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D.6.3: Report of methodologies and tools for benefit assessment

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ACRONYMS AND ABBREVIATIONS

Abbreviation	Name
DOPA	Digital Observatory of Protected Areas
DoW	Description of Work
EU-FASOM	Bioenergy | Assessment of energy crops in Europe
EO	Earth Observation
FeliX	Full of Economic-Environment Linkage and Integration dX/dt
GEOSS	Global Earth Observation System of Systems
GLOBIOM	Global partial equilibrium model of total land use sector
INSPIRE	Infrastructure for Spatial Information in the European Community
JRC	Joint Research Centre
SBA	Societal Benefit Area
VOI	Value of Information
WP	Work Package

1 INTRODUCTION

Report of Methodologies and Tools for Benefit Assessment

This report (D.6.3) fulfills the objectives of the Cost-Benefit Analysis Work Package (WP6) within the EuroGEOSS Project. WP6 aims to develop and apply methodologies and tools to assess societal benefits of INSPIRE and GEOSS for the three thematic areas of the EuroGEOSS project (Forestry, Drought, Biodiversity) as well as the other societal benefit areas of GEOSS and to undertake an overall aggregated benefit assessment. Furthermore, it aims to develop prescriptive guidance for “value of Information” analysts in the geospatial field and contribute also to current efforts in assessing the impact of public sector information.

Numerous studies have been undertaken to describe and measure the Value of Information (VOI). They typically employ a wide variety of methods and generally find a large range of benefits, from quite small to very large, in part owing to differences in methodologies (Macauley, 2006). The state of the art in understanding the VOI reflects general agreement on how to model an individual’s or a government’s decision and some useful implications about the value of information: when it is most and least valuable, its relationship to subjective prior opinions, and the decision maker’s ability to take action in light of the information (Macauley, 2006). To date, however, there have been few integrated assessments of the economic, social and environmental benefits of Global Earth Observation (EO). EuroGEOSS is an attempt to address this shortfall.

A portfolio of methodologies are being applied to assess the benefit of EuroGEOSS. D.6.3. describes both the basic functionality of the methodologies and the tools used to meet the WP6 Project objectives and the adaptation and extension of these methods (see Figure 1). Focusing on the three basic themes of EuroGEOSS, the Global Biomass Optimization Model (GLOBIOM) cluster is assessing the benefit of interoperable systems across all three themes, Bayesian decision theory and the European Forest and Agricultural Sector Optimization Model (EU-FASOM) are being applied to biodiversity, and a real options framework is applied specifically to drought. Survey techniques, largely described in D.6.1.2, address both direct and indirect benefits of EuroGEOSS and GEOSS as a whole. Finally, the system dynamics model FeliX is used to assess the societal benefits accrued across the three thematic areas of EuroGEOSS, placing the project in the greater context of GEOSS.

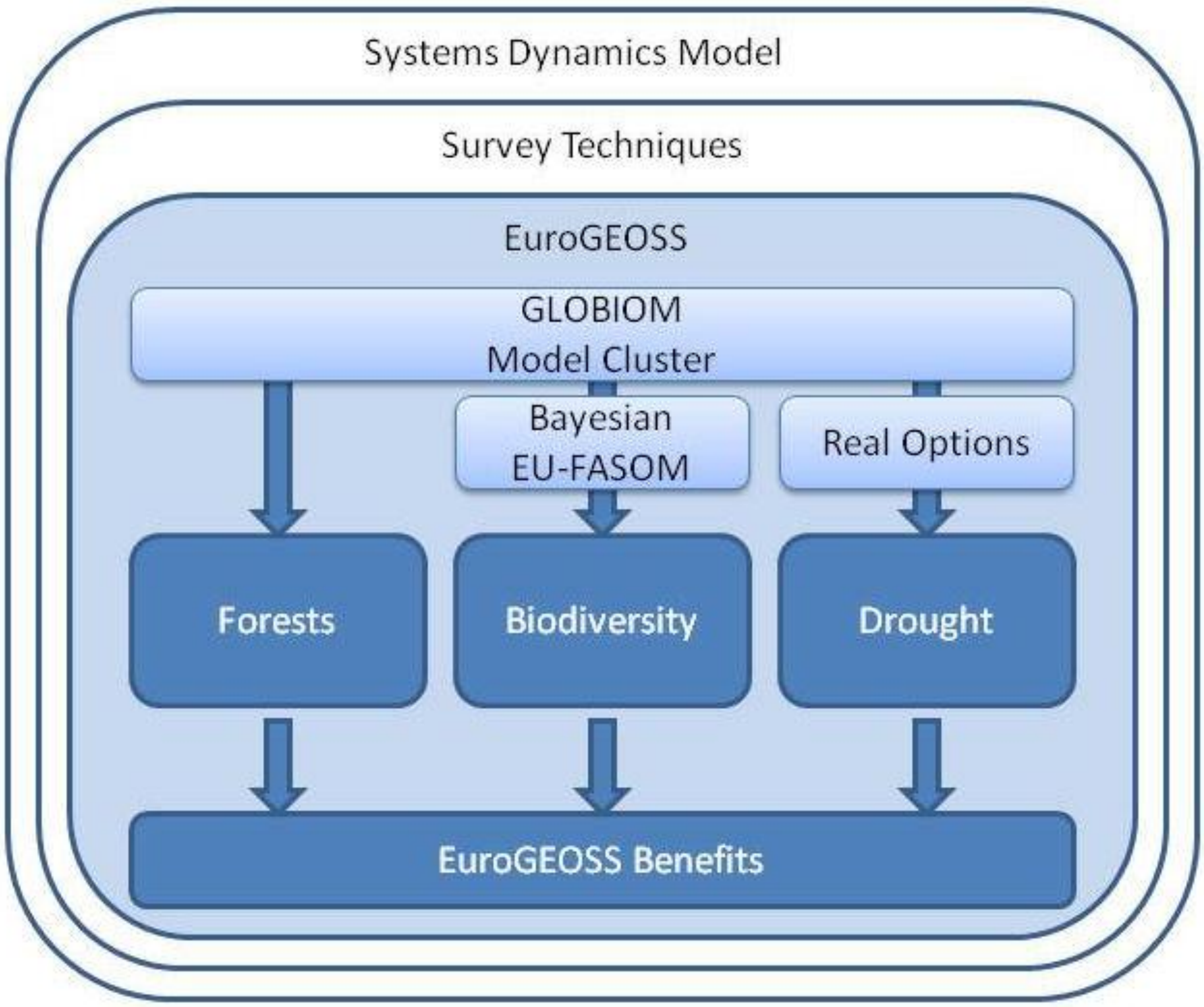

Figure 1. Schematic of the portfolio of EuroGEOSS Benefit Assessment Techniques. D.6.3 is focusing mainly on the indirect benefit assessment occurring within the shaded area.

2 DESCRIPTION OF METHODOLOGIES & TOOLS

A suite of models and tools have been developed which are suited to assess the societal benefits of INSPIRE and GEOSS across the three thematic areas of the EuroGEOSS Project – namely Forestry, Drought and Biodiversity. The following section describes the present state of these models.

2.1 BAYESIAN DECISION THEORY

A method that explicitly considers the extent to which decision-makers actually use Global Earth Observation for decision-making is Bayesian decision theory. The approach is particularly attractive as it links the value of information to the perceived accuracy of the information system.

Assessing the economic value of information basically involves two steps: First, the contribution that information makes to decision-making has to be made explicit. Second, the contribution of better decision making to welfare has to be assessed. With regard to the first step, it is important to realize that information can only improve decision-making if decision-making is uncertain. If decision-makers are completely certain about the outcomes of their decision-making, then additional information will have no influence and, hence, will have no significant welfare impact. An exception is when additional information increases the efficiency of the information system. In this case, the incremental costs of additional information are really benefits, for example, when total monitoring costs are reduced. For more information refer to Bouma et al., 2009a.

2.2 VALUE MEASURING METHODOLOGY

Value Measuring Methodology (VMM) was initially suggested and developed by US Federal Chief Information Officers Council and applied in a case study by Booz Allen Hamilton. That methodology serves primarily for the purposes of comparison of investment alternatives in the field of information technologies and information management systems. IIASA adapted that methodology for the purposes of cost-benefit assessment relevant to the EuroGEOSS project. At the core of the IIASA methodology is the analysis of a two-step questionnaire answered by experts specializing in the fields relevant to the project. We are using the VMM technique to determine the value of EuroGEOSS by comparing the current state (no EuroGEOSS), and the future state (with EuroGEOSS).

The VMM approach allows us to quantify – in particular – intangible benefits that are normally difficult to quantify, i.e. ease of use, timeliness, level of expertise required, and others. These are traditionally more difficult to measure than costs. We have modified the original VMM approach , developing a framework of values suited to measure value in a EuroGEOSS context. The three value areas are:

- Direct users
- Public/Society

- Political

Data is collected through an online survey (see Appendix). Experts are asked to first determine the value that they assign to each theme on a percent scale. Following this, they must define priority (importance) of each of the themes. Results are then quantitatively analyzed. In addition, we use the range in response answers to say something about the expert confidence in the responses and thus suggest possible risk in received information. For more information see: CIO 2002, and Booz Allen Hamilton 2005.

2.3 REAL OPTIONS FRAMEWORK/PORTFOLIO THEORY

Many VOI problems can be addressed in a real options framework, which takes into account investment irreversibility, uncertainty and the flexibility to react when new information arrives. Such a framework is proposed for use within the EuroGEOSS Project (Fuss et al., 2008).

Real Options Framework/Portfolio theory will be applied in at least two instances within the EuroGEOSS Project. Firstly, using results from the EU-FASOM/GLOBIOM model cluster under the forest theme (i.e. land cover uncertainty) and secondly looking at irrigation systems under the drought theme.

The expected Value of Information (VOI) is a concept that has been used in stochastic programming for a long time. Another term frequently used to describe this concept is the so-called willingness to pay (for information). The idea is that decisions being taken on the basis of imperfect information can differ from those being taken in a situation of complete or perfect information and thus the decision-maker might be willing to pay the difference in costs or profits to be able to make a better informed decision.

In the approach here, we compute the expected VOI for a portfolio model, where the optimal mitigation strategy depends crucially on the availability of information. The method that we use to optimize the decisions under perfect and imperfect information is standard portfolio theory, using the variance of costs as a measure of risk. Even though both concepts are not original, the approach of using them to assess the VOI in the face of uncertainty about the availability of land and thus the cost of one of the mitigation options, is worthy of demonstration, both in theory and with a practical example (using the case of avoided deforestation).

2.4 EU-FASOM/GLOBIOM MODEL CLUSTER

The EU-FASOM/GLOBIOM Model Cluster represents a unique combination of biophysical and economic land use decision models. These models interact with each other as described in Figure 2.

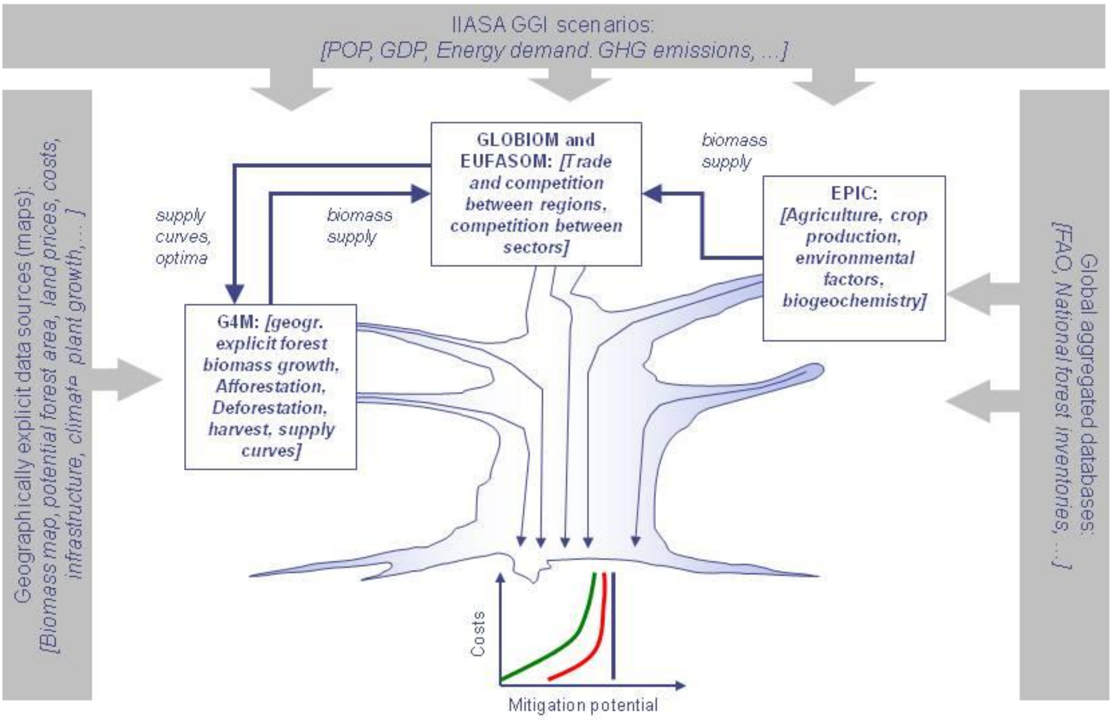

Figure 2. Biophysical/Economic model cluster.

2.4.1 EU-FASOM

Existing economic land use assessment models can be distinguished a) regarding the flow of information in top-down and bottom-up systems, b) regarding the dominating analysis technique in engineering, econometric, and optimization approaches, c) regarding the system dynamics in static, recursive dynamic, and fully dynamic designs, d) regarding the spatial scope in farm level, regional, national, multi-national, and global representations, and e) regarding the sectoral scope in agricultural, forestry, multi-sector, full economy, and coupled economic and environmental models. Additional differences involve various modeling assumptions about functional relationships (demand, supply, factor and commodity substitution) and the applied resolution over space, time, technologies, commodities, resources, and environmental impacts with the associated data.

The variation in methods indicates that land use is a complex system, whose interdependencies cannot be appropriately captured by a single approach. Instead, different methods are applied to address different questions. Using the above described classifications, EUFASOM can be characterized as a bottom-up, optimization, fully dynamic, multi-national, agricultural and forest sector model. In addition, the model portrays detailed environmental relationships and global agricultural and forestry commodity trade.

Bottom-up models are generally data intensive both with respect to inputs and outputs. Input data for EUFASOM describe important properties of resources, production technologies, and agricultural and forestry markets. Generally, while resource data are mainly derived from observations, economic data are computed based on producer surveys or engineering methods, environmental impacts based of land management from simulations with biophysical process models, and market data from national and international statistics. The following descriptions of EUFASOM input data can only give a brief overview. Detailed information on specific data item are available from the authors.

Most raw data are not directly used in EUFASOM but undergo transformations involving model processing, aggregation, and calibration. Detailed meteorological, nitrogen deposition, and soil data over more than 1,000 homogeneous response units (HRU) within the European Union are used as inputs to the EPIC model. For each HRU and all land use and land management alternatives, the EPIC model simulates in daily time steps biomass growth and multiple environmental impacts concerning greenhouse gas emissions, soil organic carbon, erosion, and nutrient leaching. However, only biomass yields and environmental impacts are passed to EUFASOM. As a result, climate and soil data are only implicitly contained in EUFASOM.

Resource data in EUFASOM include region and time period specific endowments for land quality classes, existing forests, labor, and water. National soil type distributions are estimated from a European Soil Database. Existing and suitable areas for five wetland types are estimated through a GIS based spatial analysis (Schleupner 2007).

Economic data for basic agricultural management technologies are derived from the European Farm Accountancy Data Network surveys. Bioenergy data for production and processing of bioenergy are taken from results of the European Non-Food Agriculture consortium. Agricultural management costs, for which data do not exist, are estimated based on engineering equations. Forest stand data are estimated with the OSKAR model based on sub-country level inventories of forest stocks, tree species and age classes covering most of Europe. The OSKAR model employs globally applicable biophysical principles, species characteristics, and expected climate change effects predicted by the LPJ global ecosystem model (Sitch et al. 2003) to estimate forest biomass, carbon storage, forestry production and forest management costs. Forest industry inputs are based on Pöyry consulting expert estimates.

Current production, consumption, trade, and price data for agricultural and forest commodities are taken from EUROSTAT and FAOSTAT. Assumptions about population and gross domestic product developments and technical progress are taken from GTAP.

This section documents the principal mathematical structure of EUFASOM, which is relatively unaffected by data updates or model expansion towards greater detail. EUFASOM is designed to emulate the full impacts of European land use on agricultural and forest markets and on environmental qualities related to land use. The model contains several key components: natural and human resource endowments, agricultural and forest production factor markets, primary and processed commodity markets, agricultural and forest technologies, and agricultural policies. Because of data requirements and computational restrictions, sector models cannot provide the same level of detail as do farm level or regional models. Rather than trying to depict millions of individual farms, EUFASOM represents typical crop, livestock, forest, and bioenergy enterprises for 23 EU member states. Possible producer adaptation is integrated through a large set of alternative land management technologies. These technologies are described through Leontief production possibilities each of it specifying fixed quantities of multiple inputs and multiple outputs. International markets and trade relationships are currently portrayed through eleven international regions.

EUFASOM is a large mathematical program. The objective function maximizes total agricultural economic surplus subject to a set of constraining equations, which define a convex feasible region for all endogenous land use decision variables. Full model activations contains more than 6 Million individual variables and more than 1 Million individual equations. Equations and variables are condensed into indexed blocks. Solving EUFASOM involves the task of finding the optimal levels for all endogenous variables, i.e. those levels which maximize the economic surplus subject to compliance with all constraining equations. Economic surplus is computed as the sum across time, space, commodities, and resources of total consumers' surplus, producers' or resource owners' surplus, and governmental net payments to the agricultural sector minus the total cost of production, transportation, and processing. Basic economic theory demonstrates that maximization of the sum of consumers' plus producers' surplus yields the competitive market equilibrium. Thus, the optimal variable levels can be interpreted as equilibrium levels for land use activities under given economic, political, and technological conditions. The shadow prices on resource and commodity balance equations give market clearing prices.

2.4.2 GLOBIOM

GLOBIOM is a global recursive dynamic partial equilibrium model integrating the agricultural, bioenergy and forestry sectors with the aim to give policy advice on global issues concerning land use competition between the major land-based production sectors. Concept and structure of GLOBIOM are similar to the US Agricultural Sector and Mitigation of Greenhouse Gas (ASMGHG) model (Schneider, McCarl and Schmid 2007). The global agricultural and forest market equilibrium is computed by choosing land use and processing activities to maximize the sum of producer and consumer surplus subject to resource, technological, and political restrictions, as described by McCarl and Spreen (1980). Prices and international trade flows are endogenously computed for 11 world regions.

The market is represented through implicit product supply functions based on detailed, geographically explicit, Leontief production functions, explicit resource supply functions (land and water), and product demand functions. In what follows we will focus on the presentation of the production side of the model as depicted in Figure 3.

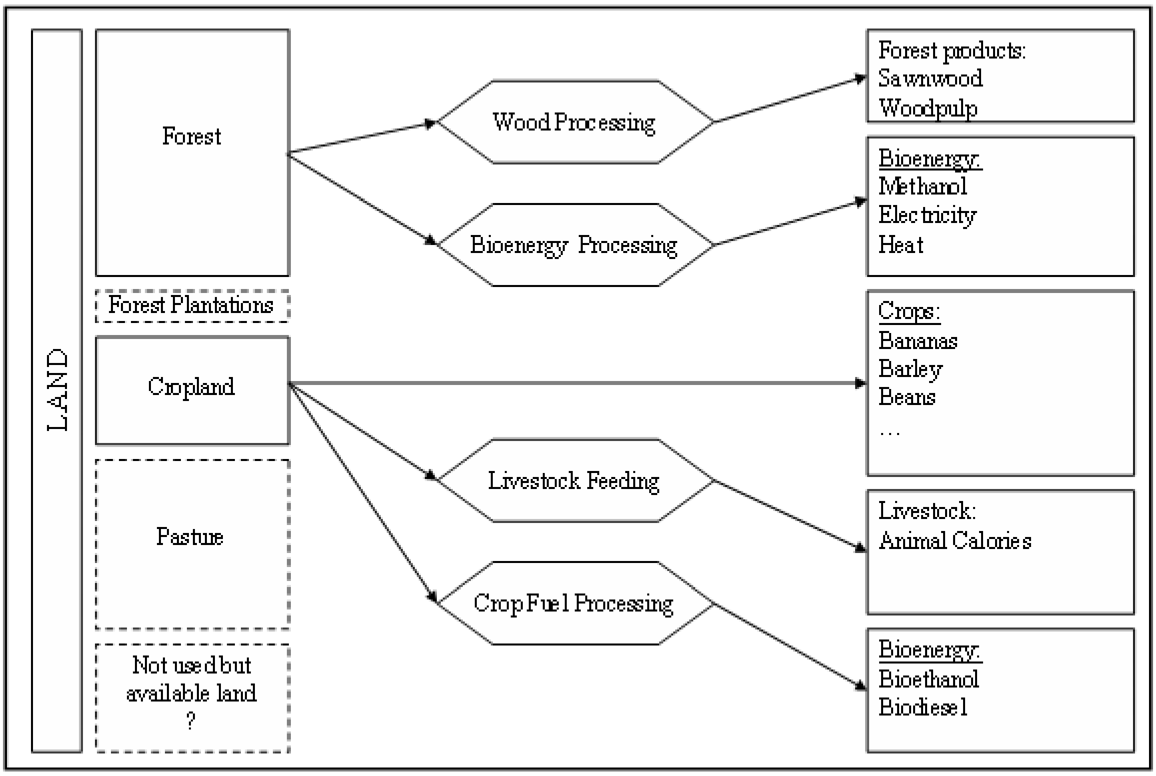

Figure 3. Supply sectors as represented in GLOBIOM.

Supply sectors as represented in GLOBIOMLand and its characteristics are the key elements of our modeling approach. In order to enable global bio-physical process modeling of agricultural and forest production, a comprehensive database has been built (Skalsky et al., 2008), which contains geo-spatial data on soil, climate/weather, topography, land cover/use, and crop management (e.g. fertilization, irrigation). The data are available from various research institutes (NASA, JRC, FAO, USDA, IFRPI, etc.) and significantly vary with respect to spatial, temporal, and attribute resolutions, thematic relevance, accuracy, and reliability. Therefore, data were harmonized into several common spatial resolution layers including 5 and 30 arcmin as well as country layers. Consequently, Homogeneous Response Units (HRU) have been delineated by including only those parameters of landscape, which are almost constant over time. At the global scale, we have included five altitude classes, seven slope classes, and six soil classes. In a second step, the HRU layer is merged with other relevant information such as global climate map, land category/use map, irrigation map, etc. to delineate Simulation Units, which are actually input into the Environmental Policy Integrated Climate model (EPIC, Williams 1995, Izaurralde et al. 2006). This HRU concept assures consistent aggregation of geo-spatially explicit bio-physical impacts that are simulated with EPIC (e.g. crop yields, nitrogen leaching, soil carbon sequestration).

Currently, two major land cover types are represented in the model: cropland and forest. [1] Crop production accounts for about 20 globally most important crops. The data are taken from FAOSTAT, where national averages over the years 2001-2005 are used to define base levels for yields, harvested areas, prices, production, consumption, trade, and supply utilization. Irrigated crop yields, crop specific irrigation water requirements, and costs for five irrigation systems are derived from a variety of sources as described in Sauer et al. (2008). For selected crops (corn, sugarcane and wheat), management and land quality specific yields have been estimated with EPIC. Four management systems are currently represented which correspond to the IFRPI crop distribution data classification (irrigated, high input - rainfed, low input - rainfed and subsistence management systems). The number of crops, systems, and parameters (especially environmental parameters like soil carbon, erosion, and nutrient leakage) estimated with EPIC is being expanded.

Crop supply can enter one of three processing/demand channels: consumption, livestock production or biofuel production. Consumption is modeled by constant elasticity demand functions parameterized using FAOSTAT data. Only a preliminary regional livestock production representation is applied in the present version of the model where a bundle of livestock products is assimilated to a generic commodity - “animal calories”. Feed requirements have been calculated from the Supply Utilisation Accounts, FAOSTAT. Demand for livestock products is represented through upward sloping demand curves. Biofuel options from crops include first generation technologies for a) ethanol from sugarcane or corn, and b) biodiesel from soya or rapeseed. The processing data are based on Hermann and Patel (2007) for ethanol and Haas et al. (2006) for biodiesel. Market demand for ethanol and biodiesel is represented through vertical demand functions.

Primary forest production is characterized also on the basis of HRUs and the resulting Simulation Units. The most important parameters for the model are mean annual increment, maximum share of sawlogs in the mean annual increment, and harvesting cost. These parameters are shared with the G4 Model – a successor of the model described by Kindermann et al (2006). More specifically, mean annual increment for the “current” management[2], is obtained by downscaling the biomass stock data from the Global Forest Resources Assessment (FAO, 2005) from the country level to the 0.5° × 0.5° grid using the method described in Kindermann et al. (2008). This downscaled biomass stock data is subsequently used to parameterize the increment curves Kindermann

(2008). Finally, sawnwood share is estimated by the tree size which in turn depends on yield and rotation time. Harvesting costs is adjusted for slope and tree size as well.

Five primary forest products are defined: sawlogs, pulplogs, other industrial logs, firewood, and energy biomass. Sawlogs, pulplogs and energy biomass are further processed. Sawnwood and woodpulp production, and demand parameters rely on the 4DSM model described in Rametsteiner et al. (2007). FAO data and other secondary sources have been used for quantities and prices of sawnwood and woodpulp. For production cost estimates of these products, for example, mill costs, an internal IIASA database and purchased data were used. The energy biomass can be converted into methanol and heat or electricity and heat, where processing costs and conversion coefficients are obtained from Leduc et al. (2008), Hamelinck and Faaij (2001), Sørensen (2005), and Biomass Technology Group (2005). Demand for woody bioenergy production is implemented through minimum quantity restrictions, similarly as demand for other industrial logs and for firewood.

The final model calibration, supposed to correct data imperfections and get the baseline solution close to the observed values, is done by adjusting the cost parameters of selected activities so that for the baseline activity levels, their marginal cost equals to their marginal revenue, as assumed by the microeconomic theory. The controlled activities are crop areas, primary forest products supply and animal calories supply.

2.4.3 G4M

The Global Forest Model (G4M) estimates the annual above ground wood increment and harvesting costs. It takes track on the above ground forest biomass. By comparing the income of managed forest (difference of wood price and harvesting costs, income by storing carbon in forests) with income by alternative land use on the same place, the decision of afforestation or deforestation is made. As G4M is spatially explicit (currently on a 0.5°x0.5° resolution which is planed to bring down to 30"x30") the different deforestation pressure at the forest frontier can also be handled.

G4M flowchartIncrement is determined by a potential NPP map. At present this NPP map is static but can be changed to a dynamic NPP model which reacts to changes of temperature, precipitation, radiation or CO_2 concentration. Main forest management options are species selection, application of thinning and choice of rotation time. G4M does not distinguish between species but a change of species can be emulated by adapting NPP, wood price and harvesting costs. The rotation time can be individually chosen but the model can estimate optimal rotation times to maximize increment, maximize stocking biomass or maximal biomass at harvest time. The model handles age classes with one year width.

Afforestation and disasters cause an uneven age-class distribution over a forest landscape. The model is doing final cuts in a manner, that all age classes have the same area after one rotation time. During this age class harmonization time the standing biomass, increment and amount of harvest is fluctuating due to changes in age-class distribution and afterwards stabilizing.

The model can use external information from other models or data bases like wood prices, prescribed land-use change which guarantee food security and land for urban development or account for disturbance. As outputs, G4M produces forecasts of land-use change, carbon sequestration/emission in forests, impacts of carbon incentives (e.g., avoided deforestation), and supply of biomass for bioenergy and timber.

2.4.4 EPIC

The EPIC (Environmental Policy Integrated Climate) model integrates a large number of terrestrial biophysical processes allowing for global environmental impact assessments of alternative land use management systems (Williams, 1995; Izaurralde et al., 2006). The major components in EPIC are weather simulation, hydrology, erosion-sedimentation, nutrient and carbon cycling, pesticide fate, plant growth and competition, soil temperature and moisture, tillage, cost accounting, and plant environment control. EPIC operates on a daily time step and is capable of simulating hundreds of years if necessary.

The new carbon cycle (Izaurralde et al., 2006), which is based on the CENTURY approach (Parton et al., 1994) is already included and the new nitrogen cycle is just about to be integrated. The new nitrogen cycle allows tracing N2O more precisely and includes microbial processes (i.e. nitrification and de-nitrification) which are the major sources of N-based GHG emissions in managed lands. The new N-cycle combines consolidated findings in microbiology as well as chemical reactions and physical processes regarding the formation of oxidized nitrogen products during the nitrification process. The new nitrification approach (Schwab et al., 2009) is based on the hypothesis that nitrite is used as alternative electron acceptor to reduce CO2 to biomass for ammonium oxidizing bacteria (AOBs) under insufficient supply of oxygen. The amount of oxygen in the environment and the process of nitrification itself are dependent on different physical and chemical environmental attributes like moisture, pH, temperature etc. As a consequence, rates of products of nitrification NO3-, NO2-, or N2O, NO and N2 are therefore sensitive to environmental conditions as well. Both, microbial nitrification and denitrification are modelled on an hourly basis in EPIC. The processes of methanogenesis and methanotrophy will be implemented as well to trace terrestrial CH4.

EPIC is used to compare land use management systems and their biophysical impacts on crop yields and biomass growth, hydrology, nitrogen emissions, soil organic carbon sequestration, sediment transport and on green house gas emissions. The management components (e.g. latest Crop maps from IFPRI) that are currently analyzed include crop rotations, legume/grass mixes, agro-forestry, tillage operations, fertilization and irrigation scheduling. The EPIC model is already operational on global and European scales and is continuously improved. The linkage to EU-FASOM Model and GLOBIOM Model is operational.

2.5 SYSTEMS DYNAMICS MODELLING

The FeliX model is a System Dynamics type model. System Dynamics models attempt to capture as many aspects as necessary of interactions within a closed system. Most variables are therefore “endogenous” (i.e. contained within the system represented by a System Dynamics model). In order to describe the system structure, System Dynamics focuses on the flow of feedback that occurs throughout the parts of a system (feedback loops) – a change in one variable affects other variables over time, which in turn affects the original variable, and so on. The dynamic behavior then occurs when flows accumulate in stocks (e.g. atmospheric carbon). Special dynamic notions are also given by delays and nonlinear relations between the system elements. All these elements produce changes in the way the system has performed in the past and might evolve in the future.

The FeliX model, following the System Dynamics approach, attempts a full systems perspective, where the underlying social, economic, and environmental components of the Earth System are interconnected to allow for complex dynamic behavior characterizing the Anthropocene. A change in one area often results in changes in other areas – for instance depletion of natural resources being a source of energy may impact population growth but also put pressure on the agriculture sector in order to produce more energy crops as a substitute for such natural resources as oil or gas. Being a dynamic model, FeliX captures important stock changes (e.g. depletion of natural resources, accrual of carbon dioxide in the atmosphere) or impacts of certain policies (e.g. afforestation, emission reduction) over time. The FeliX model was built in order to achieve congruence with the nine SBAs of GEO. The model structure of FeliX is illustrated in Figure 4. A detailed description of the FeliX model is provided in Rydzak et al. (2009).

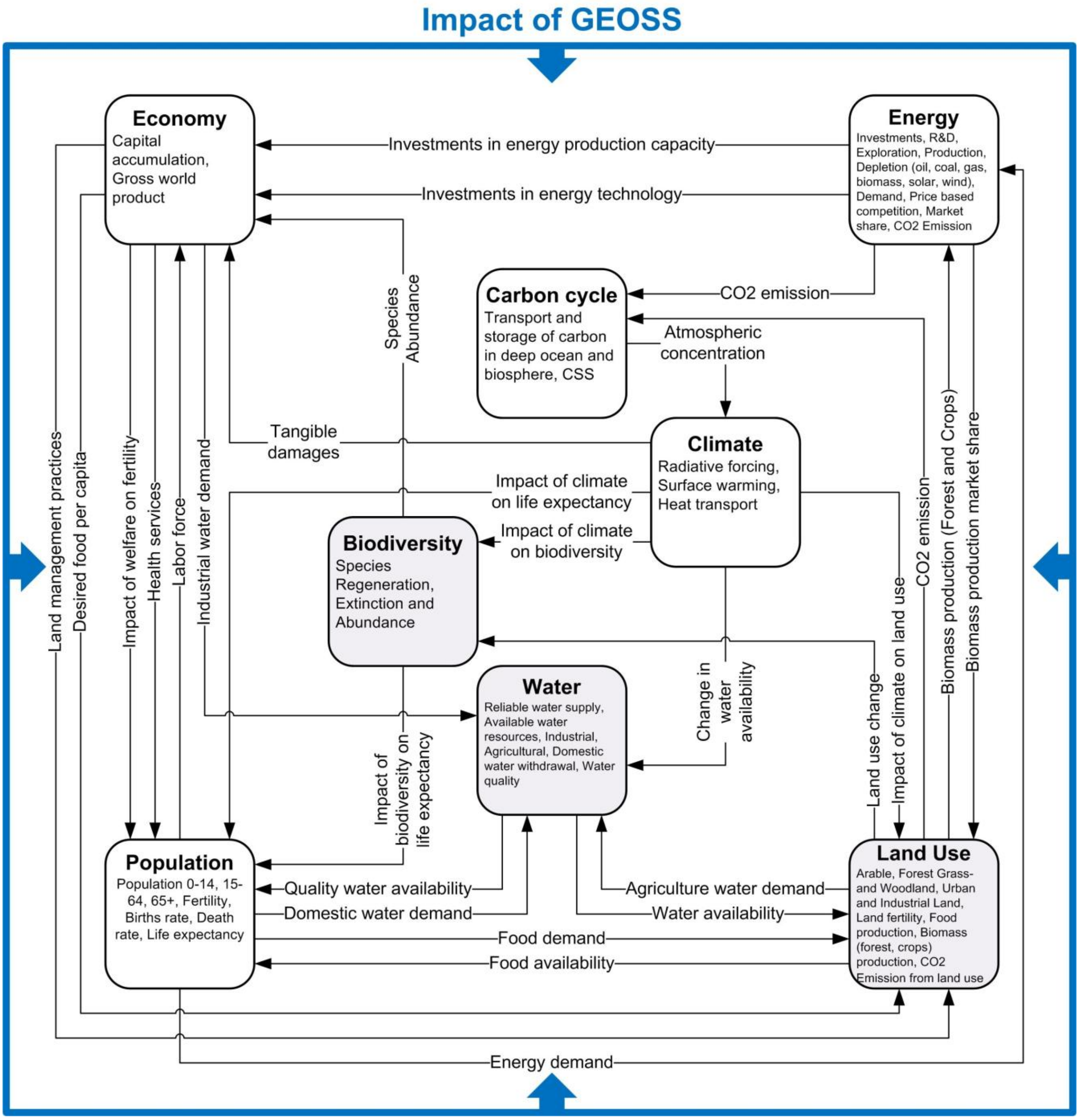

Figure 4: Overview of the FeliX model structure

At the core of the economy module is a neo-classical growth model. Capital is an accumulation of investments whereby in FeliX, investments in the Energy and GEOSS sector are separately accounted. Growth of Gross World Product is driven by increases in the labor force, which is modeled explicitly in the population module, along with capital accumulation and technological change. The economy module contains a representation of the climate system and takes into account impacts associated with global average temperature change according to the DICE model. In addition to the climate mitigation measures i.e. reduction of greenhouse gas (GHG) emissions contained in the DICE model the FeliX model accounts for climate adaptation activities following rising intensity of storms, forest fires, droughts, flooding and heat waves and also prevention/adaptation activities to new climate conditions. However, as the range of the impact from climate change is uncertain, the assumed model parameters are constantly revised. The DICE model is known to potentially underestimate climate impacts.

The FeliX model accounts for CO2 emissions with a detailed representation of emissions in the energy sector and land use change. Energy production technologies differ with regards to carbon intensity of production. The model accounts for CO2 emission from oil, gas, coal, biomass, solar and wind power energy technologies in terms of end-to-end lifecycle impacts. CO2 emissions accumulate in the atmosphere and are reabsorbed through fluxes to the terrestrial biosphere and the ocean. The model also accounts for CO2 flux between living biomass and humus and also distinguishes between the ocean mixed layer and the deep ocean.

The FeliX model takes into account the greenhouse effect and captures the additional surface warming from the accumulation of CO2. Positive forcing increases the atmospheric and upper ocean temperature. Additionally, heat transfer between the atmosphere and the upper ocean and deep ocean is modeled. This disturbance of the climate system measured by changes in temperature leads to climate impacts, accounted for in various sectors of the model. Thus, the impact of climate change is spread out across the whole model, impacting inter alia the land quality parameters, population growth and biodiversity (explicitly accounted for in a biodiversity model module).

Energy demand is driven by population development and the evolution of per capita energy demand. Exploration and production activities, investments in the deployment of energy technologies, R&D activities, and costs of energy carriers are explicitly modeled for each source of primary energy. An economic mechanism of price based competition between energy sectors determines the market share of primary energy. Technological development is explicitly modeled in the energy and land use sectors. R&D investments lead to increased growth of either sector/technology specific or economy wide technological change. Technological change is a major driver of economic growth.

The FeliX model contains a “competition for land” module. Various social and economic activities as well as natural processes may impact and change the characteristics of a land type and also cause transformation from one land type to another. A growing population and changing food preferences to more protein rich diets require sufficient amounts of food production, increasing the pressure of agricultural land expansion into forests and grasslands. The model accounts for increased agricultural land fertility due to improvements in land-use (e.g. fertilization, irrigation, improved seeds). Furthermore, Felix accounts for new demands for biomass resources for energy purposes and material use, from both forest biomass as well as biomass from energy crops. The intensification of competition for land between food and energy crops is explicitly modeled. Water resources are explicitly accounted for in a water module, constraining land fertility due to scarcities of irrigation water.

3 ADAPTATION AND EXTENSION OF METHODOLOGIES AND TOOLS

The following section describes how the methodologies and tools outlined above have been adapted and extended to meet the objectives of the EuroGEOSS Project.

In particular, adaptation and extension of existing simulation models [i.e. GLOBIOM; EU-FASOM] to be suitable for the scenario analysis (i.e. GEOSS and non-GEOSS scenarios) defined in Task 6.4 and the indirect benefit assessment as defined in Task 6.5 was necessary. These models will be prepared to run in different data environments such as Europe, Africa and the Congo Basin in particular.

3.1 BAYESIAN DECISION THEORY

Objective

With this survey we address two tasks of work package 6 of EuroGEOSS (www.eurogeoss.eu). Task 6.2 aims to assess benefits of increased interoperability in Europe with special focus on the thematic areas of the project by using different methodologies and demonstrate alternative approaches on selected case-studies in collaboration with WPs 3-5. (M26). Task 6.5 requires providing an analysis of indirect benefits of improved data through better policy decisions i.e. measure the improvements made through reducing uncertainty based on better information which results from SDI in order to be able to make better decisions (M36). The objective is to apply this approach to assess the value of DOPA, (http://acpobservatory.jrc.ec.europa.eu/themes/DOPA.html) the digital observatory for the management of protected areas.

Method

An interesting methodology to assess and quantify the value of information is Bayesian Decision Theory. Bayesian decision theory allows evaluating the role of information when decision makers are uncertain about the "state of the world" in which they are in. The state of the world can be any

scenario e.g. related to an environmental occurrence. Given the uncertainty about being in a specific state of the world, decision makers have to base their decisions on expected utilities, which depend on their perceived probabilities of being in a specific state of the world. If additional information is provided, the decision makers can update their belief about being in a specific state of the world and thus overcome, or mitigate, uncertainty.
Based on this framework, we investigate the question, how improved information, e.g. provided by a spatial data infrastructure, is expected to reduce uncertainty of decision makers. Which benefits can be derived when decisions are based on information derived from the respective information system?

The theoretical framework was developed by Hirshleifer and Riley (1979). They assume that there exists a set of states of the world, s = (1,…,S), a set of actions, a = (1,…,A), and the associated consequences of the actions in a specific state of the world, c(a,s). All this is known to the decision maker. Further, the decision maker has a prior probability distribution of initial beliefs, πs, to be in a specific state of the world. From this information the expected utility can be derived as:

$$u(a,\pi) = \sum_{s=1}^{S} \pi_s v(c_{a,s})$$

The decision maker can acquire information, message m= (1,…,M).This additional information will lead him to revise his prior probability belief, which can lead to a revision of his choice of action. The revised probability belief is determined by Baye's Theorem

$$\pi_{s,m} = Pr\{s|m\} = \frac{Pr\{m|s\}Pr\{s\}}{Pr\{m\}} = \frac{q_{m,s}\pi_s}{q_m}$$

Where the probability qm of receiving message m is related to the conditional probability qm,s of receiving message m in each state s by:

$$q_m = \sum_{s=1}^{S} q_{m,s}\,\pi_s$$

Given the message, the decision maker revises his expected utility, based on the revised probability πs,m. This possibly leads to a new choice of action am .Then Δm, the value of the message m, can be written as

$$\Delta_m = u(a_m, \pi_{s,m}) - u(a_0, \pi_{s,m})$$

Δm is a ex-post valuation and represents the expected gain from revision of best action, estimated in terms of revised probability. The decision to seek information must be made ex ante, however. The decision maker does not know in advance which message he will receive out of this set of possible messages, m = (1,…,M) he will obtain. Rather, there exists an information service μ, which attributes a probability distribution to the messages m. Based on these message probabilities, the individual can calculate the value Δm of the information service as the expectation of its associated message value Δm

$$\Delta(\mu) = E(\Delta_m) = \sum_m q_m[u(a_m, \pi_{s,m}) - u(a_0, \pi_{s,m})]$$

Hirshleifer and Riley (1979) identify three factors which determine the extent to which the decision maker updates his belief:

Confidence, which the decision maker has in his initial beliefs. The higher this confidence, the more likely the posterior probability distribution will resemble the prior for any given weight of evidence. Great confidence implies attaching a lesser value to acquiring evidence.

Belief of whether the message is true or not. The message can be false in two ways: it can incorrectly reject the true state (Type I error) or it can fail to reject the false state (Type II error). If the perceived errors are large the value of the message will be clearly less.

The value of information also depends on the content of the information: the more surprising the informational message or the larger the difference compared to existing beliefs, the greater the likelihood that the prior belief will be updated.

(also cp. Bouma et al. 2009a)

Previous Empirical implementation

There have only been few empirical studies which apply this method and estimate prior and posteriori probability. Examples are Schimmelpfenning and Norton (2003) which calculate the value of agricultural economic research in a number of case studies such as crop insurance program and food safety program, or Bouma et al. (2009a), who estimate the value of satellite based earth observation for water quality management in the North Sea. Or Bouma et al. (2009b) who estimate the value of earth observation for the management of the Great Barrier Reef.

In contrast to Schimmeplfenning and Norton (2003) who only focus on two key stakeholders to derive information about the prior and posteriors belief function, Bouma et al. (2009a) include 23 stakeholders, including policy makers, researchers, representatives from interest groups and water managers. On the one hand, they argue that a broader range of decision makers might increase the robustness of the results. On the other hand, however, the stakeholders must have a good knowledge of the issue and the information system in question because they are required to quantify their answers.

Even though Bayesian decision theory seems to be a potent method to quantify the value of information, it also has drawbacks. The most important is that the estimation of probability beliefs is highly subjective. Therefore the resulting estimates strongly depend on the chosen stakeholder, in particular when the estimations are derived from 2 key stakeholders, whose answer could be, after all, strategically motivated. Also the perceived accuracy of the information system plays a crucial role and requires decision makers to have a good knowledge of the information provided.
The following matrix depicts which parameters are necessary in order to conduct this analysis:

	Action a_1	Action a_2	Prior belief of scenario occurring π_s	Likelihoods of receiving message m in state s, $q_{m,s}$		Joint probabilities $j_{sm} = \pi_s q_{m,s}$	
State of the world 1	c_{11}	c_{21}	π_1	q_{11}	q_{21}	j_{11}	j_{21}
State of the world 2	c_{12}	c_{22}	π_2	q_{12}	q_{22}	j_{12}	j_{22}

For instance, c(a,s) can reflect the cost associated with a certain action, respectively the cost when an action is omitted. Likelihoods of received message m in state s reflect the perceived accuracy of the message, or the belief of decision makers that message is correct. With this information, Bayesian updating of beliefs can be performed. The value of information can then be quantified by comparing the expected utility given the updated posteriori beliefs.

To conduct a survey, certain requirements have to be fulfilled:

- Key decision makers or several stakeholders need to have a good knowledge of data. They must be able to answer questions concerning the accuracy of data. They should also be able to tell us their priori beliefs of an event occurring (even though this parameters can be derived from existing literature)
- They need to take decisions under uncertainty.

- The information system which is tested must be able to mitigate uncertainty (provide additional information about the state of the world)

To extract the information required, in particular the prior and posterior belief, the questionnaire therefore could include following questions:

- What is the situation with/without SDI/improved information and what is impact of additional information on respective topic. Quantify?
- Compare situation when having new information and situation without.
- What is the perceived value of information when deciding? Quantify?
- What is the extent to which improved information can reduce their uncertainty?
- How often do particular events occur (for instance and environmental occurrence about which decision makers are uncertain)?
- What is the expected likelihood that additional information is accurate?

If questions cannot be answered by several stakeholders it is possible to derive estimates from literature or from expert consultation, i.e. probability of event occurring, or accuracy of information.

3.2 VALUE MEASURING METHODOLOGY

We perform the assessment in a indirect way by answering the question: what should be the minimum level L of financing of the client-projects utilizing EuroGEOSS results per year (projects' cost share attributed to that usage to be assessed by experts on average e.g. s = 20%) so that EuroGEOSS itself (with the cost C) is beneficial when considered in the time frame of e.g. T = 5 years? This leads to an inequality

$$sLT\Delta B \geq C,$$

here we assume that client-projects are beneficial in the sense that they transform invested funds into an equally (or more) important benefits, so that sL denotes lower assessment of the projects' benefits attributed to usage of EuroGEOSS relevant information/SDIs per year. Then sLT scales it up to the time frame of T years, and $sLT\Delta B$ denotes increased benefits due to EuroGEOSS implementation stemming from the information being used in the projects over the time period T. So the assessment of L can be presented in the form:

$$L \geq L_0 = \frac{C}{sT\Delta B}.$$

If the value of Lo would be reasonably low, the EuroGEOSS project may be deemed beneficial.

Important: Values s and T should be evaluated by the experts in a questionnaire. For the assessment of the value of L, it is envisioned that some official statistics can be used.

Example of the calculation:

$$L_0 = \frac{6.0 M Euro}{0.20 \cdot 5 \cdot 0.1} = 60.0 M Euro.$$

3.3 REAL OPTIONS FRAMEWORK/PORTFOLIO THEORY

3.3.1 Land Cover Uncertainty

We use standard portfolio theory (Markowitz, 1952) to approach the problem of determining the optimal mitigation portfolio and derive the expected value of perfect information (VOI) for the results obtained (Birge and Louveux, 1997). In particular, the objective to be minimized is a weighted average of expected costs and variance:

$$\min_{x \in [0,1]} E[C(x)] + \omega Var[C(x)]$$

where the weight of the variance represents the level of risk aversion - the larger the weight of the variance in the objective, the more costs the decision-maker will adopt in order to reduce this risk. E is the expected value operator; Var is the variance; ω is the measure of the risk aversion being larger than 0 for risk-averse decision-makers and equal to 0 for risk-neutral decision-makers; x is the share of emissions abated through avoided deforestation within the mitigation portfolio; and C are the mitigation costs.

Other studies analyzing mitigation strategies have also implicitly and explicitly incorporated risk-averse decision-makers, but it is obviously challenging to estimate the magnitudes of the risk aversion parameter for global decision-makers, although much work has been conducted in eliciting the degree of risk aversion of farmers using different types of utility functions (Lin et al. (1974), Binswanger (1980), Dillon (1971), Dillon and Scandizzo (1978), etc.).

3.3.2 Irrigation under Uncertainty

The aim is to model an agriculturalist's decision to invest in a more or less water efficient irrigation system under precipitation uncertainty.: What is the optimal timing to invest in the respective irrigation system ? How is the decision to invest affected by: Policy instruments (e.g. water prices and subsidies) and additional weather information?

We use data simulated by the biophysical process simulation model EPIC (Environmental Policy Integrated Climate; Williams, 1995; Izaurralde et al., 2006) for the Austrian Marchfeld region. The region is one of the most important field crop production areas as well as driest areas in Austria.

We apply a Real Options Approach (Dixit and Pindyck,1994), which captures uncertainty about production conditions; flexibility to postpone investment to a later stage when e.g. more information is available; and irreversibility of investment. The annual precipitation sums, which are assumed to represent uncertainty in the real options model, are taken from a statistical climate model for the years 2009-2040 (Strauss et al., 2010).[1] In our model framework, decision makers choose to invest either into a sprinkler irrigation system, or into a more water efficient drip irrigation system. The decision maker chooses the optimal investment strategy and time to maximize his expected sum of profits over the proposed planning horizon (2009-2040).

Thus, we are presented with a stochastic optimal control problem on a finite horizon with a discrete stochastic component. The optimal actions can be derived recursively by dynamic programming using the Bellman equation.

The output of the optimization allows us to calculate the cumulative probability of adopting an irrigation system at a specific point in time.

3.4 EU-FASOM/GLOBIOM MODEL CLUSTER

3.4.1 EU-FASOM

On the densely populated European continent, competition for land is high. Agricultural and forestry land use lead to habitat loss, degradation, and fragmentation. These are the most important threat factors for biodiversity. Considering land scarcity and demand for alternative uses,

- [1] Strauss, F., E. Schmid, H. Formayer, E. Moltchanova, and X. Wang (2010). Climate Change and Likely Near Future Development of Ecological Indicators in the Marchfeld Region of Lower Austria, Climatic Change. [in review].

efficiency in biodiversity conservation strongly depends on the efficiency in land allocation. Systematic conservation planning provides tools to identify optimally located priority areas for conservation (Margules and Pressey 2000, Possingham et al. 2000).

The applied model allocates species habitats by minimizing the costs for setting aside land for conservation purposes. We compare two different versions of the model. In the non-GEOSS version there are no restrictions on the available habitat area per planning unit, in the GEOSS version we include explicit modelled wetland habitat data.

We employ a deterministic, spatially explicit mathematical optimization model programmed in General Algebraic Modelling System (GAMS). It is solved with mixed integer programming. We apply the minimum set problem from systematic conservation planning. Its objective is to minimize resources expended, subject to the constraint that all biodiversity features meet their conservation objectives (Possingham et al. 2000, McDonnell et al. 2002). Conservation objectives account for the two principal conditions of systematic conservation planning: representation and persistence of the biodiversity features (Margules & Pressey 2000, Sarkar et al. 2006).

The objective function minimizes opportunity cost. Opportunity costs are treated exogenously, they do not change during the model runs. The cost minimization is subject to ecological and spatial constraints. Ecological restrictions ensure that each biodiversity feature reaches a given representation target, meets its area requirements for viable populations, and is allocated to its necessary habitat types. Spatial restrictions ensure that the available habitat areas per planning unit is not exceeded and consider the spatial arrangement of the planning units.

The model is applied to European wetland species. 69 wetland vertebrate species of European conservation concern serve as surrogates for biodiversity. Vertebrate species are common surrogates for biodiversity as there are good occurrence data available and they usually have greater area demands than invertebrates, plant species, and even most ecosystems. The species are derived from the two European directives in relation to wildlife and nature conservation: the Birds and the Habitats Directive (79/409/EEC, 92/43/EEC).

As input to the model we use three types of data where the spatial resolution is of relevance:
- species occurrence data
- habitat areas
- land opportunity costs

Species occurrence data have a resolution of about 50 x 50 km (atlas data originate from Gasc et al. 1997, Hagemeijer and Blair 1997, Mitchell-Jones et al. 1999). The model is based on planning units derived from the species occurrence data. Spatially, the model encompasses the European Union 25, resulting in 2016 planning units. For the habitat areas, two different procedures are applied. In the non-GEOSS version there are no restrictions on the available habitat area per planning unit, whereas in the GEOSS version we include explicit modelled high resolution wetland habitat data. Land opportunity costs differ between countries (agricultural land costs are derived from Eurostat and Farm Accountancy Data Network (FADN) data). For a detailed description of model and input data see Jantke & Schneider (2008).

Conservation planning tools benefit from the integration of high resolution habitat area data. They enable more reliable estimations on area requirements, habitat shares and the opportunity costs of habitat protection. Especially the costs of habitat protection were severely underestimated in our non-GEOSS model version.

We plan to implement opportunity costs on homogenous response units (HRU) (see Skalský et al. 2007 for details) level which will further improve the model accuracy.
Comprehensive species occurrence data with a higher resolution are not available for the spatial scope of the model. Downscaling would therefore be an option to work on smaller scales (see Araujo et al. (2005) for an example on European atlas data). The spatial wetland distribution model is going to be extended to whole Europe.

For more information refer to: Jantke, K., C. Schleupner, and U.A. Schneider (2009).

3.4.2 GLOBIOM

In this study, we evaluate how models, which are designed to help in policy design, can be used to quantify the differences in implementation costs. By examining these cost differences, we are able to quantify the benefits, which equal the loss from making a decision under imperfect information. Taking the specific example of choosing the best mitigation option (i.e. REDD versus Carbon Capture and Sequestration) under uncertainty about the available cropland area, we have developed a methodology on how the value derived from reducing uncertainty can be assessed. By implementing a portfolio optimisation model to find the optimal mix of mitigation options under different sets of information, we are able to estimate the benefit of having an improved land cover dataset and thus determine how valuable land cover validation efforts are. We illustrate the methodology by comparing portfolio outputs of the different mitigation options modelled within the GLOBIOM economic land use model using cropland data from different databases.

These large absolute and spatially distributed differences in cropland extent have implications for the GLOBIOM economic land use model used at IIASA, as they provide the initial conditions for the evaluation of different mitigation options. For the purpose of this study, a scenario is devised in which there are two mitigation options, i.e. Reduced Emissions from Deforestation and Forest Degradation (REDD) versus the implementation of a new technology such as Carbon Capture and Storage (CCS) in the industry/energy sector. Each mitigation option has a different cost. However, the REDD mitigation option has increasing costs due to competition as the remaining land available for cropland becomes more expensive. The uncertainty in these costs is also a function of which cropland extent layer is used as an input to the land use model. The uncertainty around whether the world is correctly represented by the figures reported by the International Food and Policy Research Insitute (IFPRI) or the GLC-2000 land cover product or MODIS may carry substantial costs when choosing a policy portfolio. This is because the optimal mix of mitigation options under uncertainty might deviate substantially depending upon whether IFPRI, the GLC-2000 or the MODIS world is known to be the true state. This is also a function of the risk strategy of the decision maker. For example, a risk-averse strategy might typically be to accept higher portfolio costs to lower the overall risk. We acknowledge the potential importance of other sources of uncertainty such as uncertainty in the economic land use model and its underlying assumptions as well as the exogenous drivers of the economic land use model such as the validity of population projections and assumptions about technological change: higher than anticipated population would exert additional pressures on land, while unexpected breakthroughs in technology might lead to yield increases reducing the demand for land for food production, for example. Analyzing all sources of uncertainty is clearly beyond the scope of this study. We therefore focus on land cover uncertainty, since the methods and tools are currently available to reduce this type of uncertainty. Moreover, we acknowledge that the Value of Information which is derived in this study has itself a particular uncertainty attached, since not all types of uncertainties can be considered simultaneously without obscuring the mechanisms in which we are primarily interested at this stage.

In this study a methodology is presented that demonstrates how the value of reducing uncertainty can be assessed. A portfolio optimisation model is implemented in order to find the optimal mix of mitigation options using different estimates of cropland from two land cover datasets as inputs to the model. We therefore created 2 different land cover layers, one using the GLC-2000 cropland minimum (the cropland class is covered 50% by cropland and 50% by a non-cropland class) and the other using the MODIS cropland maximum (where the cropland class is covered 100% by cropland). This can still be considered a relatively conservative approach as the maximum cropland extent reported by GLC-2000 would be even higher.

For more information refer to: Havlik P, et al 2010

3.4.2.1Geo-Wiki

Land cover maps provide critical input data for global models of land use. Urgent questions exist, such as how much land is available for the expansion of agriculture to combat food insecurity, how high will be competition for land between food and bioenergy in the future, as well as how much land is available for afforestation projects?

Moreover the question arises as to what the most cost-effective mitigation option is (e.g. REDD policies versus biofuel targets). Such questions can only be answered if reliable maps of land cover exist. However, global land cover datasets currently differ drastically in terms of the spatial extent of cropland distributions. One of the data layers, which differs the most is cropland area. Ramankutty et al. 2008 estimate that, at the 90% confidence range, the cropland area is between 1.22 and 1.71 billion hectares which translates to a 40% difference.

Thus, even though global land cover is one of the essential terrestrial baseline datasets available for ecosystem modeling, uncertainty remains an issue. Tools such as Google Earth offer enormous potential for land cover validation. With an ever increasing amount of very fine spatial resolution images (up to 50 cm × 50 cm) available on Google Earth, it is becoming possible for every Internet user (including non remote sensing experts) to distinguish land cover features with a high degree of reliability. Such an approach is inexpensive and allows Internet users from any region of the world to get involved in this global validation exercise.

The Geo-Wiki Project is a global network of volunteers who wish to help improve the quality of global land cover maps. Since large differences occur between existing global land cover maps, current ecosystem and land-use science lacks crucial accurate data (e.g., to determine the potential of additional agricultural land available to grow crops in Africa), volunteers are asked to review hotspot maps of global land cover disagreement and determine, based on what they actually see in Google Earth and their local knowledge, if the land cover maps are correct or incorrect.

Their input is recorded in a database, along with uploaded photos, to be used in the future for the creation of a new and improved hybrid global land cover map. The crowd sourcing approach has been growing in use during the last two to three years. Applying it on a global scale in innovative and addressing an issue that would be extremely costly if done in a traditional data gathering approach.

Figure 5. Screenshot of geo-wiki.org homepage.

3.5 SYSTEMS DYNAMICS MODELLING

Major updates to the FeliX model centered around the introduction of the Biodiversity model sector (previously non-existent in FeliX) and making significant changes to the previous Water sector model. Furthermore, changes were also introduced in the Land, Energy and Population model sectors. All changes led to better fit of the model simulation to the historical data (in the near future the fit will be more formally expressed using Theil inequality statistics).

Figure 6. Homepage of the EuroGEOSS Felix Simulator.

In addition to modifications to the FeliX model, new scenarios are being developed for the EuroGEOSS Project. In order to mimic extreme events occurring in the future (i.e. drought, fire, etc.), system shocks or events can be simulated on a sub-annual scale. These can be introduced as random events, recurring, etc., lasting weeks to months, with varying levels of damage. The EuroGEOSS Scenarios are designed to demonstrate the effect that EuroGEOSS activities could have on mitigating various environmental impacts. They demonstrate the interoperable nature of EuroGEOSS, via linkages among the three benefit areas, in addition to the other SBAs.

4 SUMMARY

EuroGEOSS is tasked with implementing methodologies to assess the added value of Spatial Data Infrastructure (SDI) and interoperability in three SBAs, specifically developing, linking, and making globally available the European information systems addressing forests, drought, and biodiversity. The EuroGEOSS Cost-Benefit Analysis Work Package WP6 therefore focuses primarily on the VOI for integrated assessment, which is critical to support environmental decision-making and policy assessment.

The economic importance of integrated assessment can be gauged by a recent survey of practitioners in Europe undertaking Environmental Impact Assessments (EIAs) and Strategic Environmental Assessments (SEAs). This survey indicates that the current barriers to the discovery, access, and use of the environmental and geographic data necessary to undertake EIAs and SEAs account for an added cost of € 150-200 million per annum in the EU alone, along with reports of lower quality, i.e. greater uncertainty on the environmental impacts of the projects proposed (Craglia et al., 2010). The development of SDIs and of interoperable systems of systems in the GEOSS context can remove these barriers, and therefore provide significant economic benefits, in addition to the all important increased understanding of the complex relationships between environmental processes and human agency. With the implementation of INSPIRE requiring the development of SDIs at multiple levels across Europe, and the development of GEOSS at the global level, it is important to develop a portfolio of studies providing evidence of the benefits of these investments.

This Deliverable, titled D.6.3., describes both the basic functionality of the methodologies and tools used to meet the EuroGEOSS Project objectives and the adaptation and extension of these models. These include: Bayesian decision theory; a real options framework; value measuring methodology; and systems dynamics modeling. In forthcoming reports we will describe the scenarios and the results of modeling based on the various tools and methodologies presented herein.

The portfolio of benefit assessment methodologies described here generally target the indirect benefits of the three EuroGEOSS SBAs (Forests, Biodiversity and Drought). Furthermore, Deliverable 6.1.2 *Report on user requirements, costs, derived direct benefits, and current obstacles for a European and Global Spatial Data Infrastructure* focuses on the measurement of direct benefits derived from EuroGEOSS. As an overarching technique, we employ the dynamic systems model FeliX, which measures the potential benefits of a EuroGEOSS system operating within the broader context of GEOSS.

5 ANNEXES

EuroGEOSS Experts Survey, May, 2010

Welcome!

As we wish to establish the overall benefit of EuroGEOSS, we require a pre-EuroGEOSS and a post-EuroGEOSS assessment. Please answer the following survey, considering the current (pre-EuroGEOSS) situation. We will ask you to complete a second (post-EuroGEOSS) survey in approximately 1 year.

There are 21 questions in this survey

Personal information

1 [1]Your full name

☐ ______

2 [2]Your email

☐ ______

3 [3]Do you participate in EuroGEOSS project?

○ Yes
○ No

4 [4]Your organization

☐ ______

5 [5]Type of your organization

☐ Scientific research
☐ Governmental
☐ Commercial
☐ Academic
☐ NGO (Non-Governmental Organization, *government representatives are excluded from membership in this organization*)
☐ International
☐ Other: ______

6 [6]Your role in your organization

☐ I define strategy
☐ I define implementation
☐ I supervise implementation
☐ I work on implementation

7 [7]Your areas(s) of expertise

☐ Forestry
☐ Biodiversity
☐ Droughts
☐ Other: ______

Current situation assessment: Direct user (customer) value

This section takes a snapshot of the current "before EuroGEOSS" situation for future comparison with a "post EuroGEOSS" situation.

Current benefits directly realized by users or user groups. Consider current situation for direct users obtaining information in areas of Forests, Drought and Biodiversity.

8 [1]Data availability

Is the data you need available?

never ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ always

9 [2]Existing barriers

How much efforts do you make to locate and retrieve data you need?

very much ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ very little

10 [3]Data search time

How long does it take to find and obtain the data you need?
This is different from existing barriers question above: a few barriers could mean little time, or could still require much time.

very long ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ very short

11 [4]Ease of data use

Expertise required to work with necessary data?

very high ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ very low

12 [5]Data-sharing

With how many others do you share?
(how many data sources you use + how many users use the data you provide)

none ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ many

Current situation assessment: Public (non-direct user) value

This section takes a snapshot of the current "before EuroGEOSS" situation for future comparison with a "post EuroGEOSS" situation.

Current benefits related to indirect users. Consider the current situation for non-experts obtaining information in areas of Forests, Drought and Biodiversity.

13 [1]Public transparency

Quality (and amount) of public information accessible online in areas of Forests, Drought and Biodiversity?

very low ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ very high

14 [2]Public use of information

Number of existing public users of data in areas of Forests, Drought and Biodiversity?

none ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ many

Current situation assessment: Strategic/Political Value

This section takes a snapshot of the current "before EuroGEOSS" situation for future comparison with a "post EuroGEOSS" situation.

Consider the benefits of users at political/governmental level obtaining/disseminating information and making decisions in areas of Forests, Drought and Biodiversity.

15 [1]Science response time

What is an average response time from a scientific community addressing policy relevant issues in areas of Forests, Drought and Biodiversity?

very long ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ very short

16 [2]Data usage for better decision making

What is the current level of support provided by available data (through appropriate scientific tools) to decision makers in areas of Forests, Drought and Biodiversity?

very low ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ very high

17 [3]Data production and use efficiency

What is the redundancy of data/applications being created in areas of Forests, Drought and Biodiversity?

very high ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ ○ very low

Importance of sub-topics by impact area

Please evaluate the relative importance of the following subtopics for their respective impact areas

18 [1]Direct user (customer) values - importance relative to each other

Please evaluate the importance (relative to each other) of the following values for direct users in areas of Forests, Drought and Biodiversity.

	Not important at all					Important					Of highest importance
Data availability Data you need should be available.	○	○	○	○	○	○	○	○	○	○	○
Existing barriers Efforts to locate and retrieve data you need should be minimal.	○	○	○	○	○	○	○	○	○	○	○
Data search time Time associated with searching and obtaining the data you need should be minimal.	○	○	○	○	○	○	○	○	○	○	○
Ease of use Expertise required to work with necessary data should be minimal.	○	○	○	○	○	○	○	○	○	○	○
Data-sharing Data sharing should be widely used common practice.	○	○	○	○	○	○	○	○	○	○	○

19 [2]Public (non-direct user) values - importance relative to each other

Please evaluate the importance (relative to each other) of the following values for public users (non-experts) in areas of Forests, Drought and Biodiversity.

	Not important at all					Important					Of highest importance
Public transparency Good quality (and amount) of public information accessible online.	○	○	○	○	○	○	○	○	○	○	○
Public use of information Large number of existing public users of data.	○	○	○	○	○	○	○	○	○	○	○

20 [3]Strategic/Political Value - importance relative to each other

Please evaluate the importance (relative to each other) of the following values for users at political/governmental level obtaining/disseminating information and making decisions in areas of Forests, Drought and Biodiversity.

	Not important at all					Important					Of highest importance
Science response time Rapid response time from a scientific community addressing policy relevant issues.	○	○	○	○	○	○	○	○	○	○	○
Data usage for better decision making High level of support provided by available data (through appropriate scientific tools) to decision makers.	○	○	○	○	○	○	○	○	○	○	○
Data production and use efficiency Low redundancy of data and applications being created.	○	○	○	○	○	○	○	○	○	○	○

Valuation of impact areas (relative to each other)

This section is to measure relative importance of impact areas pertinent to EuroGEOSS and also sub-topics inside of an impact area.

21 [1]Relative importance of impact areas for the overall benefit of society

Please evaluate the importance (relative to each other) of the following EuroGEOSS impact areas for the overall benefit of society.

	Not important at all					Important					Of highest importance
Direct user (customer) Societal benefits generated by users and user groups in areas of Forests, Drought and Biodiversity.	○	○	○	○	○	○	○	○	○	○	○
Public (non-direct user) Societal benefits generated by indirect users (non-experts) using information in areas of Forests, Drought and Biodiversity.	○	○	○	○	○	○	○	○	○	○	○
Strategic/political Societal benefits generated at political/governmental level by using/disseminating information and decision making in areas of Forests, Drought and Biodiversity.	○	○	○	○	○	○	○	○	○	○	○

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