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Deliverable 3.5

Overview and interpretation of available data and information on human activity and demographic evolution

Work Package 3.2 - Human activity and demography scenarios

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1. INTRODUCTION

Deliverable 3.5 aims to present an overview of the availability of data and information on human activity and demographic evolution relevant to the SafeLand project. Therefore, information provided by institutions on the global, the EU and the national levels is assessed.

The core questions of the deliverable are:

- What are human activity and population indicators that affect or are affected by landslides?
- What recent and existing scenario projects are relevant for the activities of the SafeLand project?
- What relevant data is available for which scale, and are there forecasts for the years 2030, 2050, 2070 and 2100?

Section 2 gives a general insight into the nature of scenarios and projections and the conceptual difficulties might arise. It also includes a short discussion on some of the main issues related to data availability in Europe. Section 3 sets out the human activity and population indicators most relevant to landslides, namely land use change and infrastructure projects, and briefly describes major data sources and potential difficulties in data availability.

The next two sections focus on the prediction of land use and other relevant indicators with Section 4 being dedicated to scenarios and data that are globally relevant, while Section 5 covers the European level, integral because of the EU's role in gathering and preparing data from different level for comparative use. Reviews of relevant scenarios and projections highlight the data that is available. In Section 6 the national level is covered, especially those indicators for which no data is provided at the EU level (e.g. construction). For the national and sub-national level it was not possible to identify relevant scenario exercises both for land use in general and infrastructure in particular. Most regional studies that exist are case studies that were conducted as part of bigger, international projects.

The scenarios and projections are not organized according to indicators, because most of them include environmental as well as socio-economic variables. A summary of findings and recommendations to SafeLand are given in Section 7.

We standardized the review of scenarios as far as possible for ease of comparison. The following aspects are given for each scenario.

1.1. PROJECT CONTEXT

- Name/Details.
- Finances.
- Lead Partner.
- Aim.
- Type/role of scenarios.

1.2. SCENARIO SPECIFICATIONS

- Time horizon.
- Qualitative aspects: storylines, methods, drivers.
- Quantitative aspects: models, methods, data.

1.3. RESULTS AND LIMITATIONS

- What was the product?
- What conclusions could be made?
- What limitations are there to the scenario exercise?
- What problems were faced during the exercise?[1]

[1] We conducted the review along the line of these issues and questions, albeit not necessarily in the exact same order and covering only the points relevant for the scenario exercise.

2. BACKGROUND

2.1. SCENARIOS

Scenarios – as a tool for studies of the future – are receiving increased attention from both researchers and policy makers, who use them in different fields and sectors, on different scales and for different purposes. Environmental and especially land-use change scenarios are at the heart of the present report.

A plethora of definitions for the term scenario exists; however, most share key characteristics and fit in somewhere with the following three examples.

“Ideally, scenarios should be internally consistent, plausible and recognisable stories exploring paths into the future.” (Anastasi 1997).
“A scenario is a description of how the future may unfold based on ’if-then’ propositions and typically consists of a representation of an initial situation and a description of the key driving forces and changes that lead to a particular future state. ” (Alcamo 2008, p.15).
“Scenarios are plausible, challenging and relevant stories about how the future might unfold that integrate quantitative models with qualitative assessments of social and political trends...” (O'Neill et al. 2008, p.1).

The definition by Anastasi is a classic, emphasizing the two key criteria of a scenario – consistency and plausibility, which appear in many other definitions. Alcamo on the other hand, draws attention to key components of a scenario – the initial situation, the key drivers and the future state. Additional elements not mentioned in the definition are the time-steps (a description of changes) and the necessary alternative images (alternative pathways to the future). O’Neill’s definition includes a fact that is true for most environmental scenarios – the integration of qualitative aspects with quantitative models.

Alcamo (2008) suggested that scenarios be developed either for science or policy purposes and that they are thus, either inquiry or strategy driven. However, for many environmental issues, policy makers and stakeholders rely on scientific output for the basic understanding of these problems. Conversely, the questions important for actors in environmental policy define the research agenda. Scenarios can serve as a valuable link between science and policy. To do so and to avoid criticism, it is necessary to communicate the qualitative character of a scenario explicitly.

Qualitative scenarios Focus on narrative (storylines) Often based on participatory approaches		**Quantitative scenarios** Focus on numerical values Often based on modeling approaches	
ADVANTAGES	DISADVANTAGES	ADVANTAGES	DISADVANTAGES
Can incorporate different perspectives by involving stakeholders and experts	Assumptions behind the scenarios are not documented or articulated	Provide numerical information needed for some environmental studies	The preciseness is often misinterpreted
Can describe complex systems	Underlying assumptions cannot be tested	Assumptions can be transparent because they are documented	Models tend to bury many assumptions about the future
Storylines, if well-written can be communicated easier than numerical tables	By definition, they do not satisfy possible need for numerical information	Underlying models have often been published in the scientific literature and thus received some scientific scrutiny	Often only one point of view on how the world works is expressed

Table 1 *Comparisons between quantitative and qualitative scenarios based on (Alcamo 2008)*

While there are various scenario typologies, which serve different purposes, many in environmental studies have quoted Van Notten et al. (2003) on a regular basis. He developed an updated comprehensive typology aiming to support the credible and consistent analysis and comparison of scenarios based on the assumption that there is no “correct” scenario definition or approach. Three overarching themes comprise the key aspects of scenarios and apply to single scenarios as well as sets. The sub-division of the themes into characteristics allows for a more detailed description. This typology comprises several of the plentiful categorizations often made in scenario analysis. Other distinctions exist between process vs. product orientation (O'Neill et al. 2008) exploratory vs. anticipatory and reference vs. policy scenarios (Alcamo 2008). One basic division is often made between qualitative and quantitative scenarios (cf.*Table 1*), however, as mentioned above, recent environmental scenarios tend to combine the two because of their complementary advantages[2].

According to Tol (1998) a scenario is not:

- A prediction, understood as the best possible estimate of future developments.
- A forecast, the best estimate from a particular method or model.
- A projection “often a simple extrapolation of current trend, and often only concerns a single variable. Internal consistency is not a necessary property of projections” (Tol 1998).
- However, scientific publications use these terms randomly and there are many contradictory (across disciplines) or at least vague definitions (environmental studies). Therefore, this report suggests using these terms interchangeably as quantitative methods to evaluate the future. As such forecasts and projections may be part of quantitative scenario exercises.

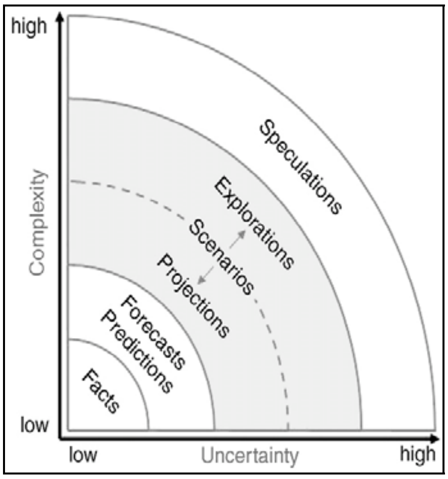

Figure 1 *Scenarios can help address uncertainty in complex systems. Source Zurek and Henrichs (2007)*

Figure 1 distinguishes between different prediction methods along two axes, uncertainty and complexity. Accordingly, scenarios should be applied in complex contexts of high uncertainty. Petersen et al. (2003) suggest studying the degree of uncertainty and controllability of a system for placing scenarios.

[2] E.g. SAS (story and simulation) approach.

Population Projections

The discipline of demographics defined, and used more distinctly, population projections. Statistical bodies, international institutions and demographers use them as an independent tool to study future developments of populations. Well known population projections are published by the UN, IIASA[3] and EUROSTAT.

UN definition of population projections and forecasts (UNDESA 1982):

“Population projections are calculations, which show the future development of a population when certain assumptions are made about the future course of population change, usually with respect to fertility, mortality and migration. They are in general purely formal calculations, developing the implications of the assumptions that are made. A population forecast is a projection in which the assumptions are considered to yield a realistic picture of the probable future development of a population.”

Contrary to Tol (1998), Preston et al. (2001) highlight in the UN definition that internal validity is an integral part of projections.

EUROSTAT definition of population projections[4] (Eurostat 2008):

” Population projections involve making population estimates or producing the most plausible figures for the years to come. Estimates are made using the latest available figures for the population on 1 January. In general, key assumptions are made with respect to mortality, fertility and migration by sex and by age, and ageing techniques are applied to the population pyramid from year to year.”

2.2. DATA AVAILABILITY

An abundant supply of data on all kinds of issues is available throughout Europe and the rest of the world. However, most countries and organizations that collect the data use different definitions of indicators, different methodologies and different territorial units. Depending on the region, data is more or less complete and reliable.

Since 1958[5], EUROSTAT has been the statistical office of the European Union. Though its role has changed throughout the decades, its key task is to provide statistics and methods at the European level that enable comparisons between countries and regions. Therefore, the Nomenclature of Territorial Units for Statistics (NUTS – nomenclature d’unités territoriales statitiques), a geocode standard for referencing the subdivisions of countries was developed. Data on these levels is available in detail for the EU-27, and also for EFTA and candidate countries (Croatia, the Republic of Macedonia and Turkey). European statistics are usually,

[3] Lutz et al. (1997) developed a probabilistic approach to population projections that explicitly takes into account the uncertainties affecting population development.
[4] EUROSTAT uses population projections and forecasts interchangeably.
[5] EUROSTAT was first established in 1953 to meet the requirements of the Coal and Steel Community (*http://*ec.europa.eu/eurostat) .

but not exclusively, based on national data produced and disseminated by the national statistical authorities of the Member States. Depending on their reliability EUROSTAT can provide more or less complete data sets. The most consistent data sets are available for demographic and economic indicators. For environmental data, Environmental Data Centers have been set up[6].

The United Nations Economic Commission for Europe (UNECE) developed a comprehensive database of land use indicators: these include the indicators such as those necessary for infrastructure and of areas used for different activities such as forest lands, conservation areas for biodiversity and landscapes, areas for plantations and seeds, wooded lands for cultural or spiritual values, etc. One of the main limitations of the UNECE database is that some of the data are old, and are not updated on a regular basis. Furthermore, it only provides data for the European countries.

The Organization of Economic Cooperation and Development (OECD) provides quantitative data on most economic, social and environmental issues for all its member countries. However, most of the OECD data are not relevant for land use as they describe the economic situation in the OECD countries on the basis of such indicators as foreign direct investment, public finance, insurance etc. Some of the data can be used indirectly for land use scenarios; such data includes the welfare, population growth, unemployment, regional migration etc. Most of the information is available on country level only. There is however a regional database covering 40 socio-economic indicators. The regions have been classified according to two territorial levels (TL): TL 2 encompasses macro-regions and TL3 encompasses micro-regions, which have been categorised on the basis of geographic setting into predominantly rural, intermediate or predominantly urban. In Europe these two levels correspond to NUTS II and III. General data is available online, while a request must be submitted for more detailed information. OECD and EUROSTAT work closely together on most statistical issues.

[6] Air, climate change, water, bio diversity and land use are located at the EEA; soil and forestry at the JRC; EUROSTAT operates the center on waste, natural resources and products.

3. HUMAN ACTIVITY INDICATORS

Human activities are all intentional and unintentional actions taken by man. In the particular case of landslides, “human activities” refer to those actions that trigger landslides or influence parameters likely to trigger landslides: e.g. erosion, changes of natural drainage, leaks of liquid, modification of slopes, digging, vibrations, and displacement of soils and rocks. Human activities combine with natural factors and prerequisites (e.g. soil conditions, local climate, extreme weather events, flora and fauna) to cause landslides.

The main focus of this report will be on land use, because it is in these categories that the highest potential to influence the initiation of landslides exists.

The land uses that globally influence mass wasting are timber harvesting, forest conversion, grazing, recreation and fire. Concentrated human activities and disturbances that locally affect slope stability are roads, urban development and mining (Sidle & Ochiai, 2006, p.163).

3.1. LAND USE AND LAND COVER CHANGE (LUCC)

Land cover is the biophysical conditions of the land, whereas *land use* is the intent to which land covers are managed (Turner, 2005).

”Land use in its functional dimension corresponds to the description of areas in terms of their socio-economic purpose: areas used for residential, industrial or commercial purposes, for farming or forestry, for recreational or conservation purposes, etc.” (EUROSTAT, 2000). It is closely related to *Land cover*, which is the directly observed (bio) physical condition of the surface: e.g. forests, fields, bare soil, rocks, buildings and lakes. Land cover can be mapped by remote sensing, whereas land use has to be identified by indirect methods such as interviews. Mapping land cover can be an intermediate step to map land use (Skidmore, 2005). Changes in land cover can be triggered by natural events and/or human activity. Changes in land use may lead to changes in land cover.

In both land use and land cover, definitions and categories are constructed by its users and thus, vary depending on the institution, the research project or the country. We use definitions based on the EUROSTAT’s Concepts and Definitions Database (CODED), the Encyclopedia of Land-use and Land-cover change (2005) and the Encyclopedia of Soil Science (2005). In some cases instead of using either *land cover* or *land use change* we apply the term *land change* to cover both.

Changes in land cover contribute to a series of major changes affecting the environment on different scales: greenhouse gas emissions, the earth’s heat balance (reflectivity) and the hydrologic cycle, including local and regional precipitation impacts. These change fragment ecosystems and watersheds and trigger biodiversity losses, soil erosion and sedimentation (Turner, 2005). Changes in land use, in turn, add to these effects not only by leading to land cover change but also by intensifying soil and air pollution, drawing down water stocks and causing other kinds of soil degradation. The massive impacts of land change on the environment and its contribution to environmental change put land change ahead on the research agenda. “Even though there is no doubt that land use has a significant effect on the probability of landslides, its influence is still discussed controversially in literature with respect to the various mountainous regions.” (Meusburger & Alewell, 2008)

3.1.1. Data on land use and land cover change

- **Global**

The World Bank has no comprehensive data set on land cover or land use; however, it provides key indicators on land use such as surface area in thousands of sq. km, urban development as a percentage of urban population and urban population growth, agricultural land as a percentage of arable land and as a percentage of permanent cropland, land under cereal production in hectares, rural population density in rural population per 100 sq. km of arable land, population density in people per sq.km, millennium development goals such as forest area as a percentage of land area, marine protected area as a percentage of surface area and nationally protected areas as a percentage of total land area

- **Europe**

The EU CORINE (Coordination of information on the environment) program was initiated in 1985, and is part of the EEA work program since 1994. Until 1990 the EEA developed an information system on the European environment and methods and nomenclatures were agreed at the EU level. The first European wide land cover inventory, CLC90 was realized between 1986 and 1998. Since then two updates have been launched CLC2000 and CLC2006[7]. Jointly with CLC2000 the IMAGE2000 project was initiated. Also in 2000 land use change was integrated. Both CLC2006 and IMAGE2006 are part of the European Land Monitoring Service. CLC2006 is available in seamless vector data. It covers the EU15, EU25, EU27 as well as Albania, Bosnia and Herzegovina, Croatia, Iceland, The Former Yugoslavian Republic of Macedonia, Montenegro, Norway, Serbia and Turkey. It provides data on almost all indicators relevant to landslides: e.g. road and rail networks and associated land; mineral extraction sites; continuous/discontinuous urban fabric; construction sites and all kinds of agricultural use and irrigation.

CORINE land cover is based on the ground-surveyed LUCAS (Land Use/Cover Area frame statistical Survey). LUCAS is an in-situ land cover and land use collection with a harmonized nomenclature that covers the entire EU territory. Based on statistical calculations it provides results on area entities (with the currently applied sample density on regional level and higher). Direct observation of the ground, allows for the delivery of a detailed land cover classification (e.g. distinction between different cereals like wheat and rye). As all LUCAS points are georeferenced and re-sampled during the time, the survey also allows monitoring the condition of the environment in Europe (EUROSTAT 2000).

The website of the EEA[8] provides data downloads and more detailed information, such as a list of available GIS data.

The EU's FP4 (RTD) funded the Pan-European Land Use and Land Cover Monitoring (PELCOM, 1996-1999). The project aimed at elaborating a land cover database at a 1-km solution that can be updated periodically based on the use of multi-spectral and multi-temporal NOAA-AVHRR satellite and ancillary data.

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[7] Details on CLC2006 can be found in the EEA Technical report No 17/2007 ("CLC 2006 Technical guidelines").

[8] The European Topic Centre on Land Use and Spatial Information supports the EEA in its work of collecting, analysing, evaluating and synthesising information: http://etc-lusi.eionet.europa.eu/.

The Space Applications Institute (SAI) of the Joint Research Institute (JRC) provided the MARS (Monitoring Agriculture by Remote Sensing), which was the core data source archive. The NDVI monthly maximum value was composited for 1997. The DLR (Deutches Zentrum für Luft und Raumfahrt) provided the main data source for the classification processes. The Digital Chart of the World (DCW) and the CORINE land cover database provided additional data[9].

3.1.2. Human induced land use change (Human activities)

Demographic and economic indicators influence landslides indirectly through land use change. Both have been identified as determinants of environmental change and thus, land use change. Although the concept of underlying driving forces[10] is a useful analytical tool, operational difficulties still occur. In particular the complex interactions of factors that in practice influence land use change and difficulties in quantifying some social and cultural components hinder a straight forward application of the concept.

The I=PAT equation (I = environmental impact, P = population, A = affluence and T = technology) is one of the conceptual sources for the underlying drivers of environmental change. The expression arose in the 1970s at a time when population and human affluence were growing rapidly and technological innovations exploded and fears concerning the sustainability of the world's resources were omnipresent. The very rudimentary equation has long since been adapted and extended by the Land Use and Climate Change (LUCC) research community.

Currently there are five well-established categories of driving forces for environmental change and land use change in particular: Population, economic development, technology, institutions and culture (Mather, 2006). Such factors have been analyzed to different extents both individually and more commonly in multi-causal contexts.

Population and economic development (affluence)

Population has been on the agenda as a driver of change since the days of Thomas Robert Malthus (1766-1834), who – in a nutshell – postulated that a growing population needs more agricultural land for food production. This causality has been proven many times since its first official pronouncement and before. To this negative relationship that seems so natural an alternative view emerged in the 20th century, when in certain parts of Europe agricultural land use decreased while the population was still growing due to intensification, global trade and agricultural production displacement for example.

Linking population dynamics and changes and land use seems to be a logical almost intuitive step. However, while a statistically significant relationship has been established, the level of explanation is limited (Mather, 2006). The geographical patterns of trade are another complicating factor. Neither communities nor regions nor cities or nation states are closed systems; therefore, population growth does not necessarily mean deforestation at the frontiers of the cultivated land in the region.

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9 More information is available at: http://www.geo-informatie.nl/projects/pelcom/public/index.htm.

10 Underlying driving forces need to be distinguished from proximity causes. The latter refers to immediate agents of change (e.g. the act of creating an artificial lake).

Social organizational and institutional patterns, factors that were missing in the original I=PAT equation, also led to limited explanation potential in the past. Especially since the 1970s land use change has been subject to increasing control by planning authorities.

Still, population is commonly used as a driver of environmental change. The main reason therefore is the availability and simplicity of the necessary data.

Economic development factors show weaknesses similar to those of population factors. The relationship between affluence and changes in land use are plausible and easy to argue on a superficial level. Increasing wealth leads to more demand, leads to more consumption which then needs higher production and thus more land. Again easily quantifiable data are available, preferably the Gross Domestic Product.

Technology and institutions

Both technology and institutions as drivers of land use change are far more difficult to grasp than population and affluence. They are passive or facilitative factors, which mediate between population and economy on the one hand and land use on the other. They are difficult to quantify, but their effects should not be underestimated.

Notwithstanding the foregoing, the influence of technological innovations on land use is important. Stronger gear, faster and long distance transport facilitated extensive land use. Technologies that enabled global communication and trade also made sure that the formerly true and direct relationship between population and land use is not as easy to explain anymore.

Institutions and social organization have long been neglected when scrutinizing drivers of environmental change. Qualitative scenarios are usually developed to try to meet these concerns. They consider existing and potential policies, governance regimes and sometimes even traditions and values.

Scenario exercises that combine qualitative and quantitative approaches can help to integrate most of the above mentioned driving forces and may be capable of showing the complex relations between them.

3.2. INFRASTRUCTURE

The term infrastructure is used to describe technical structures that support a society. These include roads, water supply, sewers, power grids, telecommunications, etc. It is possible to construct scenarios and projections that describe how the different types of land use will be affected by growing infrastructure in terms of the land surface needed for different kinds of infrastructure like transportation, energy, water and waste management.

- The transportation infrastructure is described by such indicators as roads and highway networks, railways including structures and terminal facilities, canals and navigable waterways, seaports and lighthouses, airports, including air navigational systems, mass transit systems such as subways, tramways, trolleys and bus terminals, bicycle paths and pedestrian walkways.
- The energy infrastructure includes electrical power networks such as generation plants, electric grids, substations and local distribution, natural gas pipelines including storage and distribution terminals and local distribution networks, petroleum pipelines

including storage and distribution, district heating systems including production and distribution.

- Water management infrastructure includes systems of pipes and others for drinking water supply, sewage collection, drainage system, major irrigation systems and major flood control systems.
- Waste management facilities include areas needed for solid waste landfills and incinerators as well as hazardous waste disposal facilities.

Infrastructure is a very broad term and comprehensive data sets, which cover all infrastructure spatially referenced, are limited. Infrastructure can be considered a form of land use which may affect soil and erosion and thus influence landslides at a local scale.

The CLC data sets cover several infrastructure indicators (cf. Section 3.1.1). Energy and water infrastructure, in particular pipelines are typically mapped on the national level. For the purpose of landslides risk assessment, data needs to be spatially explicit, which is straightforward for current structures but can be difficult for future projections.

- In the following scenario analysis, infrastructure is therefore an almost negligible aspect even though it implicitly appears in some land use scenarios. National and regional planning documents as well as land use plans may indicate certain construction projects and trends.

4. GLOBAL SCENARIOS

4.1. GLOBAL ENERGY ASSESSMENT

4.1.1. Project context

The Global Energy Assessment (GEA) project is funded by a group of national and international organizations, among them the World Bank, UNEP, UNDP, IEA, etc. and is conducted by the International Institute of Applied Systems Analysis (IIASA). The main aim of GEA is to examine the influence of global challenges on the energy systems including available technologies and resources, future energy systems and policies, have on the energy system. The following issues are connected with these challenges: social and economic development, Millennium Development Goals, environmental protection, climate change mitigation, governance and security; and are taken into consideration. All examined issues are addressed from global, regional and national perspectives.

4.1.2. Scenario specifications

The global issues are characterized by five groups of indicators:

- Social development includes energy access, poverty alleviation, income generation, food security, gender, inter-generation and lifestyle issues,
- Environmental issues are characterized by indicators of environmental pollution and land degradation from the energy production and use. At the global level the impacts of climate change and mitigation and adaptation measures as well as of major chemical cycles are studied,
- Health impacts issue is studied at three levels, households, local/regional and global. These concentrate on impacts on health from different types of energy generation and transmission as well as on economic costs of energy-related issues are investigated,
- Security issues cover a range of topics such as regional cooperation, trade relations, global private sector dynamism, resource, infrastructure adequacy and system resilience,
- Economic issues include financing, innovation, investment flows, governance issues, barriers, policies and institutional framework for deployment of energy technologies.

The GEA provides assessment of global and regional scenarios in light of the main question on how energy systems for sustainable future can be realized. This touches on three issues: major constraints related to resources, investment and technologies; physical uncertainties related to climate and resources and human uncertainty related to policy and development; capacity-building and investment needs for infrastructure development and technology innovation. The GEA provides assessment of urban and rural land use connected with energy generation, transmission and use. It evaluates as well land use in relation to competitive use for other goals such as food and fibre as well as land use for disposals of energy related waste.

4.1.3. Results and limitations

The work on the GEA is still on-going but there are already some preliminary results. One of the preliminary results shows a relation between different types of infrastructure land use, like land use required for energy generation, transport and distribution for fossil fuels and renewable resources.

4.2. GLOBAL ENVIRONMENTAL OUTLOOK

4.2.1. Project context

The Global Environment Outlook[11] (GEO) project is led and financed by the United Nations Environment Program (UNEP). The time horizon is up to the year 2050. The overall aim is environment and development, especially on intra and intergeneration equity and addressing inter-linkages between environmental issues such as air and water pollution, land degradation, climate change and biodiversity loss.

4.2.2. Scenario specifications

The scenario exercise highlights the pressure of human demands on land resources, which causes land degradation. It identifies the most dynamic elements of land use change such as changes in forest cover and composition, cropland expansion/intensification and urban development.

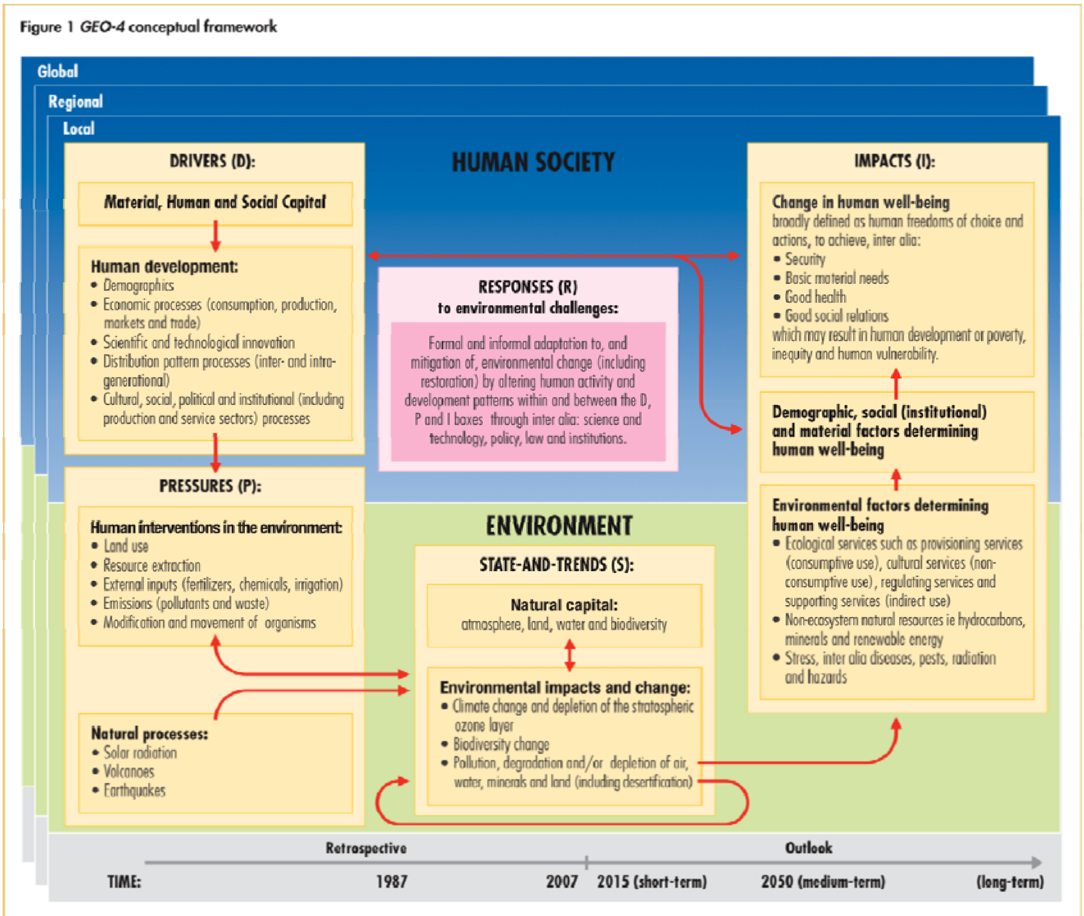

Figure 2. *GEO conceptual framework (UNEP, 2007)*

11 http://www.unep.org/geo/

It has four storylines: “market first”, “policy first”, “security first” and “sustainability first”. These storylines explain how social, economic and environmental trends influence environmental and human well-being and their vulnerability to environmental change.

- Markets First supposes that the private sector with active government support provides maximum economic growth. The economic well-being leads to environmental and human well-being. This scenario understands that the market takes over the services previously delivered by the government and means continued movement towards free trade and commoditization of nature. In terms of financing it understands movement towards direct investment and private donations and reduction of official development assistance.
- Policy First supposes that governments with the support of the private sector initiate policies that stimulate economic development. The emphasis is on a top-down approach due to the desire to make rapid progress on key targets. The main characteristic of this scenario is a highly centralized approach, lead by international institutions, to balance strong economic growth with potentials for environmental and social impacts. It is combined with increased public investment in science and technology.
- Security First supposes that governments and the private sector together make efforts to improve or maintain the well-being of the rich and powerful in a society. It focuses on regional and national rich minorities. This scenario involves restricted migration, trade barriers, continued conflicts, lack of resources for many individuals, expenditures, on security grows at the expense of other investment in other objectives. The government is influenced by multinational corporations, efforts are made to reduce corruption and the role of international organizations declines.
- Sustainability First supposes that governments, civil society and the private sector work together to improve environmental and human well-being. It speaks about accountability, transparency and legitimacy of all actors. It places emphasis on development of effective public-private partnerships not only in the context of project management but also in governance. This scenario is marked by a significant increase of allocation of resources to social and environmental needs and a reduction of military expenses.

Under all four scenarios the key drivers of environmental change include: institutional and socio-political frameworks, demographics, economic demand, markets and trade, scientific and technical innovation, and value systems. All these drivers involve decisions of actors whether to act or not with respect to environmental change.

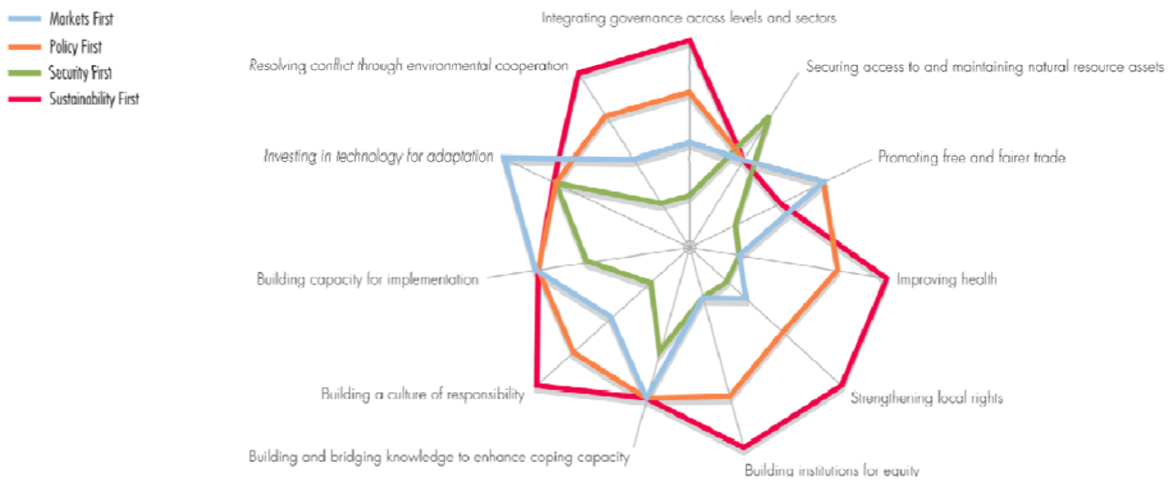

***Figure 3**. Strength of investments in opportunities to reduce vulnerability in human-environment systems and improving human well-being (UNEP, 2007).*

The scenarios use quantitative data on both regional and global levels. In presenting its four scenarios UNEP uses the drivers-pressure-state-impacts-responses (DPSIR) framework.

Several global and regional models were used to assess future environmental change and its impact on human well-being. These models were soft-linked, where output from one model was used as an input for another model. The models were calibrated for the basis year 2000. The scenario uses the following models:

- The International Futures (IFs) model provides population trends and development in GDP. This large-scale integrated global modeling system serves as a tool for analysis of long-term country-specific, regional and global futures for several areas.
- The WaterGAP (Water-Global Assessment and Prognosis) provides data on water use and availability. It gives a basis for assessment of current water resources and uses and an integrated perspective on impacts of climate change and socio-economic drivers on the future water sector. Water availability, stress and use describe irrigation, domestic, manufacturing and electricity production sectors.
- EwE (Ecopath with Ecosim) model gives estimates on catch, profits and quality of marine fisheries.
- The GLOBIO model evaluates impacts, which are caused by several factors on biodiversity.
- The LandSHIFT model provides land use dynamics and their impacts on environment at global and continental levels.
- The CLUE-S (Conversion of Land Use and its Effects) modeling framework gives projections for national land use change. It dynamically stimulates interactions between land use types. It provides detailed estimates of land use change for Western and Central Europe.
- The AIM (the Asia Pacific Integrated Model) gives assessment of policy options for stabilizing global climate and a range of other environmental problems.

The scenarios use quantitative data on both regional and global levels. In presenting its four scenarios UNEP uses drivers-pressure-state-impacts-responses (DPSIR) framework.

4.2.3. Results and limitations

Land use is affected differently under each of the four scenarios. Depending on the scenario, it will be influenced by such factors as demand for food, free trade, phasing out of agricultural subsidies, technological advances, growth of cities and increased demand for biofuels. The competition for land use will result from different goals such as production of biofuels to achieve climate goals, production of food to achieve food security and designation of areas for biodiversity.

All scenarios show that investment in health, education and environmentally friendly technologies result in an increase of GDP per capita. This increase will be higher in Sustainability First and Policy First than in Market and Security First scenarios.

All scenarios show a slow-down of environmental change, but the peak rate of change and the end point differ significantly. This will lead to different risks of abruptly accelerating changes, which can be irreversible. The reliance on markets in Market First shows a more significant pressure on the environment due to climate change and the growth of infrastructure and the slow-down of advances in achieving social targets. In Market First national economies continue to rely on fossil fuels due to little effort to reduce CO_2 emissions. Market First shows, that 13% of all existing original species will be lost and the CO_2 concentration will increase over 560 ppm. In comparison, the Sustainability First shows that only 8% of all existing original species will be lost and the CO_2 concentration will reach 475 ppm.

The total forest area will decline. However, by 2050 in all four scenarios the rates of pasture land expansion and forest loss will be declining steadily. Under the Security First scenario, the most significant losses will be of forests land use. The Policy First scenario shows prevention of changes in land use of terrestrial and marine protected areas. Under Sustainability First there will be an increase in land designated for terrestrial and marine protection. The most significant changes in land use will be in Central Africa, parts of Latin America and the Caribbean and parts of Central Asia as biodiversity in these regions will need to compete with food production and biofuels.

The land use for agriculture increases in all scenarios, especially for pasture. Globally there is a slight decline in land use for food crops but an increase in grazing land. The increase is the smallest under the Security First scenario. In Market First the growth in demand for land is compensated by technological development. In Sustainability First technological development is counterbalanced by greater concern for food availability. In Policy First this increase is the highest due to higher population growth; the lands devoted to pasture will increase significantly while land for crops will decline slightly.

4.3. MILLENNIUM ECOSYSTEM ASSESSMENT

4.3.1. Project context

The Millennium Ecosystem Assessment[12] project is coordinated by UNEP. The project provides a time horizon up to the year 2100 with its focus on ecosystems and sustainability. It estimates factors at local, regional and global level, which can directly and indirectly affect

[12] http://www.maweb.org

human-well-being and ecosystems. A driver is any factor that changes an aspect of ecosystem. The assessment develops scenarios, which connect possible changes in drivers with human demand for ecosystem services. These demands are then linked to the future of services themselves and to the aspects of human welfare, which depend on these services. The indirect drivers of change include demographic, economic, sociopolitical, science and technology, cultural and religious factors. Direct drivers include changes in local land use and coverage, introduction or removal of species, technology adaptation and use, external inputs, harvest and resource consumption, climate change, natural, physical and biological drivers.

4.3.2. Scenario specifications

The assessment uses ten categories to report its findings. Among them are such categories, relevant to land use, categories as coastal lands, forest, dryland, island, mountain, polar, cultivated and urban. Two of the scenarios involve proactive and two reactive environmental management policies.

The environmental system models measure the consequences of a change in land cover or climate. The human system models examine the impacts of changes in ecosystems on production, consumption and investment decisions by households, or the economy-wide impacts of climate change on production of a particular sector. The integrated models assess environmental and human system linkages at global and sub-global scales. CLUE-S, IMAGE and SAfMA are the main models.

The scenario includes four storylines:

- Global Orchestration (GO): a globally connected world with well-developed global markets and supra-national institutions to deal with global environmental problems and inequity, to protect and enhance global public goods and services. This scenario focuses on individual decision rather than on the state and uses regulation only where appropriate. Trade liberalization and free market are key issues.
- Order of Strength (OS): a world with fragmented connections with security and protection of regional markets and with little attention paid to the common good. The main issue is defence against economic insecurity, military and protection of lifestyles of the rich world by securing natural resources as critical for human well-being. The poorer countries are provided with some benefits but only in exchange for alliance.
- Adapting Mosaic (AM): a fragmented world resulting from discredited global institutions leads to the rise of local and regional initiatives supporting the common good. The trade barriers for goods and services increase but disappear for communication technologies. There is great regional variation in management techniques but global problems like climate change, marine fisheries and pollution get worse.
- TechnoGarden (TG): a globally connected world relying strongly on technology, also for solving environmental problems and global inequity. The ecosystems are highly managed and often engineered. The risks appear connected with large-scale human-made solutions.

4.3.3. Results and limitations

The scenarios provide an analysis of the impact of diverse drivers like climate change, population growth and the rate of urbanization. Climate change will influence all four scenarios and will lead to a loss of coastal wetlands due to sea level rise. The effects will be the strongest under GO, OS and AM scenarios. Population pressure will be high in OS and AM scenarios. Urbanization rates will be high under three scenarios – GO, OS and TG. In the GO scenario the rates will be high because of wealth and technological lifestyles, which will grow in all countries. In the OS scenario they will be high in rich countries as wealth and technological lifestyles grow. Urbanization rates will be high in poorer countries due to poverty and rural decline. In the TG scenario they will be high as ecosystems are managed remotely. In the AM scenario the rates will be moderate as people reconnect with nature and many decide to live in rural areas. The fast urbanization rate will affect infrastructure most strongly under the OS scenario when urban sprawl will compete with agriculture for the best land and water pollution will become progressively worse, as problems relating to poor infrastructure for dealing with urban waste and crop management are not addressed.

These three drivers will have different impacts on diverse types of land use such as agricultural land use, wetlands, drylands and wildlands. In OS and GO there will be a long-term increase of conversion to agricultural land use. The TG and AM will see the restoration of wetlands. The changes in drylands will be mainly due to the pressure of land management rather than climate change. In the GO scenario a significant decrease in material poverty will lead to a decrease in dryland degradation. In TG and AM there will be opportunities for reducing dryland degradation, in TG due to technological progress, in OS due to improvement of local knowledge and property rights for better managing agriculture and ecosystem services. OS will see the greatest degradation through the whole period. In the GO scenario the wildlands will be greatly affected by humans who use them for leisure and agriculture. At the same time marine ecosystems and coastal wetlands will be affected most strongly as urban land use will concentrate along coastlines and river mouths. The human impacts on terrestrial ecosystems will increase as the total area for agriculture expands. There will be a significant increase in land used for crops and livestock to satisfy growing global standards of life. The rapid expansion of crops will lead to a reduction of forest land use especially dramatically in the Sub-Sahara where 50% of forest will disappear. As an impact the population growth will be limited due a maximum of 8 billion by 2050.

4.4. IPCC SPECIAL REPORT ON EMISSION SCENARIOS (SRES)

4.4.1. Scenario context

In 2007 the Intergovernmental Panel on Climate Change (IPCC) released its Fourth Assessment Report (IPCC, 2007) and is currently preparing the Fifth Assessment Report. A set of scenarios was developed by different authors in the frame of the IPCC Special Report on Emission Scenarios (SRES) for the time horizon up to the year 2100. These scenarios were used to analyze the feasibility of meeting a range of climate stabilization targets. They encompass a multi-sector and multi-GHG perspective and focus not only on energy but also on the agriculture and forestry sectors. The scenarios not only investigate mitigation potentials across these sectors but also investigate important interdependencies like competition for land use between sectors. The scenarios consider the impacts of climate change e.g. changes in agricultural production or water needed for agricultural production (Watson et al., 2000).

The IPCC uses General Circulation Models (GCMs) to construct and apply climate change scenarios to climate change impact assessments. The GCM data are available as monthly means, and as 20- and 30-year monthly climates for the 2007 IPCC Fourth Assessment Report, 2001 IPCC Third Assessment Report and 1995 IPCC Second Assessment Report.

The data were collected by the IPCC Task Group on data and scenario support for Impact and Climate Analysis (TGIGA) and contain data on atmospheric composition, land use and land cover, sea level, water availability and water quality.

The SRES scenarios comprise four storylines, which yield four sets of scenarios called "families". The sets of scenarios consist of six scenario groups drawn from four families; one group in A2, B1 and B2 and three groups within the A1 family, which characterize alternative developments of energy technologies such as A1FI (fossil fuel intensive), A1B (balanced) and A1T (predominantly non-fossil fuel). The "HS" stands for harmonized assumptions on global population, gross world product and final energy. "OS" denotes scenarios that explore uncertainties in driving forces beyond harmonized scenarios.

The four main storylines are:

- A1 (global economic) describes very rapid economic growth, rapid development and the introduction of new technologies, a large increase in global food demand, less emphasis on food quality and environmental issues. It includes rapid market-driven growth, with convergence in incomes and culture and rapid technological change;
- A2 (regional economic) describes less concern for rapid economic development, emphasis on maintaining regional cultural identities, increasing food demand for Europe and less concern about environmental issues. It understands self-reliance and preservation to local identities and fragmented development.
- B1 (global environmental and equitable) puts emphasis on global solutions, clean and environmental friendly technologies, large increase in global food demand, interest in food quality and environmental issues. This storyline is similar to A1 but puts more emphasis on global solutions to sustainability and relies more heavily on technology.
- B2 (regional environmental and equitable) emphasises local solutions and the sustainable use of local resources, little change in food demand for Europe, the quality of life and food. It speaks about local technological and policy solutions to economic, social and environmental sustainability.

4.4.2. Results and limitations

The major goal of scenario work is to show changes in Green House Gas (GHG) emissions related to energy, industry and land use changes as well as to different socio-economic developments and a number of other driving forces. With regards to land use, A1 scenario provides different assumptions about technology and resource dynamics, which result in divergent paths for developments in the energy system and land use patterns. In most scenarios global forest area continues to decrease due to increasing population and income growth. The changes in agricultural land use are driven by changes in food demand caused by demographic and dietary shifts (Riahi et al., 2007).

5. EUROPEAN SCENARIOS

5.1. ATEAM

5.1.1. The project context

The Terrestrial Ecosystem Analysis and Modeling (ATEAM[13]) project has as its primary objective the assessment of the vulnerability of human sectors relying on ecosystem services with respect to global change. Vulnerability is considered as a function of potential impacts and adaptive capacity to global change. ATEAM accessed vulnerability as a degree to which ecosystem service is sensitive to global change and the degree to which any sector relying on this service will not be able to adapt.

5.1.2. Scenario specifications

The land use scenarios for future land use in Europe use the year 2000 as a base year and provides further scenarios for 2020, 2050 and 2080 for Europe, mainly the EU15, plus Norway and Switzerland. The ATEAM vulnerability assessment framework translates multiple scenarios of global change into their potential impacts and adaptive capacity changes on the basis of combined indicators and stakeholder dialogue. Vulnerability maps can then be developed for multiple scenarios and time-slices within the next century (Metzger et al., 2006).

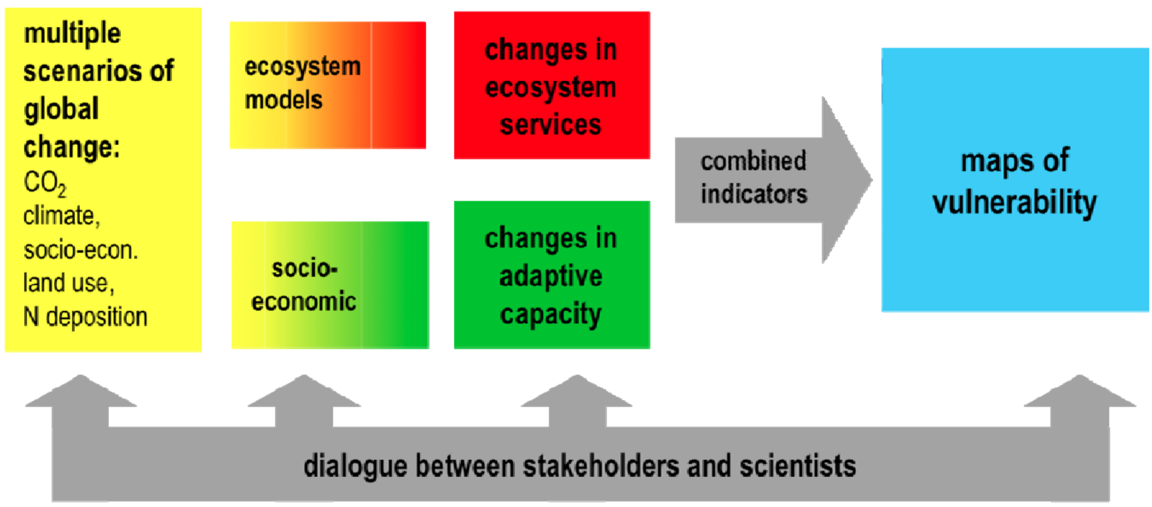

Figure 4*. Schematic overview of the ATEAM vulnerability assessment framework (Schröter et al., 2004).*

The ATEAM approach uses three levels in derivation of land use scenarios: first, qualitative descriptions of socio-economic storylines, second, description of European sector driving forces, third, quantitative projections of regional land use change.

ATEAM uses qualitative methods to describe global socio-economic storylines, including those from multiple socio-economic, climate, land use and nitrogen deposition scenarios of global change. The storylines are then applied to Europe which stimulates dialogue between

[13] Available at: http://www.pik-potsdam.de/ateam/ateam.html.

stakeholders and scientists as a part of the assessment to provide applicable results to the management of natural resources in Europe.

ATEAM based the assessment of each land use type on an interpretation of the SRES narrative storylines for European regions using knowledge about past and present European and national policy. It identified regional trends for some land use types. The project identified drivers for four kinds of land use: urban use, agricultural use, forestry and protected areas.

- ATEAM defines the urban land as land covered by buildings and other man-made structures like services, industries and transport infrastructure. The scenarios highlight the importance of this type of land use. Urban areas representing only a small proportion of the Pan-European land-cover database (PELCOM) map (1.5%), however about 80% of EU citizens live in cities with populations of more than 10,000 inhabitants. It identifies two main drivers for the *urban-demand model*: population, reflecting demographic trends and demand for housing, and economic development, reflected by degree of activity, types and intensity of activities and economic dynamism. Four variables were used as drivers of spatial patterns. These are accessibility of transport networks (reflecting transport innovation and quality of infrastructure), degree of restriction arising from land use planning policy and relative attractiveness in terms of residential location-choice of small, medium and large cities (reflecting different urbanization processes) and competition with other land uses, such as protected areas.
- ATEAM identifies the following drivers for *agricultural land use*: supply and demand market intervention through agricultural policy, rural development policy, environmental policy, EU enlargement, resource competition (urbanization and bioenergy crops), role of WTO and climate impacts through effects on productivity.
- It identifies such drivers for the *forestry land use* as forestry policies, which have a strong national and sub-national character. Unique features of this type of land use, such as a long rotation time, were highlighted.
- It identifies such drivers for *protected areas* as alternative multifunctional use for conservation and recreation goals, European and national policy for nature conservation as well as demand for recreation and tourism.

Models: The global change projections, as well as the socio-economics of land use scenarios, are based on the IPCC Special Report of Emission Scenarios (SRES) A1f, A2, B1 and B2. ATEAM uses four different general circulation models (GCMs) such as PCM, CGCM2, CSIRO2 and HadCM3. A set of state-of-the-art ecosystem models translates global change scenarios into potential environmental impacts. Assessment of the total area requirement of each land use serves as a function of changes in relevant drivers and was based on outputs from the global scale IMAGE 2.2 Integrated Assessment Model on commodity demands at the European scale, which provides demands for agricultural and forestry products.

The indicators of adaptive capacity evaluate the ability of mankind to implement planned adaptation measures. A spatially explicit generic macro-scale index of adaptive capacity evaluates the adaptive capacity of the regions.

Data from the PELCOM (Pan-European land-cover database) 1 km resolution land cover data set was combined with the REGIO statistical database at the NUTS2 level and the IPCC Data Distribution Centre. Additional data came from the CORINE land cover map while climate data stemmed from TYN SC 1.0 scenarios.

5.1.3. Results and limitations

ATEAM produced two main products: a CD-ROM with an interactive ATEAM mapping tool (Metzger et al. 2004) and a collection of papers on agricultural scenarios and biofuels, forest land use and protected areas for the journal special issue entitled Regional Environmental Change. One of the results was the production of spatially explicit maps of vulnerability and its components for multiple scenarios and time slices within the next century[14]. The ATEAM results helped to evaluate the effectiveness of environmental management implementation measures such as the European Biodiversity Strategy, and provided input to debates on the Kyoto protocol and the design of climate protection strategies.

The main result is that the provision of essential ecosystem services will alter significantly with global change due to severe European climate and land use changes, but that the vulnerabilities of specific sectors can be reduced through adaptation strategies. Some of the impacts will be positive, for instance an increase in productivity, forest areas and, potentially, surplus land for agriculture. However, the majority of impacts will be negative like the decline of soil fertility, increased fire risk and loss of biodiversity. One of the important results is that changes in land use are affected not only by events inside Europe but also from outside of Europe such as trends in global trade patterns.

- Climate change will significantly influence crop production in agricultural regions. The overall surface of arable land in Europe will decline as some regions become too hot and dry, but this will be balanced to some extent as the suitability for crop production in other areas expands. This result is particularly significant in the evaluation of the potential of biomass energy. Large reductions in agricultural areas for food production, especially grasslands, where scenario A (economic) will see the greatest decline and scenario B (environmental) the least decline, will be caused by technological development and compensated by increases in bioenergy production, forest cover, and areas for conservation and recreation.
- Climate change will have positive effects on the forest areas of northern Europe but in southern Europe drought and fire will be the main risk.
- The Mediterranean is the most vulnerable region in Europe in terms of water shortage, fire, drought and low adaptive capacity.

The problems faced during the modeling process mainly concerned the initial climate input data from TYN SC 1.0, including issues such as the lack of inter-annual variability in cloud cover and diurnal temperature ranges between the year 1991 and 1950 in the Mediterranean region. The vapor pressure data in the climate input scenarios is also problematic (Ewert et al., 2005)

5.2. EURURALIS

5.2.1. The project context

This scenario is named "A scenario study on Europe's rural areas to support policy discussion" [15] and was produced by the working group on Sustainable Development and

[14] Environmental Vulnerability Assessment for Policy and Decision-Making edited by Anthony G. Patt, Anne C. De la Vega-Leinert and Richard J.T. Klein

[15] Available at: http://www.pbl.nl/images/AlterraRapport1196_tcm61-29777.pdf.

Systems Innovation from the Wageningen University and Research with the main objective of supplying policy makers with arguments for discussions on the future of Europe´s agricultural and rural areas. It develops temporal specifications for each 10 year interval, between 2005 and 2030 information for the 25 European countries. In EuRuralis 2.0 information was downscaled from the country level to the regional level. Both, EuRuralis 1.0 and EuRuralis 2.0 use the nested approach, from the global level, via the EU-level, to the national level, to NUTS regions.

5.2.2. Scenario specifications

The methodology applies several global economic and integrated assessment models, such as Global Economy Model (GTAP) and integrated assessment model (IMAGE), to account for the structure of land use change processes. It also applies the land use allocation model (CLUE). The global models take account of the effect of global level changes on European land use and evaluate the effects of changes in Europe on other parts of the world. The global economy and integrated assessment models capture the interaction between economy and natural resources.

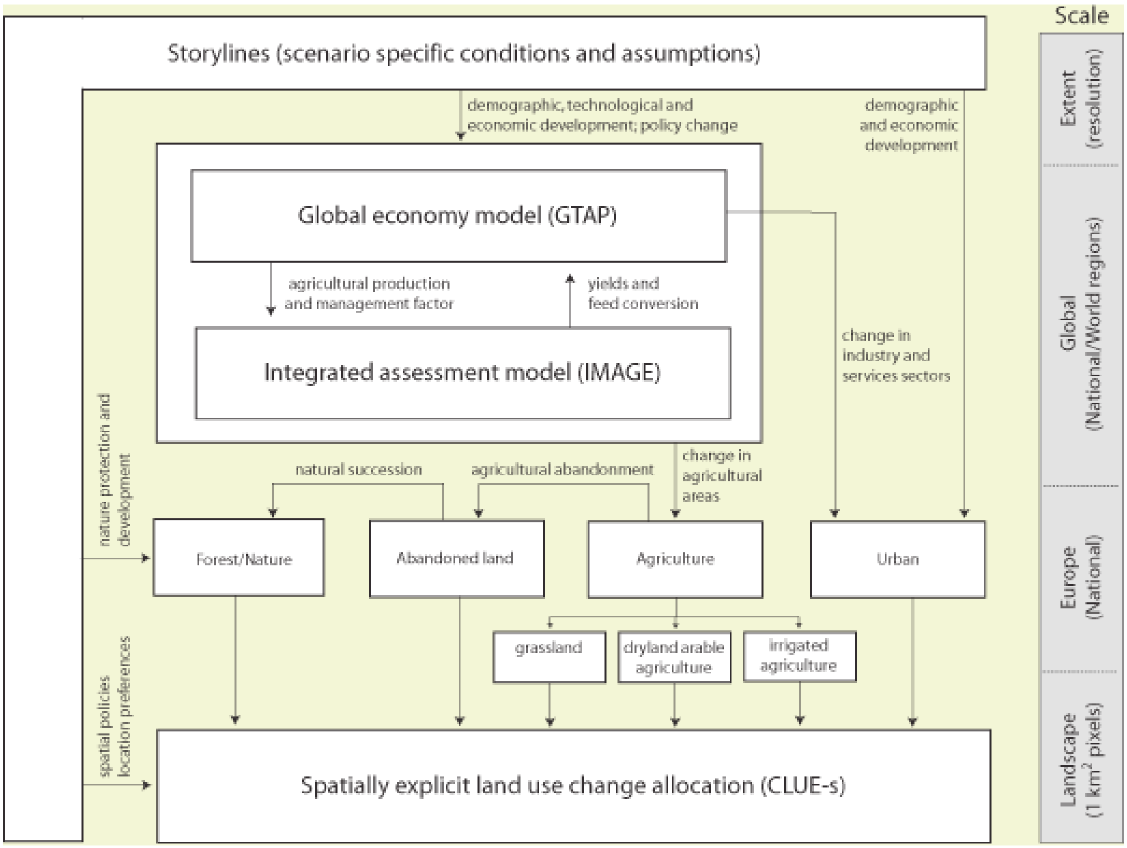

Figure 5:*Conceptual framework of EuRuralis (Klijn et al., 2005)*

The scenarios use the following indicators: yield, income, employment, self sufficiency, animal diseases, CO2 storage, biodiversity, land degradation, pollution and land use. The data for land use was derived from EUROSTAT for major rural land use categories, forest and agricultural land per country.

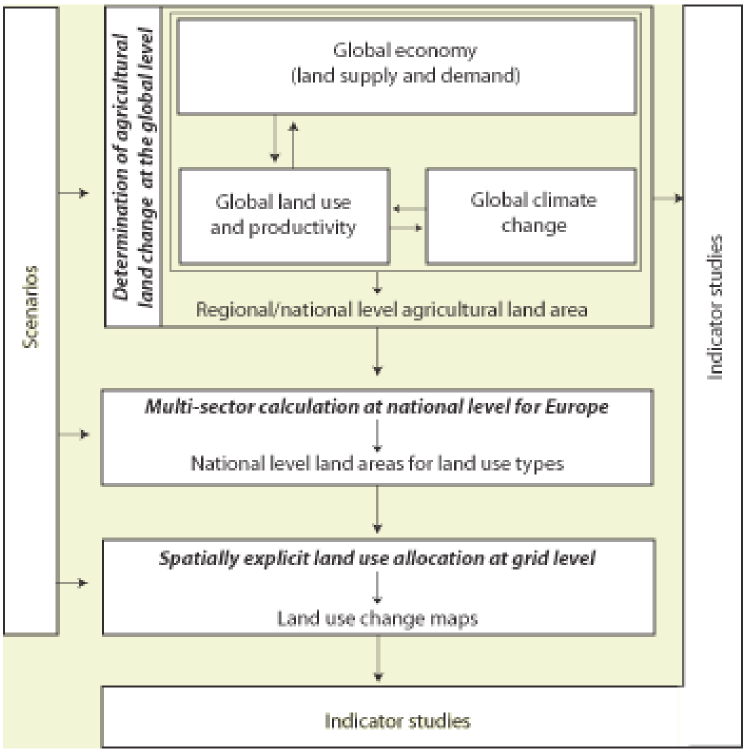

Figure 6 *Methodology of EuRuralis (Klijn et al., 2007)*

EuRuralis combines a set of sustainable development indicators for human well-being, ecology and economic issues (People-Planet-Profit). Other data derive from EEA, Wageningen University, FAOSTAT and EUROSTAT Luxemburg is also used.

In the EuRuralis methodology the storylines specify conditions, which are needed to make an assessment of land use dynamics. These conditions include demographic and economic trends, world trade regulations, consumer preferences, and policies which directly and indirectly influence land use.

EuRuralis develops four explorative, contrasting scenarios identified according to the role of governance, namely high versus low regulation and free market, and the scale level of processes and interventions such as global versus regional:

- Global economy (A1)
- Continental Market (A2)
- Global Cooperation (B1)
- Regional Communities (B2).

In the scenarios the major drivers are demography, world economy, climate change, technology, EU enlargement and consumer patterns.

- Demography: the extent and age of the population. These determine the demand for food, the need for housing and energy.

- World economy/welfare: demand and supply, exchange of goods and services. These determine the flow of labor, income, consumption patterns, capital investment and other factors, such as unemployment.
- Climate change and related conditions: shifts in precipitation, temperature and water discharge (flooding) or sea level rise bring various risks or opportunities.
- Technology: this causes significant effects on land use and other aspects e.g. mobility, communication. As such it is difficult to include specifically in the models but the dissemination of new technology can be assumed.
- EU-enlargement and trade arrangements imply change in international politics and policy making. The increasing role of international governance, international treaties (such as WTO, Agreements on Biodiversity or Environment, Kyoto). At a continental level the formation and expansion of the EU.
- Consumer patterns are difficult to define, but are influential: e.g. consumption patterns (diet changes), an increased awareness of ecological or social problems or concerns about animal welfare.

5.2.3. Results and limitations

The general results show a gradual increase in forest area in the next forty years, with a decrease in agricultural land for both arable land and permanent pastures. The land use for built-up areas and undeveloped land excluding forest will increase. The results generally show parallel trends for all European countries with some insignificant regional differences. In all four scenarios the most significant land use changes will happen in the period between 2000 and 2030.

A high level of urbanization characterizes scenario A1. It will take place across Europe with hotspots near the main cities. In conjunction with a lack of spatial policies it will have significant influence in many parts of Europe. Abandoned agricultural lands will be used partly for residential, industrial and recreational purposes, party for spontaneous development of natural land, and partly for the cultivation of biofuels.

The negative impacts on natural and culturally-historic European landscapes due to the growth of urban and agricultural lands characterize the A2 scenario. The level of urbanization will increase due to strong economic growth, which will result in the development in of many secondary dwellings. Demands for agricultural land will increase due to high production level of European agriculture and macro-economic conditions. The agricultural, residential and commercial land use will be increased at the costs of natural areas, which will decrease.

The significant reinforcement of the designated natural areas due to a decrease in agricultural and urban areas characterizes the B1 scenario. The level of urbanization will be not as high as in the two previous scenarios due to stringent spatial policies. The requirements for agricultural land will be lower due to increasing agricultural productivity.

The modest changes in landscape patterns due to low rate of urbanization and increases in agricultural productivity characterize the B2 scenario.

5.3. PRELUDE

5.3.1. The project context

The European Environmental Agency (EEA) carried out the PRELUDE project (Prospective environmental analysis of land use development in Europe) between 2005 and 2007. PRELUDE was aimed at developing coherent scenarios, which describe plausible future developments for land use in EU-25 plus Norway and Switzerland and the potential environmental impacts for the period 2005-2035 (EEA 2007, p.9).

5.3.2. Scenario specifications

The scenario's storylines are based on the SAS approach (story-and-simulation)[16], which was modified in terms of the stakeholders' responsibility. The latter was upgraded from the traditional *consultation* role to a *co-decision* role. The scenarios were then designed in three iterative workshops.

The stakeholders identified 20 key driving forces for land use types and land use change in Europe. These drivers (besides the ones addressing economy and population) were then aggregated to describe the scenarios:

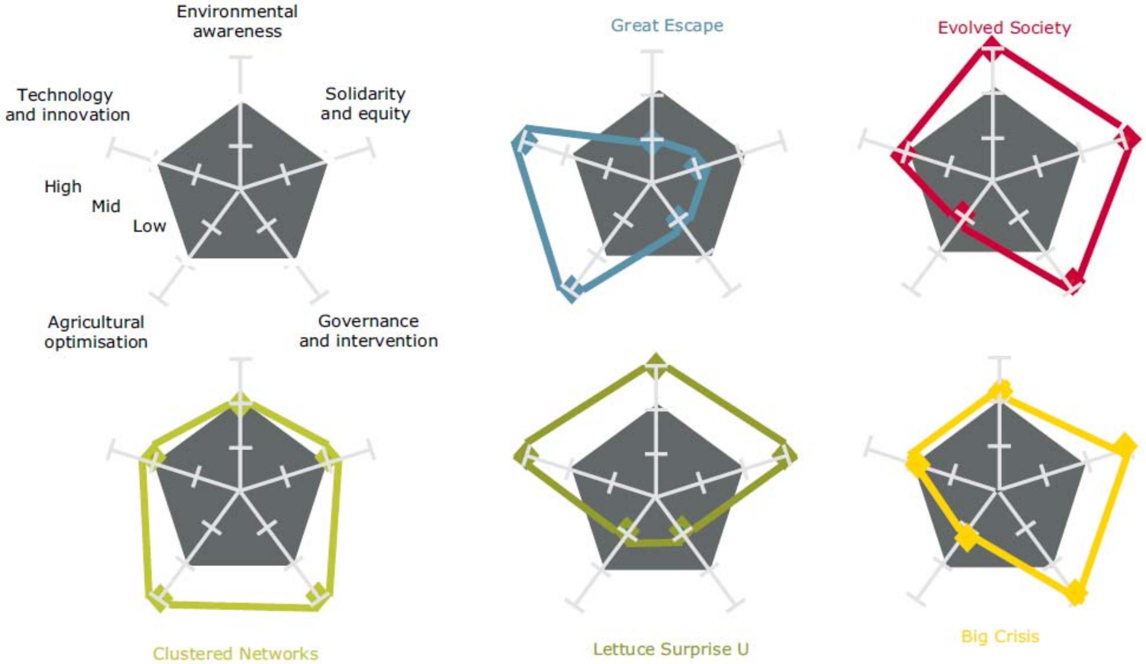

Figure 7 *Aggregated drivers and the resulting scenarios (EEA 2007).*

The quantitative assessment of the changes in land use/cover at the European level uses the Louvain-la-Neuve land use/cover change model, which on the methodology developed in the ATEAM and Accelerates projects. Initially satellite data from the PELCOM database were used.

[16] The scientists from the Centre for Environmental Systems Research, University of Kassel and the Université Catholique de Louvain-la-Neuve supported participatory process. They quantified and modeled the qualitative outcome.

The approaches have been simplified as much as possible (whilst retaining scientific soundness) in order to be 'transparent' and 'flexible'.

Land use data were derived from the FAOSTAT database, the EUROSTAT REGIO database and from the European Commission Directorate General Agriculture. For the quantification of the single scenario storylines, prices were adjusted based on the price/costs scenarios developed in the ACCELERATES[17] project.

Six land use/cover classes include: Urban, Cropland, Grassland, Bio fuels crops, Forests, Abandoned land. The input parameters for the three sub-models were population and GDP/capita for urban land use (based on IPCC SRES A1 scenario parameters); total demand for agricultural production, impact of CO2 on crop yield, impact of technology on crop yield and renewable energy demand for agricultural land use; and forest area changes, protected area changes and possible use of surplus land for forest land use. The latter included protected areas and surplus land.

Driving force	Qualitative value	Driving force	Qualitative value
Subsidiarity	4	Environmental Awareness	5
Policy intervention	5	Economic growth	5
Settlement density	7	International trade	7
Population growth	2	Daily mobility	6
Ageing society	8	Self-sufficiency	8
Immigration	3	Technological growth	5
Internal migration	3	Agricultural intensity	5
Health concern	5	Climate change	8
Social equity	5	Renewable energy	6
Quality of life	5	Human behaviour	5

Table 2 *Overview of 20 driving forces in the PRELUDE project (EEA 2007).*

5.3.3. Results and limitations

The general tendencies reflected by the different scenarios can be described briefly as follows:

Urban change is, due to its small overall share of land, hardly visible. Compared to the base-year it does not change much in any of the scenarios. The two scenarios with migration between European regions ('Clustered Networks' and 'Evolved Society') show the highest urban change rates. The spatial patterns of urban change differ in every scenario, in most of them rural areas and small cities are most attractive.

Cropland changes are mostly observed in the 'Great Escape' and the 'Clustered Network' scenarios where cropland is reduced by a third compared to the base-year. Due to expansion of agricultural land and landscape preservation fewer changes can be observed in the environmentally-aware scenarios. A similar situation can be found for grassland changes, however even in the environmentally friendly scenarios the share decreases.

[17] The ACCELERATES project was another EU level scenario excercise concerning land use change and biodiversity, but was not covered in this devliverable (Rounsevell et al. 2006).

The Great Escape scenario (Europe of contrast) and the Clustered Networks scenario (Europe of structure) show also similar patterns of agricultural change. The losses in area affect only less suitable areas, while optimal locations are preserved. These two scenarios and the Lettuce Surprise U scenario (Europe of innovation) show increasing surplus area stemming from abandoned land for agricultural production; again the two more environmentally-oriented scenarios are able to balance such a trend by effective policy mechanisms.

Forest changes increase slightly for all scenarios mostly because of current low trends in afforestation, it is again additional policy measures in Evolved Society scenario (Europe of harmony) and the Big Crisis scenario (Europe of cohesion) that make the difference and account for a somewhat higher afforestation rate.

The results of the European land use scenarios also show their limitations. When it comes to the assessment of environmental impacts, the general scope of the study becomes evident. Many impacts are local and therefore cannot be captured adequately.

5.4. ALARM

5.4.1. The project context

The ALARM project (Assessing Large scale Risks for biodiversity with tested methods) was carried out as a project of the EU 6th Framework Program from 2004 to 2009. Its core objective was to conduct an integrated large scale risk assessment for biodiversity. “Research focused on assessment and forecast of changes in biodiversity and in structure, function, and dynamics of ecosystems. This related to ecosystem services and included the relationship between society, economy and biodiversity. In particular, risks arising from climate change, environmental chemicals, biological invasions and pollinator loss in the context of current and future European land use patterns were assessed”[18]

5.4.2. Scenario specifications

The ALARM project developed three scenario narratives quantified by a mixture of partly integrated models, aiming at identifying pressures and drivers of biodiversity loss and deriving effective policy strategies (Spangenberg 2007, p.343). The project team drafted the scenario. It was discussed with the ALARM Consultative Forum, which is a body of stakeholders and scientists within the project consortium.

ALARM identifies the following drivers, i.e. in this case, EU policies:

- **Common agricultural policy** (including fisheries and forestry), drives overuse
- **Chemicals Policy**, drives pollution
- **Energy Policy**, contributes to climate change and pollution
- **Transport Policy**, drives GHG emissions significantly as well as fragmentation
- **Trade Policy**, drives biological invasion
- **Biotechnology**, drives the release of genetically modified organisms (GMOa)

[18] www.alarmproject.net

- **Structural Funds**, drive among others fragmentation

It develops three scenarios plus three shock scenarios, the latter take non-linear developments into account:

GRAS (GRowth Applied Strategy scenario) vs. GRAS-CUT, GRAS is a liberal, free-trade, globalisation and deregulation scenario. Adaptation dominates other environmental policy measures are only implemented when problems arise. GRAS-CUT equals GRAS plus cooling under thermohaline circulation collapse.

BAMBU (Business-As-Might-Be-Usual scenario) vs. BAMBUSEL vs. BAMBU-CANE, BAMBU is a policy-driven scenario, determined by the extrapolation of expected EU decision making. It includes climate mitigation and adaptation measures and explicit biodiversity protection policies. BAMBUSEL equals BAMBU plus shock in energy price level. BAMBU-CANE equals BAMBU plus contagious natural epidemic.

SEDG (Sustainable European Development Goal scenario), SEDG is a backcasting scenario (normative) dedicated to integrated sustainability.

The IPCC SRES scenarios (A1F1, A2 and B1) were chosen as climate scenarios, for land use a recalculated version of the ATEAM model was used and from the EU-funded MOSUS project GINFORS served as an econometric input-output model:

Driving forces/allocation rules	GRAS	BAMBU	SEDG
Total demand for agricultural production	GINFORS estimates	GINFORS estimates	GINFORS estimates
Change in oversupply	No oversupply permitted	Oversupply maintain as current situation	Reduction of 50% in 2020 of oversupply compared to the current situation
Impact of CO2 and climate	Coupling the ecosystem LPJ-GUESS with the LU model: A1FI climate scenario	Coupling the ecosystem LPJ-GUESS with the LU model: A2 climate scenario	Coupling the ecosystem LPJ-GUESS with the LU model: B1 climate scenario
Impact of technology on crop yield	Innovation is high	Current trend continues	Encouraging to extensification or organic farming. Reduction of pesticides. Low impact on crop yield
Energy crop demand	GINFORS estimates	GINFORS estimates	GINFORS estimates
Allocation rules for agriculture	Rent maps used as a proxy for optimal location	CAP maintains and so low decrease almost equally distributed. No change in protected areas	Extensification and so, low decrease almost equally distributed. No change in protected areas

Table 3** Driving forces and allocation rules in the ALARM project.**

The land use types in ALARM were: urban, cropland, grassland, permanent crops, biofuels, forests and land in succession (i.e. abandoned agricultural land.)

5.4.3. Results and Limitations

All three scenarios show a continuation of trends seen in the past 50 years, such as abandonment of agricultural land and increased urbanization. Due to the different models and data used the time horizons of the scenarios vary significantly. The time horizon was generally 2020 and in some cases 2050. By using different models comparatively for the quantitative analysis and including shock scenarios the ALARM team tried to enhance the validity of its scenarios.

5.5. COCONUT

5.5.1. Project context

The COCONUT[19] project (Understanding effects of land use Changes on ecosystems to halt loss of biodiversity due to habitat destruction, fragmentation and degradation) ran from November 2006 to April 2009 with the aim to provide a decision basis to meet the EU target to halt loss of biodiversity by 2010 and beyond and to improve understanding on how terrestrial biodiversity is affected by historic and current land use changes. The project horizon was 2030.

5.5.2. Scenario specifications

Even though the project used the ALARM scenarios it deserves separate mention due to the aspect of down-scaling and several other features that added value and might be relevant for the SafeLand project.

The aim of the scenario work was to provide fine-scale projections of future land use in some BIOPRESS[20] transects, by combining the information from the BIOPRESS historic data with the ALARM scenarios using a rule-based, qualitative approach. These projections would then be used to assess the effect of the scenarios on, for instance, habitat quality (COCONUT Deliverable 4.4, p. 2). The 10’ resolution of the ALARM scenarios was downscaled to a 100 m resolution in four transects (2x15 km) with the UK. The work done in WP2, on the development of land use in the past 50 years also made use of the scenario results in their analysis.

The COCONUT project also carried out an analysis of the variability in land use projections for 12 European environmental zone (Metzger et al. 2005), using ALARM scenarios and PELCOM data.

5.5.3. Results and limitations

The initial goal of the project, which aimed to link land use variables to biodiversity models proved impossible. CORINE data and other available biodiversity information from NATURA 2000 areas were of too poor a quality to allow for biodiversity modeling. The state-of-the-art pan-European land use change model MOLUSC was found inappropriate for landscape level biodiversity assessment.

[19] http://coconut-project.net/index.html
[20] BIOPRESS was a project funded by FP5 with the aim to determine historical changes (1950 – 1990 – 2000) in land cover across Europe for the purpose of measuring changes in habitats and their biodiversity (http://www.biopress.ceh.ac.uk/, download: 31 March 2010).

The downscaling process, described in detail in deliverable 4.4 of the project, showed some interesting results: The share of urban area increases in all scenarios, however, it was with a scattered pattern in GRAS and a more compact pattern in SEDG. SEDG shows the highest conversion to biofuel crops and little abandonment of pastures, and is thus the exact opposite of the GRAS scenario. Changes in urban land and forestry will become less to that experienced in the past 50 years.

It proved to be a useful downscaling exercise in terms of spatial and thematic resolution, when other projections are too coarse and fail to provide distinctive output (e.g. sufficient detail for habitat quality assessment). A distinct advantage is the ability to provide more life-like results and to support stakeholder dialogues. However, the complicated and time-intensive process limits the usability to a small number of spatial units – a problem that might be solved in the future.

During the project synergies with the ongoing ECOCHANGE project were discovered and utilized in terms of downscaling.

5.6. MEDACTION (VISION, 1998-2001)

5.6.1. The project context

The EC funded MedAction project (2001-2004) developed land use change scenarios for the European, Mediterranean and local level to aid local decision-making regarding policy formulation for sustainable land management in the target areas. Part of the scenario building process was integrated in the earlier VISION project (Integrated Visions for a Sustainable Europe), which used the Factor-Actor-Sector (FAS) framework to create storylines and scenarios. The time horizon of the scenarios is 2030[21].

5.6.2. Scenario specifications

The MedAction Scenarios equal the three European Scenarios developed in an Integrated Assessment by the Fourth Framework Program project VISIONS; however emphasizing different aspects evident in the changes made to the FAS:

	VISIONS	MedAction
Factors	Equity Employment Consumption behaviour Environmental degradation	Water Availability Land Degradation Migration Economic Stability
Actors	Governmental bodies Businesses NGOs Scientists	Governmental Bodies Businesses NGOs Scientists
Sectors	Energy Water Transport Infrastructure	Agriculture Tourism Forest (natural and planted) Civic

Table 4: *Factors, Actors and Sectors in VISIONS and MedAction (Kok et al., 2003).*

[21] The horizon was shortened to 2030 in respect to the VISIONS scenarios, which ended in 2050, based on lessons learned from the stakeholder involvement in the previous program (Kok et al. 2004).

"*The **Knowledge is King Scenario** emphasizes the ICT revolution in Europe and its economic gains. In this scenario, new technological innovations help to improve environmental quality. In the **Big is Beautiful? Scenario** people do not care much about the environment. The scenario stresses globalization, and pictures an economy dominated by large multinationals. In the **Convulsive Change Scenario**, environmental disasters disturb society and the economy. In spite of the drastic measures that were taken to protect the environment, the climate changes quickly. This causes severe problems*" (Lejour & van Steen, 2001, p.1).

While the VISIONS scenarios were focused on urban areas, MedAction had to adapt the FAS to account for its more rural perspective and the focus on land use. However, these changes did not reflect changes in the underlying scenarios (Kok et al., 2004).

The Mediterranean Scenarios

MedAction was a continuation of three previous EU projects, under the general name MEDALUS. The four Target Areas were selected during MEDALUS III. Using these same areas in MedAction had large advantages. First, they had been studied for at least three to five years and a large data and knowledge base of all Target Areas existed. The availability of data facilitated the development of the DSS (Decision Support System) and PSS (Policy Support System) in Module 3; the working experience in the areas provided an infrastructure that facilitated contacting scientists in the region; and a preliminary list of relevant stakeholders existed. The researchers in Module 1 and Module 2 of MedAction use this list. Thus, following up on an existing project gave MedAction an enormous head start and has eased much of the work that was carried out (Kok et al., 2004).

Limitations

- Long-term trends were poorly addressed in the workshops
- Topics that are relevant from a scientific point of view do not seem urgent enough to stakeholders and were thus left out (land degradation, forestry etc.)
- Up and down scaling
- Exclusively qualitative scenarios
- Many stakeholders are opposed to change in their region

Regional MedAction scenarios

Additionally to the qualitative European and Mediterranean Scenarios local quantitative scenarios were developed for two of the Target Areas. The objective of this part of the project was to refine and modify an already existing DSS and to apply it to the Agri and Cobres basins to assess hydrological, soil erosion and crop yield responses for land management, crop subsidy and climate scenarios (MedAction Deliverable 28)[22].

[22] In a third step guidelines were developed to contribute towards policy formulation for sustainable land management relevant to local end-users.

The DSS consists of a hydrological and sediment yield model SHETRAN to simulate fluxes and storages of water and sediment; a crop growth model EPIC to provide annual crop yield; and a farmer response model for selecting the crop type (Bathurst & Bovolo, 2004)[23].

5.7. ADAM

5.7.1. The project context

The project entitled "Adaptation and Mitigation Strategies: Supporting European climate policy" (ADAM) was funded by the European Commission and conducted by the Tyndall Centre for Climate Change Research in cooperation with 26 other research institutions. The main goal of ADAM was to analyse existing and new policy options that contribute to different combinations of adaptation and mitigation strategies, addressing the issue of how the changing climate will influence citizens and ecosystems, as well as the necessity to reduce humankind´s influence on climate at the global level. The time horizon is up to 2100 (Hulme et al., 2009).

The core issues that ADAM addresses is to analyze the extent to which climate policies can achieve a socially and economically viable transition to a global climate no warmer than 2°C above the pre-industrial level. Further questions relate to the climate governance regime after 2012, mainstreaming of climate change into EU development policy, the transformation of the European electricity sector and mainstreaming adaptation into regional land use planning[24].

5.7.2. Scenario specifications

ADAM studied two scenarios, mitigation and adaptation. One core scenario assumed stringent mitigation with less adaptation, which will lead to temperature increase of 2 °C by 2100. Another core scenario assumed no mitigation but efficient adaptation. According to this scenario the energy system will be mostly based on fossil fuels and there will be an average temperature increase of 4 °C by 2100.

Mitigation includes 400ppm, 450 ppm and 550 ppm scenarios. The modeling of mitigation in frames of ADAM has sensitivity to mitigation efforts on European and global levels and assumes that the EU Emissions Trading Scheme (EU-ETS) will be integrated into a World-ETS. The European strategy to achieve a low carbon society is based on two elements: energy efficiency and an increased use of renewables. Energy efficiency efforts include significant reductions in final energy demand in the following sectors: industry (by 5%), households (by 50%) and transport (by 20%) in the period 2005-2050. Significant emission reductions shall be achieved in the following sectors: energy conversion (by 80%), households (by 60%), transport (by 40%) and industry (by 25%). More than 65% of electricity will come from renewables by 2050.

The model covers the following sectors: industry, services, household, transport, renewable energy technologies and conventional energy technologies.

[23] More details on local and regional data are available on page six of Deliverable 28.
[24] http://adam-digital-compendium.pik-potsdam.de/learning-examples/

The adaptation scenario shows, for specific regions or sectors, the future risks and their economic consequences, as well as adaptation options and practical experience, which already exist. ADAM provides the first comprehensive probabilistic maps of hazards across Europe, characterized mainly by flood and drought risks. The model allows estimation of probabilistic monetary losses from these hazards.

Another dimension of scenario work is the nature of international climate governance regime. One dimension assumes a truly international architecture of agreements and commitments. Another one assumes that climate action is dominated by choices from autonomous states and private sector actors.

Particular focus is put on mainstreaming adaptation to climate change in land use and water management, including desertification and occurrence of extreme events such as floods and droughts, in three study regions: Guadiana River Basin in Spain and Portugal, the Tisza River Basin in Hungary and the Alxa region in western Inner Mongolia, China. The analysis was done according to six aspects or indicators: biophysical, technical, financial, institutional, social and cognitive.

For analysis of mitigation ADAM uses an integrated modeling system, where individual models are connected via inputs and outputs. The goal was to develop a consistent hybrid model for Europe, which covers industry sector, services, household, transport, renewable energy technologies and conventional energy technologies. The models in each of these sectors adopted a technology-based bottom-up approach. The macro-economic framework and analysis was provided by the economic modules of the ASTRA model and the global greenhouse gas emissions constraints from the POLES world energy model. ADAM uses the meta-analysis of vulnerability. On the basis of linguistic analysis and formalization to a large body of literature on climate change impacts, vulnerability and adaptation, cited in the Europe chapter of Working Group 2 of the IPCC Fourth Assessment Report. For the analysis of the role of institutions in supporting adaptation policies different methods were used such as review of academic and grey literature for different hazards, sectors and themes, policy analysis, actor mapping and the use of participatory approach.

5.7.3. Results and limitations

ADAM contributed significantly to a better understanding of conflicts and opportunities of climate policies and it is supporting EU policy development in the next stage of international climate regime. The mitigation and adaptation policies were analysed according to such criteria as costs and benefits, cost effectiveness, equity, legitimacy, public support and environmental integrity. One of the findings was that climate change increases pressure on already densely populated areas. The scenario work investigated impacts of climate change on land and water resources but did not investigate conflicts with other types of land use, in particular for food production and biodiversity protection.

The results show that all three mitigation scenarios are feasible in terms of technology and economic costs. In terms of technology, in the 550ppm scenario one technology can be replaced by another one without increasing the costs significantly. This scenario is also robust against the failure to deploy certain technologies. The 400ppm scenario cannot be achieved without extending the use of renewables and carbon capture and storage technology. In economic terms, the mitigation costs will vary between 0.8% expressed as aggregated GDP losses until 2100 in the 550ppm scenario and 2.5% in the 400ppm scenario. The costs will be lower for developed countries, including the EU27, USA and Japan, than for the rest of the world. The USA will face the highest costs among developed countries. China and India, as well as oil exporting countries, will face higher costs than the world average.

The results of the adaptation scenario show that Eastern Europe is highly vulnerable to flood risks. Monetary losses caused by floods will account for one per cent of GDP; consequently, the governments of Eastern European countries will face severe fiscal problems in financing the recovery process. Southern Europe is vulnerable to increased risks from drought and heat. Northern Europe will profit from climate change in terms of decreases in heating needs and increased hydro and biomass reserves, but may also experience more frequent storms and heavy precipitation.

The results showed that in these case study regions the ecosystems and water resources were heavily degraded due to existing landscape and resource use practices and existing technical aspects, such as building dikes. The measures taken by the local population to reduce land degradation and sand storms were shown to be financially unsustainable. The existing situation might be an opportunity for preservation and managed diversification of land use in the region, including opportunities for changing land use and water management, the introduction of new technical solutions and financial mechanisms, integration of existing local informal social networks and knowledge, as well as an increase in the level of information among local stakeholders on climate impacts and adaptation policies and options.

5.8. ONGOING PROJECTS

5.8.1. ECOCHANGE

ECOCHANGE[25] is an ongoing FP7 project (2007-2011) aiming to provide data, scenarios and associated confidence limits so that policy makers and land managers can use them for anticipating societal problems and for designing sustainable conservation strategies by accounting for the most likely global change effects on biodiversity and ecosystems. One projected outcome is spatially explicit climate, economic and land use change scenarios for the next century (up to 2100). The updating and reconstruction of land cover data; and the downscaling and extension of land use change scenarios were part of Activity 1 of the project. The ECOCHANGE scenarios have not been published yet.

5.8.2. ENVIROGRIDS

ENVIROGRIDS[26] is an ongoing FP7 project (2009-2013) intending to develop necessary research activities for capacity building relevant to Earth Observation and GEO in the Black Sea basin. Part of the project will be the creation of spatially explicit scenarios on demographic change, climate change and land cover change and the integration of the output of those scenarios.

[25] www.ecochange-project.eu/
[26] www.envirogrids.net

5.9. FOUR FUTURES OF EUROPE

5.9.1. The project context

The Dutch Bureau for Economic Policy Analysis (CBP) periodically develops socio-economic scenarios as basis for further studies. The most recent scenarios were developed in 2003 under the title Four Futures for Europe with two time horizons in 2020 and 2040. The scenarios use data for the EU-15 plus Norway and Switzerland.

The CBP develops scenarios according to two key uncertainties defined and discussed in the same study.

5.9.2. Scenario specifications

The figure below combines those two uncertainties. The vertical axis ranges from successful international cooperation at the top, to an emphasis on national sovereignty at the bottom; the horizontal axis ranges from a strong role for the public sector at the left, to private responsibility at the right. The combination of the two key uncertainties yields four scenarios for Europe and its countries (De Mooij & Tang, 2003).

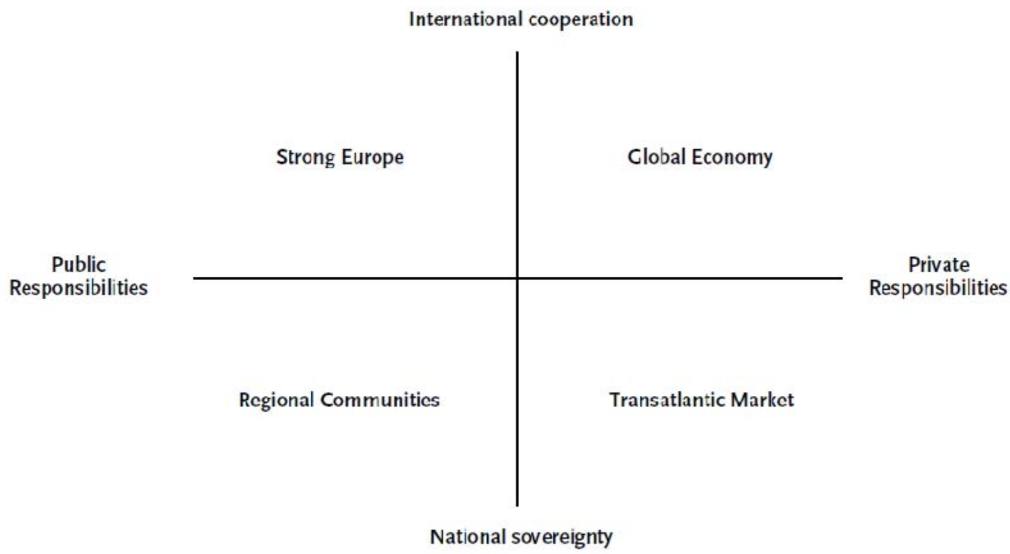

Figure 8:Four perspectives on the future of Europe (De Mooij & Tang n.d.)

The quantitative characteristics of the different scenarios are based on simulations with WorldScan, an applied general-equilibrium model for the world economy with the following quantitative indicators:

- Annual growth rates: GDP, labor productivity, employment, population, world exports
- Ratios: participation rate, unemployment, saving rate, real interest rate, sharing intra-EU trade (data source: World Bank).

5.9.3. Results and Limitations

• Strong Europe

The first scenario shows a strong European Union after a successful reform of its decision making processes. Enlargement and integration succeed geographically, economically and politically. Europe is the driving force behind broad international cooperation – not only in the area of trade, but also in other areas such as climate change and poverty reduction. This success comes at certain expense for some groups in society in the course of reforms of social security, the labor market and public production, necessary to ascertain a stable and growing economy.

• Global Economy

The second scenario is characterized by global economic integration, based on strengthened global institutions. Closer cooperation in non-trade areas is not feasible; international organizations in these areas cannot overcome the problem of conflicting interests and free-riding.

The problem of climate change intensifies. National institutions become increasingly based on private initiatives and market-based solutions. European governments focus on a few core tasks, such as the provision of pure public goods and the protection of property rights and take less care of income redistribution and public insurance. Growing but unequal incomes, high social-economic mobility

• Transatlantic Market

In Transatlantic Market, countries are reluctant to give up their sovereignty. Reforms of EU decision making fail. Instead, the European Union agrees on transatlantic economic integration with the U.S., which means a growing gap between rich and poor countries. The role of the state in Europe is strongly limited, which boosts technology-driven growth and at the same time increases inequality. New markets such as those for education and social insurance lack transparency and competition. The elderly dominate political markets.

• Regional Communities

The last scenario is defined by a fragmented world consisting of different trade blocks and only modest multilateral cooperation. EU reforms following enlargement fail and a core of rich European countries emerges. European economies are severely strained due to unsuccessful modernization of the welfare state and strong lobbies of vested interest, which block reforms.

Based on their purpose to serve future studies, the scenarios narratives are the outcome of the Four Futures Project and as such constructed in a very general fashion.

5.10. SCENARIOS ON THE TERRITORIAL FUTURE OF EUROPE

5.10.1. The project context

The transnational project group of the ESPON project 3.2, lead by IGEAT – Institut de Gestion de l'Environnement et d'Aménagement du Territoire, Université Libre de Bruxelles at the Free University of Brussels produced these scenarios.

The policy scenarios aimed at raising awareness among decision makers on the driving forces which will shape territorial developments in the coming decades and to investigate the likely impact certain policy decisions taken at the European level will have on the territorial structure. A combined scenario approach using qualitative storylines, quantified with model-based approaches that included more creative and speculative contributions was applied to address the complexity of the topic. The scenario horizon is set to 2015 (mid-term) and 2030 (long-term). The assumptions include concrete EU policies such as the CAP and the Cohesion Policy in the context of the Lisbon Process.

5.10.2. Scenario specifications

The group developed four main scenarios, the territorial trend scenario served as a baseline for a competitiveness-oriented (Rhine-Rhone Europe) and a cohesion oriented (Danubian Europe) scenario. It created finally a desirable proactive territorial scenario on the basis of a combination of policies likely to best enable its realisation. On the basis of these scenarios approximately 20 thematic scenarios deal with some of the main driving forces in nine different fields (demography and migration, transport, energy, economy, governance, enlargement, rural development, socio-cultural evolution and integration). Due to the immense extent of this scenario exercise a detailed presentation is not possible in this report. The detailed outcome is published on the ESPON website in several volumes. A digestive version is available as an ESPON publication also on the website.

The creation of the scenario knowledge bases, the Macroeconomic, Sectoral, Social and Territorial (MASST) model, the Know trans-European Networks (KTEN) transport model, the exploration of potentials for a European Index of Territorial Cohesion (ETCI), an Indicator of Sustainable Demographic Development (ISDD), a Long-term Database (LTDB), and a methodology for territorial impact assessment (TIA) were scientific contributions to the project.

Baseline	Competitiveness-oriented	Cohesion-oriented
Enlargement - Combination of deepening and widening - Western Balkans in 2020 - Turkey in 2030	- Priority given to enlargement - Western Balkan and EFTA/EEA countries in 2015 - Turkey in 2020	- Priority given to deepening - Break on further enlargement
Demography - Stable total population - Significant population ageing - Increasing but controlled external migration - Unchanged constraints on internal migration	- Selective external in-migration; no constraints to internal migration - Increase in retirement age - Encouragement of fertility rate through fiscal incentives	- Restrictive external in-migration - More flexible retirement ages - Encouragement of fertility rates by more flexible arrangements for child care
Economy - Slowly increasing activity rate - Decreasing public expenditure - Growing R&D budget	- Strong reduction of EU budget - Further liberalisation and privatisation of public services - Strongly growing R&D budget	- Maintaining EU budget - Reinforcement of structural funds and concentration on weakest regions
Energy - Steady increase of energy prices - Stable energy consumption - Increasing use of renewables	- Increasing energy consumption - Realisation of TEN-E: investments in infrastructure according to market demand	- Realisation of TEN-E - Promotion of decentralised energy production, particularly renewables
Transport - Continued traffic growth - Constant investments in infrastructure, but below demand - Partial application of Kyoto Agreement	- Realisation of TEN-T: investment in infrastructure according to market demand - Priority given to links between metropolitan areas	- Development of TEN-T, priority given to peripheral regions - Support to transport services in rural and less developed areas
Rural development - Further liberalisation of international trade - Progressive reduction of CAP budget - Rapid industrialisation of agricultural production	- Rapid and radical liberalisation of CAP: reduction of tariffs, budget and export subsidies - Reduction of support to rural development	- Minor CAP reforms, shift from pillar 1 to pillar 2 - Priority given to environment and animal health - Priority given to less developed areas
Governance - Increasing cooperation between cross-border regions - Increase in multi-level and cross-sectoral approaches, but limited to specific programmes	- Abolishment of cross-border market barriers - Less public intervention - Wider application of the Open Method of Coordination	- Active multi-level territorial governance in areas supported by structural funds - More public intervention
Climate change - Temperature rise of 1° and more frequent extreme events - Mitigation measures based on new technologies - Few adaptation measures	- Increasing emission levels - Mitigation measures based on flexible schemes - Adaptation measures only where cost efficient	- Constant emission levels - Strict mitigation measures - Wide range of adaptation measures

Table 5. *Overview of some of the main hypothesis of the three prospective scenarios (ESPON 2006)*

5.10.3. Results and Limitations

The results of the scenario exercise were a set of policy recommendations. The most important insights were:

- Territorial goals cannot be reached through the implementation of territorial policies alone.
- Support of the emergence of new economic zones of concentration.
- There should also be a precise evaluation of the risk of local and regional climate hazards and investment in adaptation measures.
- Policies should promote the production of renewables.
- Policy should provide more support for, and investments in, public transport, "intelligent" solutions to providing transport services.
- Infrastructure and service provision should be adapted to depopulation.
- Within cities socio-economic segregation should be moderated by the targeted intervention of public.
- Actors in housing markets.

6. NATIONAL SCENARIOS

This chapter gives a short and example-based insight on national scenarios, projections and available data for the case study countries of the SafeLand project. In particular, construction data rarely exists on the European level and is mostly a competency of national governments or even lower level administration. Indeed, the existing data is mostly economically inspired and rarely on a small spatial scale as would be relevant for landslides. Furthermore, construction data is rarely projected into the future. Interesting sources could be planning documents on different scales and operational programs regulating EU investments as they can indicate construction plans at least for a short time horizon.

Many countries have their own land use data and different institutions provide also land use change scenarios for the national and sub-national level. In the context of an EU project that intends to yield comparable results it seems advisable to use a harmonized data set such as CORINE2006 that was developed together with national and regional partners for the respective countries. It provides the necessary comparable data and can be downscaled to the regions in question.

6.1. FRANCE

The "*Institut National des Statistiques et des Etudes Economiques*" (INSEE) (National Institute of Statistics and Economic Studies), which belongs to the "*Direction Générale du ministère de l'économie, de l'industrie et de l'emploi"* (Directorate General of the Ministry of the Economy, Industry and Employmen*t*) develops national and regional statistics. This is a government agency and operates under the government accounting rules. The institute uses business classification (NAF, "Nomenclature d'Activité Française", *French Bill of activities*), which is an adaptation of the European classification (NACE, "Nomenclature des Activités économique dans la Communauté Européenne', *Statistical Classification of Economic Activities in the European Community*) and French classification of products (CSP), which is an adaptation of the European classification (Classification of Products by Activity (CPA) in the European Economic Community). However, it uses the classification of occupations and socio-professional categories (PCS, "Professions et Catégories Socioprofessionnelles"), which is different from the International Standard Classification of Occupations (ISCO). Therefore, it plans to conduct a number of studies, which will look into the possibility of direct ISCO coding.

It develops statistical databases for different fields and levels, from national to regional and sub-municipal. There are two main databases: multi-theme series and macro-economic database. The multi-theme series contain over 7,000 statistical indices produced by ministerial statistic departments. The macro-economic database contains over 90,000 series and covers all areas of public statistics. These data are mainly national, sometimes regional and more rarely departmental.

INSEE developed key indicators for land use, land use for industry, and population. It provides data on the level of municipalities. The key indicators are size of territory, number and density of population, number of houses for permanent and vocational use, urban, agricultural, including lands for cereals, vegetables and fruits, grasslands, used for animal husbandry and land not in use, and other types of land use, territories used for tourism, including the types of hotels, and recreation. The industry data include land use for industrial, commercial, construction and services enterprises as a percentage of territory and in comparison to benchmarks as well as the age of an enterprise and number of people employed.

6.2. ITALY

Istituto nazionale de statistica (“ the national institute for statistics of Italy”, ISTAT) developed a system of demographic, social, environmental and economic indicators referring to geographic areas, regions, provinces and regional and provincial capitals. The indicators are grouped into 16 information areas. Some of them are relevant to land use such as agriculture, environment, industry, housing, construction and public works, transport and tourism, population, households and social issues, culture and leisure as well as sustainable development. The data are available in time series from 1999 to 2005, which allows analyzing evolution of different events referring to the considered territory.

Agriculture land use includes agricultural holdings from 1 to 50 hectare of utilized agricultural area, according to the type of breeding for cattle and buffalos, pigs, sheep, goats, poultry and rabbits, agricultural holdings according to the number of people working and their type of occupation, regular or irregular, manager or family run etc., holdings with irrigable areas, holdings specializing on seeds and seedlings, permanent crops, other gainful activities, various crops and livestock combined, used agricultural land according to the size of agricultural holdings, holdings with seeds and seedlings, permanent grassland and pasture, permanent crops, wooded areas and other areas. Other land use include forest land distinguished for mountains, hills, plain land, owned by State or regions, by municipalities, by other public bodies, private forest land. Land used for wood production in total and for industrial roundwood and for fuels.

The state of environment relevant for land use is described by following indicators: forest areas which are susceptible to forest fire, municipal waste and waste -water treatment, mountain, hill, plain areas with reference to national area, available green areas and their density, public transport demand in square meters per inhabitant, density of urban transport networks for railways, buses and trolleybuses and subways, limited traffic zones including buildings, pedestrian areas and bicycle lanes as a percentage of municipal area.

The land use for infrastructure is described directly and indirectly by indicators on transport and on infrastructure for tourism such as road networks for motorways, national, regional and provincial roads as well as road junctions, well-developed data on tourism such as the number of nights spent, types of hotels, nationality of tourists, etc.

The Bank of Italy is another essential source of statistics. It produces mainly monetary, financial, real economic and balance-of-payments indicators and conducts regular surveys of Italian households, industrial and services firms.

6.3. NORWAY

Statistics sentralbyrå (*Statistics Norway*) is the central body for the preparation and dissemination of official statistics in Norway. It is an independent institution; however, its supervisory guidelines and financial frameworks are set by the Government and the National Assembly. The institute provides statistics on all relevant demographic and socio-economic data. Population projections are available up until 2060.

Statens Kartverk, the Norwegian Mapping Authority (NMA) is the national provider and administrator of geodesy, geographical and cadastre information. Norsk institutt for skog og landskap, the Norwegian Forest and Landscape Institute is a government agency and provides information related to land cover, forestry, agriculture, landscape and the environment.

6.4. ROMANIA

The Romanian national statistical body is the INS (*Institutul Național de Statistica*). In the past official statistics were considered little trustworthy in Romania; however, the institute has improved its reputation throughout the process of implementing of the Acquis Communautaire and the European Statistics Code of Practice. A peer review conducted in 2007 states:

“The present high level of public trust in official statistics in Romania was built gradually during the last two decades as a result of INS’s commitment to scientific independence, objectivity, transparency, impartiality and service culture. It should be underlined that the efforts of Romania to comply with the Acquis Communautaire in the field of statistics during the pre-accession period have greatly contributed in building a solid image for INS.”

The INS provides all relevant demographic and economic data, harmonized according to EU requirements. The institute’s multi-annual program 2008-2010 foresees population projections until 2050. The National Commission of Forecasting is responsible for economic prognoses, which do not reach beyond 2020. No information could be found on specific Romanian land cover/use data sets. However, *Agentia Spatiala Romania,* the Romanian Space Agency has been involved in projects that yielded a crop information system.

Other institutions that produce statistical data are most ministries and the National Bank of Romania.

Information on construction planning is not available in quantifiable form. Due to the massive EU investments (cohesion and structural funds) in infrastructure, the Ministry for Transport and Infrastructure provides extensive plans and strategies.

There are no national or regional socio-economic scenarios that have been developed explicitly for Romania. The climate change scenarios developed by the National Administration for Meteorology have a horizon until 2030. These are exclusively quantitative. The National Commission on Forecasting only provides economic forecasts that are typically limited to short-term prognoses of a few years.

6.5. SPAIN

The *Instituto Nacional de Estadisticas* (INE)[27], (National Institute for Statistics), is the designated body for provision of data for European Statistics.

The Spanish statistical system is complex for two reasons. On the one hand each ministry has its own statistical office, on the other hand because of independent statistical systems on the level of the autonomous regions, which need to be coordinated and integrated where possible.

[27] INE is an autonomous body subordinated to the Ministry of Economy and Trade.

The Spanish National Geographic Institute[28] in its role as National Reference Centre in Land Cover and Land Use is responsible for the coordination of the relevant data and information. The IMAGE2000 and CLC2000 projects and INSPIRE were the background[29] for initiating new forms of cooperation between the national and regional Spanish administrations. The new National Land cover/Land use Information System for Spain is called SIOSE.

The MedAction project developed multi-scale scenarios on land use, which were also applied for Spain (c.f. chapter 5.6).

INE provides short (2019) and long term (2049) population projections using fertility, mortality and migration indicators according to sex, age and cohort. Population projections on the level of the autonomous communities have different projection horizons and different indicators but are often available down to the local level.

[28] The Spanish National Geographic Institute subordinated to the Ministry of Public Works and Transport.
[29] The CORINE project required national teams and in the case of Spain also regional teams to work on the respective data sets.

7. SYNTHESIS

This deliverable provides an overview of data availability and scenario and projection exercises that have recently been conducted in Europe and to a certain extent at the global and the national level. The land use change scenarios were at the core of this review as land use change was identified as the most important human induced factor affecting landslide risk directly.

We selected scenarios in accordance with the list of global and European future studies conducted by Tony Zamparuti (Milieu Ltd.) and other researchers, and used an online research to add more recent projects. It was important that the selected scenarios used land use change as an indicator or used variables that drive land use change was the key criterion.

We reviewed scenarios according to some central aspects such as, time horizon, spatial scale and methods and data used. Environmental scenarios are still in an experimental phase and most exercises are structured quite differently though many components are of course the same.

7.1. SPATIAL AND TEMPORAL SCALES

While the general data situation for the present and recent past is quite positive, especially due to European harmonization efforts, coherent data for future data sets is more difficult to find. Indeed, it is already difficult to find a consensus on the terms long-, medium- and short-term. In some projects short-term is 2015 while in others it is 2030, a time horizon that some projects would consider long-term. There was no way to find coherent data for the dates required in the DOW 2030, 2050, 2070 and 2100. Global scenarios often extend 100 years into the future, but regional and national data rarely ever go beyond 2050/2060 (except for population projections).

In terms of the spatial coverage in the global scenarios, the extent always depends on the data availability in different countries and the capacity of international institutions to collect and prepare comprehensive data. EUROSTAT in cooperation with the OECD has succeeded in harmonizing many data sets for all EU countries, EFTA states and EU candidate countries. The number of current EU member countries that were included in each scenario exercise was dependent on when the project was running and the number of Member States at that time. Many EU projects working with scenarios also conducted downscaling exercises with the result that local and regional case studies are available for some regions and methods, though not yet refined, exist to downscale coarse data for regions of one’s own choice in order to assess aspects that require high resolutions (e.g. infrastructure land use and small settlement areas).

The harmonization process on the European level facilitates data collection for the most part. Cooperation with the Member States in preparing the data – for example the CORINE land use data – lead to harmonized data in many sectors and on different scales (cf. NUTS regions). The more refined the scale the more difficult it was to find comprehensive and complete data.

	Spatial Scale	Time horizon
Global Energy Assessment (ongoing)	global	N.A.
Global Environmental Outlook	global	2050
Millenium Ecosystem Assessment	global	2100
IPCC Special Report on Emission Scenarios	global	2100
ATEAM	EU15, + Norway and Switzerland	2020, 2050, 2080
EURURALIS	EU27	2030
PRELUDE	EU25 + Norway and Switzerland	2035
ALARM	N.A.	2020 (2050)
COCONUT	Sub national	2030
MEDACTION	Sub national	2030
ADAM	EU27 (regional case studies)	2100
Four Futures for Europe	EU15 + Norway and Switzerland	2020, 2040
European Futures	ESPON space	2015, 2030

7.2. QUALITATIVE ASPECTS

Many of the reviewed scenario exercises make direct use of, or adapt, the global SRES storylines. New storylines were developed mostly in those cases where a participatory process was relevant to the project. Most of the scenarios used were exploratory, i.e. they typically use several assumptions about development pathways that lead to very different outcomes and are applied over long-term time horizons. Though the narratives of the storylines are often quite different in character the general categories are very similar. A baseline is usually accompanied by a more liberal and growth oriented pathway and one that supports solidarity and equity as well as cohesion and environmental awareness. Many of the scenarios are refined and well differentiated.

	Storylines	Driving Forces
Global Energy Assessment	N.A.	N.A.
Global Environmental Outlook	Market first Policy first Security first Sustainability first	institutional and socio-political frameworks, demographics, economic demand, markets and trade, scientific and technical innovation, value systems
Millennium Ecosystem Assessment	Global Orchestration (GO) Order of Strength (OS) Adapting Mosaic (AM) TechnoGarden (TG)	Indirect drivers of change: demographic, economic, sociopolitical, science and technology, cultural and religious factors. Direct drivers: changes in local land use and coverage, introduction or removal of species, technology adaptation and use, external inputs, harvest and resource consumption, climate change, natural, physical and biological drivers.
IPCC Special Report on Emission Scenarios	A1, global economic A2, regional economic B1, global environmental and equitable B2, reg. envir. and equitable	N.A.

ATEAM	European interpretation of SRES storylines	Urban land: Population, economic development, accessibility of transport networks, land use planning policy. Agricultural land use: Agricultural, rural development and environmental policy, EU enlargement, resource competition, role of WTO and climate impacts. Forestry land use: Forestry policies. Protected areas: Demand for recreation and tourism, European and national policies on nature conservation
EURURALIS	Global economy (A1) Continental Market (A2) Global Cooperation (B1) Regional Communities (B2)	Demography, World economy, Climate change, Technology, EU enlargement, Consumer patterns
PRELUDE	Great Escape Evolved Society Clustered Networks Lettuce Surprise U Big Crisis	The aggregated driving forces were Environmental awareness, Solidarity and equity, Governance and intervention, Agricultural organization, Technology and innovation
ALARM	**GRAS** (GRowth Applied Strategy scenario) **BAMBU** (Business-As-Might-Be-Usual scenario) **SEDG** (Sustainable European Development Goal scenario)	Common agricultural policy Chemicals Policy, Energy Policy, Transport Policy, Trade Policy, Biotechnology, Structural Funds
COCONUT	ALARM scenarios	ALARM drivers
MEDACTION	Knowledge is King Big is Beautiful Convulsive Change	Water Availability Land Degradation Migration Economic Stability
ADAM	mitigation scenarios: 400, 450, 550 ppm adaptation scenarios:	N.A.
Four Futures for Europe	Strong Europe Global Economy Regional Communities Transatlantic Market	
European Futures	competitiveness-oriented scenario (Rhine-Rhone Europe) cohesion oriented scenario (Danubian Europe) scenario trend/baseline scenario	demography and migration, transport, energy, economy, governance, enlargement, rural development, socio-cultural evolution and integration

The situation is similar with respect to the drivers, they differ in details but the overall categories are the same: population, economic development, institutions, technology and innovation (cf. chapter 3).

7.3. QUANTITATIVE ASPECTS

	Models	Data sources
Global Energy Assessment	N.A.	N.A.
Global Environmental Outlook	International Futures (IFs) model WaterGAP (Water-Global Assessment and Prognosis) EwE (Ecopath with Ecosim) LandSHIFT CLUE-S (Conversion of Land Use and its Effects) modeling framework by AIM (the Asia Pacific Integrated Model)	FAOSTAT database, IEA, UNDESA, World Bank, UNEP GEO Dataportal, UNDP, WTO, WHO, UNICEF
Millenium Ecosystem Assessment	CLUE-S IMAGE SAfMA	UNEP, FAOSTAT, IEA
IPCC Special Report on Emission Scenarios	General Circulation Models (GCMs)	TGIGA database
ATEAM	PCM, CGCM2, CSIRO2 and HadCM3 IMAGE 2.2	PELCOM, CORINE, REGIO statistical database, IPCC Data Distribution Centre, TYN SC 1.0 scenarios
EURURALIS	GTAP, IMAGE, CLUE-s	
PRELUDE	Louvain-la-Neuve land use/cover model	FAOSTAT database EUROSTAT REGIO database PELCOM
ALARM	ATEAM model for land use change, GINFORS as econometric input-output model	
COCONUT	c.f. ALARM	c.f. ALARM
MEDACTION (local quantitative scenarios)	hydrological and sediment yield model SHETRAN a crop growth model EPIC and a farmer response model	N.A.
ADAM	ASTRA POLES	
Four Futures for Europe	WorldScan (applied general-equilibrium model)	World Bank 2001
European Futures	MAcroeconomic, Sectoral, Social and Territorial (MASST) model, the Know trans-European Networks (KTEN) transport model, the exploration of potentials for a European Index of Territorial Cohesion (ETCI), an Indicator of Sustainable Demographic Development (ISDD), a Long-term Database (LTDB), and a methodology for territorial impact assessment (TIA)	

All of the environmental scenarios assessed integrated both qualitative and quantitative work. Even though certain models such as CLUE-S and IMAGE were used repeatedly, there is a wide variety of different models developed for different scenarios. However, most of models use data from the same sources: PELCOM and CORINE for land use and EUROSTAT, UN and OECD for socio-economic data. To date no scenarios were found that used CLC2006, which has an improved resolution.

The research (literature and online) on the national level revealed no relevant (comparable) data or scenario exercises though scenarios (mostly socio-economic or climate change) do exist at that level. Language barriers and time constraints may have limited our findings. Having done this review it seems that European projects which included downscaling exercises to regional and local levels (e.g. COCONUT, MEDACTION and BIOSCENE) could provide input for the SafeLand project.

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