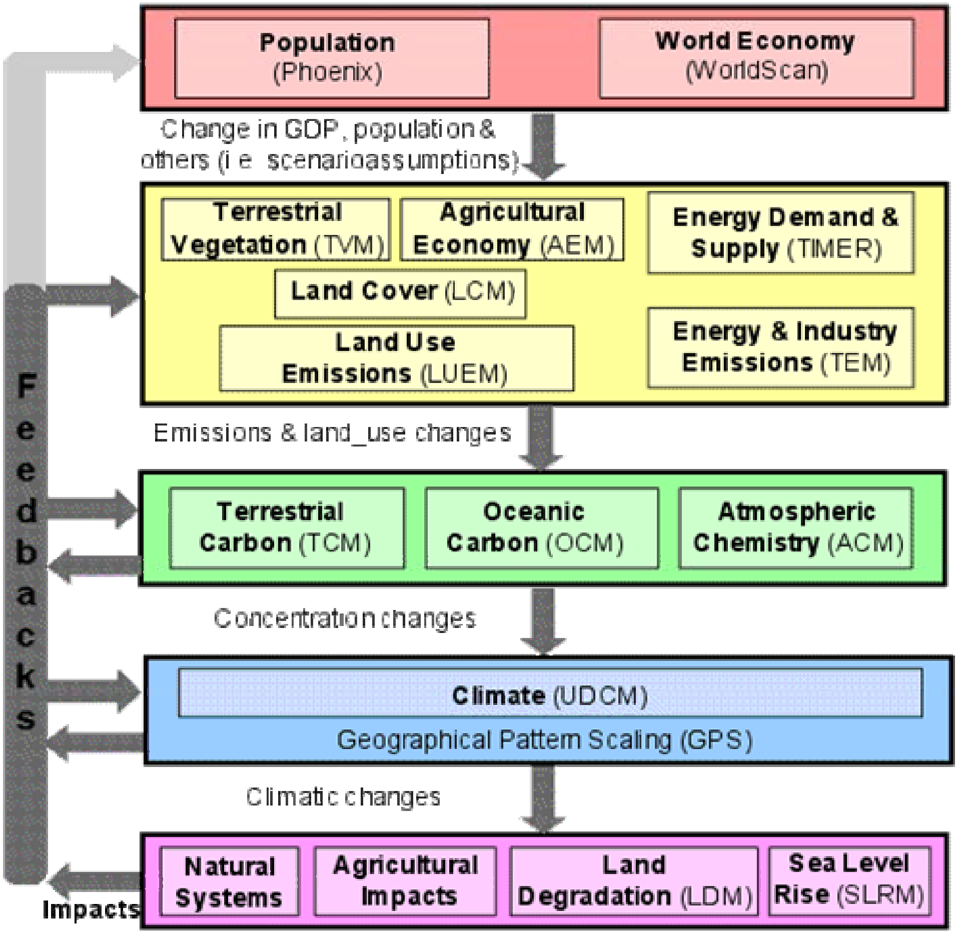


Figure 4.8: The IMAGE 2.2 framework

4.3.4 Land-use change

The IMAGE Land Cover Model simulates the spatial changes in land-cover transformation by reconciling the demands for land-use products (from LEITAP, as described in Section 4.2.3) with the potential of land. The potential of land is calculated by the crop growth model of IMAGE 2.2. The crop production model (Leemans and van den Born, 1994) is based on the FAO Agro-Ecological Zones Approach (FAO, 1981). This model calculates 'constraint-free rainfed crop yields' accounting for local climate and light attenuation by the canopy of the crop considered. The climate-related crop yields are adjusted for grid-specific conditions by a soil factor with values ranging from 0.1 to 1.0. This soil factor takes into account three soil quality indicators: (1) nutrient retention and availability; (2) level of salinity, alkalinity and toxicity; and, (3) rooting conditions for plants. The crop growth model is calibrated using historical productivity figures and also includes the fertilisation effect of changes in the atmospheric concentration of CO_2.

A key aspect of the Land Cover Model is that it uses a crop- and regionally-specific management factor (MF) to represent the gap between the theoretically feasible crop yields simulated by the crop production model, and the actual crop yield which is limited by less than optimal management practices, technology and know-how. If nutrients are applied optimally, there is sufficient weeding at the plantation and the harvest is optimal, the management factor reaches a value of 1. Irrigation, improvement in the harvest index and biotechnological developments can increase the management factor further to values above 1. Regional management factors are used to calibrate the model to regional estimates of crop yields and land-cover for the period 1970-1995 from FAO (FAO, 2003). For years after 1995 the management factor is a scenario variable, which is generally assumed to increase with time as an indication of the influence of technological development on crop yields. This change in crop yield is also used as input for the LEITAP analysis (see Section 4.3.5).

The allocation of land-use types is done at grid cell level. Among these land-cover types are agricultural land and forest areas. Land-use transformations are in reality influenced by forces of a social, physical and economic origin. These forces are too complex to be integrated in a dynamic way in the IMAGE 2.2 model. As a proxy, the allocation of land-use types in the IMAGE 2.2 model is based on several criteria or logical rules. These are considered as simplifications of the complexity of the real forces that can be encountered due to the demand and supply of land. The Land-cover model explicitly deals with four land cover transitions:

1. Natural vegetation to agricultural land (either cropland or pasture) because of the need for additional agricultural land;
2. Agricultural land to other land-cover types because of the abandonment or unsuitability (under climate change) of agricultural land;
3. Forests to 'regrowth forests' because of timber and fuelwood extraction;
4. One type of natural vegetation to another because of climate change and/or increased water use efficiency.

The Land-cover model allocates the agricultural demand (including wood demand), grid cell by grid cell within each region, giving preference to cells with the highest crop production potential for satisfying this demand. The preference ranking of grid cells is based on 'land-use rules'. Grid cells are given a higher ranking for agricultural production if they:

- are close to existing agricultural land;
- have high potential crop productivity;
- are close to large rivers or other water bodies.

Furthermore, an extra factor is introduced that allocates a random value at grid cell level. The food or feed crops are allocated to grid cells of the type agricultural land. In each grid cell, various types of crops can be allocated, with preference to the productivity levels. The specific crops are allocated within the agricultural cell according to their crop productivity (Alcamo et al., 1998). The land-cover model results in land cover allocation of all 19 land-cover types at grid cell level. The changes in European land-use are disaggregated to a country level and are used as input for CLUE. The changes in biofuel area, calculated by the energy model and land cover model, are also used as input for CLUE.

4.3.5 Linkage between LEITAP and IMAGE

The production changes between 2000 and 2030 of LEITAP are aggregated to the IMAGE region levels, using production levels at 2000 from FAO statistics (FAOSTAT). To generate the right input for the IMAGE model the LEITAP commodities are aggregated to the IMAGE commodities (temperate and tropical cereals, rice, maize, rice, roots & tubers, oil crops, dairy and non-dairy cattle, pigs, sheep and goats and poultry).

An important aspect of land use is the need of pasture for grazing cattle. This commodity is not taken into account by LEITAP, although the land-use impact can be large. In this analysis the changes in desired production levels of meat are taken from LEITAP. Within IMAGE, the demand for animal feed is computed on the basis of the production of meat and milk. For cattle, the total feed demand is calculated on the basis of the energy requirements for maintenance, obtaining feed, growth, lactation, animal traction and calving. Feed requirements for dairy and non-dairy cattle increase along with increasing animal productivity. For the other animals the total feed requirement is calculated from feed efficiencies, i.e. the amount of feed required to produce 1 kg product.

The composition of the feed depends on the animal category considered. Grazing animals such as cattle, goats and sheep depend mainly on pasture and fodder species, while pigs and poultry rely primarily on crops. For the historical period the composition of the feed was calibrated against data from the literature for various regions.After 1995 the feed mix is scenario-driven; here, the importance of food crops in the animal diet increases at the cost of pasture and fodder species and crop residues, along with increasing intensity of production on the basis of recent trends observed (Alexandratos, 1995; de Haan et al., 1999; FAO, 1996). More details of the IMAGE grazing simulation are described in Bouwman et al. (2005). The calculated demand for grass and fodder are used as input in the Land Cover Model of IMAGE. The demand for other crop types are not used in the further analysis, since it is assumed that these quantities are considered by LEITAP. Hence, here we used the crop production levels as given by LEITAP.

Productivity changes per crop type and animal type are based on FAO assumptions in its study 'World Agriculture towards 2015/2030' (FAO, 2003). Per scenario productivity changes differ from the FAO assumptions, depending on economic growth (see Table 4.1, Eickhout et al., 2004).

Table 4.1: Land productivity (in kg/ha or kg/animal); relative difference with FAO prognosis for 2030

	Canada	USA	Central America	South America	North Africa	West Africa	East Africa	South Africa	Rest of Europe	Rest of CEEC	Former Soviet U.
	1	2	3	4	5	6	7	8	9	10	11
A1	5%	5%	0%	0%	0%	2,5%	2,5%	2,5%	5%	5%	5%
B1	0%	0%	0%	0%	-5%	7,5%	7,5%	7,5%	0%	5%	5%
A2	-5%	-5%	-10%	-10%	-10%	-5%	-5%	-5%	-5%	-5%	-5%
B2	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%

	Middle East	South Asia	East Asia	South-East Asia	Oceania	Japan	Rest of EU15	CEEC	Baltic countries	Turkey	Netherlands
	12	13	14	15	16	17	18	19	20	21	22
A1	0%	0%	0%	0%	5%	5%	5%	5%	5%	0%	5%
B1	-5%	-5%	-5%	-5%	0%	0%	0%	5%	5%	-5%	0%
A2	-10%	-10%	-10%	-10%	-5%	-5%	-5%	-5%	-5%	-10%	-5%
B2	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%

In the simulation process, we change these productivities in iterative manner using GTAP simulation results. The description of this iterative procedure can be found in the section

4.3.6 Linkage between IMAGE and CLUE

The changes in pasture and crop area per IMAGE region, as calculated by IMAGE, are disaggregated to country level (see Annex). This disaggregation is done by using the country-level production changes as computed by LEITAP. The production changes per country are calculated for crop and animal products in total. These two production changes are used to calculate the country-level change in pasture and crop area. Since we not only calculated the change in cropland and grassland on the basis of changes in production levels by LEITAP, but we also calculated the change in land on the basis of constant production levels between 2000 and 2030, we could determine a relationship between land use change and production change. It is assumed that each country within an IMAGE region encounters the same relationship of change in land as the IMAGE region itself. By using these relationships for grassland and cropland, we could disaggregate the regional land change to country-specific information.

Furthermore, climate change is also used as input for CLUE.

4.4 CLUE

4.4.1 Introduction and background

Within the EURURALIS project, the Conversion of Land Use and its Effects modeling framework (CLUE, version: CLUE-s 2.3; Verburg et al., 2002, 2004) is used to simulate the spatial pattern of land use change resulting from changes in demand for urban, agricultural and natural area at the level of the 25 European countries. Based on the demanded areas for the different land use types, the variability in social and environmental conditions and the behavioral and policy conditions as specified in the scenarios are expected to lead to different spatial patterns in land use. The CLUE model is used to allocate the changes in land use requirements to specific locations and visualize the effect of the scenario decisions. The CLUE modeling framework was developed for spatially explicit simulation of land use change using empirical analysis of location suitability in combination with dynamic simulation of competition and interactions between the spatial and temporal dynamics of land use systems. Policies and spatial restrictions are taken into account, as well as dynamic factors that influence the allocation of land use, e.g. population density.

The CLUE model was chosen since it is a widely used, flexible framework that combines some of the most popular concepts in land use change modeling. The models has been validated for a number of case studies and is respected as one of the most advanced frameworks in the field.

4.4.2 Technical outline CLUE

The CLUE-s model is divided into two distinct modules, namely a non-spatial demand module and a spatially explicit allocation module (Figure 4.9).

In the non-spatial module, land use requirements are calculated at the aggregate level (a whole country or group of countries) as part of a scenario. The land use requirements constrain the simulation by defining the totally required change in land use. All changes in land use should add up to these requirements. Land use requirements are calculated independently from the CLUE model itself. For the land use demand module different model specifications are possible ranging from simple trend extrapolations to complex economic models. The choice for a specific model is very much dependent on the nature of the most important land use conversions taking place within the study area and the scenarios that need to be considered. In the EURURALIS project the combined use of GTAP/IMAGE is used to specify the demand for the agricultural land use types. Demands for the other land use types are based on these developments and on a number of simple models based on the scenario specifications. Within the spatial module of the model, the land use requirements translated to land use changes at different locations in the study area.

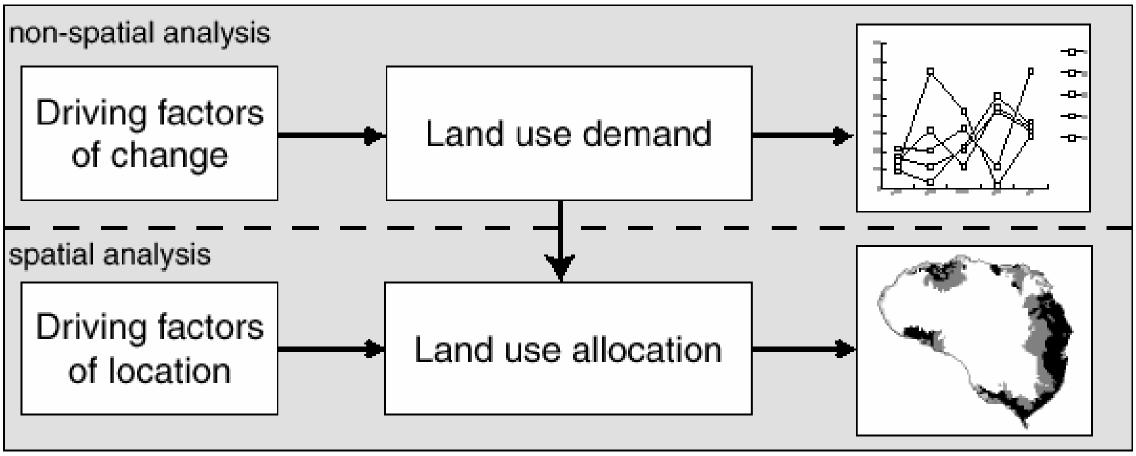


Figure 4.9: Overview of the modeling procedure.

4.4.2.1 Non-spatial module: land use requirements

The non-spatial module contains of some data conversions and simple model calculations to specify the demand for land by the different land use types. Demands are calculated for each country or group of countries (Baltic countries are combined and Belgium and Luxembourg are combined). In EURURALIS, land use requirements are specified for each of seven different land use types (Table 4.2) while during simulation a new land use type develops (abandoned farmland). The calculations heavily rely on the specification of demands for agricultural land by the IMAGE/LEITAP models. An overview of the data used as input to the non-spatial module is provided in Table 4.3.

Table 4.3: CLUE-EURURALIS land use types.

Description
Built-up area (including urban/residential area, industry, recreation, airports)
Non-irrigated arable land
Permanent pastures
Forest, nature and natural grasslands
Inland wetlands
Abandoned farmland
Irrigated arable land (including rice fields)
Other land use types that are considered static during the simulations (including beaches, rock outcrops, glaciers, coastal wetlands, …)

Requirements for non-irrigated arable land and permanent pastures are calculated in the IMAGE model for each scenario with 10-year intervals. For the CLUE simulations these outputs are interpolated to two-years-time steps and some scenario conditions affecting the demand are taken into account (e.g., permanent grassland policy).

Built-up area consists of residential area and areas occupied by industry, business parks, airports and so on (see the "data description" chapter for a full description). It is assumed that growth of built-up area can be attributed to both residential area and changes in the sectors 'service and industry', which are expected to occupy a share proportional to the production values of the two sectors in 2001.

The demand for residential area depends on population change and GDP change. If population grows, more houses are needed and if the GDP increases, humans tend to use more space for housing, but also for recreation, services and commercial activities. In the industry and service sectors, growth of the required area is proportional to the growth of the sector as calculated by the GTAP model.

If the demands for agricultural land increase, nature will be converted to agricultural land. If agricultural land is abandoned, part of it can be converted into nature, spontaneously as well as actively depending on the attitude of the population and the prevailing policies in this field. The fraction of abandoned farmland that is actively converted to nature is therefore dependent on the scenario conditions. Natural regrowth of shrubs, forest or natural grasslands on abandoned farmland is assumed to occur on 50% of all abandoned farmlands. Other abandoned farmlands are expected to be managed in such a way (e.g., recreational or hobby farming) that they cannot be classified as nature. After 10 years of undisturbed regrowth it is assumed that the vegetation is in such a state that abandoned farmland can be classified as nature.

In the current specification it is assumed that the requirements for inland wetlands, static land use types and irrigated arable land do not change.

The non-spatial module results in a specification of the areas used by all land use types for each scenario (on a yearly and two-yearly basis).

Table 4.3: Inputs used in CLUE-EURURALIS non-spatial module.

Name	***Description***
GTAP	Output of the GTAP model. Contents: Growth of several agricultural and economic sectors in each country in % over the periods 2000-2010, 2010-2020 and 2020-2030.
IMAGE	Output of the RIVM IMAGE model. Growth of GTAP agricultural sectors combined with additional scenario conditions is converted to required areas for agricultural land in general and required areas for pasture and non-irrigated arable land more specific for the years 2000, 2010, 2020 and 2030 for all scenarios.
Population change	Population numbers for all European countries in 5-year time steps from 1950 to 2050. Source: RIVM; Phoenix Europe. This is an application of SRES scenarios methodology applied to Europe (Hilderink, 2004).
GDP	Change in GDP per capita in % over the periods 2000-2010, 2010-2020 and 2020-2030. Source: LEI.
Production values	Production values of several agricultural and economic sectors in 2001 for each country. Source: LEI

4.4.2.2 Spatial module: land use allocation

In the spatial module, the land use demands are allocated to locations within the countries. The allocation is based on a combination of spatial analysis and dynamic modeling. Besides the land use demands that are calculated in the non-spatial module, information on spatial policies and restrictions, land use type specific conversion settings and location characteristics are needed to run the model (Figure 4.10). These settings are based on an empirical analysis of current land use in combination with a quantitative translation of the storylines into model settings:

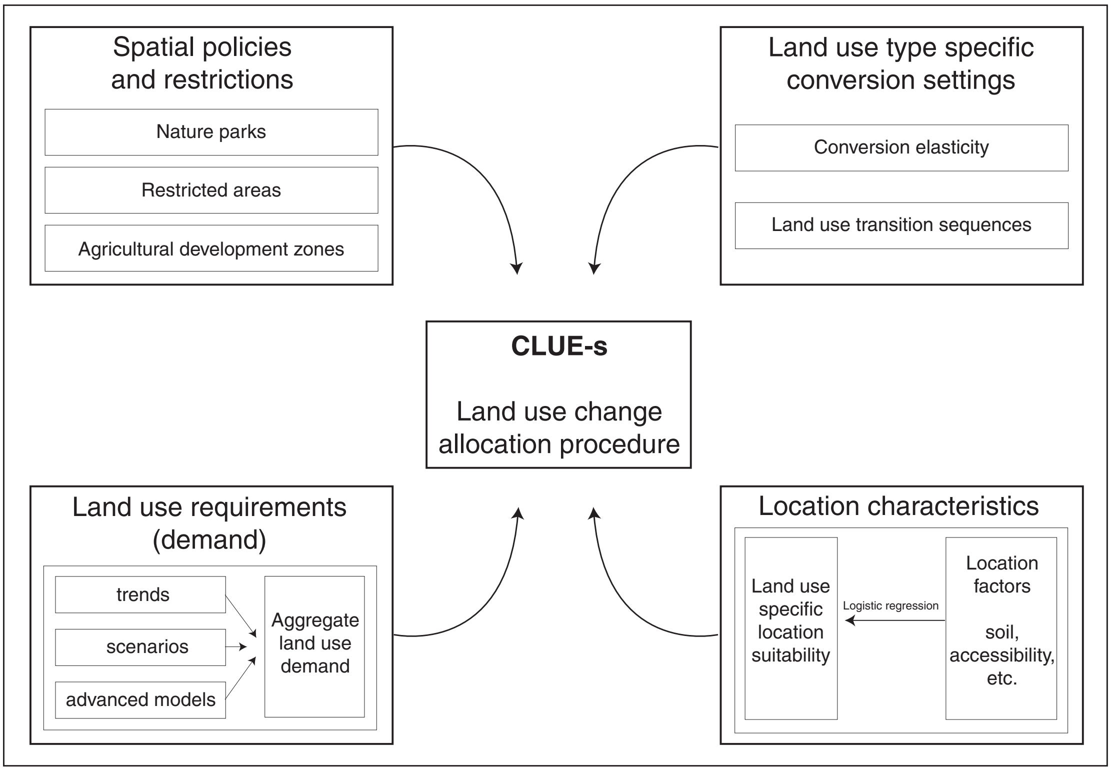


Figure 4.10. Overview of the information flow in the CLUE-s model

Spatial policies and restrictions

Spatial policies can influence the pattern of land use change. Spatial policies and restrictions mostly indicate areas where land use changes are restricted. Some spatial policies restrict all land use change in a certain area, e.g. to protect a national park. Other land use policies restrict specific land use conversions, e.g., residential construction in designated agricultural areas or permanent agriculture in the buffer zone of a nature reserve. Furthermore, there are spatial policies that stimulate or discourage certain ways of land use, e.g. subsidies to maintain agricultural land in Less Favoured Areas. To take into account these restrictions in modelling, maps that indicate the locations of the restricted or favoured areas must be supplied as input, and the effect of the measure must be specified. The restriction and stimulation policies used in EURURALIS differ per scenario and are determined based on the specific storyline (see scenario chapter).

Land use type specific conversion settings

Land use type specific conversion settings determine the temporal dynamics of the simulations. Two sets of parameters are needed to characterize the individual land use types: conversion elasticities and land use transition sequences. The first parameter set, the conversion elasticities, is related to the reversibility of land use change. Land use types with high capital investment will not easily be converted in other uses as long as there is sufficient demand. Examples are residential locations but also plantations with permanent crops (e.g., fruit trees). Other land use types easily shift location when the location becomes more suitable for other land use types. Arable land often makes place for urban development while expansion of agricultural land occurs at the forest fringes. These differences in behavior towards conversion can be approximated by conversion costs. However, costs cannot represent all factors that influence the decisions towards conversion such as nutrient depletion, esthetic values etc. Therefore, for each land use type a value is specified that represents the relative elasticity to change.

The second set of land use type characteristics that needs to be specified are the land use type specific conversion settings and their temporal characteristics. These settings are specified in a conversion matrix. This matrix defines:

- To what other land use types the current land use type can be converted or not (Figure 4.11).
- In which regions a specific conversion is allowed to occur and in which regions it is not allowed.
- How many years (or time steps) the land use type at a location should remain the same before it can change into another land use type. This can be relevant in case of the regrowth of forest. Open forest cannot change directly into closed forest. However, after a number of years it is possible that an undisturbed open forest will change into closed forest because of regrowth.
- The maximum number of years that a land use type can remain the same. This setting is particularly suitable for arable cropping within a shifting cultivation system. In these systems the number of years a piece of land can be used is commonly limited due to soil nutrient depletion and weed infestation.

It is important to note that only the minimum and maximum number of years before a conversion can or should happen is indicated in the conversion table. The exact number of years depends on the land use pressure and location specific conditions. The simulation of these interactions combined with the constraints set in the conversion matrix will determine the length of the period before a conversion occurs. Figure 4.11 provides an example of the use of a conversion matrix for a simplified situation with only three land use types.

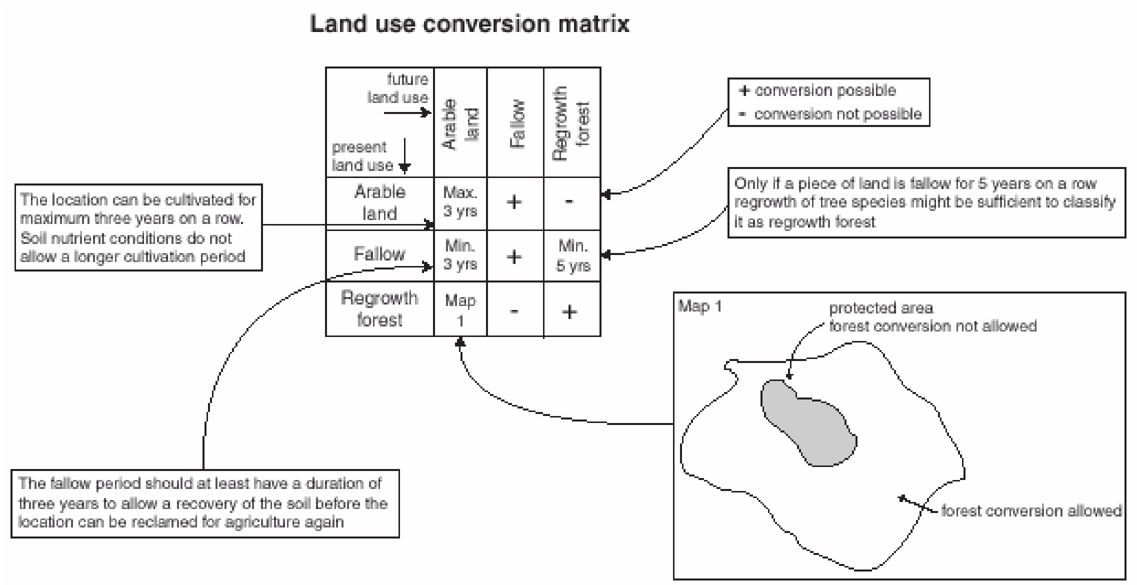


Figure 4.11: Example of a conversion matrix for a case with three land use types.

Location characteristics: Biophysical and socio-economic factors

Land use conversions are expected to take place at locations with the highest 'preference' for the specific type of land use at that moment in time. Preference represents the outcome of the interaction between the different actors and decision making processes that have resulted in a spatial land use configuration. The preference of a location is estimated from a set of factors that are based on the different, disciplinary, understandings of the determinants of land use change. The preference is calculated following:

$R_{ki} = a_k X_{1i} + b_k X_{2i} + ...$

where R is the preference to devote location i to land use type k, X1,2,... are biophysical or socio-economical characteristics of location i and ak and bk the relative impact of these characteristics on the preference for land use type k. The exact specification of the model should be based on a thorough review of the processes important to the spatial allocation of land use in the studied region.

To explore the current situation a statistical model can be developed as a binomial logit model of two choices: convert location i into land use type k or not. The preference Rki is assumed to be the underlying response of this choice. However, the preference Rki cannot be observed or measured directly and has therefore to be calculated as a probability. The function that relates these probabilities with the biophysical and socio-economic location characteristics is defined in a logit model following:

$$Log\left(\frac{P_i}{1-P_i}\right) = \beta_0 + \beta_1 X_{1,i} + \beta_2 X_{2,i} ...... + \beta_n X_{n,i}$$

where Pi is the probability of a grid cell for the occurrence of the considered land use type on location i and the X's are the location factors. The coefficients (β) are estimated through logistic regression using the actual land use pattern as dependent variable (see the “specification of location suitability” chapter). This method is similar to econometric analysis of land use change, which is very common in deforestation studies. In econometric studies the assumed behavior is profit maximization, which limits the location characteristics to (agricultural) economic factors. In EURURALIS we assume that locations are devoted to the land use type with the highest 'suitability'. 'Suitability' includes the monetary profit, but can also include cultural and other factors that lead to deviations from (economic) rational behavior in land allocation. This assumption makes it possible to include a wide variety of location characteristics or their proxies to estimate the logit function that defines the relative probabilities for the different land use types.

Most of the location characteristics relate to the location directly, such as soil characteristics and altitude. However, land management decisions for a certain location are not always based on location specific characteristics alone. Conditions at other levels, e.g., the household, community or administrative level can influence the decisions as well. These factors are represented by accessibility measures, indicating the position of the location relative to important regional facilities, such as the market and by the use of spatially lagged variables. A spatially lagged measure of the population density approximates the regionally population pressure for the location instead of only representing the population living at the location itself.

The empirical specification of the relation between suitability and location factors can only capture the current preferences. Therefore, for some scenarios the specification has been modified to enable deviation from the current set of location factors and assumed behaviour. A good example is the preference for construction sites for residential and industrial/commercial activities. These locations are very much dependent on the policy attitude towards open space in the countryside and urbanization policies, therefore, the location 'suitability' for these activities is dependent on the scenarios.

A complete list of data used to derive factors that were assumed to determine current and future 'suitability' of locations is provided in Table ?3. Another factor that determines the relative suitability of locations is the occurrence of land uses in the neighborhood. For example, new urban area is more likely to develop at the fringe of existing urban area than elsewhere. To characterize the neighborhood of a location the enrichment factor (F) is used (Verburg et. al., 2004). In EURURALIS, neighborhood characteristics were used for built-up area and forest / nature / natural grassland.

Table 4.4: Spatial data used in the CLUE application.

name	***description***
access1_m	Traveltime to cities with more than 100.000 inhabitants (in seconds)
access2_m	Traveltime to cities with more than 500.000 inhabitants (in seconds)
access3_m	Traveltime to ports with more than 15.000 kTon/year of freight (in seconds)
access4_m	Traveltime to cities with more than 650.000 inhabitants (in seconds)
access5_m	Airlinedistance to nearest road level 0 and level 1 (in meters)
access6_m	Traveltime to major airports (in seconds)
access7_m	Traveltime to major airports & major ports (in seconds)
aglim1	Dominant limitation to agricultural use
aglim2	Secondary limitation to agricultural use
avgtemp	Average temperature (in ^{o}C)
biogeo	Biogeographical regions
dem	Height (in meters)
envmap	Environmental regions
euac120	Number of people that reach a location from their home within 120 minutes
euac30	Number of people that reach a location from their home within 30 minutes
euac60	Number of people that reach a location from their home within 60 minutes
il	Presence of an impermeable layer within the soil profile
landscan2	ORNL LandScan (population) derived from World02
lfa_code	Less favoured areas (LFA)
lu	The EURURALIS Land Use Map for 2000, the base year of simulation
mat11	First level dominant parent material code
poppot_log	Log of the gaussian population potential
poppot_sum1mi	Gaussian population potential, with a maximum of 1.000.000.
poppot_sumtot	Gaussian population potential
pre1990_spli	Precipitation, mean 1961-1990 (in mm)
slope	Slope on the basis of the dem (in degrees)
slope1	Dominant slope class
smrain12_spli	Sum of average rain a year (in mm)
smrain3_spli	Sum of average rain during the average summer season (3 months) (in mm)
smrain6_spli	Sum of average rain during the average EU growing season (6 months) (in mm)
t_min0	Count of months a year with average temperature < 0 degrees C
t_plus15	Count of months a year with average temperature > 15 degrees C
text1	Dominant surface textural class
tmp1990_spli	Temperature, mean 1961-1990 (in ^{o}C)
wr	Dominant anual average soil water regime class of the soil profile
protect_low	Protected areas for the low protection scenarios
protect_high	Protected areas for the high protection scenarios
erosion_risk	Erosion risk
approx_natura	An approximation of the NATURA 2000 map

Allocation procedure
When all input is provided the CLUE model calculates, with discrete time steps, the most likely changes in land use given the before described restrictions and suitabilities. The allocation procedure is summarized in Figure 4.12. The following steps are taken to allocate the changes in land use:

1. Determination of all grid cells that are allowed to change. Grid cells that are either part of a protected area or presently under a land use type that is not allowed to change are excluded from further calculation. Also the locations where certain conversions are not allowed due to the specification of the conversion matrix are identified.
   For each grid cell i the total probability (TPROPi,u) is calculated for each of the land use types u according to:
   $$TPROP_{i,u} = P_{i,u} + ELAS_u + ITER_u$$
2. where Pi,u is the suitability of location i for land use type u, ELASu is the conversion elasticity for land use u and ITERu is an iteration variable that is specific to the land use type and indicative for the relative competitive strength of the land use type. Pi,u consists of a part based on the biophysical and socio-economic factors and the empirical or else-wise determine relations, and a neighborhood interaction part. The weight of neighborhood function relative to biophysical/socio-economic part depends on the scenario and the land use type. Settings can be found in the "scenarios" chapter and Annex 4.
3. A preliminary allocation is made with an equal value of the iteration variable (ITERu) for all land use types by allocating the land use type with the highest total probability for the considered grid cell. Conversions that are not allowed according to the conversion matrix are not allocated. This allocation process will cause a certain number of grid cells to change land use.
4. The total allocated area of each land use is now compared to the land use requirements (demand). For land use types where the allocated area is smaller than the demanded area the value of the iteration variable is increased. For land use types for which too much is allocated the value is decreased. Through this procedure it is possible that the local suitability based on the location factors is overruled by the iteration variable due to the differences in regional demand. The procedure followed balances the bottom-up allocation based on location suitability and the top-down allocation based on demand.

Steps 2 to 4 are repeated as long as the demands are not correctly allocated. When allocation equals demand the final map is saved and the calculations can continue for the next time step. Some of the allocated changes are irreversible while others are dependent on the changes in earlier time steps. Therefore, the simulations tend to result in complex, non-linear changes in land use pattern, characteristic for complex systems.

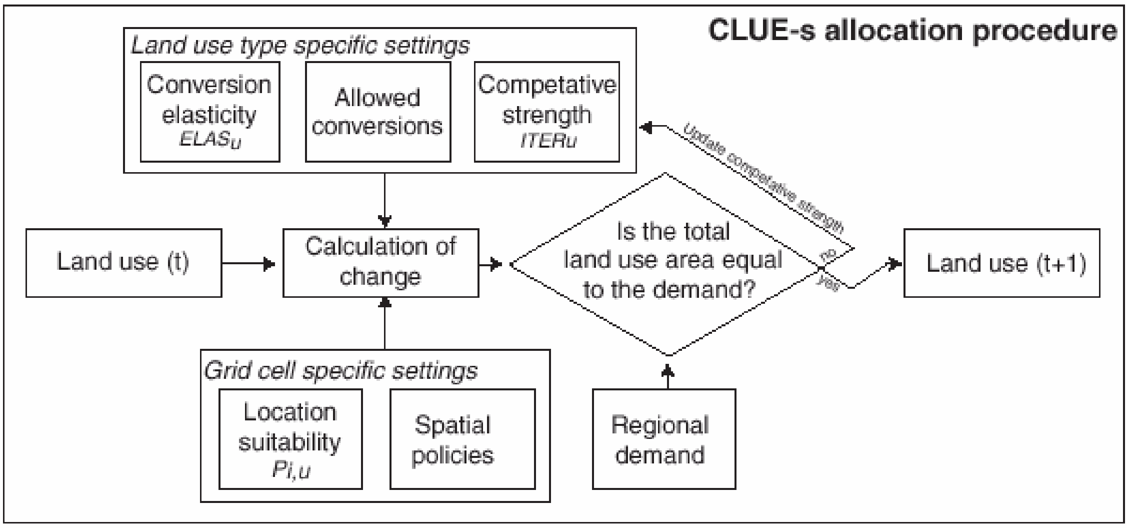


Figure 4.12 Flow chart of the allocation module of the CLUE-S model.

4.4.2.3 Calibration and Validation of LUCC models

Calibration and validation of land use change models are often based on the comparison of model results for a historic period with the actual changes in land use as they have occurred. Such an exercise makes it necessary to have land use data for another year than the data used in model parameterisation. The time period between the two years for which data are available should be sufficient to actually compare the observed and simulated dynamics. Ideally this time period should be as long as the period for which future scenario simulations are made. Such data are often difficult to obtain and even more often data from different time periods are difficult to compare due to differences in the classification scheme of land use maps or the resolution of remote sensing data. Methods for validation of model performance should make a clear distinction in the model performance concerning the quantity of change and the quality of the spatial allocation of the land use changes. Appropriate methods for validation of land use change models are described by Pontius (2002, 2004) Costanza (1989)(Pontius and Schneider 2001, 2004).

Geographical disciplines have given considerable attention to the spatial dynamics of land use. The temporal aspects, especially the interaction between spatial and temporal dimensions, have been given much less attention. Also the influence of non-linear pathways of change, feedbacks and time-lags deserve considerable attention in future studies. Availability of data with the necessary temporal and spatial resolution will be the most important constraint for such research. Connected to this issue is the validation of models: how good are the models that we produce for projections into the future. Validation is possible on historic data and should be standard to any model. The lack of validation of most current land use models makes it impossible to properly assess the performance of these models. Validation would enable to inform policy makers, and other users of model results, on the uncertainties in the model outcomes and help to assess the suitability of the model for a particular situation and provide ideas to improve the model.

The CLUE model has been validated several times. The technical most independent testing was done for a combined Honduras and Costa Rica case study. The model was calibrated for Honduras and consequently run for Costa Rica on a historical data set (no calibration based on Costa Rica data). A comparison of the modeled result and the real world provided a real independent validation. I turned out that the model is doing much better then random allocation and has a resolution dependent accuracy on the correct location (Kok et al, 2001)

Validation exercises (Kok et al., 2001 and Pontius, 2004) have indicated that uncertainty in land use simulations is high. These limitations are common for models of complex integrated systems and, although progress is made, some of these constraints are inherent to the land use system. Therefore, visualization issues and adequate presentation of the results is most important to communicate land use modeling results to policy makers and other stakeholders.

4.5 Discussion on methods; calibration/validation

Reflecting upon ways to define quality and quality shortcomings as well as ways to improve the current version EURURALIS it is important to keep the following points in mind:

1. Quality has always to be seen against the background of intended use: EURURALIS is aimed at policy making on a international or at best national level for a relatively long term by showing possible, by definition not the most probable, futures (plural!) of the rural area. The tool claims to give support to discussions rather than offer a blueprint for decisions. This explains why qualitative/ semi-quantitative outcomes will suffice or are downright inevitable, whereas other goals should require far more detail, quantification and a defined quality standard regarding uncertainties.
2. Within the before mentioned context quality questions should address: i) the quality of the separate steps or instruments : e.g. *scenarios* , the *core models* (LEITAP, IMAGE, CLUE), subsequent thematic models or "rules of the thumb", *underlying data* that has been fed to the various models and ii) the quality of the output generated by the full chain of scenario's, data, models and output. It is well known that a chain of scenario's and models lined up can sometimes be subject to errors or special sensitivities that are more than what can be expected from shortcomings or partial sensitivity present in the separate components. It has to be stressed that the overall check has not been done for EURURALIS, at least not through a formal procedure. What we can explain is how quality awareness and checks relate to the separate components:

4.5.1 Scenarios

The choice of the scenarios in EURURALIS can directly be retraced to the scenario methods followed by IPCC/SRES and close relatives as has been explained in chapter 4.4. These scenarios have been published and discussed in a wide audience of scientists and politicians. This does not mean that the scenarios as such are immune for criticism, on the contrary. Still, they are explicit and transparant and have some history of open debate. This was the main reason for EURURALIS to use them as far as possible. Within this general framework EURURALIS tried to specify some aspects, e.g. by making concrete what a certain scenario specifies for CAP measures and/or other policy domains (environmental laws and regulations) within Europe. Also other assumptions have been made clear by positioning them carefully within the four contrasting scenario's. The best you can do is to make the "world visions"or "story lines" internally consistent (i.e. not contradictory) and to be complete and precise on the full set of assumptions. Most aspects could be positioned in the four quadrants (A1, A2, B1, B2) defined by the axes that represent a global point of view vs a more regional point of view respectively the axis representing a strong belief in a free market vs. the conviction that governments are required to take care of e.g. social and ecological values and sometimes economical values not taken care of by the ïnvisible hand" of a free market. In short: the quality of scenarios builds upon rather well tested predecessors, full transparancy of additional features and an internal check on consistency of story lines. Some relevant aspects proved very difficult to label: for example the question which scenario should be the most appropriate to link to vaccination policy aimed at animal diseases.

4.5.2 Core models

All core models (LEITAP/GTAP; IMAGE; CLUE) are existing and calibrated and validated models, extensively discussed in their respective scientific circles.and can be considered "state of the art". Still, each model has its own set of assumptions that can be criticized as such. GTAP and its adapted version LEITAP is built upon the crucial assumption that changes in demand and supply operate in a fully transparant market generating trade (flows of goods, services, capital) according to a supposed equilibrium situation. These assumptions can be and have been criticized as imperfectly working markets are the rule rather than the exception. The CLUE model (discussed in 4.4) , aiming at reallocating land use according to demand and supply, operates on a set of formal rules derived from more or less logical assumptions about the most logical preference of an area to undergo a transition in land use (e.g. urban expansion near existing concentrations or along infrastructure). Again criticism is justified to a certain extent as these modelling rules do not include all other complicating factors and sources of inertia in land use (change) that can be observed in the real world. Still, overall the core models are state of the art, explicit in their rules and quite useful when qualitative/ semi-quantitative outcomes linked to contrasting scenarios, that intentionally discard many of the real world complications and inertia to support discussions are at stake.

4.5.3 Other models and "rules of the thumb"

For indicators from the 3P domains either direct output from core models (especially in the socio-economic variables), simple models or "rules of the thumb "are used to describe effects. These methods are state of the art, were made transparant and explicit. The same was done for the overall (meta) indicators.

4.5.4 Data

We used authorised and the most recent data, referring to the sources. When data were incomplete or otherwise less reliable we included our remarks. A good example is the attempt to predict the spreading of animal diseases after an outbreak in various scenarios. Relianble data on concentrations of animals, relevant distances and the "permeability"of landscapes for spreading were insufficient for more than some general statements.

4.5.5 Concluding remarks

Separate steps and models as described above are reasonably well-tested and discussed within their own scientific domains, whereas their use in a highly qualitative scenario study can be judged as well within the limits of acceptable use.Still, as EURURALIS follows a chain of scenario's > models lined up in a certain, linear order producing indicator values a more formal procedure to analyse errors and specific sensitivities has still to be done.

5 Some data on the past and their function in a scenario study

With including a chapter on trends of drivers, land use and indicators in the past, Eururalis shows what transformations drivers, indicators and the land use have undergone in the past. Insight in the past is necessary to become aware of the scale and rate of changes in Europe and the fact that Europe's history is full of regional and national differences. Users should have a sense to value recent and future trends.

5.1 Drivers, a few examples

Drivers are dealt with conceptually in chapter 2.1 and it has been explained which driving forces can be distinguished in both past and future. We restrict ourselves to a few examples occurring in the past : climate, population dynamics and European Agricultural Policies, not suggesting that other factors were not relevant.For details and the visual presentation of data we refer to the CD ROM.

5.1.1 Climate change

Evidence is abundant that climate has already changed considerably over the last century. According to many sources, both correlative studies based upon empirical data and modelling studies the increased contents of greenhouse gases in the atmosphere – with an acceleration since the fifties , are held responsible (IPCC, 2001; EEA, 2004). In Europe the average increase of temperature (yearly) was 0.5 Centigrade per 100 years, somewhat higher than the global average (0.7 Centigrade +/- 0.2). Between 1962 and 1995 the growing season increased by 10 days. Together with a change in temperature a change in precipitation patterns was observed, though data are less systematic and continuous. The last decade showed significant anomalies: northern Europe was 10-40 % wetter than the centennial average, South Europe up to 20 % drier. Effects of climate change can be found in the rapid melting of glaciers of which one third of the area disappeared and about half of the mass between 1850 and 1980, since then again 20 - 30 % of the remainder.In general one can state that the recorded changes are obvious, meaningful for ecology and human use and a strong indication of ongoing or foreseeable changes that might accelerate in coming decades and have more serious effects than the already observed ones.

5.1.2 Population (demographic changes)

We included some data on population growth and the related change in population densities over Europe as visualised in the CD ROM for a period since 1700 in which population numbers increased enormously, mostly in urbanised areas. Still, a slow down and a related ageing can already be observed in post-war years. Since 1950 the percentage of people above 65 years showed an increase of 9.5 – 15 % (Hildering, 2004). These average data conceal significant extremes looking at various separate countries: Ireland, The Netherlands and Greece saw a solid population growth since 1970 – 2000, whereas Bulgaria and Hungary saw a decline. In chapter we will see that future developments could well show a general pattern that quite differs from preceding countries in that most countries will witness stagnating population numbers, further ageing and a continued or even accelerated migration to urban areas.

The available data on abolute population, population density, rural and urban population for the years 1970, 1980, 1990 and 2000 is from Eurostat.

5.1.3 Common Agricultural Policy (CAP)

One of the drivers that affected agriculture and land use over the Europe of the expanding European Union has been the CAP. Europe's agricultural policy ha s been designed and forcefully put in action from the fifties as an attempt to ban hunger from its territories, to provide cheap food for a growing population that shifted its economic activities to industries and services and to guarantee reasonable incomes for farmers. A combination of measures and massive investments from public funds were put in motion: export subsidies, tarfiff walls to protect the own market, price support measures, research, education, subsidies enhanced a large scale modernisation and upscaling phase during which many successes were observed in view of the once set goals. Nevertheless, side effects were observed: negative effects on non-European economies (3rd World countries), overproduction, adverse effects on environment, nature and landscape and a very large claim the EU budget, both absolutely and relatively. In view of various draw-backs of the CAP of former days various steps were taken to reform the CAP structurally, by shifting attention from production support ("first pillar") to a multiple goal strategy promoting rural development, taking into account ecological, socio-cultural and economical goals (the second pillar). Budgetary ceilings are set synchronously to control expenses, not the least due the arrival of millions of farmers after the accession of the EU 10 countries. Lastly, we emphasize that in between the EU developed all kinds of complementary policy fields attempting to prevent environmental or ecological deterioration that often directly relates to intensification and upscaling in agricultural practices: Habitat and Bird Directive, Natura 2000, Nitrate Directive, Landscape Convention, Water Directive to mention the more important ones.

We took this example of the CAP as a driving force as an illustration how (geo) political changes can have great influence on land use in rural areas and widespread effects on all aspects of People, Planet and Profit domains. Secondly because the future conditions could well be quite different from the preceding decades.

5.1.4 Regional dynamics.

The Eururalis CD Rom contains a condensed geographical zonation of the EU's territory in groups of countries that large and by have a comparable development in recent decades regarding the rural areas.We divided Europe in large zones: northern countries, western Europe, Southern Europe, the Alpine Countries and the former Central and eastern nations that joined the EU. For each of these zones the dominant processes in land use have been given. The picture helps to re-emphasize that Europe is a very diverse continent where many processes take place, but their nature, importance, rate or period can differ considerably. Striking differences can be attributed to climate or other physical conditions (mountains), population pressure, geopolitical differences (former communistic countries versus western countries), stages in agricultural modernisation and so on. The picture thus shown is based upon expert judgement primarily. Inspiration was found in EEA's Third assessment (EEA, 2003 ; Chapter 11 on Biodiversity) where major trends were listed having affected biodiversity conditions.

5.2 Indicators

To get some notion on processes the past a number of indicators were selected, namely yield, income, employment, self sufficiency, animal diseases, CO_2 storage, biodiversity, land degradation, pollution and land use. Each of these indicators will briefly be discussed.

5.2.1 Yield

Yield increases in agriculture during the existence of the EU were huge and a major driving force for food supply, import/export changes, decrease in employment and impacts on nature and landscape. The significance of yield increase for land use, food production and labour is evident.It explains increase in farm scales, low food prices, a shift from an import to an export position of many countries, large scale expulsion of labour and impacts on nature and landscapes due to scale enlargement, intensification and specialization.

Source: Data on Middle ages onwards on cereals from Rabbinge (2001 Sustainability and sustainable development, Inaugural address, Wageningen University)
Data on yield increase in Europe (1962 -2000): source FAOSTAT
Other data: Hafner, S. 2003. Trends in maize, rice and wheat yields for 188 nations over the past 40 years: a prevalence of linear growth.Agriculture, Ecosystems and Environment. 97(2003).275-283

5.2.2 Income

Particularly in the more industrial regions the share of agriculture in gross value added is low. In many regions of the United Kingdom, for example, the share of agriculture, is lower than 2.5 %. In Poland and areas of Spain the share of agriculture actually is still higher than 10 %. Also in Bulgaria and Romania the share of agriculture is still very significant. In general the share of agriculture is expected to decrease as economies develop. The real income in agriculture has increased in the EU 15, but in recent years has decreased slightly.

Source: Eurostat, Luxembourg

5.2.3 Employment

The share of agriculture in rural employment is an important indicator for rurality. Not only in many of the new member states the share of agriculture is above 10 %, but this is also the case for some of the original EU 15 regions. For example, in the Greek regions of Peloponnese, Western Greece and Thrace, agriculture provides even more than 40 % of employment. Data is incomplete to show trends for all EU 25 countries, however, recent studies of EUROSTAT show that for some 40 regions of the United Kingdom and Finland saw agricultural employment stabilise or even rise between 1983 and 1997. The expectation is that the share of agriculture in regional employment in general will decrease in many regions. Reasons for that are further modernisation of the agricultural sector and employment opportunities moving to industry and the tertiary sector.

Source: Eurostat, Luxembourg and
http://europa.eu.int/comm/agriculture/envir/report/en/rur_en/report_en.htm#map5 (September 2004)

5.2.4 Self sufficiency

A self-sufficiency level gives the relation between production and domestic consumption. When there is a surplus, the self-sufficiency ratio will be higher than 100. During the initial days of the European Economic Community, the aim was to achieve self-sufficiency. During the post war period, food production and self-sufficiency were central issues for policy makers. Consequently, during those early days of the community, increasing food production was an important part of policy goals. These efforts resulted in the seventies and eighties into enormous surpluses for several agricultural products such as beef, grain, wine and dairy products. Due to several reasons, policies are now more directed at reducing these surpluses and these are quite succesful.

Source: Eurostat Luxembourg

5.2.5 Animal diseases

Recent outbreaks in the EU member states of Foot-and-Mouth Disease in cattle, Classical Swine Fever in pigs, and Avian Influenza in poultry have generated massive direct and indirect economic damage. These epidemics also caused severe animal welfare problems as well as significant psychological damage to farmers and other individuals directly involved. Indirect damage (e.g. to tourism) has been considerable.

The use of stamping-out strategies to stop the spread of the virus also caused societal outcry. As a result, the legal and practical frameworks determining the options for intervention policy have recently been revised or are currently being reconsidered, at EU and national levels, with a view to make better provisions for the use of emergency vaccination as a first line of defence.

The 2001 epidemic of Foot-and-Mouth Disease in Britain was devastating in its size and impact. About 4.9 million sheep were culled, 0.7 million cattle and 0.4 million pigs. Due to capacity limitations of other means of carcass destruction, on-farm burning (photograph) as well as landfill disposal had to be used.

Control measures in the 2003 epidemic of Avian Influenza in The Netherlands included the killing and destruction of 30.7 million animals. In the 1997/1998 epidemic of Classical Swine Fever in The Netherlands in total 11 million pigs were culled.
Source:
Farm Structure Survey (FSS, EUROSTAT New Cronos)
Variables:

- Number of holdings with dairy cows, other cows, sheep, goats, pigs and poultry
- Land use: Arable land and permanent grassland
- Years: 1995 and 2000
- Coverage: EU 15
- Resolution: NUTS 1, NUTS 2

5.2.6 CO_2 storage

The history of European forests is very important to understand any historic, present and future carbon balance of the total system. Some 5000 years ago Europe was almost completely covered with forests. But with the north-ward spreading of civilization and agriculture over Europe, a process of deforestation started. This deforestation left many countries with less than 10% of forest cover in the late Medieval years. Much of the deforested areas were further degraded through heathland sod cutting, fuelwood collection, grazing, slash and burn agriculture, and wind erosion. Then, in the late 19th, early 20th century, due to intensification of agriculture, much of the degraded areas were not needed anymore and were afforested. Therefore, European forests can be characterised as forests in a vegetation rebound phase, intensively tended for wood production.

Sources: A. Janssens, A. Freibauer, B. Schlamadinger, R. Ceulemans, P. Ciais, A. J. Dolman, M. Heimann, G.-J. Nabuurs, P. Smith, R. Valentini and E.-D. Schulze. The carbon budget of terrestrial ecosystems at country-scale. A European case study. Submitted to Biogeosciences

5.2.7 Biodiversity

Europe's biodiversity in past, present and future relates to a high natural variety in climate, topography, soil conditions and a long-time and regionally different pattern of extensive land use. Typical for Europe is the large portion of cultural landscapes and semi natural landscapes adding to the natural variety. Low intensity farming added to biodiversity in many regions, especially in mosaic landscapes and extensive grassland ecosystems.
Biodiversity is subject to serious decline over decades or even centuries. Major causes of decline are:

- agricultural intensification and scale enlargement of farms
- land reclamation and drainage
- hunting/fishing
- deforestation
- pollution (e.g.nutrients, pesticides,metals)
- urban sprawl and infrastructure :loss of biotopes and fragmentation of natural areas)
- recreational pressure
- land abandonment; loss of extensive agriculture
- climate change within and outside the EU

Sources : EEA 1998, EU environment: 2nd Assessment
EEA 2000, Enviroment at the turn of the century
B.C.W. 1998, Facts and figures on biodiversity

5.2.8 Land degradadtion

Soil erosion in Europe is mainly due to water (about 92% of area affected), and not to wind. In EU25, it is most serious in central Europe and the Mediterranean region, where 50-70 % of agricultural land is at moderate to high risk of erosion. The problem mainly occurs in agricultural land, especially where ploughing is intensive, and where the soil remains uncovered by vegetation all year round. Soil erosion also has a major economic impact, with on-site losses estimated at 53 euros per hectare per year, and off-site losses (e.g. damage to infrastructure) at around 32 euros per hectare per year.

Source: EEA, 3rd Assessment (chapter Soil Degradation)

5.2.9 Pollution

In agriculture artificial fertilisers and animal manure are often out of balance with crop demands. Surpluses cause problems for humans, plants and animals Pesticides to combat diseases in agriculture also affect human health and biodiversity. Nitrogen surplus in the EU-15 is slowly but steadily reduced, a trend that might point to a more efficient use of nitrogen. EU's Environmental regulation (Nitrate Directive) is likely to be an important driver here. Nonetheless, implementation has turned out to be troublesome in a number of Member States and will take time to result in long term improvement of the environment.. The map shows the nitrogen surplus per ha due to the use of fertilizers and manure in 1995. More than roughly 20% of EU-15 groundwaters are facing excessive nitrates concentrations, in particular in the most intensive areas of livestock breeding and fertiliser application At least 30-40% of EU-15 rivers and lakes show eutrophication symptoms or bring high nitrogen fluxes to coastal waters and seas. The agricultural origin of these nitrogen fluxes accounts for 50 to 80% of total nitrogen inputs Some 55% of terrestrial ecosystems in EU-25 also receive nitrogen loads above the critical values . Pesticide policy is still highly influenced by national policies and differs among Member States. Harmonised testing and market allowance of pesticide components at the EU level is ongoing; a thematic strategy on the sustainable use of pesticides will be finished in 2004.

Source: Posh et al (2001)
Eurostat, Luxembourg

5.2.10 Land use

Changes in rural (and urban) land use in history reflect the effects in driving forces. Population growth or decline, demand for food or fibers, the shift towards an industrial and service oriented economy, dynamics in trade (import or export of farm products), the need for forest and nature or recreation areas have affected land use, as can be read in land use statistics. We derived data from EUROSTAT for the EU15 countries in total for the major rural land use categories and give examples for forest and agricultural land per country. The general picture for the period of about forty years is a gradual increase in forest area, a decrease in agricultural land (about 160 million to 140 million), a decrease showing for both arable land and permanent pastures. Not shown in the graphs is the increase in area of built up area and nature (other than forest). Both other graphs give national data for forest and permanent pasture. These show in general a very parallel trend for most countries, though interesting differences appear. For example the decrease in permanent pasture is more outspoken in countries such as France and Germany, whereas Spain shows a decline followed by a recovery after the eighties. Synchronously arable land declined in area.

Source: http://faostat.fao.org/faostat/collections
(september 2004)

6 Simulation per scenario/per time step

This chapter provides information on drivers and indicators. Assumptions on drivers have been incorporated in scenarios and models. Modelling outputs yielded data on indicators in the three-P domains.

6.1 Drivers

6.1.1 Demographic projections

For the development of the global population the IPCC\SRES-scenarios were followed (see Section 3.2). Since these scenarios are meant to be used at a continental scale, the projections were not suitable to be used at European scale. Therefore a slightly different and more specific approach was followed for Europe, partly based on the Eurostat-projections (see Section 6.1.1.1), including a subdivision between urban and rural population dynamic (Section 6.1.1.2 and 6.1.1.3).

6.1.1.1 Demographic projections for the EU-25

Population size and structure are determined by three fundamental demographic processes fertility, mortality and migration. For each of these three variables scenario-specific assumptions have been made (Table 6.1). For the (extended) EU it is assumed that the fertility rates will be highest in A1/B1. Life expectancy in Western European countries is considered to be high and slowly rising in all scenarios. The speed of converging in other EU-countries to this level of life expectancy also depends on the economic growth rate in these countries. The same holds more or less for the migration rate.

Table 6.1 Overview of assumptions for European population projections (Source Hilderink 2004)

Variable	A1	A2	B1	B2
Fertility	Converging High	Diversity Low	Converging High	Diversity Medium
Life expectancy	Converging Medium-High	Diversity Low	Converging High	Diversity Medium
Migration	Converging High	Diversity Low	Converging Medium-High	Diversity Low

The assumptions lead to projected size of population as presented in figure 6.1. It shows that in the A1 scenario the population of the EU-25 will grow with approx. 8% from 453 to 491 million people in 2030. Also in the B1 scenario there will be an increase in population, limited to 5% increase leading to a European population of 476 million in 2030. In the A2 scenario the total population of EU-25 will increase slightly, but the population size in the 10 new member states will decrease by 12%. In the B2 scenario the population will decrease 5% to 430 million inhabitants. In all scenarios the “grey pressure” (age 65 and over as a ratio of 15-64 years) will sharply increase. For the EU-15 this will be an increase from 25% in 2000 to 38% in 2030 in the A1 scenario to almost 45% in the B2-scenario.

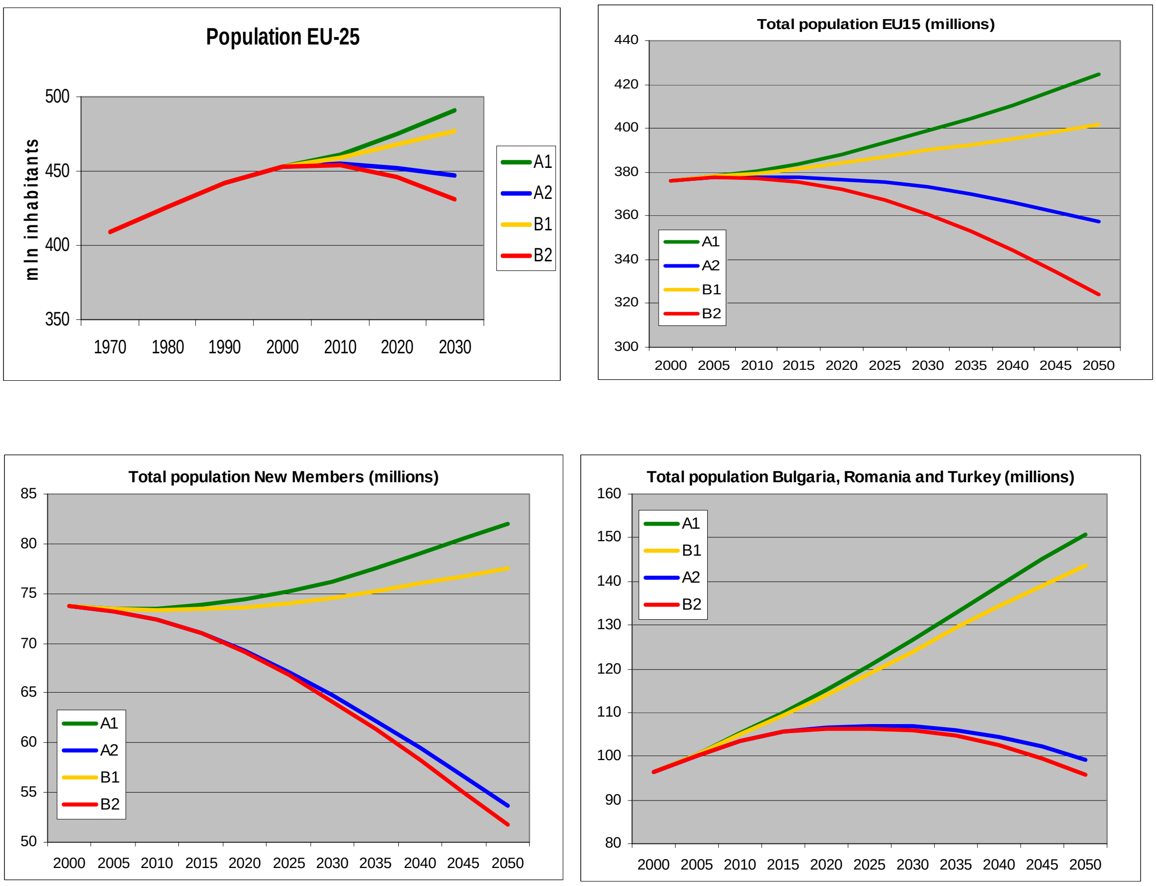


Figure 6.1: demographic projections

6.1.1.2 Rural population

For the rural areas, the development of the rural population is of eminent importance. Projections of the development of Europe’s rural population are scarce. The Eurostat-data are on NUTS-2 level, but give no insight within NUTS-2 region of division of urban and rural population. Another problem is that the definition of “urban” and “rural” is not harmonized between EU-members. Furthermore, it was difficult to differentiate between the scenarios on the base of the storylines. Therefore a more simple approach was followed. The UN-report “World urbanization prospects: the 2003 revision” provides projections of the shares of urban and rural population per country for 2030 (UN, 2004). The share of rural population for 2030 was multiplied with the projections of the total population per country in the different scenarios. This yielded the data shown in Figure x.x. They show a strong decline of the rural population in all scenarios, most dominant of course in scenarios with a decrease in total population (A2 and B2). However, also in the scenarios A1 and B1 there is a significant decrease in the rural population. The decrease in the size of the rural population in the A1 and B1 scenario is in line with the trend between 1970-2000, while in the A2 and B2 scenario, the decrease in population is even larger than the trend. In the actual quantification the changing ratio urban/rural only played a role in determining the need for land for urban development.

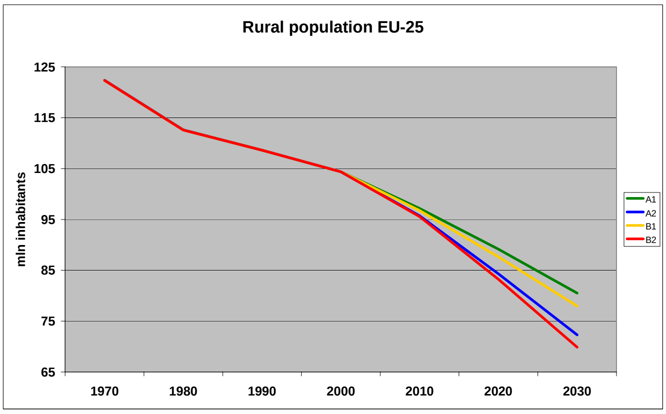


Figure 6.2: Historic development of rural population 1970-2000 and assumptions in the four scenarios for 2000-2030.

6.1.1.3 World population

The assumptions on the development of the population in other continents world were taken from the IPPC-SRES scenarios {Nakicenovic, 2000; IMAGE, 2001}. These data played a major role in the calculations with the GTAP- and with the IMAGE-model, since population developments are a major driving force for a.o. economic development, global food demand and emissions the environment. Figure 6.3 shows the demographic development in the different scenarios. Especially in the A2 scenario the world population is growing fast.

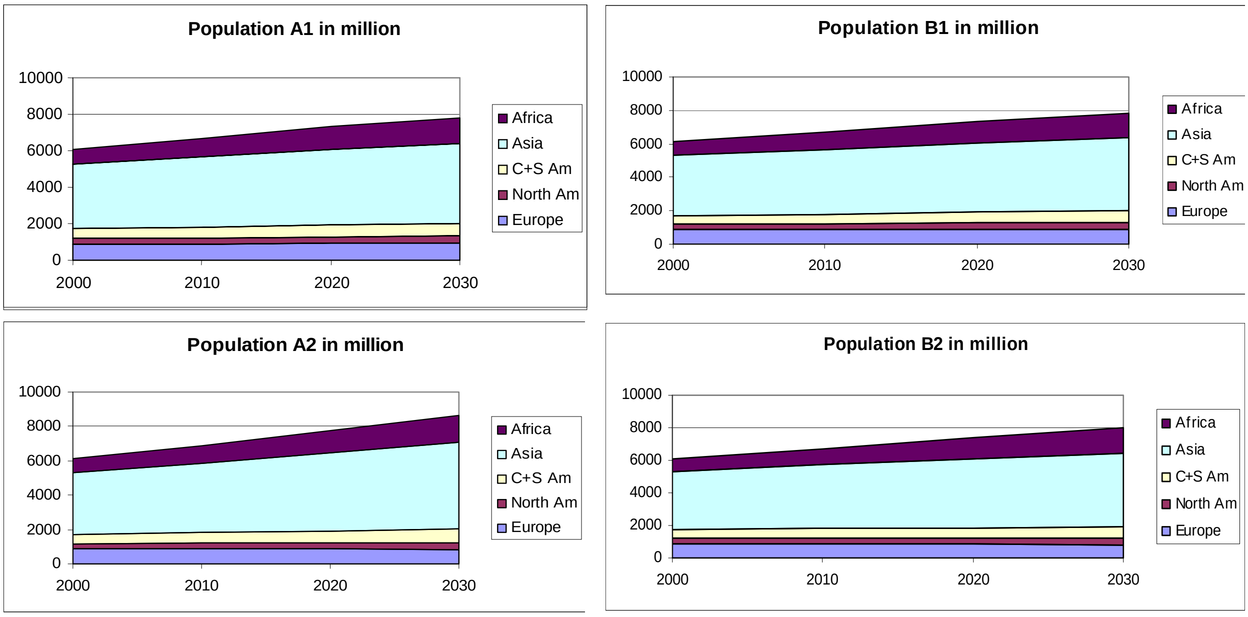


Figure 6.3: Global demographic development in the four scenarios. Source: IPCC-SRES

6.1.1.4 CAP

For CAP and Non-CAP products we give the total production effect which is the result of all scenario's assumptions ("CAP-total" and "Non-CAP-total" respectively). For CAP products the isolated contribution of changes in border support (CAP-border support) and domestic support (CAP-domestic support) is also depicted.

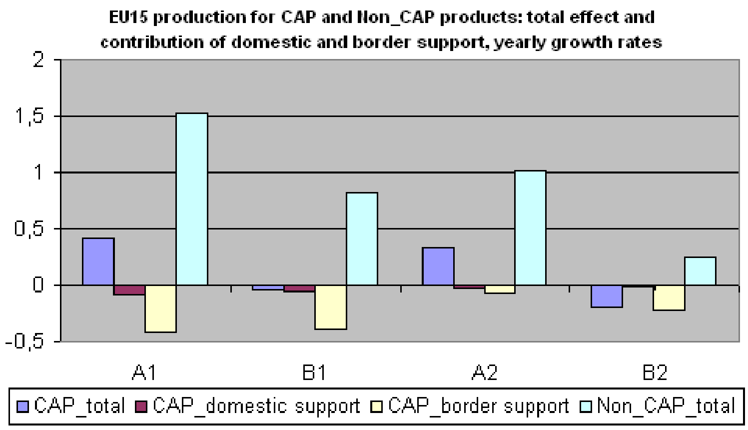


Figure 6.4 : EU15 production for CAP and non-cap products

Production growth of products with protection of CAP (grains, oilseeds, sugar, beef and dairy) is lower than for other agricultural products (horticulture, pork and poultry). If income rises people spend relatively more money on Non CAP products (higher income elasticity).

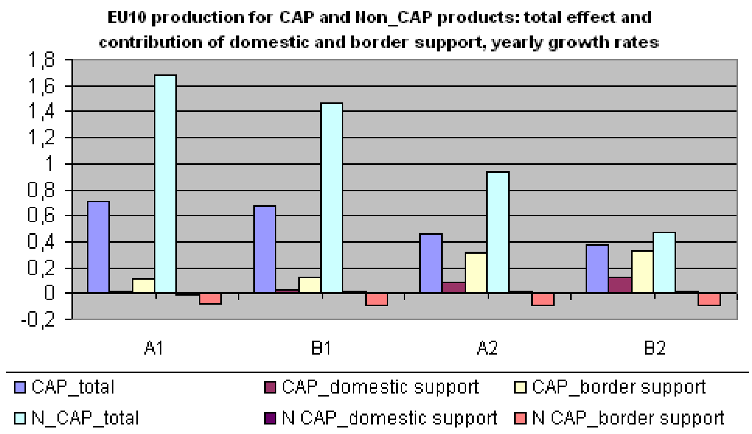


Figure 6.5 : EU10 production for CAP and non-cap products

CAP (Common Agricultural Policy of European Union
Products under CAP: product with a relatively high degree of market regulation due to the common agricultural policy. Products in this category are grains, oilseeds, sugar, beef and dairy.
Non-CAP products: agricultural products with a low degree of market regulation under CAP. Products in this category are horticulture, pork and poultry.
Border support: Changes in export subsidies and import tariffs
Domestic support: changes in subsidies to the farmer (e.g. area payment, slaughter premiums)

6.1.1.5 Source

The information on developments of Cap in future is derived from the LEITAP model.
Model: LEITAP (modified version of GTAP: Global Trade Analyses Project, WWW.GTAP.ORG)
read more about GTAP/LEITAP Data: GTAP version 6.2
(http://www.gtap.agecon.purdue.edu/databases/v6/default.asp)

6.1.2 Climate

Future climate change strongly depends on emissions of CO_2, CH_4 and N_2O,. Scenario A1 shows the highest emissions and B1 is the only scenario where climate policy is successfully implemented. Here, it is assumed that the greenhouse gas concentration will stabilize at 550 ppmv CO_2-equivalents. In B2 climate policy is implemented on a local scale through regional initiatives like implementation of wind and solar energy systems. Because of the low economic growth in the A2 scenario, this scenario shows low emissions until 2030 (see Figure 6.6). However, the expected growth of population in A2 will probably result in high temperatures by the end of the century.

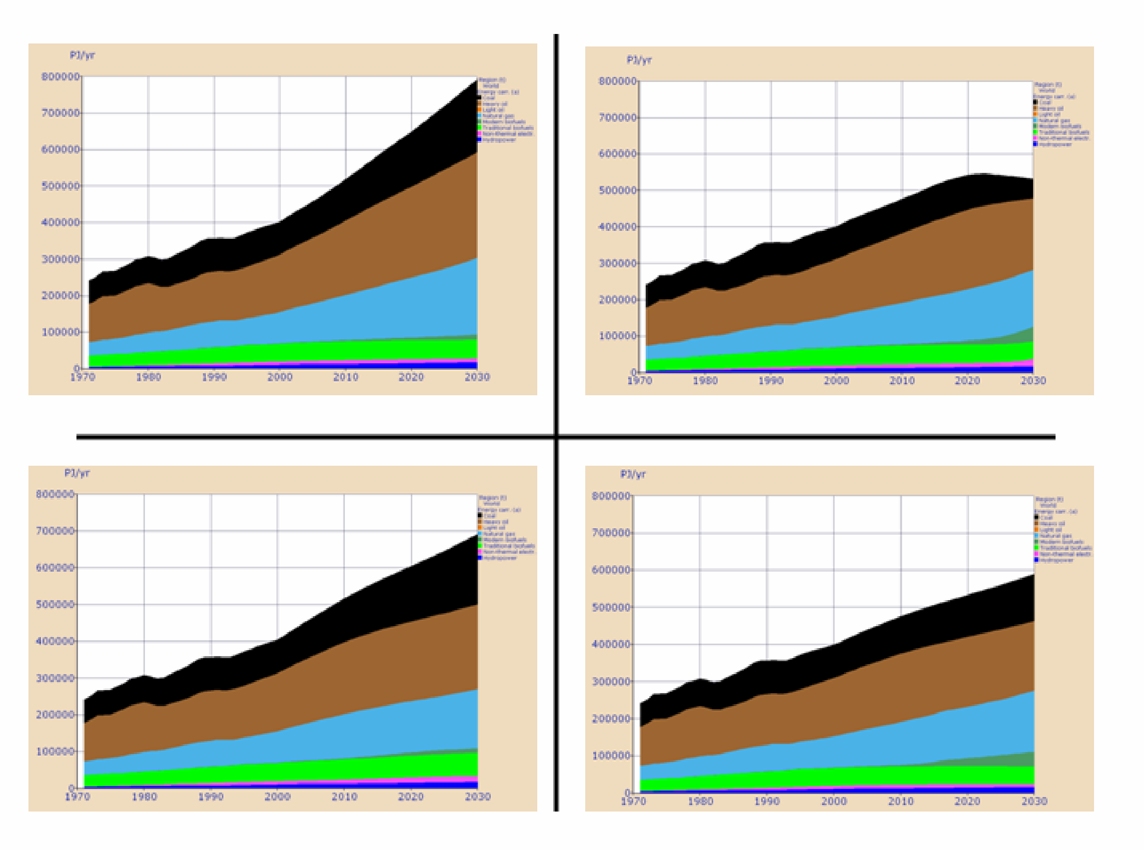


Figure 6.6: Global primary energy use within the four scenarios (black = coal, brown = oil, blue = natural gas, dark green = modern biofuels, light green = traditional biofuels, pink = wind, solar and nuclear and blue = hydro).

Because of inertia in the climate system the consequences for the global-mean temperature change are very similar in the four scenarios for the coming three decades as taken by EURURALIS as time horizon The B1 scenario even shows the highest temperature in the first decades. This result is related to the climate policies that are implemented in the energy system: less coal not only decreases the CO_2 emissions, but also the SO_2 emissions. And since SO_2 aerosols have an instant cooling effect compared to a long-lasting warming effect of CO_2 concentrations, the decrease of SO_2 particles increases the temperature immediately. The effect of CO_2 reductions are visible after 2030 (not shown).

Results for A1 show that this high-consumption scenario will lead to high temperature levels by 2030, having a major impact on the agricultural system through CO_2 fertilization and changes in temperature level and precipitation.

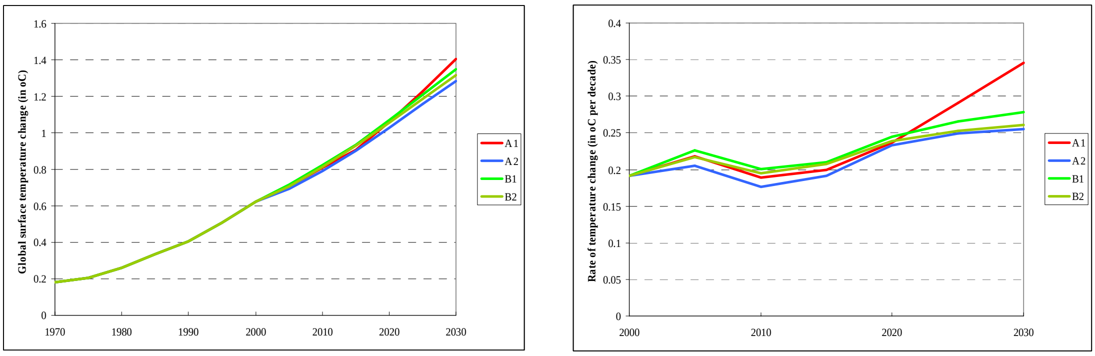


Figure 6.7: Global-mean temperature change (left) and Rate of emperature change (right)

The impacts of climate are very different regionally.
The local effects are very uncertain. Studies of the Intergovernmental Panel on Climate Change concluded that the models are very consistent in simulating warmer winters in Northern parts of Europe, when high emission scenarios are assumed. In contrast, the Mediterranean area will experience warmer summers in most of the models. These warmer summers will be combined with drier conditions. It is important to see that models often disagree on where precipitation is less or more, but that most of the models show a consistent drying sign in the Mediterranean area (Fig 6.8 a/b for temperature and precipitation change). The combination of drier and warmer summers can have a major impact on the natural system and for humans (health, water supply, ecosystem services). In the North of Europe wetter winters are likely.

Impacts on extreme weather events are very uncertain and are not included in this study.

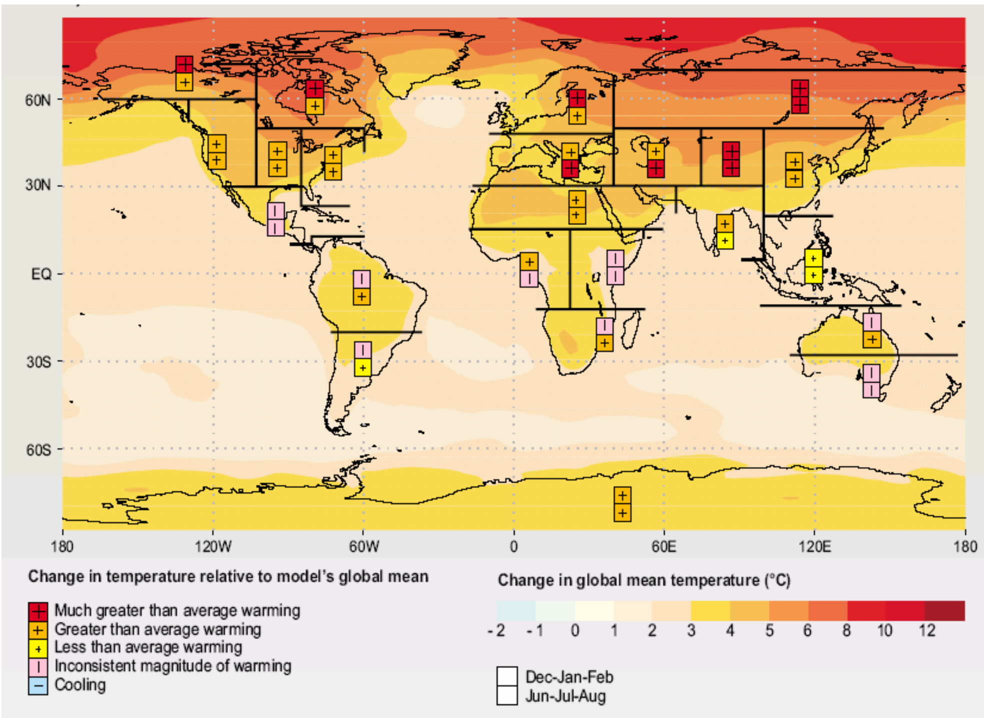


Figure 6.8a: Temperature change for the 2080s relative to the averaged period between 1961 and 1990 for a high emission scenario (A1 or A2). Results are based on results from several General Circulation Models.

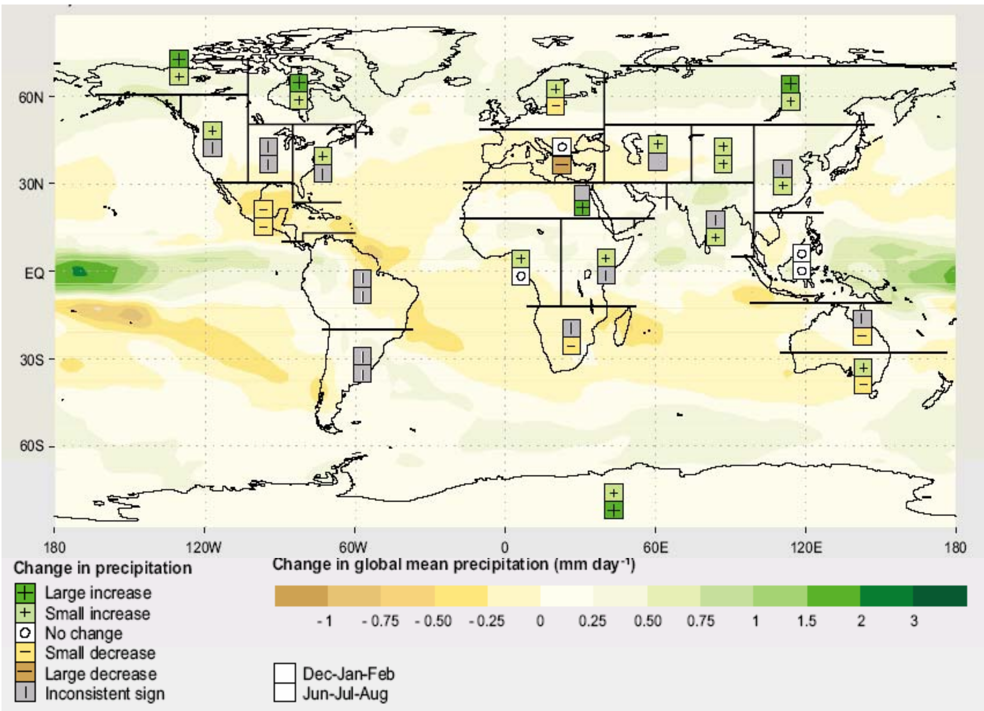


Figure 6.8b: Precipitation change for the 2080s relative to the averaged period between 1961 and 1990 for a high emission scenario (A1 or A2). Results are based on results from several General Circulation Models.

6.1.2.1 Source

The energy emissions are taken from the CPB/RIVM-study "Four futures of Energy"
This stabilization level in scenario B1 has a good chance to coincide with the EU climate policy objective of a maximum temperature increase of 2 degrees Celsius over its pre-industrial level (Bollen et al., 2004).

6.1.3 Gross Domestic Production (GDP)

The process of transition continues in the accession countries (EU10). Income growth is high (2-3 times that of the EU-15). The level of income is less than 50% of that of the EU-15 and there is ongoing structural change in their economies and especially in agriculture. Economic growth will accelerate in the EU-10 after accession. Structural change will be supported by structural funds and rural development. The EU-15 economies are more saturated. Their economies grow slowly and there are relatively stable structures in the whole economy

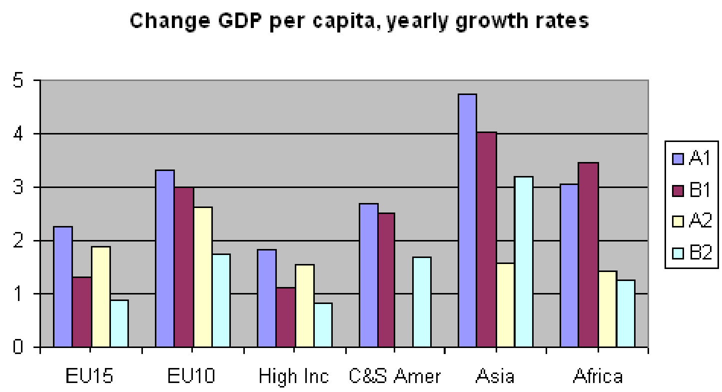


Figure 6.9: Change GDP per capita

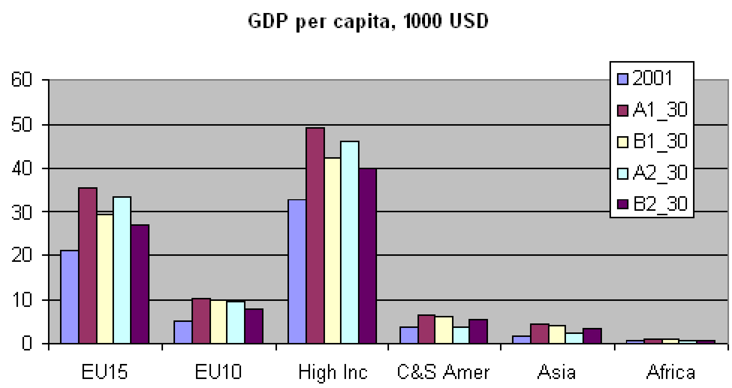


Figure 6.10: GDP per capita

6.1.3.1 Source

The information on developments of GDP in future is derived from the LEITAP model.
Model: LEITAP (modified version of GTAP: Global Trade Analyses Project, WWW.GTAP.ORG) read more about GTAP/LEITAP
Data: GTAP version 6.2
(http://www.gtap.agecon.purdue.edu/databases/v6/default.asp)

6.1.4 Trade

A fast growth of exports of agrifood of EU15 with EU10 due to accession occurs in all scenarios The highest growth in trade with the rest of the world, especially Asia and Africa, takes place in the Global scenarios (A1 and B1). Intra EU15 trade growth is limited.

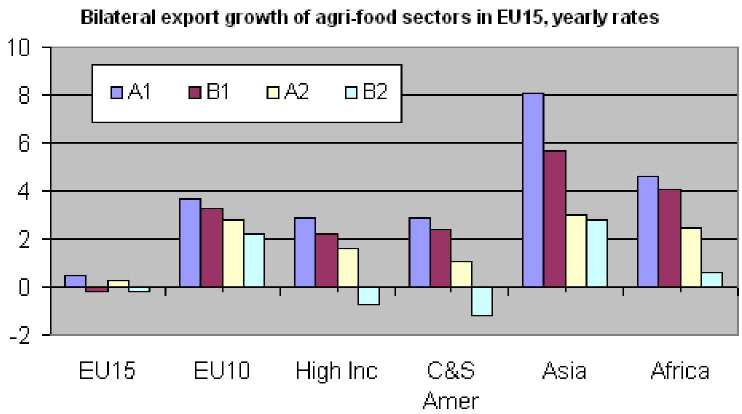


Figure 6.11 : Bilateral export growth of agri-food sectors in EU15, yearly rates

Economic growth and changes in border support are important drivers of trade. The impact of changes in domestic support are limited. Export Growth with EU10 countries will be high due to accession.

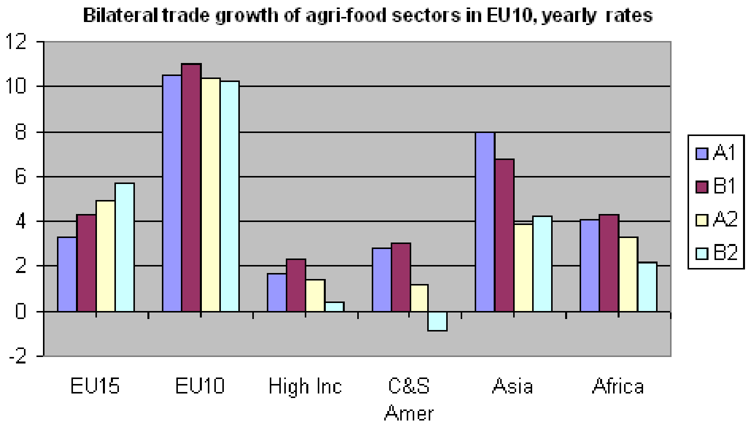


Figure 6.12 : Bilateral trade growth of agri-food sectors in EU10, yearly rates

6.1.4.1 Source

The information on developments of trade in future is derived from the LEITAP model.
Model: LEITAP (modified version of GTAP: Global Trade Analyses Project, WWW.GTAP.ORG) read more about GTAP/LEITAP
Data: GTAP version 6.2
(http://www.gtap.agecon.purdue.edu/databases/v6/default.asp)

6.1.5 Production

Crop production growth is low in the EU relative to other countries/continents. Lower economic growth in combination with a low income elasticity are important in this respect. In the liberalisation scenario's (A1, A2) sugar production in the EU will decline substantially (see Figure 6.13). In the B1 and B2 scenario's crop production is relatively low due to lower demographic and economic growth and less demand for fodder crops due to less meat consumption. These effects are higher for the EU15 than for the EU10.

For countries outside the Transatlantic market in the A2 scenario crop production is lower than in other scenario's due to low economic growth and no enhanced access to Transatlantic market.

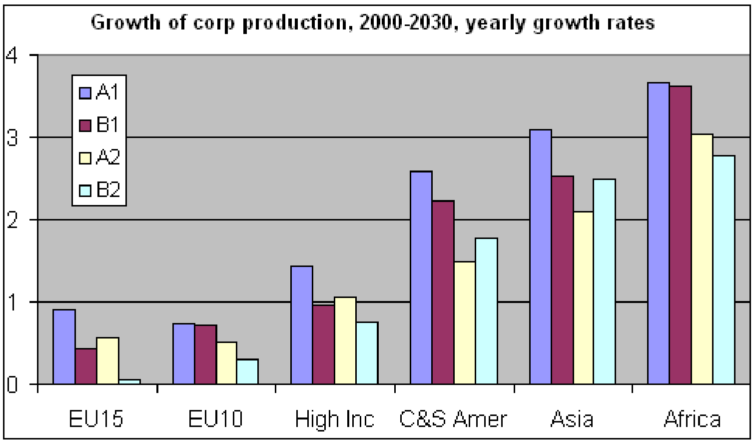


Figure 6.13 : Growth of crop production

Livestock production growth is low in the EU relative to other countries. Lower demographic and economic growth are important explanations. In the EU15 and other high income countries meat consumption declines due to preference shift in diet, especially in the B1 and B2 scenarios. For the EU10 (and developing countries) this effect is smaller: higher income leads to higher consumption. The pig and poultry sector are hardly influenced by the CAP. The pig and poultry sector therefore respond mainly to trends in global markets. Developments in meat demand are determined by world population, combined with changes in GDP per capita and consumer preferences. In general, meat consumption increases when people get richer. In Global Economy (A1), the world demand for meat and other animal products doubles up to the year 2030.

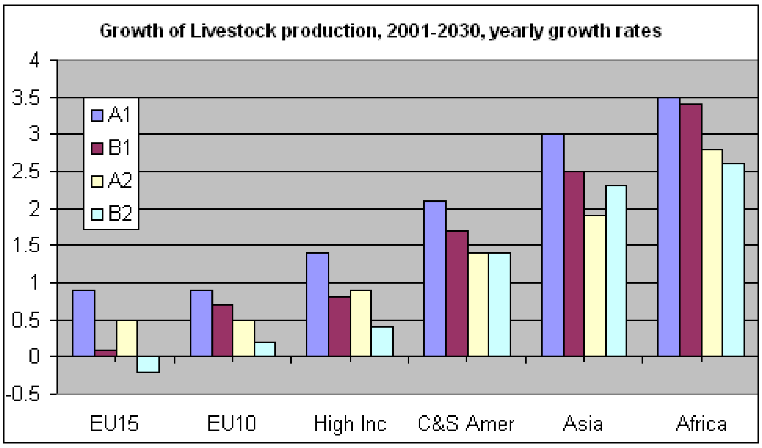


Figure 6.14 : Growth of livestock production

6.1.5.1 Source

The information on developments of production in future is derived from the LEITAP model.
Model: LEITAP (modified version of GTAP: Global Trade Analyses Project, WWW.GTAP.ORG) read more about GTAP/LEITAP
Data: GTAP version 6.2
(http://www.gtap.agecon.purdue.edu/databases/v6/default.asp)

6.2 Landuse change

Land use change can be seen as an intermediate shackle in the cause-effect chain. Land use is driven by a combination of drivers and as such exerts strong influence on depent variables expressed in the various indicators.

The results of the high-resolution (1 km^2) assessment of land use changes based on the CLUE simulations comprise several land use maps and hotspot maps that are used as input for quantifying the effect on indicators and are included in the interactive user interface. Beside that, the impact of the scenario conditions was assessed at the landscape level. Table 6.2 gives an overview of the results and their purpose. This chapter describes some outputs in more detail. Maps for the full EU25 and short animations can be found in the interactive user interface (CD Rom) .

Table 6.2: Overview of CLUE-EURURALIS results

Name	Description	
Land use maps	Eu25-maps, time range 2000-2030 in 2 years time step, A1-A2-B1-B2 scenario.	Used as input for quantifying the effect on indicators: 2000, 2010, 2020, 2030
Hotspot maps: - Urbanization - Agricultural abandonment - Nature development and loss	A1- A2- B1- B2 scenario 2000, 2010, 2020, 2030	These maps show where concentrations of a certain land use conversion occur. The hot-spots may be a target for policy intervention.
Meta- indicator: hotspots	- Urban development - Agricultural abandonment - Development and loss of nature	These maps compare the hotspot maps of the four scenarios and show which changes are scenario independent and which locations only change in certain scenarios.
Scenario options	A2 without LFA policy B1 without erosion reducing policy B2 without LFA policy B2 without erosion reducing policy	To assess the effect of LFA compensation policy on biodiversity and erosion reducing policy on the amount of erosion sensitive land, additional model runs are performed without implementing these policies. The 2000-2010-2020-2030 maps of these runs are used as input for quantifying the effect on biodiversity and erosion indicators.
Land use change impact	Several themes, all scenarios.	Zoom-in on specific locations, to show effect of change at the landscape level.

Interpretation of land use change at the European level: scenario results

A1: Most striking in the A1 scenario is the large extent of urbanization. The urbanization is a result of high population growth, high economic growth leading to a larger use of space per person (e.g., due to the demand for shopping and recreation facilities) and growth in the industry and services sector. Urbanization is found throughout the whole of Europe with hotspots located near to the main cities and agglomerations such as the Dutch Randstad and the Flemish Diamond. The lack of spatial policies to prevent urban sprawl cause urbanization to have large influences on the landscapes in many parts of Europe. Since abandonment of agricultural land is found in most countries the future function of these lands is an important discussion item. Partly they are used for residential, industrial and recreational purposes, while in less accessible areas with low population pressure spontaneous development of nature is expected. This leads to an expansion of some of the larger natural areas of Europe. Other options include the possible cultivation of biofuels on abandoned agricultural lands.

A2: The A2 scenario is characterized by high pressure on available land resources. In spite of a slight decrease in population numbers, requirements for build-up area increase due to strong economic growth and prosperity growth leading to sprawled spatial patterns of urbanization (e.g., proliferation of second houses). At the same time the high protection level for European agriculture and macro-economic conditions cause an increase in land requirements for agricultural purposes. In many countries the combined requirements for agricultural and residential/commercial purposes are very high such that the conversions come at the cost of natural areas. Mostly the small patches of nature and landscape elements such as hedgerows that remain within the prime agricultural areas will be lost first. Therefore, it is expected that the conditions of this scenario have an important, negative, impact on the natural and cultural-historical values of the European landscapes.

B1: In the B1 scenario urbanization has less impacts on the rural landscapes. This is due to the lower requirements for residential/commercial areas compared to the A scenarios. At the same time the spatial policies that are assumed under this scenario aim at concentrating urbanization in designated areas, leading to compact urbanization patterns. Policies in this scenario aim at reinforcing the natural values and ecological strengths of natural areas designated in the Natura2000 network. Large areas of abandonment of agricultural lands offer opportunities to actually implement these policies. Land abandonment is the results of the macro-economic conditions in combination with increasing productivity leading to strong decreases land required for agricultural purposes. The results suggest the existence of a significant reinforcement of the designated natural areas at the cost of agricultural area that is concentrated in the prime agricultural regions.

B2: This scenario shows relative modest changes in landscape patterns due to the low rate of urbanization, policies to maintain agricultural production in the 'Less Favored Areas' and no policies to establish a European level network of natural areas. Land abandonment is, therefore, found distributed over different landscapes.

Modest increases in agricultural productivity in combination with the decrease of agricultural area offers opportunity to maintain diversity, natural and cultural-historical values in most rural areas.

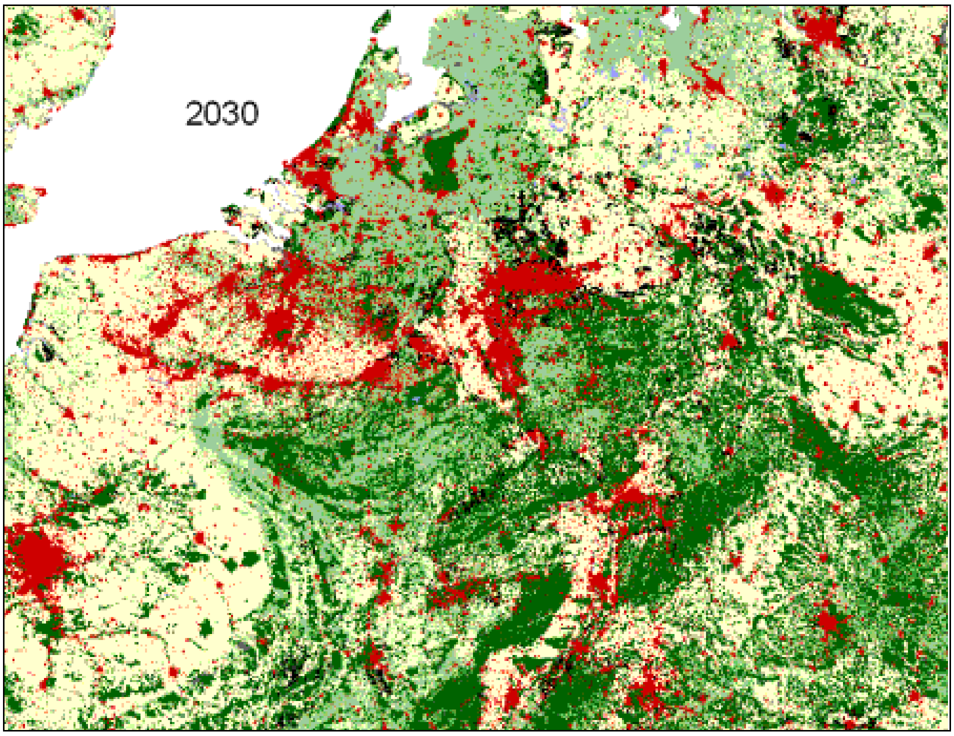


Figure 6.15: Land use pattern in 2030 in northwest Europe, B2 scenario.

6.2.1 Comparison of the scenarios

The interplay between demand for agricultural and urban land, spatial policies and competition among land uses leads to different dynamics of land use between the scenarios. Table 6.3 indicates which part of the land area of the EU will see a change in land use between 2000 and 2030. This table indicates a tremendous impact on land use in this period: even in the scenario with the smallest dynamics (A2) almost 5% of the total land area will be converted to another land use type. Note that this only includes conversions within the legend classes used in this study; conversions between crop types or residential and industrial functions are not counted.

Due to large land abandonment the B1 scenario appears to be most dynamic. These changes have huge impact on the aesthetic and functional quality of the landscapes. In the A2 and B2 scenarios the dynamics are much lower than in the scenarios with a focus on globalization, most likely causing less damage to the historical landscapes of Europe.

Another pattern of interest is the relative strength of land use dynamics in the EU15 versus the accession countries. Whereas the accession countries show more dynamics in the A scenarios compared to the EU15 countries, the pattern is opposite in the B scenarios where most dynamics occur in the EU15 countries.

Table 6.3: Total change in land use across the EU for the different scenarios.

Scenario	***% of land area changed between 2000-2030***		
	EU25	EU15	New countries
A1	7.65	7.15	9.83
A2	4.74	4.53	5.62
B1	8.07	8.51	6.19
B2	6.02	6.30	4.79

Of all changes in land use abandonment of agricultural land is the most important in terms of area. While in the A2 scenario 2.5% of the land area (which equals approx. 5% of the agricultural area in 2000) is abandoned this is 6.4% (approx 13% of the agricultural area) in the A1 scenario where abandonment of the current agricultural area is largest. Due to some conversion of some new lands to agriculture in this scenario the net loss of agricultural area is less than in the B1 scenario. Land abandonment poses important issues concerning alternative uses to policy makers. Part of the abandoned land, especially in the A1 scenario, is used for residential, industrial and recreation purposes. In all other scenarios this is less and nature has possibilities to develop on these lands. In the A scenarios nature development is assumed to occur spontaneously: Especially in the A2 scenario the extent of nature development is therefore very restricted. Under the conditions in the B scenario active nature development leads to large expansion of the natural areas, mainly on former agricultural land. The lower urbanization rates provide opportunities for this development.

Table 6.4: Percentage of total land area of the EU that faces urbanization, land abandonment or the development of new nature.

	A1	***A2***	***B1***	***B2***
Urbanization	2.37	1.38	1.33	0.41
Land Abandonment[1]	6.35	2.49	6.28	5.21
New nature*	2.11	0.55	4.58	3.18

[1] this only includes abandoned agricultural land, not corrected for new agricultural areas at other locations
** this only includes the areas of new nature, not corrected for loss of nature area at other locations*

6.2.2 Interpretation of land use change: Landscape impact

To assess the impact of the scenarios on the landscapes and land use patterns in more detail several regions(19) in Europe are highlighted in the user interface. For each of the regions (see Figure 6.16) a set of specific conversions is identified and analyzed in more detail. Two examples are given in this report.

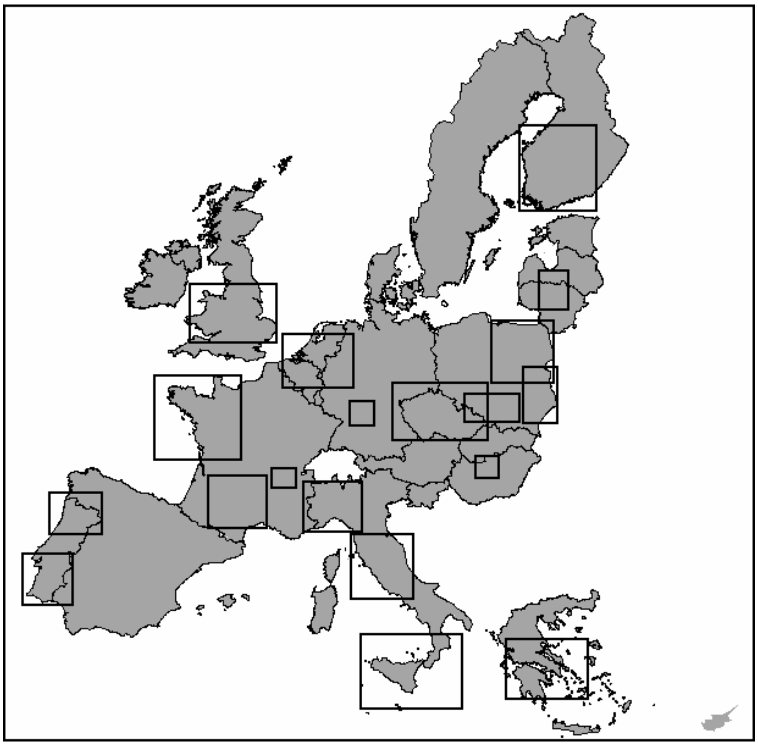


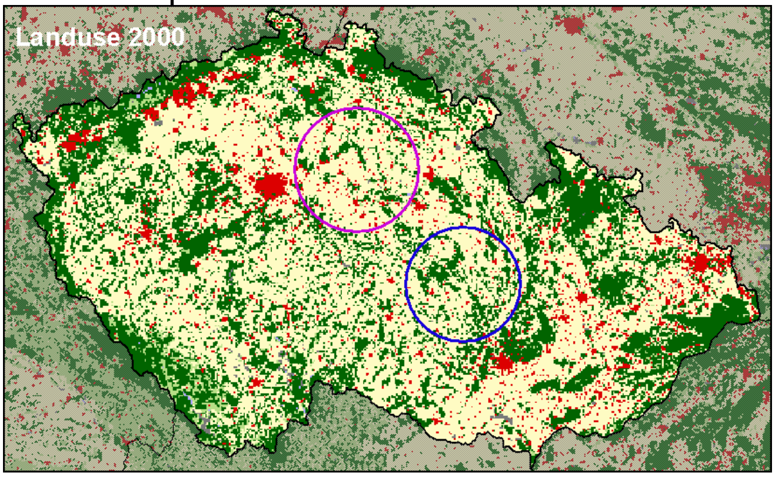
Figure 6.16: Locations for which Landscape level impacts are described in the user-interface

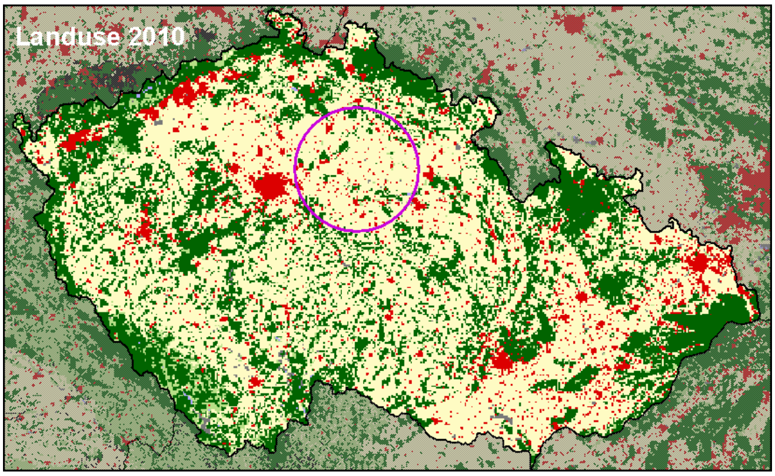
6.3 Indicators

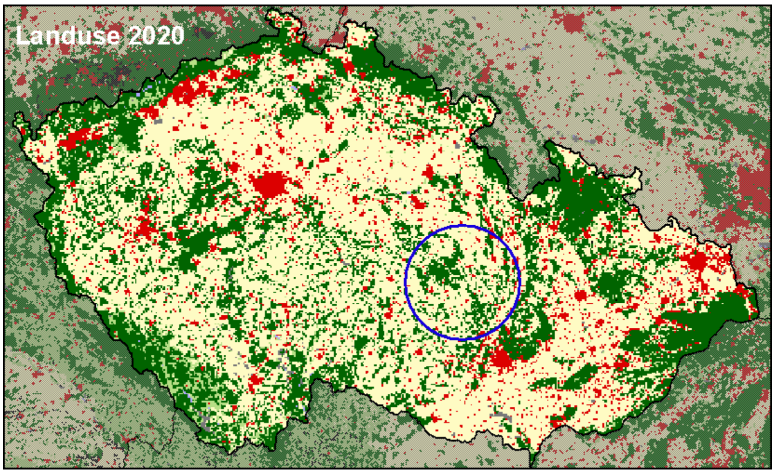
6.3.1 Introduction

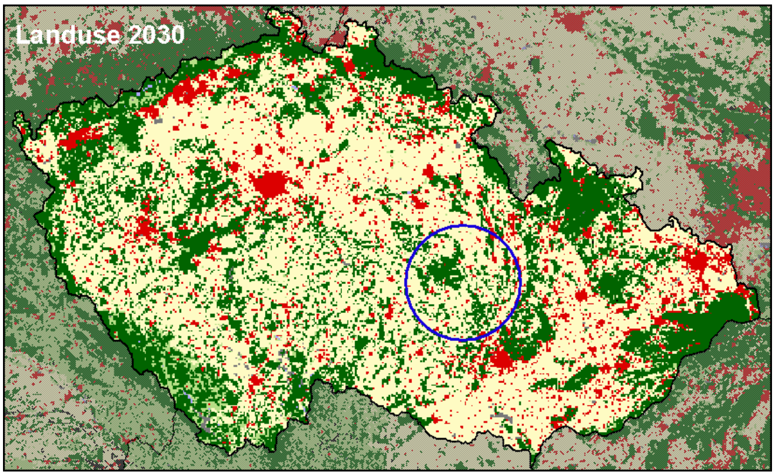
The EU committed itself to various international treaties or agreements such as made in Rio de Janeiro, Johannesburg, Kyoto, that basically were inspired by the concept of sustainable development. This concept (Brundtland et al., 1987) puts a balanced development of economic, socio-cultural and ecological domains at the forefront, while safeguarding all essential resources for coming generations. Its basics are expressed and visualized in the well-known People, Planet, Profit (3P-) triangle. While committing itself to these general principles the EU has the challenge to tune this with the current bio-physical cultural, social, economic and administrative / political situation. From a recent Policy document on the strategy for sustainable development (European Commission, 2001) we derived the following issues that underline both the general attitude towards sustainable developments as well as the then expected - and in between realized - accession of new member states.

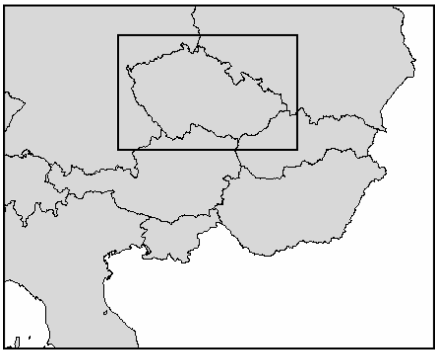
Non-linear changes in arable land area lead to irreversible changes in the rural landscape







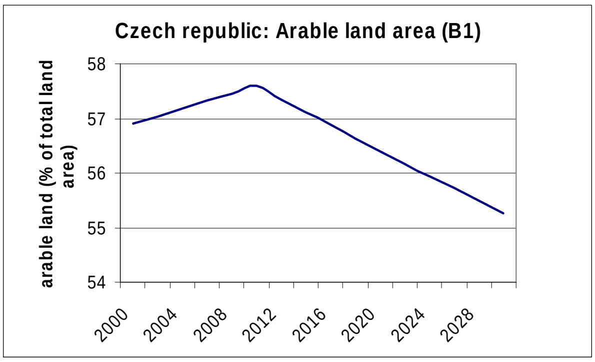




In most accession countries, a non-linear change in the demand for non-irrigated arable land is found in the B1 scenario. Typically, the arable land area increases until 2010 followed by a decrease in area until 2030. This is due to changes in agricultural policies after 2010: until 2010 the accession countries will benefit from European agricultural policy and production quota. This scenario, however, implies that production quota are abolished which will result in a stronger influence of liberalization after 2010.

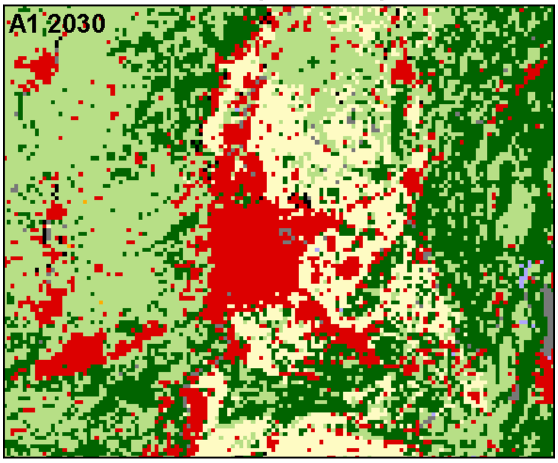
In the Czech Republic, the increase of arable land comes at the cost of a decrease in nature area in the first 10 years, followed by a decrease of arable land area and the development of new nature on abandoned land in the last 20 years.

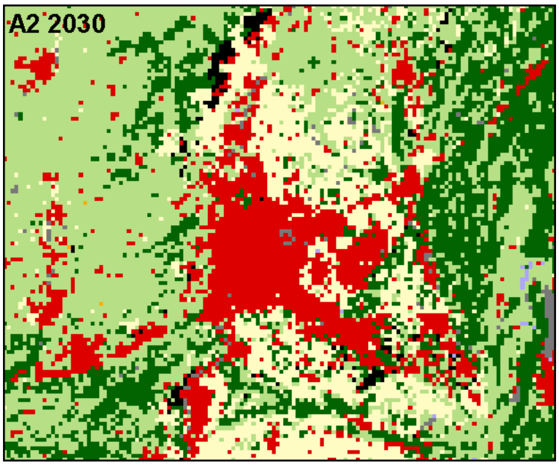
However, nature will not return automatically at the locations where it is lost during the first ten years. During the first ten years it is mainly the small patches of nature in the main agricultural area that are lost (purple circle in maps), while new nature develops on abandoned marginal lands adjacent to existing nature areas (blue circle). This pathway of change has important, irreversible consequences for the rural area and landscape. diversity.

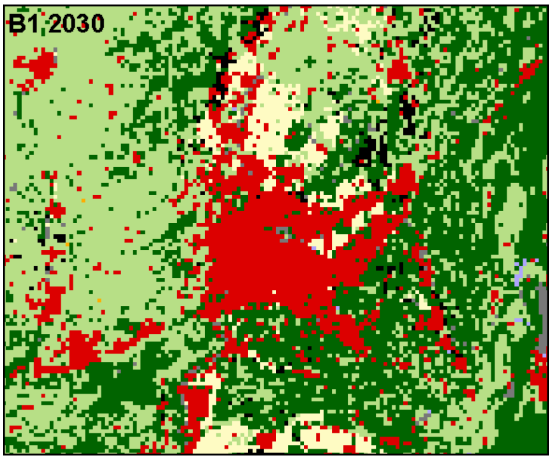


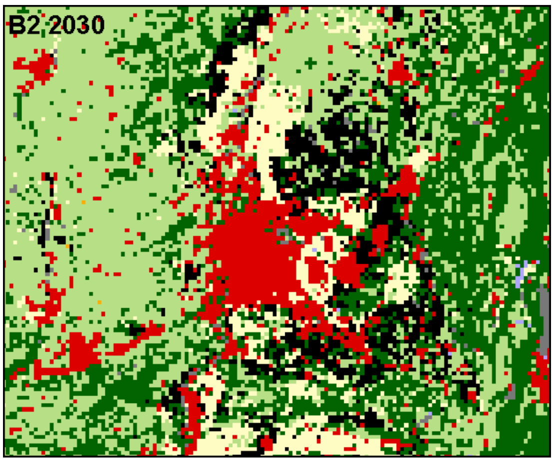
- built-up area
- non-irrigated arable land
- pasture
- forest/nature/natural grasslands
- inland wetlands
- static land use types
- irrigated arable land
- abandoned land

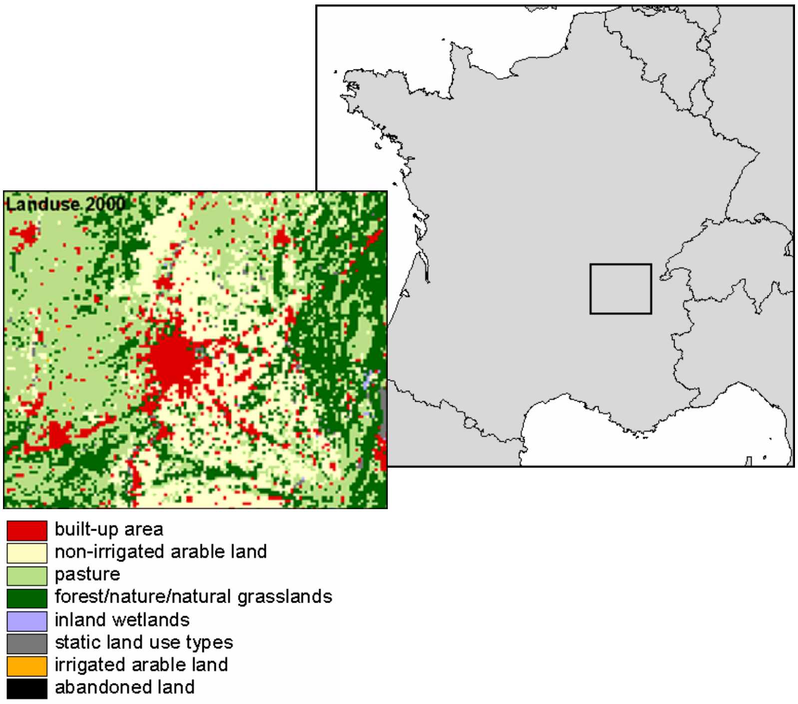
Urban development patterns differ by scenario: Lyon as an example











Urban development patterns differ between scenarios not only by urbanization strength, but also due to different spatial policies. The urbanization assumptions related to urban growth differ between the four scenarios as indicated in the table below.

	A1	A2	B1	B2
Type of urban growth	Sprawled	Sprawled	Compact	Compact
Large cities	No restrictions ; growth is favoured	No restrictions ; growth is favoured	Growth restricted to designated areas	Restriction s on growth

The pictures show the growth of the city and suburbs of Lyon for the 4 scenarios. A1 shows growth of the city, suburbs and urban sprawl to the smaller town in the surroundings. and there is sprawled urban growth in the area around Lyon. In A2 there is somewhat more growth in the suburbs, but the general picture comparable with A1. The spatial policies in the B1 scenario aim at compact urbanization, leading to more growth of the city and less sprawled growth in the surrounding area. In B2 urbanization rates are relatively low compared to the other scenarios.

In the B2 scenario France faces large areas of land abandonment. In this scenario agricultural land is not only abandoned in marginal areas due to the Less Favoured Area policies. Land abandonment in the surroundings of large cities offers opportunities for recreational use of the area.

We rephrased and classified themes according to the 3 P categories ourselves!

- Climate change (drought, increase in precipitation, flooding, rising sea levels, violent events) =Planet
- Threats to public health (toxic substances, food safety risks, sufficient health services) =People
- Pressure on natural resources (bio-diversity, fish stocks, fresh water, increased amounts of waste) =Planet
- Poverty/social exclusion = People
- Ageing/shrinking labour force = People
- Gap between rich and poor regions (between enlarged EU member states) =People +Profit
- Congestion/pollution related to urban sprawl/ urbanisation; impacts on rural areas related to sub optimal spatial planning =Planet + Profit.

As can be noticed this list focuses at the Planet and People rather than Profit aspects. We can assume that Profit aspects are left somewhat implicit, but still regarded by the EU as crucial for a.o. social development and, sometimes, ecological improvements. We refer to the Lisbon strategy that aims at economic restoration and even a leading position of the EU. Such will affect rural area qualities undoubtedly, though suspicions arise about the safeguarding of Planet and People aspects (EEA, 2004).

In the EURURALIS study items as mentioned above were used to select 3P indicators as elaborated later, adding a few topics such as soil erosion or salinization, carbon sequestration, and animal diseases on the one hand and leaving out some others due to data shortage or insufficient time or money. The final choice as elaborated hereafter was made in close interaction with a Policy Advisory Group and a Scientific Advisory group, both installed by the Dutch Ministry of Agriculture, Nature and Food Quality.

The policy context made it necessary to present data, insights and model results in a user friendly format. This explains the choice of a CD ROM that is easily to approach and to browse (Wageningen University and Research, RIVM, 2004). This tool is made highly visual by a liberal use of possibilities for users to make their own graphs, maps and comparisons of scenarios, countries or periods according to their interest. We tried to build in several levels of detail: I) the level of the simple "take-home" messages (one-liners), II) a second level with some more explanation and III) if necessary more detailed, technical information as background (e.g in PDF format). Indicators for sustainable development in 3P domains form the alpha and omega of the project. As made clear the "raison d'être" of EURURALIS lies in the choice of policy- relevant indicators that represent 3P domains sufficiently. In view of their central importance we focus on them and explain how we dealt with them or what could be added in later stages.

Generally indicators for use in policy making ought to be I) limited in number, II) comprehensible and policy relevant and III) representative for the 3 P domains. Compared to what was theoretically desired, we had to be practical as not all data were available with sufficient cover over all EU 25 countries. Finally we selected the following list, grouped after the People, Planet and Profit categories:

6.4 People indicators

6.4.1 Employment

Negative employment growth in agricultural sectors occurs in all scenarios. The decline is highest in the B2 scenario due to a low population and employment growth in the whole economy. However, the share of agricultural employment in total employment stays highest in this B2 scenario. Employment growth is highest in primary crops sector due to high possibilities vor labour productivity growth. In the B1 and B2 scenario employment declines relatively fast in the livestock sector due to low production growth caused by low economic growth and diet changes. The decrease in employment in the processing sector is relatively modest due to relatively high production growth. The share of agricultural employment declines in all scenarios due to lower production growth in these sectors and a higher labour productivity (production per hour) growth. The decline is highest in the A1 scenario because labour productivity growth is relatively high. High demand growth in the services sectors induces pressure in the labour market and opportunities for people in other sectors. In the low income growth B2 scenario opportunities for agricultural employees outside agriculture are limited and people stay within the agri-sectors.

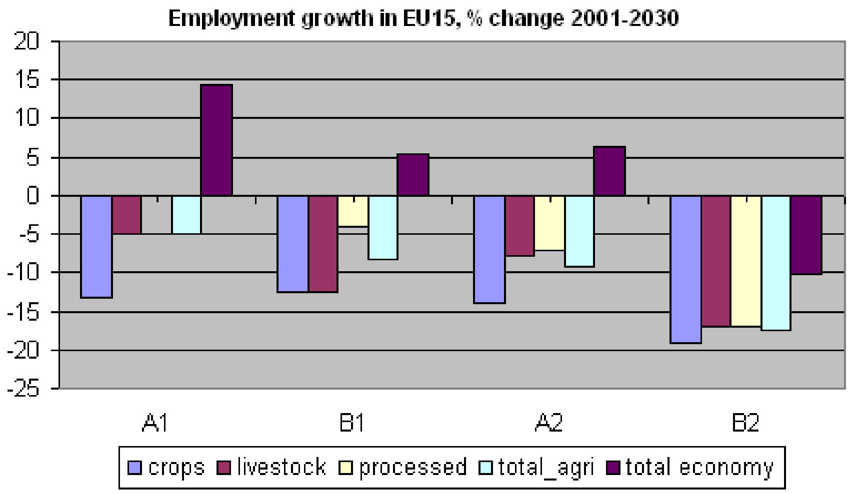


Figure 6.17: Employment growth in EU15

Overall employment growth in the economy in the EU 10 countries is negative due to a declining population and higher labour productivities. Employment declines more in the agricultural sectors, where productivity will increase relatively fast. The decline is highest in the scenarios with the highest economic growth.

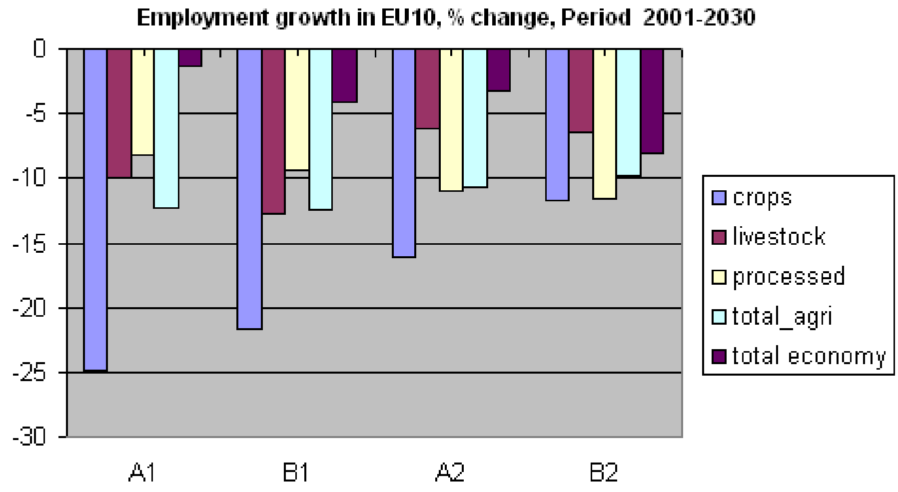


Figure 6.18: Employment growth in EU10

6.4.1.1 Source

The information on developments of employment in future is derived from the LEITAP model.
Model: LEITAP (modified version of GTAP: Global Trade Analyses Project, WWW.GTAP.ORG) read more about GTAP/LEITAP
Data: GTAP version 6.2
(http://www.gtap.agecon.purdue.edu/databases/v6/default.asp)

6.4.2 People: Self-sufficiency.

The general tendency is that the self-sufficiency of some CAP commodities (sugar, beef and to a lesser extent dairy) declines for the EU15 and the selfsufficiency of Non-CAP products (horticulture, pork and poultry) increases. This is most profound in the liberalisation scenarios. Grains are exceptional within the CAP commodites because its self-sufficiency increases in all scenarios.

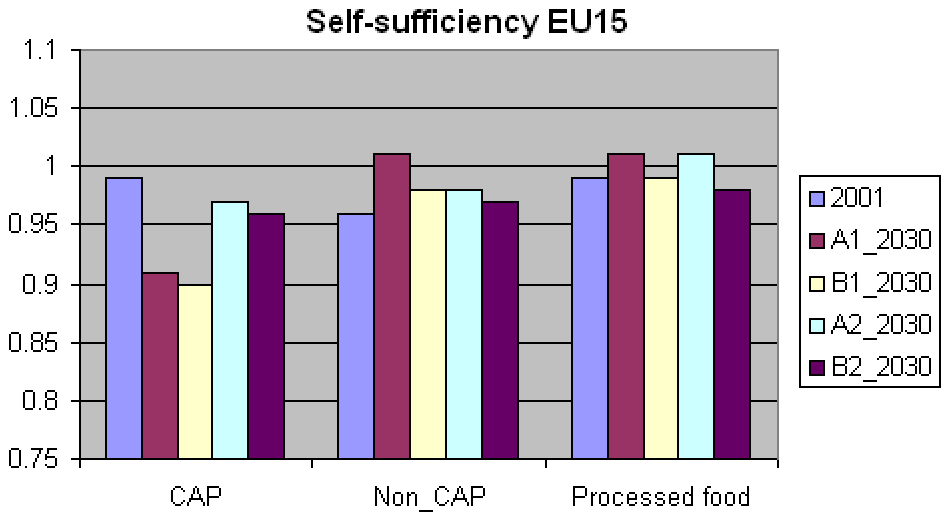


Figure 6.19 Self-suffiency EU15

Self-sufficiency of CAP commodities increases especially in non-liberalisation scenarios. Accession to the larger market of the European Union (trade creation) and the existing CAP facilities increases production and self-sufficiency in the EU10. This is most pronounced in the Regional communities (B2)scenario where the EU25 market does not integrate further with the rest of the world. In the Continental market (A2) the impact of the preferential access of the EU10 to the EU15 declines because the US and Canada get the same preferential access. Another aspect is the lower economic growth in the EU10 in this scenario that implies also a smaller increase in demand.

The Global economy or A1 scenario leads to a lower self-sufficiency of CAP, Non-CAP and processed food in 2030 relative to 2001. The high income growth stimulates demand for food.

In general the self-sufficiency of food in the EU10 is inversely related to the general economic growth. The main explanation is that the differences in income growth between the scenarios lead to substantial changes in the demand for food while supply is more inelastic due to smaller differences in productivity between scenarios.

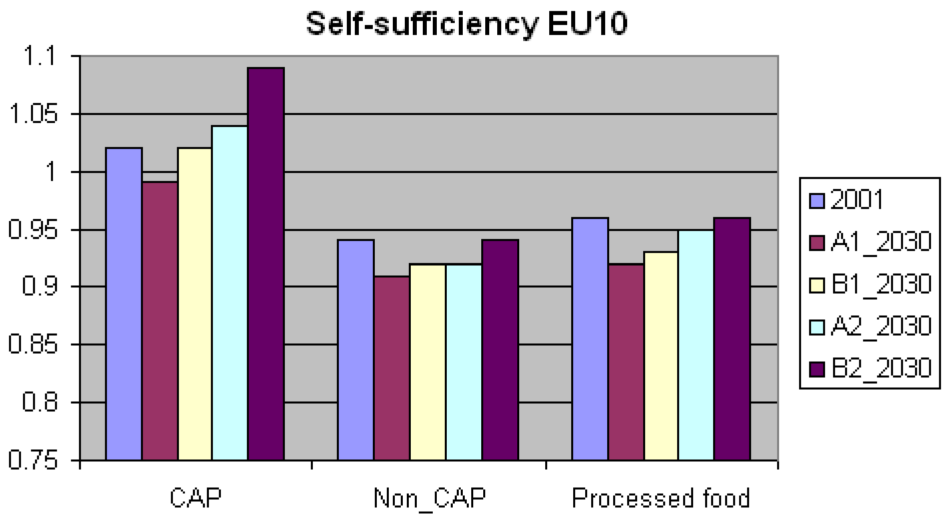


Figure 6.20 self-suffiency EU15

6.4.2.1 Source

The information on developments of self-suffiency in future is derived from the LEITAP model.
Model: LEITAP (modified version of GTAP: Global Trade Analyses Project, WWW.GTAP.ORG) read more about GTAP/LEITAP
Data: GTAP version 6.2
(http://www.gtap.agecon.purdue.edu/databases/v6/default.asp)

6.4.3 People: Animal Disease

6.4.3.1 Introduction

In the year 2000, the risk of spread of CSF (Classical Swine Fever)and AI (Avian Influenza) was high in most of the regions of Austria and the majority of the Mediterranean countries, i.e. Italy, Greece, Spain and Portugal. The Netherlands had also some regions with high risk for CSF. The risk of spread of FMD ranged from medium to high for most of the European countries. Only some regions in Spain, France and Germany had a low risk.

From 1995 until 2000, a decrease in the risk of the three diseases was the general trend in EU15. This decline was mainly caused by a strong decrease in number of livestock holdings in most of the areas. There were some exceptions in Italy (e.g. Toscana, Emilia-Romagna) and Portugal (Algarve), where the number of poultry holdings increased. There were hardly changes in the land use area for arable land and permanent grassland.

6.4.3.2 Future risk of spread of contagious animal diseases in livestock

Within the framework of the EURURALIS project, it was not possible to estimate quantitatively the future risk of spread of contagious animal diseases in livestock in a scientifically sounded way. The current knowledge and available scale of the data sets at European level (EU25) do not allow to link in a quantitative way the output of the models (GTAP, IMAGE and CLUE) and the 4 scenario's on international trade, development and cooperation with the risk of spread. Therefore a qualitative approach was made, identifying the key factors determining changes in the spreading of livestock epidemics. Consequently, links between these factors and the outputs of models were established in order to estimate changes in risk depending on the EURURALIS scenarios. Figure 6.21 shows the former links in a flow diagram, and could serve as a conceptual basis for future research aiming at obtaining more quantitative insight into these matters.

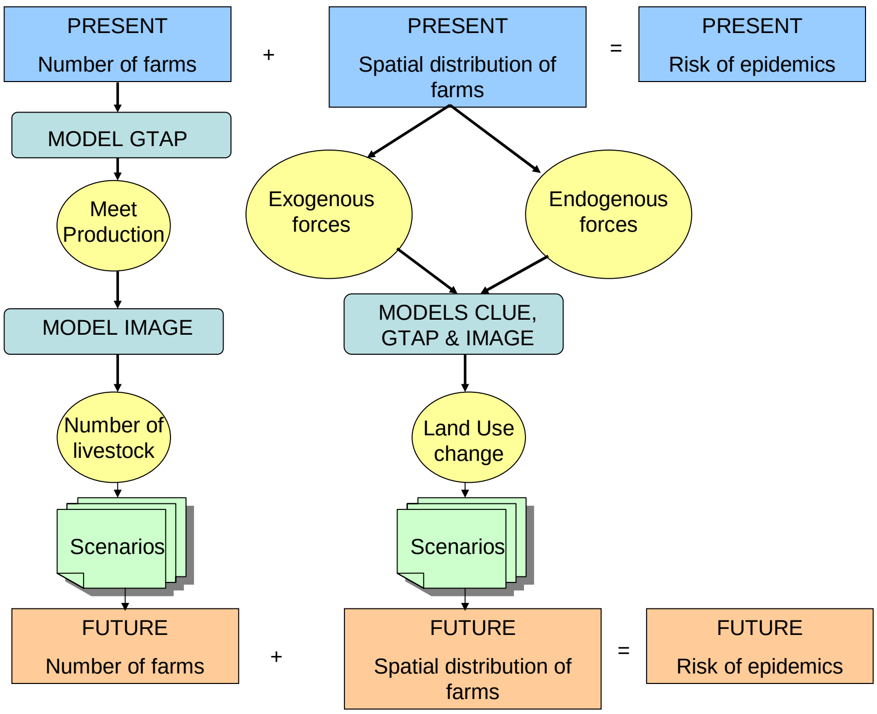


Figure 6.21 Qualitative links between main risk factors, models and scenarios in order to predict future risk of dispersal of contagious animal diseases in livestock.

Once the first infected farm of an epidemic of FMD, CSF or AI has been detected, and subsequently intervention measures have been introduced to stop further spread between farms, the remaining spreading potential is determined to a large extent by the density of farms (number of farms/km2). The density of farms depends on the number of farms and their spatial distribution, which are the input variables in the flow diagram (Figure 6.21). Figure 6.22 shows the difference between the density of farms in a region and the density of neighbouring farms, which determines the local risk of spread.

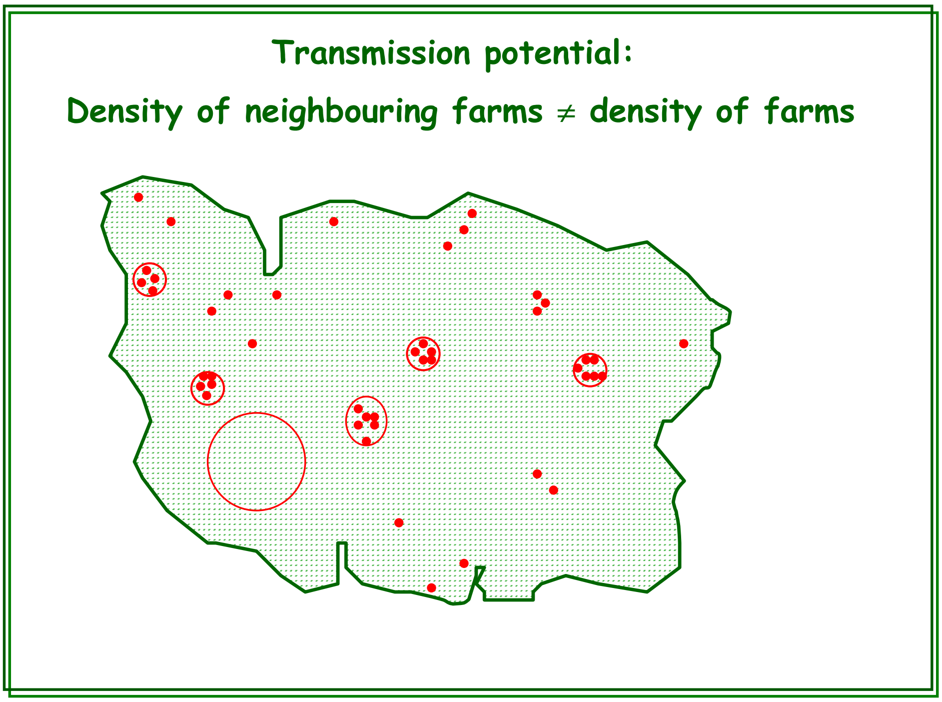


Figure 6.22: Density of neighbouring farms within a region differs from the density of farms in that region.

Future changes in number of farms will depend on changes in meat production, which in turn will result in changes in the number of livestock. Changes in the spatial distribution of farms are influenced by exogenous and endogenous forces, partially estimated by the models CLUE, GTAP and IMAGE, which result in changes in land use, that in turn causes changes in the density of farms in different regions. Endogenous forces are the pressures caused by the variation in the number of farms in the existing cluster, leading to areas with higher density or causing movement of farms to other areas. These forces are independent of the scenarios, e.g. economy of scale and regional facilities. Exogenous forces are agricultural and environmental policy, public opinion and farmer behaviour, and they depend on the scenarios. Table 6.5 shows the qualitative influence of the scenarios on the exogenous forces, assuming that (i) the importance level of the exogenous forces opposing clustering of farms do not depend on the endogenous forces, and (ii) exogenous forces are weighed different depending on the endogenous forces. We consider the four EURURALIS scenario's (A!, A2, B1 and B2) and estimate qualitatively their effect on the exogenous forces.

Table 6.5 :Qualitative influence of EURURALIS scenarios on the exogenous forces causing changes in the spatial distribution of farms.

Scenario	Public opinion	Environmental policy	Farmer behavior
A1	++(+) (1)	+ (2)	+++ (3)
A2	+ (4)	+ (5)	++ (6)
B1	++ (7)	++ (8)	++ (9)
B2	+++ (10)	+++ (11)	+ (12)

The three exogenous forces considered are:

- Public opinion: the arguments are most valid for intensive livestock holdings; much less for land dependent livestock (cattle, sheep and goats)
- Environmental policy: environmental legislation opposing clustering (e.g. regarding ammonia emissions, smells, possibilities for manure disposal etc.)
- Farmer behaviour: risk of the consequences of outbreaks as perceived by the farmer.

This depends on concerns regarding liability and the willingness of public authorities to bear (part of) the (financial) consequences.

The explanation of the estimation of risks is as follows:

1. Because of 'claim culture' there is much resistance from citizens against clustering of livestock holdings. Citizens do not want to live next-door to pig- or poultry holders. They could claim financial compensation for happiness foregone or the declined value of their real estate. These arguments would be strongest in areas with a high proportion of people working in services or industries, which are not related to agriculture (i.e. densely populated regions and rural areas near urban centres), as well as in remoter areas with many tourists, second houses, retired people migrated from urban centres etc.
2. In this scenario free markets (i.e. international competition) and focus on private responsibilities prevent the accomplishment of stringent environmental legislation.
3. High risks perceived by farmers. No government support for farmers means that they would have to seek private insurance. If not, they would have to cope with the financial consequences. In case of negligence they could even be hold responsible for damage or income foregone by colleagues and other sectors (e.g. tourist sector).
4. In this scenario, intensive livestock holding is seen more as an economic pillar, sustaining jobs in rural areas than as a burden for society.
5. In this scenario, any measures implying increased costs to producers encounter strong opposition. Free markets within EU and prevailing national interests prevent effective legislation at EU level.
6. Farmers assume that risks are lower than in A1, due to protected market. Besides somewhat more government support for farmers in case of animal disease outbreak than in A1. Farmers are aware that if this happens they are considered victims rather than culprits.
7. Same arguments as B2 and elements of A1, but somewhat less pronounced.

8. In this scenario, environmental legislation is somewhat less stringent than in B2, because it is much more the result of international agreements. Due to free international markets and less funds available for farm support and agri-environment programmes than in B2, legislators would encounter stronger opposition from farmers against stringent rules.
9. More government support in case of outbreak + more faith in stringent international legislation on sanitary measures to prevent outbreaks than in A1 and A2.
10. In this scenario public resistance is more based on moral ground, i.e. the feeling that intensive animal husbandry is ethically wrong. The higher the density, the more people are confronted with this feeling. Besides, the public is well aware of the risk of spread of diseases in regions with a high density of livestock holdings and the traumatic consequences of culling.
11. Political and societal conditions are favourable for stringent legislation. Stringent national and EU-legislation can be afforded thanks to protected markets and consumer preference for locally produced food.
12. Same arguments as A2, but even more pronounced.

The recent Classic Swine Fever and Avian Influenza epidemics in The Netherlands, showed that in areas of high farm density, the remaining local transmission that occurs in the presence of movement standstills, bio-security measures and culling of infected farms can be self-sustaining. In this situation, additional culling (and/or vaccination) is necessary to achieve epidemic control.

Conclusively, there are many factors which can affect the outcomes from the scenario's, e.g. production levels, consumption levels and patterns (number of people, diet), consumer concerns regarding farm management and transport of animals, and regulation measures by authorities concerning spatial distribution of farms, (e.g. scale enlargement of farms, spatial concentration of production chain. On one hand, the A scenarios, rooted in free market thinking and lower levels of intervention by governments combined with less conscious consumers, may increase risks of spread more than B scenarios. On the other hand, the A scenario's may stimulate a strong modernization of the sector, which could result in better control of diseases by (i) improvement of the hygienic control and (ii) scale enlargement of farms which in turn may result in larger distances between farms, i.e. overcome critical densities ..

Vaccination to prevent further spread of the disease between farms is considered to be an issue independent of the scenarios.

As said it was not possible to quantitatively estimate the future risk for animal diseases, but in a qualitative way it is possible to make a few statements about the future risk. Future changes in number of farms will depend on changes in meat production, which in turn will result in changes in the number of livestock. Changes in the spatial distribution of farms are influenced by exogenous and endogenous forces, which result in changes in land use, that in turn causes changes in the density of farms in different regions. Exogenous forces are agricultural and environmental policy, public opinion and farmer behaviour. Endogenous forces are the pressures caused by the variation in the number of farms in the existing cluster, leading to areas with higher density or causing movement of farms to other areas. These forces are independent of the scenarios and include phenomena that favour clustering such as economy of scale and location assets in the form of regional facilities.

The recent Classic Swine Fever and Avian Influenza epidemics in The Netherlands, showed that in areas of high farm density, the remaining local transmission that occurs in the presence of movement standstills, bio-security measures and culling of infected farms can be self-sustaining. In this situation, additional culling (and/or vaccination) is necessary to achieve epidemic control.

6.4.4 Planet: Nitrogen emission and deposition

6.4.4.1 Introduction

Eutrophication and acidification and have been recognized as major environmental problems since the early 1970s. The main responsible compounds are nitrate and sometimes ammonium for ground and surface waters, whereas for emission to the air nitrogen oxides (NO_x) and ammonia (NH_3) are the most important forms. Sulphur dioxide (SO_2) is also a compound contributing to acidification.

In agriculture artificial fertilisers and animal manure are often out of balance with crop demands. Surplus manure and artificial fertilizers cause major problems for human health and ecosystems by polluting ground- and surface waters and by their eutrophication effects on biodiversity.

Concerning the past, the emission of nitrogen is covered. Concerning the future, only the emission of nitrogen to the air is quantified. This includes both ammonia losses from agriculture as NOx-emissions from fuel combustion (traffic and power generation). These emissions are translated to nitrogen deposition, resulting in maps showing the exceedence of critical load values. A critical load is the maximum deposition of acidifying or eutrophying compounds that can be tolerated by the ecosystem without damaging effects. The critical load is dependent on the soil type, the ecosystem involved and the climate.

6.4.4.2 Future

Based on a European critical load dataset, covering 5.7 million square kilometer of ecosystems, from the UNECE Coordination Center for Effects (e.g. Posch et al; 2001) and nitrogen depositions derived from the EMEP model the average exceedance of the nutrient N critical load (eq ha^{-1} yr^{-1}) for ecosystems in a 50x50 km grid has been calculated. On average, the critical load for nitrogen is estimated at 800 mol N ha^{-1} yr^{-1}).

In 2000, 66% of the ecosystems in the EU25 were not protected against eutrophication with an average exceedance of 230 eq ha^{-1} yr^{-1} (Table x.x). In 2030 the percentage unprotected area decreases in the A scenarios for the EU25 to 62-65%, with an average exceedance in 2030 of 220-250 eq ha^{-1} yr^{-1}. In central Europe (EU10) the area unprotected ecosystems increases in the A-scenarios from 72% to 81-91% with an average exceedance of 400-460 eq ha^{-1} yr^{-1}.

In the B-scenarios the percentage unprotected area decreases for the EU25 from 66% 36-41% with an average exceedance in 2030 of 80-100 eq ha^{-1} yr^{-1}). For central Europe the unprotected area decreases in the B-scenarios from 72% to 58-62% with an average exceedance of 170-200 eq ha^{-1} yr^{-1}.

Compared to 2000 the NO_x emissions in 2030 will decrease in the EU-15 (-17 to -22% and -52 to -65% for the A and B scenarios respectively) and show a mixed pattern for central Europe (+13-14% and -10 to -11% respectively). The ammonia emissions show less changes, for the A-scenarios (B-scenarios) +5-8% (-10-11%) for the EU-15 and +13-14% (0-7%) for central Europe.

Table 6.6 : Eutrophication, unprotected ecosystems (%) and average exceedance (AAE, in eq ha^{-1} yr^{-1})

Region	**2000**		**2030 A-scenarios**		**2040 B-scenarios**	
	%	AAE eq/ha^{-1} yr^{-1}	%	AAE	%	AAE eq $ha^{-1}yr^{-1}$
Europe	27	67	28-32	70-80	15-18	25-30
EU-25	66	230	62-65	220-250	36-41	80-100
EU10	72	250	81-91	400-460	58-62	170-200

6.4.4.3 Source

Information on pollution developments in future is derived from IMAGE model results

6.4.5 Planet: Soil degradation and salinisation

6.4.5.1 Introduction

About 17% of the total land area in Europe is to some agree affected by erosion.

Soil erosion in Europe is mainly due to water (about 92% of area affected), and not to wind. In EU25, land degradation is most serious in central Europe and the Mediterranean region, where 50-70 % of agricultural land is at moderate to high risk of erosion. The problem mainly occurs in agricultural land, especially where ploughing is intensive, and where the soil remains uncovered by vegetation all year round.

Soil erosion also has a major economic impact, with on-site losses estimated at 53 euros per hectare per year, and off-site losses (e.g. damage to infrastructure) at around 32 euros per hectare per year.

Salinization due to semi-arid climates, poor irrigation practices and the occurrence of saline soils has affected regions in the Mediterranean and Eastern Europe.

Some countries in susceptible areas have been affected by salinization due to adverse condition: a precipitation deficit, initially saline soil conditions, inappropriate irrigation techniques and locally seepage of salt water (salt water intrusion). In the Mediterranean some 25 % of irrigated cropland has been affected. Spain has 0.6% of the land area affected in a moderate or high degree; Hungary about 4 %, varying from light, moderate to a high degree.

6.4.5.2 Future

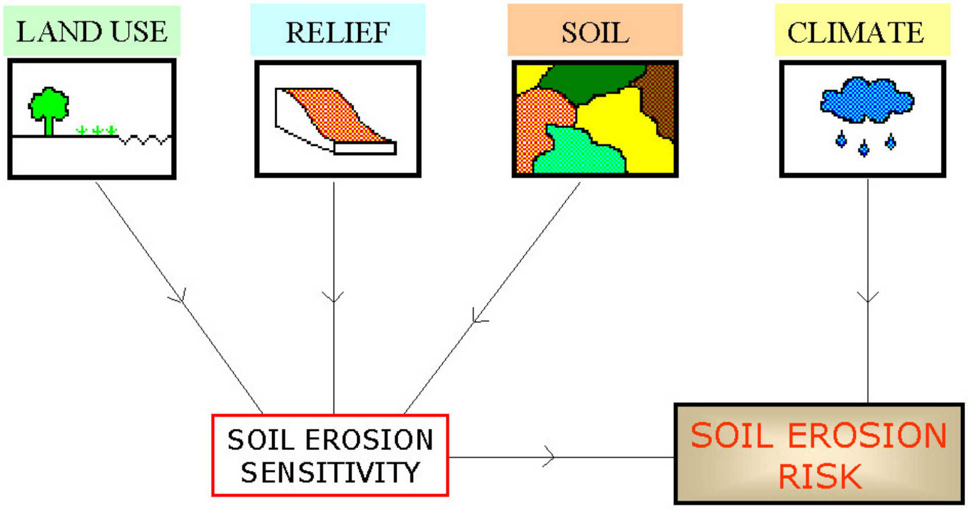
In general, soil degradation decreases for all scenarios, but there are differences. Most profit is in Southern Europe, where the current unfavourable situation improves most. In Central Europe there is a bad situation as well, but shows only a minor improvement (improving with same sequence in scenarios). This causes that differences are less pronouced in the EU10 countries in comparison with the EU25.
For salinisation, the general trend is that the risk in 2000 is highest in the Mediterranean area, small in Eastern Europe and no risk in Northern and Western Europe. Along the shore, there are some areas potentially in risks due to seawater intrusion (e.g. western part of the Netherlands) and a small area in Hungary, France and Spain is potentially in risk due to saline soil types. The difference in salinisation risk between north and south Europe is increasing for the 2010, 2020 and 2030 scenarios. This is totally due to the foreseen climate change. The northern part is getting wetter, whereas the southern part is getting drier. Differences between scenarios within one year are minor.

In general, soil degradation decreases for all scenarios, but there are regional differences in amount of decrease. The difference in salinisation risk between north and south Europe is increasing for the 2010, 2020 and 2030 scenarios. Differences between scenarios within one year are minor.

6.4.5.3 Method

In order to create maps of the 25 member states of the EU, showing the risk of soil degradation and salinisation for scenarios that differ with respect to land use and climate, the following approach has been followed.

Since soil erosion is a complex process, many simplifying assumptions are needed to produce a map of erosion risk for Europe in a short time period. The most obvious is that at this scale it is not possible to take much process knowledge into account; methods need to be quite simple.



- The model runs only on processing cells. Processing cells are those that have a value in all of the database input layers.

Figure 6.23. Concept of INRA method

The most recent methods that have been developed are the INRA and PESERA methods. Because of the limited time available, and because of copyrights issues surrounding PESERA, it was decided to use the INRA method. The INRA method is based on a decision tree, which uses 4 input maps: slope, land use, soil and climate. It was first applied to France (Le Bissonnais et al., 2001), and afterwards also to Europe. Figure 6.23 shows the concept of the INRA method.

The decision tree is included as Annex X. This decision tree was slightly adapted as the CLUE land use maps have somewhat different units than the INRA land use map.

Neither INRA nor PESERA simulate salinisation risk. Nor were data about it available at JRC. Therefore, a very simple method was developed that assumed that salinisation risk consists of 3 parts: elevation (below sea level), soil type (salt containing soils), the balance between precipitation and evaporation (evaporation more than 10% larger than precipitation). If none of these 3 factors are present, salinisation risk is assumed to be absent, if one is present, it is assumed moderate and if 2 or 3 are present it is assumed high.

The land use maps provided by CLUE were used as input for the scenario simulations. Climate scenarios were provided by IMAGE. The other input data for the INRA method was assumed not to be changing, therefore existing slope map and soil map were used. All these data are in raster format, so that no vector-raster conversions are needed. The analysis is done for all of EU25.

The results are presented in maps, giving the soil erosion risk in 5 ordinal classes and the salinisation risk in 3 classes.The results are at 1x1 km pixel scale. It should be realised that the DEM that is used also has 1-km resolution, and can therefore not be expected to give very accurate slope angles. For the other input maps (like soil and land use) each pixel will be assigned a single value, which is a generalisation of reality.

6.4.6 Planet: Biodiversity nature

6.4.6.1 Introduction

Biodiversity refers to the variability among living organisms from all sources and the ecological complexes of which they are part. This includes diversity within species (genetic diversity), between species and of ecosystems. Over the last centuries, biodiversity in Europe declined due to agricultural expansion and intensification, urban and infrastructure sprawl and other causes such as pollution and disturbance. Especially the last 50-70 years the biodiversity seriously declined.

Biodiversity can be expressed as percentage of biodiversity in a pristine reference situation, untouched by humans in sufficiently large areas. We distinguished biodiversity in nature sensu stricto (forest, natural grasslands, wetlands and comparable natural areas and in agricultural areas). In nature sensu stricto major impacts are related to climate change, fragmentation by roads, nitrogen deposition and disturbance.

6.4.6.2 Future

The overall sum effect for biodiversity in Europe in natural areas in all scenarios is negative, more notably in Central and eastern Europe. Some countries will experience a minor increase in biodiversity.

The main results concerning biodiversity in the four scenarios are:

- Decline of alpine ecosystems. Rare alpine species are predicted to be replaced by wide-spread species. Local biodiversity may seem to increase, but this is caused by an increase in common species overcompensating the loss of rare species.
- Land abandonment and urbanization lead to changes in area of nature. Overall effect is more area for nature in 2030 in scenarios B1> B2 > A1 compared to the situation in 2000. There is less nature in A2.
- More nature but lower average biodiversity. Increase in population pressure, urbanization, and traffic intensity, especially in A1 scenario, lead to local decrease in biodiversity in densely populated areas. Despite of more area for nature in scenarios B1, B2 and A1, average biodiversity is predicted to drop in most countries in all scenarios in 2030 compared to the situation in 2000. Average biodiversity in natural areas is predicted to increase only in Germany, only B1 scenario, Estonia, only B2 scenario, Latvia, A2, B1 and B2

scenarios, Malta, only A1 scenario. The largest declines are expected in especially central and eastern European countries, most in A1 scenario. The ranking of scenarios differs per country. See figure.
- Most nature areas have a biodiversity value between 30 and 60%. The current situation (2000) is less represented in the 0-30% biodiversity class, and more in the 61-100% class. Especially the A1 scenario, but also the other scenarios for 2030 show an overrepresentation of low biodiversity values (<50%). Average biodiversity values for natural areas are 48.4 (2000), 45.8 (A1), 46.0 (A2), 46.5 (B1), and 46.2 (B2).

6.4.6.3 Method

In order to quantify the effects of climate change and land use change scenarios on biodiversity, two methods were combined. First, the LARCH approach developed at Alterra (Opdam et al., 2003; Verboom et al. 2001; etc.) and simplified for the PEEN project (2002) is used for assessing the effect of area, taking into account fragmentation by roads. Second, the GLOBIO approach developed at RIVM and others is used to account for other factors, i.e. nitrogen deposition and disturbance. For agricultural land-use types, only the GLOBIO approach is used because area effects are not expected to be a limiting factor for biodiversity.

The core of the area-based assessment is the equation based on Thomas et al. 2004, assuming that in a natural area of 10.000 km^2 biodiversity is maximal:

Biodversity = 50+(area-1)**0.25 if the area < 10000 km^2.

The core of the GLOBIO assessment is the equation:
B = X * Y * Z

where X, Y and Z are facors between 0 and 100%. In the current aplication, X can be interpreted as area-based biodiversity, Y as nitrogen deposition, and Z as disturbance by infrastructure. More globally, these two factors stand for high human pressure in the surroundings.

Note that the biodiversity-in-nature algorithm under-estimates biodiversity for a number of reasons:
- Fragmentation by roads does not take into account the fact that animals will occasionally successfully cross these roads. Nature patches on both sides of the road are handled as if in complete isolation, i.e. the populations in the patches are regarded as isolated from each other. All (major) roads are treated the same way, regardless of traffic intensity. These simplification leads to an under-estimate of biodiversity.
- The biodiversity algorithm takes into account populations, but not metapopulations. Thus, patches below the size for a minimum viable population (MVP) get the assessment 'not viable' for larger species, which

decreases their biodiversity. In reality, patch populations can form metapopulations and biodiversity can be higher.

- Disturbance due to traffic intensity data are on the scale of 50 x 50 km cells, thus roads have an impact at larger distances than desirable.
- While disturbance is known to mainly affect fauna, and nitrogen deposition mainly flora, both factors affect total biodiversity in the algorithm, which leads to an under-estimation

Input is based on data from CLUE, EnZ output (on climate change), NEA-road data base, traffic intensity, land-use intensity, and nitrogen deposition.. Land-use intensity can only be taken into account at the national (or NUTS2l) level. Nitrogen deposition has a c. 50x50 km resolution.

There are many sources of uncertainty: the scenarios themselves, the fact that the CLUE output classes are rather course and the resolution of 1 km squares with dominant land-use is rather coarse too for determining biodiversity. Dissecting nature areas into environmental zones might be a bit artificial, adding some fragmentation effect. All the other input data have uncertainties and scale problems too, the biggest problem being the fact that agricultural land use intensity is unknown at the pixel level. This will lead to an under-estimation of biodiversity on localities where agriculture will have low intensity and over-estimation at high intensity locations. Last, the algorithms are based upon certain simplifying assumptions such as that 10.000 km2 nature has a biodiversity of 100%. If the results will be used in a relative way, to highlight differences between scenarios rather than absolute interpretation ('the biodiversity of spot x in year y under scenario z') there will be no great problem with accuracy.

The applied method will give a reasonable assessment of biodiversity for the climate change/land-use change scenarios, but will fail to deal with the change of low intensity agriculture (e.g. North-East Poland) into either high intensity agriculture or land abandonment. Low intensity agriculture is associated with high biodiversity which will drop either way, both by intensification and by land abandonment. As there will be no spatially explicit data about land-use intensity, this process will not be correctly described by the indicators, since land abandonment will lead to a rise in biodiversity – as nature areas become larger, instead of a drop.

6.4.7 Planet: Biodiversity agriculture

6.4.7.1 Introduction

This chapter assesses the current state and future change in wild species in agro-ecosystems in de EU-25. The state of biodiversity is expressed as ecosystem quality. Ecosystem quality is defined here as *the average abundance of a core set of wild species living in agricultural ecosystems, as a percentage of the original natural ecosystem*. The deviation from the original state may result from various anthropogenetic factors such as conversion into agriculture, exploitation, eutrophication, water management, pollution, climate change, fragmentation and introduced species (Ten Brink, 2000; Ten Brink et al., 2002). This indicator is derived from the indicator selected under the Convention of Biological Diversity (UNEP, 2004). It should be stressed that the ecosystem quality figures in this document are not directly measured from field monitoring (as it should, but a regular monitoringsystem is still lacking) but are proxies, derived from the pressures on agro-ecosystems[11].. Next to the current state projections are made for the year 2030 for 4 scenarios.

- Biodiversity in agro-ecosystems depends on production intensity
- Production intensity is unevenly distributed in EU25
- Average ecosystem quality in arable production systems is 10% and 26% in grazing area (add two maps for 25 countries)
- Production intensity did not change from 1990-2000 in EU15
- Scenarios for 2030 showed divergent impact on biodiversity in the agricultural landscape
- Conversion to organic farming can mitigate negative effect of intensification
- Small increases of ecosystem quality in agro-ecosystems have significant impact on their appearance and landscape beauty.

6.4.7.2 Future

In arable farming the impact on biodiversity is the highest in the scenario A1, with in the middle A2 and B1, and lowest in B2. A1 results for many countries in half of remaining ecosystem quality in cropland compared to B2 scenario in 2030. Differences between countries are considerable, depending from the production intensity in 2000 (see tables). In all scenarios ecosystem quality in arable land decreased between 2000 and 2030, because of intensification of production and accompanying higher yields, except for 9 countries in the B2 scenario.

For grazing systems, differences between scenarios are relatively smaller, but in absolute terms more biodiversity is left compared to arable land. Biodiversity gain by 2030 is expected in most countries in the B2 scenario, except the Czech Republic, Slovenia and Slovakia in Eastern Europe. The A1 scenario resulted in biodiversity loss in all countries.

Organic farming
Land use conversion into organic farming showed a differentiation between scenarios. Because it is expected that organic conversion will be highest in the B2 scenario, positive impact will be highest also. In absolute terms the increment is on average for the EU25: maximum 2% ecosystem quality gain in 30 years. The positive effect from organic farming was nullified by the negative effect of intensification in the A1 and A2 scenarios.

[11] Pressure-quality relationships are established for various pressures

Small increases of ecosystem quality in agro-ecosystems have great impact on landscape appearance
Wild species diversity is generally low in intensive agricultural landscapes. If the average production intensity will not change so much, biodiversity in absolute terms of ecosystem quality will not change too. One would possibly conclude that the overall comparison between scenarios is a grey mass of more of the same, rather than significant differences. However, the translation in terms of wild species, the gap between 5-10% on the one hand and 20-25% ecosystem quality on the other makes the difference in grassland from a "uniform green baize" into a flower bouquet. It is also the difference of mono-cropping and production specialisation in a uniform landscape in comparison to the highly diversified production systems before the "green revolution" of the 1850 pre-industrial era.

Agricultural landscapes are designed to maintain the provision of specific ecosystem services and traditional agricultural landscapes. Semi natural grasslands are highly valued also from biodiversity and landscape reasons. An increase of the overall agro-biodiversity of –for example- around 5% by 2030 will not be reached in each of the four scenarios under study, on the contrary. For such a goal additional policy measures would be needed that slow down and invert the increasing production intensity, that promote organic farming and that guide strictly the process of land use change.

6.4.7.3 Method

The remaining wild species biodiversity in agricultural landscapes depends highly on the intensity of the production system (Wilson et al 2003; Hoffmann et al. 2001; Zechmaister and Moser 2001 in Haberl et al 2003). Intensity of the production can be calculated based on:

- the input (technology investments) for production: applications of external inputs (fertilisers and pesticides), Livestock Units per ha., long-term water and soil improvements, or
- the output (productivity) of crops and grassland (Haberl et al 2003).

The production intensity maps 2000 for crop and grassland area per country (EU25) are calculated based on input (differences on production technology – investments) and scenario calculations were carried out with estimation of output (expected changes on the productivity by the IMAGE model).

The Farm Accountancy Data Network (FADN) for EU15 and data from FAO, IFOAM and Eurostat for the New Ten EU countries (except Cyprus) were used to estimate production intensity for cropland and grassland in the year 2000. We recommend to calculate production intensity in the New Ten countries based on sub-national farming account data rather than on National statistics.

Future impact on biodiversity in the four scenarios was assessed based on three complementary pathways of analysis:

1. different scenario story lines with divergence in estimates based on 30-year changes in productivity of agricultural – grassland production;
2. Land use change per production system (analysis on the conversions; in-out analysis) and;
3. different estimations of expected rates of conversion into organic farming or other types of sustainable farming per scenario

6.4.8 Planet: Carbon sequestration

6.4.8.1 Introduction

Forests are young in Europe, meaning they are in a stage of fast sequestration. This has occurred since 1900, and will most likely continue until at least 2050. The history of European forests is very important to understand any historic, present and future carbon balance of the total system (see paragraph 5.2.6).

6.4.8.2 Future

The objective is to assess the carbon sequestration regimes under the land use change scenarios as derived with CLUE model.CLUE provides the following land use categories : abandoned, forest, cropland, grassland. For each of these carbon sink/source estimates per country are derived from literature, we assume that when land use changes, the emission factor changes immediately as well. Furthermore:

- static calculation of emission factor * area per time step
- assumed that the emission factors do not change over time (i.e. no saturation)
- only for the land use change of 'deforestation' the loss of stock was calculated. It was assumed that 80% of the biomass will be lost
- for all other land use changes no carbon stock loss was assumed (e.g. conversion between grassland and arable land)

Besides the CLUE model, EFISCEN (European forst resource model) has been used. The emission factors are derived from literature.

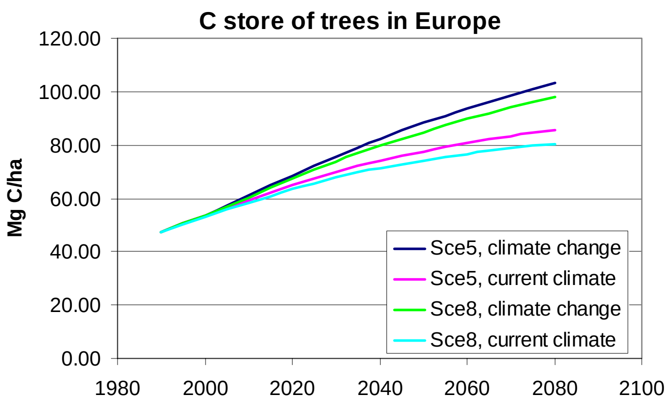


Figure 6.24: C store of trees in Europe

Forests are young in Europe, they are in a stage of fast sequestration,. This has occurred since 1900, and will most likely continue until at least 2050 .

6.4.8.3 Accuracy

Rather large assumptions are made on immediate change of emission factor when land use changes. These responses take years to decades in reality.

6.4.8.4 Results

Land use changes insofar re;lated to the abandonment of agricultural area and its conversion into forest result in an additional net sequestration of 24 Million tonnes carbon per year. The highest scores are for B1 and B2 scenarios, lower scores for A1 and A2 The contribution in reaching Kyoto targets (reduction of 108 M tonnes for Europe) is limited to some 10%.

The most important contribution in forests can be expected in Central and Eastern European countries, where growth conditions are good and fellings are modest.

For the net change in forest area: both the B1 and the B2 scenarios result in a net increase of forest area of respectively 14 million and almost 11 million ha in total by 2030 (Figure 6.25). The A1 scenario initially leads to a small loss of forest, and then a sharp increase in the period 2010-2020. In total the A1 shows a net forest area increase of 6.7 million ha. The A2 leads to deforestation until 2020 of in total more than 5 million ha. In the last period, some recovery of forest area occurs, but this is less than 0.8 million ha. Compared to the existing forest area of 164 million ha initially, these changes are small.

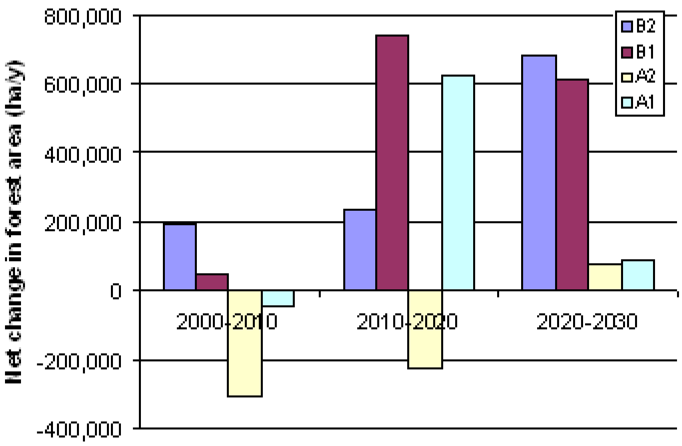


Figure 6.25: Net change in forest area in EU25

A1 and A2 scenarios differ strongly partly because of very different forestation trends. Around 2010, the difference is the largest with some 20 million tonnes C/y. This shows that policies do have a large impact on land use and its related greenhouse gas balance In view of Kyoto commitment of a total required reduction of around 108 million tonnes C scenarios differ significantly. Taking into account what formally can be considered as an extra contribution to the Kyoto goals forest expansion could contribute some 24 tonnes or (because of the CAP on eligibility under Kyoto) some 10 % of the commitment. Generally the largest part of this contribution can be found in Central and Eastern European countries where growing conditions are favourable and fellings are modest. It has to be stressed that other land use and changes in land management could reduce greenhouse gas emissions considerably, in cropland (fertilizers) and especially in animal husbandry.

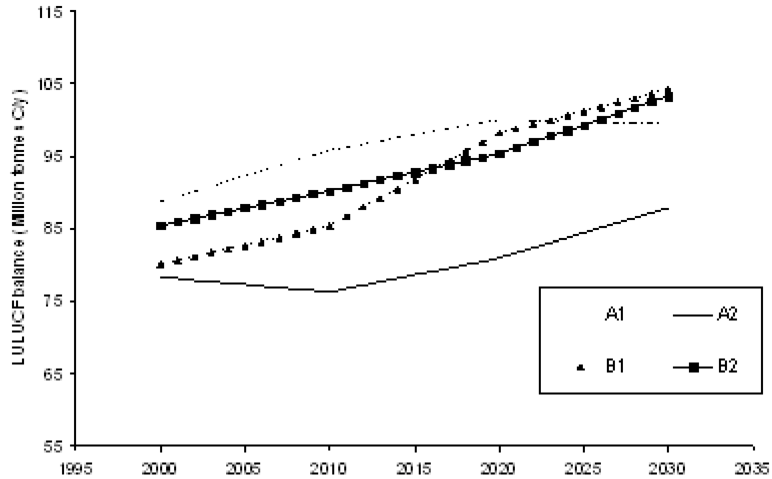


Figure 6.26 Balance for land use, land use change and forestry 2000-2030 for four scenario's

6.4.8.5 Method

The objective was to assess the carbon sequestration regimes under the land use change scenarios as derived with CLUE model. The following assumptions are made:

- We use land use change scenarios as provided by CLUE
- CLUE uses land use categories : abandoned, forest, cropland, grassland. For each of these carbon sink/source estimates per country are derived from literature, we assume that when land use changes, the emission factor changes immediately as well.
- Rather large assumptions are made on immediate change of emission factor when land use changes. These responses take years to decades in reality.
  - static calculation of emission factor * area per time step
  - assumed that the emission factors do not change over time (i.e. no saturation)
  - only for the land use change of 'deforestation' the loss of stock was calculated. It was assumed that 80% of the biomass will be lost
  - for all other land use changes no carbon stock loss was assumed (e.g. conversion between grassland and arable land)
  - literature (National scale emission factors (Janssens et al. in prep.))

6.4.9 Profit: Yield

6.4.9.1 Crop production

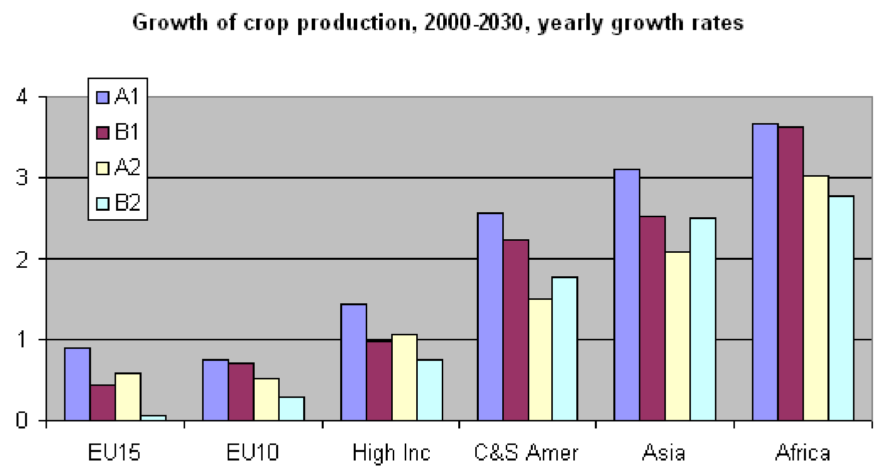


Figure 6.27: Growth of crop production

Crop production growth is low in the EU relative to other countries/continents. Lower economic growth in combination with a low income elasticity are important in this respect. In the Global scenarios (A1, B1) sugar production in the EU will decline substantially (see Figure above). In the B1 and B2 scenario's crop production is relatively low due to lower demographic and economic growth and less demand for fodder crops due to less meat consumption. These effects are higher for the EU15 than for the EU10.

6.4.9.2 Livestock production

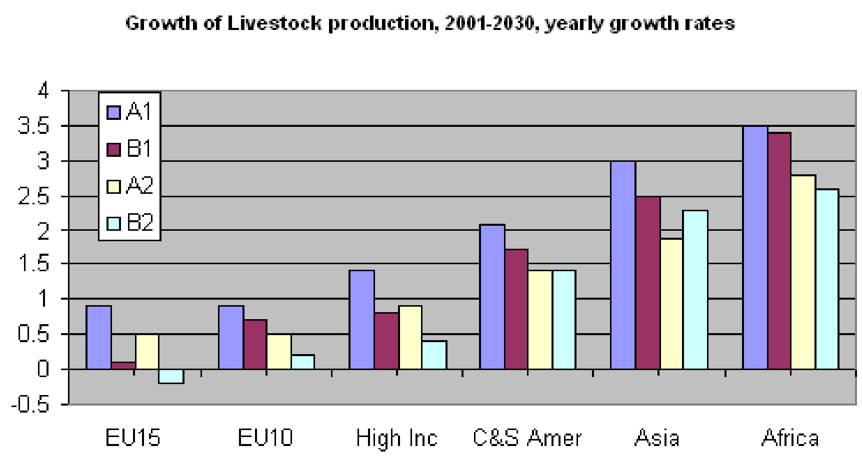


Figure 6.28: Growth of crop production

Livestock production growth is low in the EU relative to other countries.

Production growth in primary agriculture is lower than in processed food, industry and services. In this liberalization scenario (A1) sugar production declines strongly.

6.4.9.3 Yield and climate change

Climate change projections for 2030 resp 2050 assume higher CO2 concentrations .Pre-industrial concentrations were 280 ppm, currently 375 ppm, and are projected to reach between 449-485 (B2 resp .A1) in year 2050. Average temperature and precipitation are presented in maps illustrating future regional climatic patterns. Generally temperatures are higher, more notably in northern and northwestern regions where rainfall increases as well. Lower precipitation and higher evaporation will especially affect Mediterranean countries and central-eastern Europe. Climate dynamics seem to change, resulting in more extreme events (droughts, high intensity rainfall, flooding). All these factors potentially affect agriculture (choice of crops, potential yields, risks).

Generally the expectation is that yields will increase due to technology improvements, as has been demonstrated in past, most notably, since World War II (see past); in more favorable areas where growing conditions improve (higher CO2, length of growing season, water availability) a combined positive effect is to be expected. A northward shift of potential production areas enlarges possibilities considerably. In other areas drought stress will occur. It is, however, expected that adaptive strategies could compensate potential losses or hazards: careful planning of land use in favorable areas (irrigated areas with good soils and adapted management, introduction of appropriate crops and specific varieties (e.g. maize). In those areas very high yields could be expected. The outcome shows the overall positive development assuming that effective adaptive strategies were applied in case of less favorable conditions.

Climate change is undoubtedly accompanied by a change in weather dynamics: the occurrence of long-term, severe droughts, higher intensities of rainfall and related processes (erosion) causing higher risks for agricultural use. However, these changes can not yet be predicted with sufficient accuracy for making meaningful impact assessments and spatial differentiations. The ultimate impact of climatic changes on agricultural land use and yields will strongly depend on adaptive measures including effective land use planning, land management strategies and supportive policies. Therefore, it is difficult to predict the overall effects.

Most expert judgments agree that for Europe's agriculture in a changed future climate overall production will not be affected negatively. Adverse regional effects will be found in southern and central eastern countries. Effective land use planning and adequate management combined with technological advances are expected to enable the agricultural sector to cope with most of the climate-induced problems. Uncertainties relate to extreme events.

6.4.9.4 Source

The information on crop production and livestock production is derived from LEITAP model results.
LEITAP (modified version of GTAP: Global Trade Analyses Project, WWW.GTAP.ORG) read more about GTAP/LEITAP
Data: GTAP version 6.2
(http://www.gtap.agecon.purdue.edu/databases/v6/default.asp)
The information on yield and climate change is a review from literature and internet:

- EEA (European Environment Agency), 2004.
- Hafner, S., 2003. ;
- Harrison, P., Butterfield, 1999.
  IPCC – Intergovernmental Panel on Climate Change, 2001.
- Parry, M., 2000.
- Roetter, R., Van de Geijn, S., 1999.
- Wolf, J., Van Diepen, C.A., 1995.
- Source global temperature anomaly data :
  http://www.ukcip.org.uk/cc_how_global_change.shtml

6.4.10 Profit: Income (agriculture)

6.4.10.1 Future

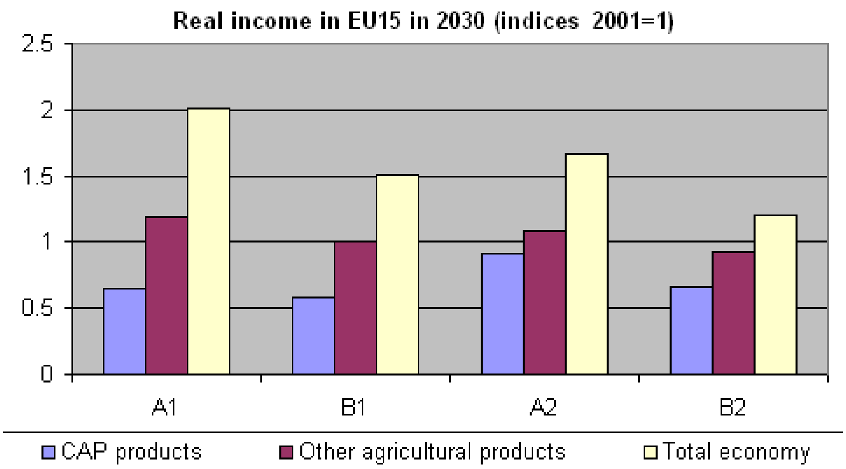


Figure 6.29: real income in EU15 in 2030

Market oriented scenario's (A1 and A2) lead to highest income growth for all sectors. The exception is the real income of Common Agricultural Policy (CAP) products in the A1 scenario where subsidies are abolished and markets are liberalised. Especially, the abolition of domestic support (area payments\animal premiums or decoupled payments) has profound negative impact. The real income of CAP commodities is about 50% in 2030 in the Global scenarios. The A2 scenario leads to the highest real income for CAP commodities because overall income growth is relatively high, domestic support is sustained, and markets are only partially liberalised (only accession and creation TransAtlantic market). Real income is more or less stable for other agricultural products while it increases in the whole economy. A large part of real income in other "less protected" sectors can be explained by overall income growth and the share of income consumers spend on a certain product.

6.4.10.2 Source

Model: LEITAP (modified version of GTAP: Global Trade Analyses Project, WWW.GTAP.ORG) read more about GTAP/LEITAP
Data: GTAP version 6.2
(http://www.gtap.agecon.purdue.edu/databases/v6/default.asp)

6.4.11 Profit: Expenses

6.4.11.1 Future

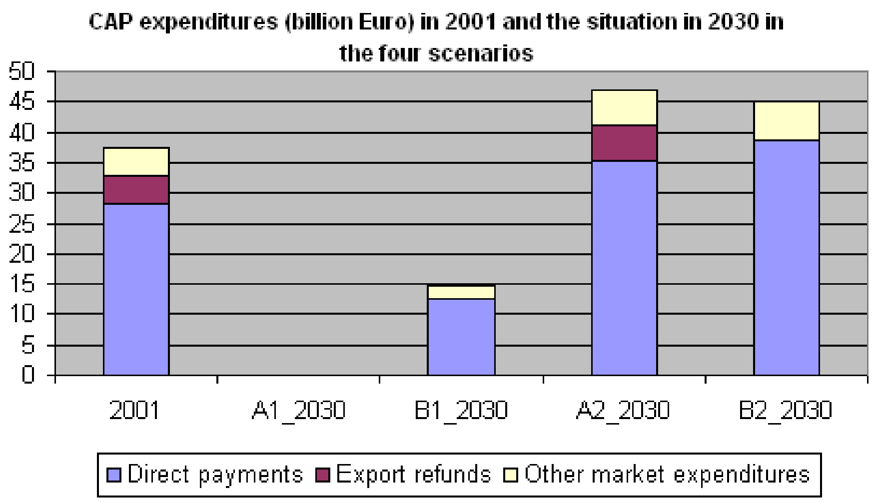


Figure 6.30: CAP expenditures

The current CAP expenditures are about 37 billion euro (without rural area payments). In 2030 these expenditures will be zero in the A1 scenario because there is full trade liberalisation and abolishement of all domestic support. In the B1 scenario payments are reduced to almost 15 billion euro because all export subsidies will be abolished and only 37.5% of domestic support is sustained. In the A2 scenario CAP expenditures will be highest (47 billion euro) due to accession and export subsidies (refunds) are kept. In the B2 scenario CAP expenditures are lower than in the A2 scenario because export refunds are abolished. Direct payments are higher in the B2 scenario than the A2 scenario because these payments increase with 10%.

6.4.11.2 Source

Model: LEITAP (modified version of GTAP: Global Trade Analyses Project, WWW.GTAP.ORG) read more about GTAP/LEITAP
Data: GTAP version 6.2
(http://www.gtap.agecon.purdue.edu/databases/v6/default.asp)

7 Meta-indicators and integrated outcomes

7.1 Introduction

In addition to the single indicators for various 3P aspects as dealt with in Chapter 6 we added overall indicators (more aggregated/ combined or essentially extra data) focussing on I) a *helicopter view* on the balance or unbalance of developments for the three P domains (e.g. expressed in three P triangles, II) *east-west relationships* within Europe in which (un) balance in development can be shown) .A third category III) is to indicate geographical zones or regions where most land use change can be expected: the so-called *hot spot areas*. A fourth category (IV) presents extra information related to the consequences of the various scenarios for developing countries (the "*north-south"relationships*. A last addition is an overview of differences between what was intuitively desired or expected (should be) in each of the scenarios compared with the outcome of our modelling procedures (will be). The results show where expectations and outcomes can deviate from each other and can be called counterintuitive.

7.2 Meta-indicators

7.2.1 Overall methodology

The acquirement of overall indicators and the comparison of the Eururalis results with the 'a priori' expectations or assumptions according to a world vision have been based on a number of steps (actions) shown in Figure 7.1.

Based on the assumptions on driving forces that differ for the four world visions (data A) the model chain gave (action A.1) a number of quantitative data (data B). These data have been interpreted and analysed (action B.1) by the various indicator experts. These expert judgement (that included mostly a simple ranking) delivered the indicator information (data C) in a simplified manner, compared to the more detailed and quantified outcomes in Chapter 6.

The four world visions firstly have been compared (action A.2) to find their position regarding *a selected set of political intentions (data A")*. The question was whether and to what extent a certain story line explicitly formulates a defined goal (e.g. on income, environmental quality, Kyoto goals, self sufficiency, responsibility for the Third World) and / or a degree of importance. Differences between scenario's in goal setting could be compared.

Indicator results as outcomes of modeling procedures have been interpreted (action C.1) into overall indicators (data C"). These overall indicators show results of the modeling chain and subsequently how the indicator experts ranked them on the level of the 3P domains. This has been done for the EU 25 as a whole and. specified for the EU 15 respectively EU 10 countries. The latter enables to compare developments in older and newer member states. This enables users to identify convergent or divergent processes in social, economic or environmental sense. This is important in view of policy goals aimed at bringing more cohesion between member states.

The *results of the overall indicator values have finally been processed (action C.2) to compare the simulated outcome with the prioritized intentions (data A")*. In the following sections some relevant choices will be explained.

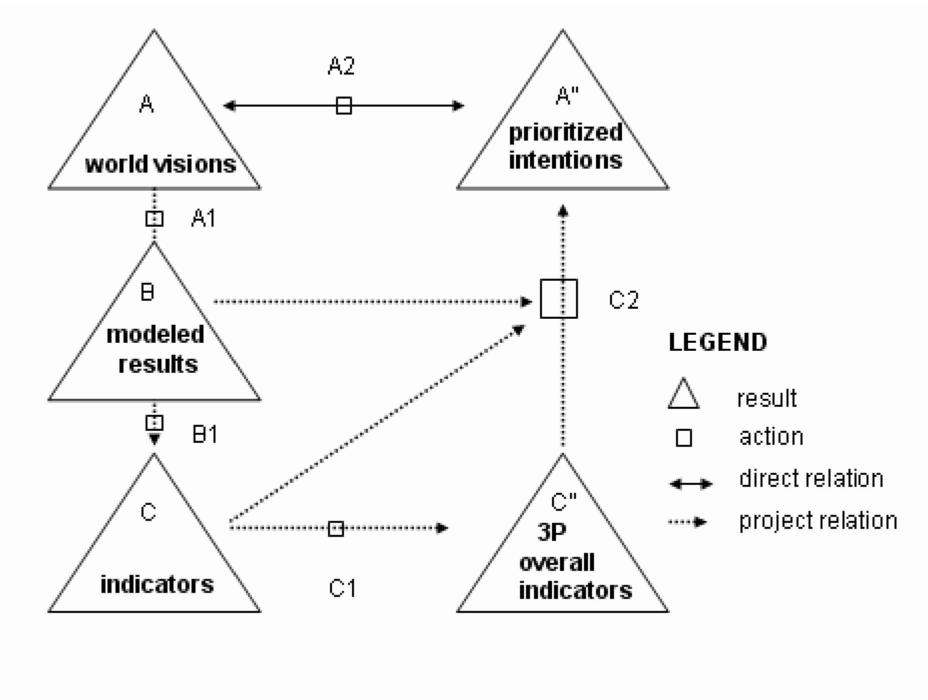


Figure 7.1 methodology to derive overall indicators and a comparison with prioritized intentions

For each 3P domain we selected the following indicators to be analysed aand ranked by indicator experts.

Profit:

- yield
- yield and climate change
- agriculture activities based income
- expenses (CAP)

People

- employment
- self sufficiency
- animal disease

Planet

- CO2 storage
- Biodiversity (nature)
- Biodiversity (agriculture)

- Erosion
- Salinization
- Pollution

Each indicator expert analyzed the outcome of the model-chain which delivered the indicator results. For each of the indicators results for 2030 we asked the indicator experts to give his/her judgement. The assessment was done in simple rankings on a scale of 7 values [-3, -2, -1, 0, +1, +2, +3]. These values express very positive impacts(+3) via no significant impact (0) to a very negative impact (-3). Expert judgement was done by using simple matrix formats, shown below.

Table 7.1: example of matrix

Driver / Indicator	Spatial domain	A1 - 2030	A2 - 2030	B1 - 2030	B2 - 2030
Agrarian prod. share of GDP	EU25				
Agrarian prod. share of GDP	EU10				
Agrarian prod. share of GDP	EU15				

Scores: 3 = very positive ; 2 = positive ; 1 = little positive, 0 = no significant change ,
-1 = little negative, -2 = negative , -3 = very negative. “

We slighly adapted the set-up of indicators by lumping some of them, by including landscape quality and by skipping the aspect of animal diseases (too hard to assess for all countries and the complexity of the various mechanisms) and asked the indicator expert to give an expert judgement for:

Profit domain:

- Agricultural production share
- Agricultural income in relation to average income
- Decreases of CAP expenses

People domain:

- Food self sufficiency
- Population of rural areas
- Cultural-historic landscape quality

Planet domain:

- Biodiversity ‘Nature’
- Biodiversity ‘Agriculture’
- Biodiversity ‘Grasslands’
- Land degradation
- Support Kyoto protocol
- Critical load exceedance of nitrogen

Some single indicators were eventually lumped when necessary (e.g. biodiversity). Finally all indicators per 3P domain have been grouped and for each group an overall assessment per scenario has been calculated based on an *unweighed average* indicator score for the combined EU25 countries and the old EU15 versus the new EU10 countries.

Important to realize is that the simple ranking of indicators for each scenario and attaching values from -3 to + 3 only enable a rough comparison of scores for the four scenario's within the indicator as such; i.e. in a horizontal direction). Any attempt to come to a total of scores by adding all scores for all indicators in a vertical direction is to be considered as unjustified since both the nature of indicators and the way ranking was done do not allow such a simplification.

Intentions as assumed in scenarios A1,A2,B1 and B2;
For each of the assumed intentions (table 7.2) we presented the most important (goal) indicators. More information is given in the various appendices describing the scenario's in detail

Table 7.2: prioritized intentions

	A1	B1	A2	B2
Competitiveness EU agriculture	●●●	●●	●	○
Self sufficiency potential	○	●	●●	●●●
Food quality and safety	●	●●	●	●●●
Competitive prices of food products	●●●	●●	●●	○
Viability of the countryside	○	●	●●	●●●
Biodiversity	○	●●●	○	●●●
Landscape values	○	●	●●	●●●
Greenhouse gas mitigation	○	●●●	○	●
Reduction of nutrient and pesticide loads	○	●●	○	●●●
Wealth convergence between EU regions	●	●●●	○	●●
Wealth convergence world wide	●	●●●	○	●
Control expenditure and bureaucracy	●●●	●	●●	●

○ no/little priority ●●● high priority

For each goal the scores of the related goal-indicators are firstly compared to each other. For example if an indicator scored subsequently for world visions A1, A2, B1 and B2 the values -3, 0, +1, -1, the distances between the scores, starting with the lowest score the 0 value, are respectively 0, 3, 4 and 2. Goalsetting implies that a goal is either not mentioned or acknowledged or positively defined and given some weight. The values higher than 0 (0 means no priority at all) were rescaled for a range of maximally 3 values [1, 2, 3].

If more indicators are related to an intention the unweighed average of the score distances were calculated before the priority values have been rescaled (see appendixes 6 and 7)

7.2.1.1 Results of EURURALIS modelling expressed in meta indicators; comparison of goal indicators and modelling results

As explained earlier the modelling results could deviate from the goals as shown above before in the various scenario's. Table 7.3 combines both the intentional scores (upper rows) and the calculated scores lower rows as shown in the interactive tool CD ROM. Please note that this representation proved to contain errors (B1 and A2 results of modelling (that is the lower rows) were abusively interchanged !) so that a corrected version is given later

Table 7.32: "should be vs. will be": prioritized intentions compared (UNCORRECTED, CONTAINS ERRORS !)

Sub: meta-indic compared with intentions

	A1	B1	A2	B2
Competitiveness EU agriculture	●●●	●●	●	○
	●●●	○	●●●	○
Self sufficiency potential	○	●	●●	●●●
	●	○	○	○
Food quality and safety	●	●●	●	●●●
Competitive prices of food products	●●●	●●	●●	○
	○	●	○	●
Viability of the countryside	○	●	●●	●●●
	○	●	○	●
Biodiversity	○	●●●	○	●●●
	○	●●	●	●●●
Landscape values	○	●	●●	●●●
	○	●	●●	●●●
Greenhouse gas mitigation	○	●●●	○	●
	●●	○	●●●	●●●

intentions: ○ no/little priority ●●● high priority

model outcome: ○ no/little priority ●●● high priority

From this comparitive table the following conclusions may be derived with respect to the various "built-in" expectations (should be) that are either confirmed or denied by modelling outcomes (will be) :

- food self sufficiency in B1 and B2 seems to show less positive differences compared to A1 and A2 as suggested in intentions. However a distiction should be made for CAP and non CAP products.
- competitiveness of food products seems to best supported by scenarios A1 and A2 instead of B1 and B2;
- greenhouse mitigation will be supported by scenarios B1 and B2 and A1 instead of B scenarios alone
- viability of the countryside is less supported by a B2 scenario than intentionally assumed.
- For most other scores there are slight anomalies between "should be and will be"

- In general outcomes should be considered more in detail or broken down intospecific categories (e.g biodiversity in natural and.or semi-natural areas; Cap- Non-Cap products; EU 10 vs EU 15) . From this a warning may be derived to use underlying data rather than simplified and aggregated data

Table 7.4: Corrected "should be vs. will be" priorities (upperr rows in italic represent intentions, lower rows modelling outcomes)

Scenario Storylines	A1	B1	A2	B2
	ranking			
Competitiveness of EU agriculture	*3*	*1*	*2*	*0*
	3	3	0	0
Self sufficiency potential	*0*	*2*	*1*	*3*
	0	0	0	0
Food quality and safety	*1*	*1*	*2*	*3*
	pm	pm	pm	pm
Competitive prices of food products	*3*	*2*	*2*	*0*
	0	*0*	*1*	*1*
Viability of the countryside	*0*	*1*	*2*	*3*
	0	0	1	1
Biodiversity	*0*	*3*	*0*	*3*
	0	1	1	3
Landscape value	*0*	*1*	*2*	*3*
	0	2	1	3
Support Kyoto protocol	*0*	*3*	*0*	*1*
	2	3	0	3

7.2.2 Hot spots

In the user-interface three maps are provided that summarize the overlap between the main land use changes for the different scenarios. For each of the main land use changes the frequency of change is indicated among scenarios.

Agricultural abandonment: Hotspots for agricultural land abandonment are typically found in the neighborhood of important cities, where urban pressure is high, or in areas that are surrounded by or border natural areas. These areas are mostly marginal areas for agriculture and easily abandoned in scenarios where production efficiency increases. In the scenarios in which nature development is an important issue, these areas are (as a consequence of location adjacent to nature areas) favored for nature development.

Nature: Locations of areas where nature is lost differ by scenario. Hardly any hotspots of nature loss can be identified since the losses mostly are small patches within or bordering the agricultural areas. Hotspots for development of nature are often found in the neighborhood of existing natural areas. This is most often due to abandonment of agricultural lands on marginal soils bordering nature areas or due to spatial policies such as the reinforcement of the Natura2000 conservation plan.

Built-up area: Only a few locations are hotspot for urban growth in all scenarios: Paris, the Ruhrgebiet en Southern Poland. These areas are in 2000 already major urban areas, and as a result urban growth is concentrated here. Locations that are hotspots for urban growth in three scenarios are more abundant: they also are connected with major urban areas, like the Randstad, Lyon, the surroundings of Brussels and Antwerp, and Budapest. Dispersed urban growth is mainly found in the A scenarios but less frequent in the B scenarios due to compact urbanization policies.

The three maps in the user interface summarize the overlap between the main land use changes for the different scenarios. For each of the main land use changes the frequency of change is indicated among scenarios. Some locations change in each scenario: these are not dependent on the scenario conditions and could be indicated as locations that have little dependence on the differences in spatial policies among the scenarios. Many other locations are only subject to change in one or two scenarios, partly because the differences in the extent of change among the scenarios, but also because of the differences in spatial policy.

The maximum possible overlap between locations of change is indicated by the scenario with the least change. Table 7.5 compares the maximum possible overlap with the real overlap for every location on the map. The maximum overlap for urbanization is very much restricted in the B2 scenario due to the low urbanization rate. However, in spite of the small area, only 73% of the area in the B2 scenario is also urbanized in the scenarios where urbanization is more dominant. Land abandonment and new nature are even more different in spatial allocation between the scenarios. Only 39% of the new nature area in the A2 scenario is also converted to nature in the other scenarios. This is mainly due to the largely different spatial policies concerning nature protection and enforcement of attention for the Natura2000 structure versus the maintenance of natural patches within the agricultural landscapes.

Table 7.5: Overlap in location for the main land use conversions on an European scale.

	Maximum overlap (% of land area)	***Real overlap (% of land area)***	***Ratio between real and maximum overlap (%)***
Urbanization	0.41	0.30	73
Land Abandonment	2.49	1.03	41
New nature	0.55	0.21	39

North - south relationships

In addition to what was modelled in EURURALIS for the various indicators and what was derived from them by expert assessments it was found necessary to include some conclusions with respect to the relationship between Europe and developing countries. An important motive is that I) there is an important relationship between the EU and these countries taking into consideration trade from and into Europe and these countries, II) there is an outspoken responsibility in socio-economic sense for the EU, iii) there is a comparable responsibility for the EU with regard to global values or resources (biodiversity, climate control) and IV) there is an often criticized EU policy with respect to world trade, market protection and export subsidies especially for agricultural goods and services.For this reason we tried to identify the various pro's and con's in the four scenario's from these viewpoints. These outcomes are based upon expert assessments primarily and presented in qualitative terms.

8 Conclusions

8.1 Policy recomendations

Rural population : shrinking and ageing more than proportionally
All scenarios yield a strong decrease in rural population: from 100 million people in 2000 to around 75 million in 2030. The ageing of Europe's population as forecasted will be even stronger in rural areas compared to urban areas. Ageing and depopulation will affect the viability of rural communities.

Firm future for farming, also in a global economy
Agriculture, though shrinking in GDP share, employment and area will remain the principal player in rural areas in all scenarios. Also in a free market scenario where support measures are abolished. The scenarios encompass quite different agricultural policies, from abolition of Europe's Common Agricultural Policy (tariffs, export subsidies, farm support) to maintenance of the present policy. Most scenarios (except A2) show a decrease of agriculturally used land. Land abandonment could create possibilities for a more sustainable agriculture and nature restoration.

Inescapable climate change asks for adaptive strategies
Climate change will affect all Europe, more notably the Mediterranean, Alpine and northern regions. Impacts will increase in future decades due to time lag of processes and expected increase of problems due to economic growth in the 3rd World, especially in A1 scenario. Next to source oriented policies adaptive strategies are inevitable, to safeguard biodiversity, to allocate sustainable agriculture and to avoid risks such as flooding. Carbon sequestration by conversion of cropland into forest or by large scale bio-fuel production have limited contributions to Kyoto targets.

Accession: mutual profits for existing and new countries
The EU enlargement (EU15 + EU10) will bring economic profits to both the EU15 and EU10 countries. The EU 10 countries will be affected most, in economy, in socio-cultural and in ecological sense. Rates of transformations seem to be highest here, especially in free market conditions, having strong impacts in the social and ecological domains

Rural transitions require support for social, cultural, ecological values in marginal areas.
Transitions in rural areas can be fast and massive in certain regions. Most marginal areas will see land abandonment and socio-cultural and economic decline. Areas where agriculture will undergo further intensification, will be affected negatively in environment, biodiversity and landscape qualities. Both transformations demand an adequate strategy to safeguard values by spatial planning and management.

Urbanisation has many effects on rural areas
The tendency in all scenarios is that further urbanisation takes place, having effects on biotope losses, fragmentation of natural areas, environmental stress and larger

claims on rural areas for recreation and tourism. Careful planning with respect to existing values and possible future risks due to climate change is required to direct urbanisation processes.

Supranational spatial planning still a missing link?
Many driving forces are Europe wide, many European policy responses tend to be thematic (aimed at a certain issue) and at the same time generic (valid everywhere), whereas national policies disregard supranational interests. In view of many problems surpassing national boundaries international spatial strategies including urban and rural areas are required.

Responsibilities for developing countries
In two scenario's (A2, B2) strong trade barriers remain between the EU (and the USA + Canada) and other countries (both industrialized and developing countries). In developing countries this will lead to continued poverty of many people, accompanied by high population growth and more land conversion for subsistence agriculture. This affects social and ecological aspects negatively. Dismantling of trade barriers in itself is not enough: development aid and good governance in development countries are crucial as well.

Scenarios are just a support to envisage threats and opportunities, no blueprint.
Scenarios as presented serve as a help to envisage alternative futures. The four contrasting scenarios are not intended to suggest an either-or type of choice. Policy makers can, as the present state of policy making may illustrate, make their own choices that are well-considered compromises of policy elements from more than one scenario.

8.2 Further research

To use the current version of EURURALIS and to upgrade the version in the next years we recommend some improvements in:

- methods,
- coverage in geography and 3P variables,
- validation and data quality,
- adapting the interface ,
- active dissemination of the tool for discussions

8.2.1 Concepts and methods

EURURALIS starts from generally accepted and acknowldged explorative and partly extrapolitive scenarios and atempts to answer "what-if"questions for selected parameters. Other approaches can be seen as complementary:

backcasting scenarios starting from e.g. desirable futures (for example optimal land use allocation or best technical means to produce food) and then design a new map of Europe. EURURALIS data and tools can be used to define boundary conditions or to calculate effects. It focusses on the existing or conceivable policy measures as main entrance to find out what will be their effect for selected indicators (what policy knobs could we turn and how effective are these?)

The methods and models used in the approach need to be connected in a more thorough way. The different models rely on different data sources that are not always consistent and the interaction between the models can be improved to better include top-down and bottom-up analysis of land use change effects that include important feedbacks.

8.2.2 Geographical extent, wider coverage of issues

EURURALIS had restrictions in coverage (EU25, for many data EU10) and issues addressed for the various domains of sustainability (3P approach). Extensions can be sought in other countries (candidate members), more detail or for issues and related indicators that were not yet included. We plea for a balanced set of data for landscape values. For which methods and data gathering should be organised.

A major limitation of all assessments based on these data is the lack of information on the intensity of the land use. Currently, agricultural practices differ strongly both between different regions in Europe and within regions. Also in the scenarios major changes are expected in crop productivity and farming intensity, with significantly different developments for the different scenarios. The transition into organic farming systems and multi-functional agricultural landscapes will face varying opportunities in the different scenarios. In many areas intensification and extensification or abandonment happen side by side. Such changes in farming intensity have enormous impact on the landscape and environmental issues (groundwater pollution etc.). In the current application changes in crop productivity have been accounted for in the calculations with the integrated assessment model at the national scale, but has not been included in the spatial allocation procedure. A major constraint for including this is the availability of high-resolution data on farming systems and production intensity. For administrative units production data are available that may give some indication, but data on crop types and associated livestock systems (e.g. grazing intensities) are needed for a detailed assessment.

An analysis of the results for the four scenarios presented in this study reveals that land abandonment is likely to become an important issue for land use in Europe. Many case studies in different parts of Europe indicate that already in the current situation land abandonment is a common phenomenon. In the simulation results these abandoned arable lands are classified as abandoned land or, after some years, as natural area if active nature management or spontaneous regrowth is assumed. However, this does not clarify the actual use of the abandoned lands. Part of these lands may still have some extensive agricultural functions, as some farmers have compensated the loss of income as result of agricultural policy reforms by additional activities outside agriculture. Such agricultural lands may remain under extensive forms of agriculture as result of 'part-time' or 'hobby' farming. Other abandoned lands may transform into estates with houses for the rich or obtain recreational functions. Another option not considered in this study is the use of such lands for the cultivation of biofuels. Biofuel cultivation may become an interesting option when abundant land is available and may compete with the conversion of abandoned agricultural lands to nature. As indicated by other authors studying developments in European land use, the future function of the areas that become available due to agricultural abandonment poses an enormous challenge to planners and policy makers to find options that best preserve the quality and identity of the landscapes. Scenario simulations can help to support the discussion on this issue.

8.2.3 Quality of data, validation of models, sensitivity analysis

EURURALIS had to rely on existing data, which were sometimes not covering all countries or had shortcomings in actuality or geographical resolution (see animal diseases) . From these experiences improvements could be enhanced EURURALIS coupled various models to pre-formulated scenarios. Further validation and sensitivity analysis should improve results and insights in how assumptions or policy measures could be assessed upon their effect

The validity of the model results is an issue not addressed in this paper. In this respect it should be noted that the simulation results are not meant as predictions of future land use but as projections based on the assumed scenario conditions, or rather, as a quantified, visualization of the qualitative scenario descriptions. However, validation could still contribute to an assessment of the validity and uncertainty in the downscaling procedure. Although the individual models have been validated in different applications, the validity of a model is mainly determined by the case study specific characteristics and the quality of the input data. Therefore, a proper validation for the European case can only be made based on historic land use changes. This requires consistent land cover databases for two years. The new CORINE database that highlights changes in land cover between 1990 and 2000 of the European Environmental Agency will make such a validation possible.

8.2.4 The interface

EURURALIS built an interface to facilitate discussions on the future of Europe's rural area: its role could be improved by inferring specific policy questions as entrance to exploit the tool in a more policy-oriented manner. The visualization of changes in land use pattern for different scenarios can support policy discussions on the development of the European landscape, support the identification of priority areas for intervention and test the potential consequences of certain policy options. Although technically it is possible to calculate the consequences of individual spatial policies on land use patterns, such an approach may not be consistent with the scenario approach. Scenarios are commonly developed, as much as possible, as internally consistent storylines. Variations in a certain policy may not be consistent with the basic ideas underlying the scenario and conflict with the socio-economic and political assumptions of the storyline. Therefore, the sensitivity of the land use patterns to specific policies can only be explored as far as such a variation is acceptable within the overall storyline of the scenario.

An Internet version could be made in which feed back from users could be exploited, e.g. by assembling criticism, suggestions, policy preferences.

Dissemination of present knowledge and insights

* To take full advantage of the current contents of EURURALIS for its goals (Discussion support) policy makers, other stakeholders (NGO's) or intermediate organisations are invited to organize discussions in which EURURALIS could be one of the supportive tools.

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Appendix 1 Descriptions of Scenarios

A1 (Global market)

Conditions:
General development philosophy:
- Strong commitment to market-based solutions in order to obtain an optimum balance between demand and supply of goods, services and environmental quality at national, regional (EU) and global levels.
- Government intervention, as limited as possible, should focus on core responsibilities (i.e. basic education, public health, basic security, planning of major infrastructure, ensuring conditions for competitive markets, law enforcement) and market failures.
- Lean government implies low taxes.
- International co-operation is focussed on the removal of trade barriers and the creation of a "level playing field".

Political situation EU:
- Turkey, Romania and Bulgaria as well as some Balkan countries, Ukraine and some smaller countries of the former Commonwealth of independent states have joined the EU.
- No further development of supranational powers. National governments remain responsible for Foreign and security policy (2nd pillar) and fiscal policy as well as Justice and Home Affairs (3rd pillar). However, competition forces and lack of border control force national governments to converge levels of corporate taxes, VAT and excise duties.
- Flexible policy regarding international mobility of people from outside the EU. No limitation for migration among member countries.
- Cohesion policy: Abolished
- Social security systems converge to a very basic level. Additional retirement schemes, unemployment risks etc. covered by private institutions.
- CAP subsidies: none (phased out or one-time pay off)

Market protection:
- Import tariffs very low or eliminated,
- Codex alimentarius is used as basis for food safety standards; countries are not allowed to impose more stringent criteria on imports unless unacceptable risks to public health can clearly be proven.
- Little attention to non-trade concerns [only in case of excesses (e.g determined in co-ordination with ILO regarding child labour and freedom of organisation)].

Environment (pollution):

- Relatively relaxed national or EU regulations to avoid that competitiveness (at global level) is affected. Legislation principally focussed on issues related to public health.
- enforcement of environmental legislation by (random) sampling and investigation of complaints
- Additional environmental standards (esp. for imports) are increasingly imposed by purchasers (contracts with supermarket chains and processing industries; e.g. according to standards of ISO 14000 family)
- The polluter pays principle is applied where possible
- little attention to GHG emissions. Kyoto targets not met; global warming considered as a fact of life.
- Maintenance (and acquisition) of natural and cultural heritage mainly privately funded, e.g. through foundations set up and funded by private stakeholders (e.g. tourist sector, hunter clubs, private sponsoring and donations; some co-funding by local-and national governments and or EU or international institutions such as UNESCO).
- Government payments to farmers severely restricted by WTO regulations to avoid market distortions.
- Hotspots of biodiversity (as indicated by UNESCO?) are protected by national law and international agreements; no or few changes in area as compared to 2000 situation;
- Gene banks are maintained by private enterprises (mainly agricultural) and governments (mainly natural) to preserve the source of genetic variation.
- Restrictions on land use / production: few, except in a few sensitive areas; production quotas are abolished.

Consequences

Economic growth

- Strong in most OECD countries
- Even stronger economic growth (at least in relative terms) in new member states and (politically) stable developing countries with open economies; i.e. global convergence in wealth.
- Economic growth lags behind in less stable regions, and regions with a deficit in financial and human resources especially land-locked countries and many small island states in today's developing world. These countries will not be able to provide the package of public goods necessary to trigger accelerated development and to attract substantial amounts of (foreign) investments. They present a deficit in smooth and transparent (government) administration, insufficient availability of skilled workers and a poor physical infrastructure.
- Technology development
- Strong, mostly focussed at cost reduction and yield increase (ICT, GMO's); and on less hazardous agrochemicals, especially regarding human health.

- More efficient use of energy, fertilisers and agrochemicals
- Higher yields per ha, requiring less labour input
- More efficient (international) trade, transportation and storage management.

A2 (Transatlantic market)

Conditions:

General development philosophy:

- Social and cultural values can best be preserved in regional political alliances, within which nation states should keep as much sovereignty as possible. Optimum resource allocation among co-operating societies can largely be obtained by market-based solutions, but protection from other markets is necessary because different standards regarding e.g. working conditions, food safety, animal well-being and the environment impede the creation of a level playing field.
- Self-sufficiency is the key to steady development, shielded against the vagaries of third countries.
- Government intervention should be limited to core responsibilities with a strong focus on defence and security.
- Relatively lean government but high costs related to security (and support to agriculture) imply higher taxes than A1.
- International co-operation: non-interference unless vital interests of the alliance are at stake (e.g. combating international crime). Humanitarian aid, mostly by private initiatives, is given in reaction to catastrophes. Loose Ad hoc alliances, driven by political motives, may be formed with third countries.

Political situation EU:

- The EU forms a single market with the US and Canada.
- No further EU enlargement after accession of 10 CEEC; CEEC integration remains limited.
- No further development of supranational powers. National governments remain responsible for Foreign and security policy (2nd pillar) and fiscal policy as well as Justice and Home Affairs (3rd pillar).
- Very restrictive policy regarding international mobility of people from third countries. Limited possibilities for migration among member countries.
- Cohesion policy: not seen as priority. It is assumed that the market will take account of this.
- Social security systems unequal among member states; generally at lower level than currently in EU15.
- CAP subsidies: approximately at current level.
- Market protection:

- Prohibitive import tariffs for competing products (e.g. meat, sugar, dairy, COP); low tariffs for tropical products, usually under politically motivated bilateral agreements.
- Food safety standards determined by European Food Authority (?);
- Little attention to non-trade concerns regarding imports form third countries.

Environment (pollution):
- Legislation principally focussed on issues related to public health.
- Enforcement of environmental legislation: zie A1
- Additional environmental standards (esp. for imports) may be imposed by purchasers (see A1 narrative); however, in practice consumer preference for regional products if available.
- The polluter pays principle is applied where possible.
- little attention to GHG emissions, but the use of bio-energy is supported in order to spare fossil reserves within the region and to relieve dependence on imports from third countries. R&D investments in technology to make this economically more attractive.

Nature, biodiversity and cultural heritage:
- Maintenance (and acquisition) of natural and cultural heritage is not a priority at EU level. Divergent policies among member countries. Within regions specific areas may be funded privately as in A1. This results in a strongly fragmented network of nature reserves.
- Hotspots of biodiversity are protected by national law; special attention is given to areas with a symbolic value confirming regional identities.
- Gene banks: As A1
- Restrictions on land use / production:
- few and uneven restrictions to control competition between nature, agriculture and urban sprawl, except in a few sensitive areas;
- Agricultural production: production quotas of milk and sugar decrease to the level of self-sufficiency.

Consequences (interacting)

Economic growth
- Unequal, globally and within EU. CEEC lags behind; increasing poverty in rural areas of CEEC.
- Even more unequal in other regions; i.e. wealth disparities increase both regionally and globally.
- Technology development as related to agriculture
- Uneven and fragmented. Communication on – and access to – new technologies is hampered by weak international institutions and lack of interest to participate in international platforms. Technology development is mostly targeted to cost reduction.

B1 (Global co-operation)

Conditions:

General development philosophy:
- Sustained development can only be achieved through well-coordinated efforts at regional and global level towards a fair distribution of wealth, social justice and environmental stewardship.
- Government intervention: relatively strong, aimed at internalising environmental and social costs in order to channel market forces, removing their bias on short-term economic gains. Strong policy instruments at national, regional and global level are developed to achieve this.
- Large government implies high taxes (in between A2 and B2).
- International co-operation is intensive, focussed on the gradual removal of trade barriers and support to developing regions to eliminate poverty and reap the benefits of freer trade, while concurrently working towards high international standards for product quality, working conditions, environmental quality etc…

Political situation EU:
- Turkey, Romania and Bulgaria have joined EU (EU28).
- Considerable transfer of national to supranational powers. The EU has practically developed into a federation. Foreign and security policy (2nd pillar) are fully incorporated. Uniform levels of corporate taxes, VAT and excise duties. Minimum levels for social security are set at EU level. Justice and many parts of Home Affairs (3rd pillar) mostly intergovernmental.
- Flexible policy regarding international mobility of people from outside the EU. No limitation for migration among member countries.
- Cohesion policy: maintained and further targeted towards convergence.
- Social security systems somewhat relaxed. Retirement schemes, unemployment risks etc. above minimum levels are covered by private institutions.
- The level of CAP subsidies is maintained, with domestic support strongly targeted at environmentally sustainability and rural development (2nd pillar of CAP).

Market protection:
- Export subsidies and import tariffs are abolished for all sectors.
- Codex alimentarius is more elaborated than in A1; EU and other developed countries actively support developing nations to meet these requirements.
- Much attention to non-trade concerns. Countries may refuse imports which do not meet internationally agreed minimum standards regarding production conditions related to e.g. labour (established by ILO), environmental impact, animal well-being etc.
- Admittance of GMO’s after individual scrutinising by EU institutions (e.g. EU Food Authority and EEA).

Environment (pollution):

- High standards. E.g. water framework directive is fully implemented.
- Assessment of the effectiveness of environmental legislation by comprehensive monitoring of management practices and the state of the environment.
- Strong attention to GHG emissions. US joins Kyoto and Kyoto targets are further accentuated. This (and physical and political(?) scarcity) results in increasing energy prices; rapidly increasing interest in - and funding of - research and investments in alternative energy. In some parts of Europe, production of commercial biofuels becomes big business.

Nature, biodiversity and cultural heritage:

- Maintenance (and acquisition) of natural and cultural heritage mainly publicly funded, e.g. through CAP support (green payments) for the maintenance / improvement of rural landscapes and agroecological diversity; and by national, EU and international institutions such as UNESCO for nature reserves. Private funding mainly in areas that are attractive for tourism and recreation.
- Payments of national governments to farmers are restricted to avoid market distortions.
- Nature development actively engaged in the creation of extensive international networks of protected areas and green corridors.
- Restrictions on land use / production:
- nature areas and rural areas receiving support for the maintenance of landscapes and biodiversity are strictly protected.
- Urban sprawl: UNEP, 4S4E: Restrictive and homogeneous spatial planning. Human settlements are controlled by promoting compact cities and major transport / communication corridors based on improvement of current infrastructure rather than extension.
- Agricultural production: production quotas are abolished.

Consequences (interacting)

Economic growth

- Strong in EU and other OECD countries, but less than in A1.
- Southern and Eastern member states converge rapidly to EU average
- Even stronger economic growth (on average stronger than A1) in developing countries; i.e. global convergence in wealth is stronger than in A1.
- Technology development
- Strong, mostly focussed at development of environmentally friendly production methods.
- More efficient use of energy, fertilisers and agrochemicals (more than in A1)
- Higher yields per ha, requiring less labour input (but not as much as in A1)
- More efficient (international) trade, transportation and storage management. (but transport costs are higher than in A1).

B2 (Regional Co-operation)

Conditions:

Development paradigm:

- Sustainable development should be geared to local dynamics. Social and cultural values can best be preserved at the community level. Resource allocation cannot be left to the market. Local communities are the cornerstones of society.
- Self-reliance, ecological stewardship and equity are the keys to sustainability.
- Participatory bottom-up approaches towards policy making at local level. Government intervention is necessary to facilitate negotiations between stakeholders and enforce decisions, rather than to impose regulations.
- International co-operation is necessary to obtain sustainable development at global level. This should be targeted at the elimination of poverty by promoting self-reliance regarding food and energy in the poorest countries.
- Large government and high costs to maintain social achievements, cohesion, agriculture etc..,

Political situation EU:

- No further EU enlargement after accession of 10 CEEC (?); Romania, Bulgaria(?) Turkey does not accede. Reinforced co-operation among core group of EU15 members ends up in a two tier Europe. While co-operation within the core group becomes more important, the EU loses power.
- No further development of supranational powers. National governments remain responsible for Foreign and security policy (2nd pillar) and fiscal policy as well as Justice and Home Affairs (3rd pillar). Harmonisation of unemployment insurance and corporate taxes in core group.
- Restrictive policy regarding international mobility of people from third countries. Limited possibilities for migration among member countries; migration from CEEC citizens countries of the core group is strongly restricted.
- Cohesion policy receives little attention and remains ineffective.
- Social security: Governments of the core group largely maintain the welfare state in its original form.
- CAP subsidies: increase of some +10%, linked to environmental and social targets. Export subsidies are eliminated.

Market protection:

- Agricultural markets protected against competing products to avoid cheap import surges, disrupting EU agriculture.
- Many mature European industries are protected from outside competition through trade barriers. This holds in particular for agriculture, but also for network industries.
- Food safety standards determined by European Food Authority (?);

- Strong attention to non-trade concerns regarding imports form third countries. Production standards of imports regarding health, environment and animal welfare should be at least as high as EU.
- Preference for products from own region.
- Environment (pollution):
- High standards agreed at national and EU level. E.g. water framework directive is fully implemented.
- Assessment of the effectiveness of environmental legislation by comprehensive monitoring of management practices and the state of the environment.
- The use of solar energy and bio-energy is supported in order to spare fossil reserves and to relieve dependence on imports from third countries. Subsidies and R&D investments in technology to make this economically more attractive. However, international coordination is weak.

Nature, biodiversity and cultural heritage:

- Maintenance (and acquisition) of natural and cultural heritage is a priority. Requests for funding by EU and national governments are prepared by local communities.
- Hotspots of biodiversity protected by EU regulations. Increase in area as compared to 2000 situation, but an Ecological Main Structure is difficult to achieve due to lack of co-ordination.

Restrictions on land use / production:

- Land use: Restrictions mainly determined at local level.
- nature areas and rural areas receiving support for the maintenance of landscapes and biodiversity are strictly protected.
- Production quotas: Production quotas of milk and sugar decrease to the level of self-sufficiency. New quota may be introduced when self-sufficiency levels tend to be exceeded and excess cannot be sold without subsidies.
- Urban sprawl: restrictive and heterogeneous spatial planning; compact settlements in small and medium-sized cities;

Consequences (interacting)

Economic growth

- Relatively low, especially in periphery. Income disparities decrease within these groups.
- More unequal in other regions but in general some decrease in wealth disparities.

Technology development

- Uneven, especially in resource poor regions with rapid economic development focussed at the development of energy-efficient and environmentally friendly production methods.

- More efficient use of energy, fertilisers and agrochemicals (in between B1 and A2)
- Relatively low agricultural yields, due to extensive production and stagnating technology
- Decrease in (international) trade.

Rather weak international institutions (UN, WTO) resulting in weak co-ordination of international co-operation; mostly bilateral.

Appendix 2 Specifications of scenarios

A1 (v 20-04-2004)

Models		2010	2020	2030
GTAP/IMAGE/CLUE	Countries in EU	EU15+AC10	+Romenia + Bulgaria + Turkey	(+ some FSU-states and some republics of former Yugoslavia)
	Trade arrangements			
GTAP	EU - Turkey	Customs Union	Turkey enters EU	no further arrangements
GTAP	EU - Former Soviet Union	no specific arrangements	elimination of bilateral tariffs in manufacturing	same as 2020
GTAP	EU - USA	no specific arrangements	no specific arrangements	no specific arrangements
GTAP	EU - Latin America and Carribean, Middle East, Africa	no specific arrangements	no specific arrangements	no specific arrangements
	Trade / WTO			
GTAP	Export subsidies	25% reduction	50% reduction as compared to 2010	abolished for all sectors
GTAP	Import tariffs	25% reduction	50% reduction as compared to 2010	abolished for all sectors
GTAP	Non-tariff barriers for agricultural products (SPS, TBT…) between trade blocks (see footnote *)	situation 2001	no further arrangements	no further arrangements
	Consumer preferences			
GTAP	Preference for products from own IMAGE region	no specific arrangements	-	-
GTAP	Consumption of animal protein from meat	endogenous GTAP outcome	endogenous GTAP outcome	endogenous GTAP outcome
	Domestic support in agriculture			
GTAP	Intervention prices	25% reduction as compared to post MTR CAP reform levels	safety net just below average world market price levels	abolished

GTAP	Production quota (milk)	level as decided for 2003 MTR CAP reform and agreed with Acceeding Countries	abolished	-
GTAP	Production quota (sugar)	maintained at 2003 levels and agreement with Acceeding Countries	abolished	-
GTAP	Distribution of quota among Member States (tradable)	tradable (??)	-	-
GTAP	Distribution of quota among stakeholders in Member States (tradable?)	tradable (??)	-	-
GTAP	Coupled payments	25% reduction after full incorporation in decoupled single farm payment scheme	-	-
GTAP	Decoupled payments (single farm payment scheme; partial, full, regional implementation)	full decoupling of single farm payment scheme; payments reduced by 25%.	reduction by 50% as compared to 2010	abolished for all sectors
	Rural development funds (2nd CAP pillar)	25% reduction i.r.t. 2001-2006 level	reduction by 50% as compared to 2010	virtually abolished for all sectors
GTAP/IMAGE/CLUE	compulsory set-aside of arable land (excl. organic farms)	abolished	-	-
	Nature development (EU)			
GTAP/IMAGE/CLUE	Area (EU)	Protected areas and (semi-)natural areas within (proposed) Natura 2000 network are maintained	no further developments	-
CLUE	Policy measures to control fragmentation	no fragmentation of existing nature areas; no serious efforts to create ecological corridors	no further developments	-
CLUE	Agro-biodiversity	agricultural areas within (proposed) Natura 2000 network remain under extensive agriculture	agricultural areas within (proposed) Natura 2000 network either remain under extensive agriculture or are abandoned	same as 2020
CLUE	Local patches of (semi-)natural areas	no specific arrangements	no specific arrangements	no specific arrangements

	Less favoured areas			
CLUE	Area (classification criteria)	maintained at current level + designations for Accession Countries	LFA concept abolished	-
CLUE	Incentives/compensation for farmers	partial compensation; i.e. moderate resistance to land use change	compensation to farmers abolished	-
	Permanent pasture			
IMAGE/CLUE	Total area	Outcome IMAGE	Outcome IMAGE	Outcome IMAGE
CLUE	Remains on same sites?	no restrictions	no restrictions	no restrictions
CLUE	Restrictions on expansion of horticulture, fruit and permanent crops	no restrictions	no restrictions	no restrictions
	Energy crops			
IMAGE/CLUE	Crops for biofuels (sugarbeet, potatoes, coleseed), coppice, firewood:	Outcome IMAGE	Outcome IMAGE	Outcome IMAGE
	Crop residues / manure (ethanol, methane…)	?	?	?
IMAGE	Proportion of bio-fuels in transport fuel consumption	no specific target	no specific target	no specific target
IMAGE	Import restrictions for bio-fuels	on basis of carbon prices	on basis of carbon prices	on basis of carbon prices
CLUE	Crops for biofuels (sugarbeet, potatoes, coleseed), coppice, firewood:	Outcome IMAGE	Outcome IMAGE	Outcome IMAGE
	Crop residues / manure (ethanol, methane…)	?	?	?
	Proportion of bio-fuels in transport fuel consumption	no specific target	no specific target	no specific target
	Import restrictions for bio-fuels	no imports (?)	no imports (?)	no imports (?)
	Incentives for organic farming	share of organic products 5%	share of organic products 5%	share of organic products 5%

	Environmental legislation, public health, animal welfare etc. (inc. cross-compliance, good agricultural practices)	loose interpretation of directives and regulations	no further developments	-
GTAP/IMAGE	Effects on productivity growth (irt FAO projection)**			
	EU15 + CEEC	+5%	+5%	+5%
	Turkey	0%	0%	0%
CLUE	Effects on land suitability (erosion)	no restriction	no restriction	no restriction
CLUE	Effects on land suitability (nutrient leaching)	no restriction	no restriction	no restriction
	Land conversion policy to control growth of human settlements			
CLUE	Large cities	no restrictions; in practice, growth of urban centres is favoured in this scenario	same as 2010	same as 2010
CLUE	Provincial towns	no incentives or restrictions	same as 2010	same as 2010
CLUE	Small villages	no particular incentives or restrictions; loose regulations combined with high incomes may lead to proliferation of second houses	same as 2010	same as 2010
CLUE	Type of growth (compact/sprawled)	sprawled	same as 2010	same as 2010

* Regional blocks: 1 Netherlands / rest of EU15 / CEEC / Baltic countries / Rest of Europe; 2 Canada / USA / Central America / South America; 3 Oceania; 4 Japan; 5 East Asia / South-east Asia;
6 South Asia; 7 Former Soviet Union; 8 Middle Africa / South Africa; 9 Turkey / Middle East / North Africa; 10 Rest of World.

** Effects on productivity growth are the resultant of a combination of environmental constraints and technology development.

Models		2010	2020	2030
GTAP/IMAGE/CLUE	Countries in EU	EU15+AC10+Romenia + Bulgaria + Turkey	no further accession	-
	Trade arrangements			
GTAP	EU - Turkey	Turkey enters EU	-	-
GTAP	EU - Former Soviet Union	elimination of bilateral tariffs in manufacturing	no further arrangements	-
GTAP	EU - USA	no specific arrangements	-	-
GTAP	EU - Latin America and Carribean, Middle East, Africa	no specific arrangements	-	-
	Trade / WTO			
GTAP	Export subsidies	25% reduction	50% reduction as compared to 2010	abolished for all sectors
GTAP	Import tariffs	25% reduction	50% reduction as compared to 2010	abolished for all sectors
GTAP	Non-tariff barriers for agricultural products (SPS, TBT…)	situation 2001	global SPS and TBT leads to 1% cost price increase for agricultural products in developing countries	2,5% cost price increase (as compared to 2010) for agricultural products in developing countries
	Consumer preferences			
GTAP	Preference for products from own IMAGE region	no specific arrangements	-	-
GTAP	Consumption of animal protein from meat	endogenous GTAP outcome	5% lower than endogenous outcome	10% lower than endogenous outcome
	Domestic support in agriculture			
GTAP	Intervention prices	maintained at post MTR CAP reform levels	safety net just below average world market price levels	abolished

GTAP	Production quota (milk)	level as decided for 2003 MTR CAP reform and agreed with Acceeding Countries	abolished	-
GTAP	Production quota (sugar)	maintained at 2003 levels and agreement with Acceeding Countries	abolished	-
GTAP	Distribution of quota among Member States (tradable)	tradable (??)	-	-
GTAP	Distribution of quota among stakeholders in Member States (tradable?)	tradable (??)	-	-
GTAP	Coupled payments	full incorporation in decoupled single farm payment scheme	-	-
GTAP	Decoupled payments (single farm payment scheme; partial, full, regional implementation)	full decoupling of single farm payment scheme;	reduction by 25% as compared to 2010	reduction by 50% as compared to 2010
	Rural development funds (2nd CAP pillar)	as foreseen in 2004 proposal financial perspectives; strongly targetted at agri-environment, farm restructuring and off-farm investments for maintenance / restoration of the viability of the countryside	effective income support to farmers reduced by 25% as compared to 2010	effective income support to farmers reduced by 50% as compared to 2010
GTAP/IMAGE/CLUE	compulsory set-aside of arable land (excl. organic farms)	10% (or less if cereal production < domestic demand)	abolished	-
	Nature development (EU)			
GTAP/IMAGE/CLUE	Area (EU)	Main existing areas are protected; abandoned agricultural areas are actively managed to strengthen Natura 2000 network (see below)	same as 2010	same as 2020
CLUE	Policy measures to control fragmentation	no fragmentation of existing nature areas; serious efforts are undertaken to create bufferzones and ecological corridors at national and international level	same as 2010	same as 2020

CLUE	Agro-biodiversity	agricultural areas within (proposed) Natura 2000 network remain under extensive agriculture (farmers are compensated)	agricultural areas within (proposed) Natura 2000 network either remain under extensive agriculture or are used for nature development. Main grassland areas in LFA's are incorporated in Natura 2000 network (extensive pastures).	same as 2020
CLUE	Local patches of (semi-)natural areas	generally protected, but some conversion to agriculture or urban development is possible.	no further developments	-
	Less favoured areas			
CLUE	Area (classification criteria)	maintained at current level + designations for Accession Countries	Main grassland areas in LFA's are incorporated in Natura 2000 network (extensive pastures). LFA concept abolished.	-
CLUE	Incentives/compensation for farmers	almost full compensation; i.e. fairly strong resistance to land use change; but no intensive land use	-	-
	Permanent pasture			
IMAGE/CLUE	Total area	> area in 2000 in each member state	> area in 2000 in each member state	> area in 2000 in each member state
CLUE	Remains on same sites?	shifts are allowed	shifts are allowed	shifts are allowed
CLUE	Restrictions on expansion of horticulture, fruit and permanent crops	no restrictions	no restrictions	no restrictions
	Energy crops			

IMAGE/CLUE	Crops for biofuels (sugarbeet, potatoes, coleseed), coppice, firewood:	Outcome IMAGE. Upto 50% of set-aside land is used for energy crops; remainder (mostly coppice and firewood) on abandoned land if available.	Outcome IMAGE	Outcome IMAGE
	Crop residues / manure (ethanol, methane…)	?	?	?
IMAGE	Proportion of bio-fuels in transport fuel consumption	target 6%	13%	20%
IMAGE	Import restrictions for bio-fuels	on basis of carbon prices	on basis of carbon prices	on basis of carbon prices
CLUE	Crops for biofuels (sugarbeet, potatoes, coleseed), coppice, firewood:	Outcome IMAGE. Upto 50% of set-aside land is used for energy crops; remainder (mostly coppice and firewood) on abandoned land if available.	Outcome IMAGE	Outcome IMAGE
	Crop residues / manure (ethanol, methane…)	?	?	?
	Proportion of bio-fuels in transport fuel consumption	target 6%	13%	20%
	Import restrictions for bio-fuels	no imports (?)	no imports (?)	no imports (?)
	Incentives for organic farming	share of organic products 5%; organic farming mostly linked to Natura 2000 network	share of organic products 10%	share of organic products 15%
	Environmental legislation, public health, animal welfare etc. (inc. cross-compliance, good agricultural practices)	strong: minimization of environmental hazards	no further arrangements	-
GTAP/IMAGE	Effects on productivity growth (irt FAO projection)**			
	EU15	0%	0%	0%
	CEEC (inc Baltic)	+5%	+5%	+5%
	Turkey	0%	0%	0%
CLUE	Effects on land suitability (erosion)	no arable agriculture on land with high erosion risk	no arable agriculture on land with high erosion risk	no arable agriculture on land with high erosion risk

CLUE	Effects on land suitability (nutrient leaching)	no restriction	no intensive agriculture on well drained sandy soils in nitrate vulnerable zones.	no intensive agriculture on well drained sandy soils in nitrate vulnerable zones.
	Land conversion policy to control growth of human settlements			
CLUE	Large cities	growth restricted to designated areas	same as 2010	same as 2010
CLUE	Provincial towns	designated areas adapted to demand	same as 2010	same as 2010
CLUE	Small villages	growth (if any) restricted to designated areas;	same as 2010	same as 2010
CLUE	Type of growth (compact/sprawled)	compact	same as 2010	same as 2010

* Regional blocks: 1 Netherlands / rest of EU15 / CEEC / Baltic countries / Rest of Europe; 2 Canada / USA / Central America / South America; 3 Oceania; 4 Japan; 5 East Asia / South-east Asia;
6 South Asia; 7 Former Soviet Union; 8 Middle Africa / South Africa; 9 Turkey / Middle East / North Africa; 10 Rest of World.

** Effects on productivity growth are the resultant of a combination of environmental constraints and technology development.

A2 (v 20-04-2004)

Models		2010	2020	2030
GTAP/IMAGE/CLUE	Countries in EU	EU15+AC10	+Romenia + Bulgaria	no further accession
	Trade arrangements			
GTAP	EU - Turkey	Customs Union	no further arrangements	-
GTAP	EU - Former Soviet Union	no specific arrangements	-	-
GTAP	EU - USA	no specific arrangements	elimination of bilateral tariffs	no further arrangements
GTAP	EU - Latin America and Carribean, Middle East, Africa	no specific arrangements	-	-
	Trade / WTO			
GTAP	Export subsidies	no change	no change	no change
GTAP	Import tariffs	no change	no change	no change
GTAP	Non-tariff barriers for agricultural products (SPS, TBT…) between trade blocks (see footnote *)	no specific arrangements	-	-
	Consumer preferences			
GTAP	Preference for products from own IMAGE region	1% shift (i.e. stronger preference)	additional 2% shift	additional 2% shift
GTAP	Consumption of animal protein from meat	endogenous GTAP outcome	endogenous GTAP outcome	endogenous GTAP outcome
	Domestic support in agriculture			
GTAP	Intervention prices	maintained at levels decided for 2003 MTR CAP reform	no further change	-
GTAP	Production quota (milk)	level as decided for 2003 MTR CAP reform and agreed with Acceeding Countries	set at level to safeguard self-sufficiency	no further arrangements
GTAP	Production quota (sugar)	maintained at 2003 levels and agreement with Acceeding	set at level to safeguard self-sufficiency	no further arrangements

Countries

GTAP	Distribution of quota among Member States (tradable)	non-tradable	non-tradable, reductions e.g. according to key of sugar CMO	no further arrangements
GTAP	Distribution of quota among stakeholders in Member States (tradable?)	tradable	no further arrangements	-
GTAP	Coupled payments	maintained at maximum levels of 2003 MTR CAP reform	no further arrangements	-
GTAP	Decoupled payments (single farm payment scheme; partial, full, regional implementation)	partial decoupling	no further arrangements	-
	Rural development funds (2nd CAP pillar)	maintained at average 2001-2006 level	no further arrangements	-
GTAP/IMAGE/CLUE	compulsory set-aside of arable land (excl. organic farms)	10% (or less if cereal production < domestic demand)	abolished	-
	Nature development (EU)			
GTAP/IMAGE/CLUE	Area (EU)	Protected areas and (semi-)natural areas within (proposed) Natura 2000 network are maintained	no further arrangements	-
CLUE	Policy measures to control fragmentation	no fragmentation of existing nature areas; no serious efforts to create ecological corridors	no further arrangements	-
CLUE	Agro-biodiversity	agricultural areas within (proposed) Natura 2000 network remain under extensive agriculture	agricultural areas within (proposed) Natura 2000 network either remain under extensive agriculture or are abandoned	no further arrangements
CLUE	Local patches of (semi-)natural areas	generally protected, but some conversion to agriculture or urban development is possible.	no further arrangements	-
	Less favoured areas			
CLUE	Area (classification criteria)	maintained at current level + designations for Accession	no further arrangements	-

		Countries		
CLUE	Incentives/compensation for farmers	no change in financial compensation; i.e. gradually decreasing resistance to land use change	no further arrangements	-
	Permanent pasture			
IMAGE/CLUE	Total area	Outcome IMAGE	Outcome IMAGE	Outcome IMAGE
CLUE	Remains on same sites?	no restrictions	no restrictions	no restrictions
CLUE	Restrictions on expansion of horticulture, fruit and permanent crops	no restrictions	no restrictions	no restrictions
	Energy crops			
IMAGE/CLUE	Crops for biofuels (sugarbeet, potatoes, coleseed), coppice, firewood:	Outcome IMAGE. Upto 50% of set-aside land is used for energy crops; remainder (mostly coppice and firewood) on abandoned land if available.	Outcome IMAGE	Outcome IMAGE
	Crop residues / manure (ethanol, methane…)	?	?	?
IMAGE	Proportion of bio-fuels in transport fuel consumption	No target	No target	No target
IMAGE	Import restrictions for bio-fuels	on basis of carbon prices	on basis of carbon prices	on basis of carbon prices
CLUE	Crops for biofuels (sugarbeet, potatoes, coleseed), coppice, firewood:	Outcome IMAGE. Upto 50% of set-aside land is used for energy crops; remainder (mostly coppice and firewood) on abandoned land if available.	Outcome IMAGE	Outcome IMAGE
	Crop residues / manure (ethanol, methane…)	?	?	?
	Proportion of bio-fuels in transport fuel consumption	?	?	?
	Import restrictions for bio-fuels	no imports	no imports	no imports

	Incentives for organic farming	share of organic products 5%	share of organic products 8% (?)	share of organic products 10% (?)
	Environmental legislation, public health, animal welfare etc. (inc. cross-compliance, good agricultural practices)	loose interpretation of directives and regulations	no further arrangements	-
GTAP/IMAGE	Effects on productivity growth (irt FAO projection)**			
	EU15 and CEEC (inc Baltic)	-5%	-5%	-5%
	Turkey	-10%	-10%	-10%
CLUE	Effects on land suitability (erosion)	no restriction	no restriction	no restriction
CLUE	Effects on land suitability (nutrient leaching)	no restriction	no restriction	no restriction
	Land conversion policy to control growth of human settlements			
CLUE	Large cities	no restrictions; in practice, growth of urban centres is favoured in this scenario	same as 2010	same as 2010
CLUE	Provincial towns	no incentives or restrictions	same as 2010	same as 2010
CLUE	Small villages	no incentives or restrictions; in practice, rural population will tend to decrease in regions with land abandonment	same as 2010	same as 2010
CLUE	Type of growth (compact/sprawled)	sprawled	same as 2010	same as 2010

* Regional blocks: 1 Netherlands / rest of EU15 / CEEC / Baltic countries / Rest of Europe; 2 Canada / USA / Central America / South America; 3 Oceania; 4 Japan; 5 East Asia / South-east Asia;
6 South Asia; 7 Former Soviet Union; 8 Middle Africa / South Africa; 9 Turkey / Middle East / North Africa; 10 Rest of World.

** Effects on productivity growth are the resultant of a combination of environmental constraints and technology development.

B2 (v 20-04-2004)

Models		2010	2020	2030
GTAP/IMAGE/CLUE	Countries in EU	EU15+AC10	+Romenia + Bulgaria	no further accession
	Trade arrangements			
GTAP	EU - Turkey	Customs Union	no further arrangements	-
GTAP	EU - Former Soviet Union	no specific arrangements	elimination of bilateral tariffs in manufacturing	no further arrangements
GTAP	EU - USA	no specific arrangements	elimination of bilateral tariffs in manufacturing	no further arrangements
GTAP	EU - Latin America and Carribean, Middle East, Africa	no specific arrangements	elimination of bilateral tariffs in manufacturing	no further arrangements
	Trade / WTO			
GTAP	Export subsidies	25% reduction	abolished for all sectors	-
GTAP	Import tariffs	no change	no change	no change
GTAP	Non-tariff barriers for agricultural products (SPS, TBT…) between trade blocks (see footnote *)	3% increase increase compared with 2001	3% increase compared with 2010	4% increase compared with 2020
	Consumer preferences			
GTAP	Preference for products from own IMAGE region	1% shift (i.e. stronger preference)	additional 2% shift	additional 2% shift
GTAP	Consumption of animal protein from meat	endogenous GTAP outcome	5% lower than endogenous outcome	10% lower than endogenous outcome
	Domestic support in agriculture			
GTAP	Intervention prices	maintained at levels decided for 2003 MTR CAP reform	5% increase	additional 5% increase
GTAP	Production quota (milk)	level decided after 2003 MTR CAP reform	set at level to safeguard self-sufficiency	no further arrangements
GTAP	Production quota (sugar)	set at level to safeguard self-sufficiency; no B-sugar; no	no further arrangements	-

		export of C-sugar		
GTAP	Distribution of quota among Member States (tradable?)	non-tradable, reductions e.g. according to key of sugar CMO	no further arrangements	-
GTAP	Distribution of quota among stakeholders in Member States (tradable?)	maintained, limited trade of quota	no further arrangements	-
GTAP	Coupled payments	maintained at maximum levels of 2003 MTR CAP reform	no further arrangements	-
GTAP	Decoupled payments (single farm payment scheme; partial, full, regional implementation)	partial decoupling	further modulation: additional cut of 10% as compared to 2010 on payments exceeding Eur 5000	further modulation: additional cut of 10% as compared to 2020 on payments exceeding Eur 5000
	Rural development funds (2nd CAP pillar)	as foreseen in 2004 proposal financial perspectives; strongly targetted at agri-environment and maintenance/restoration of the viability of the countryside	further increase by 5% + modulation money	further increase by 5% + additional modulation money
GTAP/IMAGE/CLUE	compulsory set-aside of arable land (excl. organic farms)	10% (or less if cereal production < domestic demand)	no further arrangements	-
	Nature development (EU)			
GTAP/IMAGE/CLUE	Area (EU)	Existing areas are protected; 50% of abandoned agricultural areas are actively managed for nature development	no further arrangements	-
CLUE	Policy measures to control fragmentation	no fragmentation of existing nature areas; no serious efforts to create ecological corridors at international level	no further arrangements	-
CLUE	Agro-biodiversity	agricultural areas within (proposed) Natura 2000 network remain under extensive agriculture	no further arrangements	-
CLUE	Local patches of (semi-)natural areas	protected	protected	protected

	Less favoured areas			
CLUE	Area (classification criteria)	maintained at current level + designations for Accession Countries	no further arrangements	-
CLUE	Incentives/compensation for farmers	full compensation; i.e. strong resistance to land use change; but no intensive land use	no further arrangements	-
	Permanent pasture			
IMAGE/CLUE	Total area	> area in 2000 in each member state	> area in 2000 in each member state	> area in 2000 in each member state
CLUE	Remains on same sites?	yes	yes	yes
CLUE	Restrictions on expansion of horticulture, fruit and permanent crops	remain preferentially on same sites	remain preferentially on same sites	remain preferentially on same sites
	Energy crops			
IMAGE/CLUE	Crops for biofuels (sugarbeet, potatoes, coleseed), coppice, firewood:	Outcome IMAGE. Upto 50% of set-aside land is used for energy crops; remainder (mostly coppice and firewood) on abandoned land if available.	upto 75% of set-aside land is used for energy crops; remainder on abandoned land if available.	upto 100% of set-aside land is used for energy crops; remainder on abandoned land if available.
	Crop residues / manure (ethanol, methane…)	?	?	?
IMAGE	Proportion of bio-fuels in transport fuel consumption	target 5,75%	10%	15%
IMAGE	Import restrictions for bio-fuels	on basis of carbon prices	on basis of carbon prices	on basis of carbon prices
CLUE	Crops for biofuels (sugarbeet, potatoes, coleseed), coppice, firewood:	Outcome IMAGE. Upto 50% of set-aside land is used for energy crops; remainder (mostly coppice and firewood) on abandoned land if available.	upto 75% of set-aside land is used for energy crops; remainder on abandoned land if available.	upto 100% of set-aside land is used for energy crops; remainder on abandoned land if available.
	Crop residues / manure (ethanol, methane…)	?	?	?
	Proportion of bio-fuels in transport fuel consumption	target 5,75%	10%	15%

	Import restrictions for bio-fuels	no imports	no imports	no imports
	Incentives for organic farming	share of organic products 5%; organic farming mostly linked to Natura 2000 network	share of organic products 10%	share of organic products 20%
	Environmental legislation, public health, animal welfare etc. (inc. cross-compliance, good agricultural practices)	very strong: minimization of environmental hazards	no further arrangements	-
GTAP/IMAGE	Effects on productivity growth (irt FAO projection)**	-5%	-5%	-5%
CLUE	Effects on land suitability (erosion)	no arable agriculture on land with high erosion risk	no arable agriculture on land with high erosion risk	no arable agriculture on land with high erosion risk
CLUE	Effects on land suitability (nutrient leaching)	no restriction	no intensive agriculture on well drained sandy soils in nitrate vulnerable zones.	no intensive agriculture on well drained sandy soils in nitrate vulnerable zones.
	Land conversion policy to control growth of human settlements			
CLUE	Large cities	restrictions on growth;	same as 2010	same as 2010
CLUE	Provincial towns	incentives for growth	same as 2010	same as 2010
CLUE	Small villages	targetted to maintain existing size and structure	same as 2010	same as 2010
CLUE	Type of growth (compact/sprawled)	compact	same as 2010	same as 2010

* Regional blocks: 1 Netherlands / rest of EU15 / CEEC / Baltic countries / Rest of Europe; 2 Canada / USA / Central America / South America; 3 Oceania; 4 Japan; 5 East Asia / South-east Asia;
6 South Asia; 7 Former Soviet Union; 8 Middle Africa / South Africa; 9 Turkey / Middle East / North Africa; 10 Rest of World.

** Effects on productivity growth are the resultant of a combination of environmental constraints and technology development.

Appendix 3 Eururalis regions and comprising GTAP regions

EURALIS regions			Comprising GTAP regions		
No.	Code	Description	No.	Code	Description
1	belu	Belgium and Luxembourg	38	bel	Belgium
			47	lux	Luxembourg
2	dnk	Denmark	39	dnk	Denmark
3	deu	Germany	42	deu	Germany
4	grc	Greece	44	grc	Greece
5	esp	Spain	50	esp	Spain
6	fra	France	41	fra	France
7	irl	Ireland	45	irl	Ireland
8	ita	Italy	46	ita	Italy
9	nld	The Netherlands	48	nld	Netherlands
10	aut	Austria	37	aut	Austria
11	prt	Portugal	49	prt	Portugal
12	fin	Finland	40	fin	Finland
13	swe	Sweden	51	swe	Sweden
14	gbr	United Kingdom	43	gbr	United Kingdom
15	euis	Cyprus, Malta	58	cyp	Cyprus
			61	mlt	Malta
16	cze	Czech Republic	59	cze	Czech Republic
17	euba	EU Baltic countries	66	est	Estonia
			67	lva	Latvia
			68	ltu	Lithuania
18	hun	Hungary	60	hun	Hungary
19	pol	Poland	62	pol	Poland
20	svn	Slovenia	65	svn	Slovenia

21	svk	Slovakia	64	svk	Slovakia
22	apeu	EU applicants countries	56	bgr	Bulgaria
			63	rom	Romania
23	reur	Resf of Europe	52	che	Switzerland
			53	xef	Rest of EFTA
			54	xer	Rest of Europe
			55	alb	Albania
			57	hrv	Croatia
24	fsu	Former SovieT Union	69	rus	Russian Federation
			70	xsu	Rest of Former Soviet Union
25	tur	Turkey	71	tur	Turkey
26	usa	USA	22	usa	United States
27	can	Canada	21	can	Canada
28	cam	Central America	23	mex	Mexico
			24	xna	Rest of North America
			34	xca	Central America
			35	xfa	Rest of FTAA
			36	xcb	Rest of the Caribbean
29	sam	South America	25	col	Colombia
			26	per	Peru
			27	ven	Venezuela
			28	xap	Rest of Andean Pact
			29	arg	Argentina
			30	bra	Brazil
			31	chl	Chile
			32	ury	Uruguay
			33	xsm	Rest of South America
30	oce	Australia, New Zealand	1	aus	Australia
			2	nzl	New Zealand
			3	xoc	Rest of Oceania
31	jap	Japan	6	jpn	Japan
32	eas	East Asia	4	chn	China
			5	hkg	Hong Kong
			7	kor	Korea
			8	twn	Taiwan
			9	xea	Rest of East Asia
33	seas	South-East Asia	10	idn	Indonesia

			11	mys	Malaysia
			12	phl	Philippines
			13	sgp	Singapore
			14	tha	Thailand
			15	vnm	Vietnam
			16	xse	Rest of Southeast Asia
			17	bgd	Bangladesh
			18	ind	India
			19	lka	Sri Lanka
			20	xsa	Rest of South Asia
34	meast	Rest of Middle East	72	xme	Rest of Middle East
35	naf	North Africa	73	mar	Morocco
			74	xnf	Rest of North Africa
36	caf	Central Africa	83	xsd	Rest of SADC
			84	uga	Uganda
			85	xss	Rest of Sub-Saharan Africa
37	saf	South Africa	75	bwa	Botswana
			76	zaf	South Africa
			77	xsc	Rest of South African CU
			78	mwi	Malawi
			79	moz	Mozambique
			80	tza	Tanzania
			81	zmb	Zambia
			82	zwe	Zimbabwe

EURALIS sectors			Comprising GTAP sectors		
No.	Code	Description	No.	Code	Description
1	grain	Cereal grains nec	2	wht	Wheat
			3	gro	Cereal grains nec
2	oils	Oil seeds	5	osd	Oil seeds
3	sug	Sugar cane and beet, sugar	6	c_b	Sugar cane, sugar beet
4	hort	Vegetables, fruit, nuts	4	v_f	Vegetables, fruit, nuts
5	crops	Other crops	1	pdr	Paddy rice
			7	pfb	Plant-based fibers
			8	ocr	Crops nec
6	cattle	Cattle,sheep,goats,horses	9	ctl	Cattle,sheep,goats,horses
			19	cmt	Meat: cattle,sheep,goats,horse
7	oap	Animal products nec	10	oap	Animal products nec
			20	omt	Meat products nec
8	milk	Raw milk	11	rmk	Raw milk
9	dairy	Dairy products	22	mil	Dairy products
10	sugar	Sugar	24	sgr	Sugar
11	agro	Other agr-food products	12	wol	Wool, silk-worm cocoons
			13	frs	Forestry
			14	fsh	Fishing
			21	vol	Vegetable oils and fats
			23	pcr	Processed rice
			25	ofd	Food products nec
			26	b_t	Beverages and tobacco products
12	ind	Industry	15	coa	Coal
			16	oil	Oil
			17	gas	Gas
			18	omn	Minerals nec
			27	tex	Textiles
			28	wap	Wearing apparel
			29	lea	Leather products
			30	lum	Wood products
			31	ppp	Paper products, publishing
			32	p_c	Petroleum, coal products
			33	crp	Chemical,rubber,plastic prods
			34	nmm	Mineral products nec

			35	i_s	Ferrous metals
			36	nfm	Metals nec
			37	fmp	Metal products
			38	mvh	Motor vehicles and parts
			39	otn	Transport equipment nec
			40	ele	Electronic equipment
			41	ome	Machinery and equipment nec
			42	omf	Manufactures nec
13	ser	Services	43	ely	Electricity
			44	gdt	Gas manufacture, distribution
			45	wtr	Water
			46	cns	Construction
			47	trd	Trade
			48	otp	Transport nec
			49	wtp	Sea transport
			50	atp	Air transport
			51	cmn	Communication
			52	ofi	Financial services nec
			53	isr	Insurance
			54	obs	Business services nec
			55	ros	Recreation and other services
			56	osg	PubAdmin/Defence/Health/Educat
			57	dwe	Dwellings

Appendix 4 Overview of unweighed scores for all EU 25 countries

rvl	Euro25	A1	A2	B1	B2
Pr	Agrarian Production Share	-2	-2	-1	-1
Pr	Agricult. Income in relation to average income	-3	-2	-3	-2
Pr	Decrease of CAP expenses	3	-1	2	-1
	Overall Profit (unweighted)	-0.7	-1.7	-0.67	-1.3
Pe	Food self sufficiency	1	0	0	0
Pe	Population of rural areas	-2	-2	-2	-2
Pe	Cultural-Historical Landscape quality	-2	-1	0	0
Pe	Animal diseases risk				
	Overall People (unweighted)	-1	-1	-0.67	-0.7
Pl	Biodiversity 'Nature'	-2	-1	-1	-1
Pl	Support Kyoto protocol	2	0	3	3
Pl	Landdegradation	2	1	3	3
Pl	Biodiversity 'Crop land'	-2	-1	-1	0
Pl	Biodiversity "Pastures"	-2	0	-1	1
Pl	Critical load exceedance in eq/ha per ecoarea/country	-3	-1	-1	-3
	Overall Planet (unweighted)	-0.8	-0.3	0.33	0.5

Appendix 5 Overview of unweighed scores for EU 15 countries and EU 10 countries

####	META-IND	E10				E15			
	Euro10	A1	A2	B1	B2	A1	A2	B1	B2
Pr	Agrarian Production Share	-3	-3	-3	-2	-2	-2	-1	-1
Pr	Agracult. Income in relation to average income	-2	-1	-2	-1	-3	-2	-3	-2
Pr	Decrease of CAP expenses	0	-2	0	-2	3	-1	2	-1
	Overall Profit (unweighted)	-1.7	-2	-1.67	-1.7	-0.67	-1.7	-0.7	-1.33
Pe	Food self sufficiency	-1	0	0	1	1	0	0	0
Pe	Population of rural areas	-2	-2	-2	-2	-2	-2	-2	-2
Pe	Cultural-Historical Landscape quality	-2	-1	0	0	-3	-2	-1	0
Pe	Animal diseases risk								
	Overall People (unweighted)	-1.7	-1	-0.67	-0.3	-1.33	-1.3	-1	-0.67
Pl	Biodiversity 'Nature'	-2	-2	-2	-2	-1	-1	-1	-1
Pl	Support Kyoto protocol	3	2	2	3	1	1	2	2
Pl	Landdegradation	1	1	1	1	2	1	3	3
Pl	Biodiversity 'Crop land'	-3	-2	-2	-1	-2	-1	-1	0
Pl	Biodiversity "Pastures"	-3	-1	-2	1	-2	0	-1	1
Pl	Critical load exceedance in eq/ha per ecoarea/country	-3	-2	-2	-3	-2	-1	-1	-2
	Overall Planet (unweighted)	-1.2	-0.7	-0.83	-0.2	-0.67	-0.2	0.17	0.5

Appendix 6 Ranking and score distances

###	META-IND								
	Scenario Storylines	A1	A2	B1	B2	A1	A2	B1	B2
						ranking			
Pr	Agrarian Production Share	pm	pm	pm	pm				
Pr	Agricult. Income in relation to average incor	0	1	2	3	0	1	2	3
		-3	-2	-3	-2	0	1	0	1
Pr	Decrease of CAP expenses/competitivenes	3	2	2	0	3	2	2	0
	controll expenditure	3	-1	2	-1	4	0	3	0
	Overall Profit (unweighted)	1.5	1.5	2	1.5				
Pe	Food self sufficiency/Self sufficiency pot.	0	1	2	3	0	1	2	3
		1	0	0	0	1	0	0	0
Pe	Population of rural areas/viability of country	0	1	2	3	0	1	2	3
		-2	-2	-2	-2	0	1	0	1
Pe	Cultural-Historical Landscape quality/landsc	0	1	2	3	0	1	2	3
		-2	-1	0	0	0	1	2	2
	Overall People (unweighted)	0	1	2	3				
Pl	Biodiversity 'Nature'/Biodiversity	0	3	0	3	0	3	0	3
	nature	-2	-1	-1	-1	0	2	1	3
	agriculture	-2	-1	-1	0				
	grasslands	-2	0	-1	1				
Pl	Support Kyoto protocol/Greenhouse Gas m	0	3	0	1	0	3	0	1
		2	0	3	3	2	0	3	3
Pl	Landdegradation								
		2	1	3	3				
	Overall Planet (unweighted)	0	2	0	1.33				
Pe	Animal diseases Risk/Food quality+safety	1	2	1	3				
Pl	Pollution by pesticides and nutrients/reducti	0	2	0	3				

Appendix 7 Original priorities

130904	META-IND				
	Scenario Storylines	A1	A2	B1	B2
		ranking			
1	Competitiveness of EU agriculture	3	2	1	0
		2	2	1	0
2	Self sufficiency potential	0	1	2	3
		1	0	0	0
3	Food quality and safety	1	2	1	3
		pm	pm	pm	pm
4	Competitive prices of food products	0	1	2	3
		0	1	0	1
5	Viability of the countryside	0	1	2	3
		0	1	0	1
6	Biodiversity	0	3	0	3
		0	2	1	3
7	Landscape value	0	1	2	3
		0	1	2	2
8	Greenhouse gas mitigation	0	3	0	1
		2	0	3	3
9	Reduction of nutrients and pesticides loads	0	2	0	3
		2	0	0	2
10	Wealth convergence between EU-zones	1	3	0	2
		2	1	1	0
11	Wealth convergence worldwide	1	3	0	1
		1	1	0	1
12	Control expenditure and bureaucracy	3	1	2	1
		pm	pm	pm	pm