EU FP 6 Project
GOCE 037063 with DG Environment

GEO-BENE

Global Earth Observation
Benefit Estimation: Now, Next and Emerging

STREP
PRIORITY [1.1.6.3]
[Global Change and Ecosystems]

DELIVERABLE D7 (T21)
INTERIM AGGREGATE BENEFIT ASSESSMENT REPORT

Due date of deliverable: 31 March 2007

Start date of project: 1 July 2006 Duration: 36 Months

Organization name of lead contractor for this deliverable:
International Institute for Applied Systems Analysis (IIASA)

Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

Content

Purpose and Overview of Deliverable

According to the DOW WP 5000 Aggregate Benefit Assessment is comprised of the following tasks

1. In accordance with information gathered and defined in WP2000, decisions made 3100 and based on the tools build under WP 3200 supported by input data from WP 4000 carry out simulations in the respective benefit areas.
2. Describe the decision tree for the methodological and tool choice and give a precise, mathematical and database reference description of the scenario calculations. Store the simulation results such that they can be analysed for later use or independent outside assessment.
3. Describe quantitatively and qualitatively the results of the simulations for the aggregate (WP 5100) and by benefit area (WP 5200).
4. Describe synergies and trade-offs within sub-benefit areas and between GEO-Benefit areas in the production of geo-benefits.

With respect to **task 1** GEOBENE has developed in WP 2000 the GEOBENE benefit chain concept which is described in D4 deliverable and has been accepted for publication in a special issue on GEOSS with the IEEE journal. GEO-BENE has decided that in the disaster and health SBAs stochastic simulation and optimization approaches were selected to be used for benefit assessment. In the Energy SBA GEOBENE has developed an operational Real Options framework combined with Portfolio models. In the remaining SBAs GEOBENE decided to use a more deterministic framework. A large GEOBENE database was build and is fully coupled with the GEOBENE tools.

In respect to **task 2**: The methodological and tool choices are described for each case study described below. The precise mathematical descriptions and results from the assessment are provided for each case study in the form of an scientific paper to be or already submitted to scientific journals or as book contributions. The drafts of these papers are available via the internal GEO-BENE website. The individual simulation results are not stored in a centaral database, but are available upon request from each research group leader.

In respect to **task 3** GEOBENE has developed the FeliX model (ref. GEO-MACRO the wording of the GEOBENE DOW) for global integrated GEO benefit assessment. FeliX is described below with a simple illustrative example of aggregation of benefit assessment. Aggregation by individual SBAs has not yet been performed and there is ongoing discussion about the sensibility of such an exercise as GEOSS emphasises integration. This discussion links to **task 4** describing and quantifying synergies and trade-offs within sub-benefit areas and between GEO-Benefit areas. The advantage of the FeliX model is that it provides a more visually appealing representation of the interconnectedness of benefit areas.

WP 5100 GEO-MACRO – Overall Benefit Assessment

FeliX – **F**ull of **E**conomic-Environment **L**inkage and **I**ntegration d**X**/dt Model

Introduction

The **FeliX** (**F**ull of **E**conomic-Environment **L**inkage and **I**ntegration d**X**/dt) is a simulation, dynamic computer model being developed within confines of the GEO-BENE Project "Global Earth Observation – Benefit Estimation: Now, Next and Emerging".

Thinking about benefits of Global Earth Observation and its measurement it is hard to focus and consider them only in one selected area, like Energy, Climate or Agriculture. Usually the impact of certain actions and activities, even those designed for a particular problem, is visible across a wide variety of societal benefits areas. The reason for that is that societal areas are interconnected and constitute a complex system. Rather than considering them separately one shall treat them as a whole, in all its complexity.

The FeliX model undertakes the challenge and is purposefully designed to:

- explore economic and environmental linkages and interrelations *within* and *between* the respective societal benefits areas,
- provide a quantitative framework to assess the benefits of Global Earth Observation across SBAs.

There are two main purposes of FeliX

- *Integration* of various societal areas requires crossing the boundaries, discovering and acknowledging certain mechanisms responsible for their interrelations. As far as *measurement* of benefits is concerned one has to be aware that in complex dynamic systems cause and effects are often distant in time and space. Thus, the benefits shall be considered on short and long-time scale.

- Aggregation of individual case studies results (both of Rifle and Shot-gun sources) to the global economy level.

Model Description

For both reasons – societal benefits areas integration and benefits measurement – the modeling technique that is used to build **FeliX** is System Dynamics. The model tries to aggregate findings from particular case studies conducted as a part of the GEO-BENE Project in particular Societal Benefits Areas. It maps in an explicit manner important elements of complex systems, especially resources (e.g. energy raw materials, forest, water, land, etc.), mechanisms responsible for growth and depletion of resources as well as resources management policies.

Model Overview

The preliminary idea of the model is presented in Figure 1. The model will consist of 9 sectors, namely Economy, Energy, CO2 Emissions, Carbon Cycle, Climate, Population, Technology, Land, Energy and GEOSS. Over time the structure of the model will evolve to encompass the most significant issues that have impact on considered in the GEO-BENE Project Societal Benefit Areas.

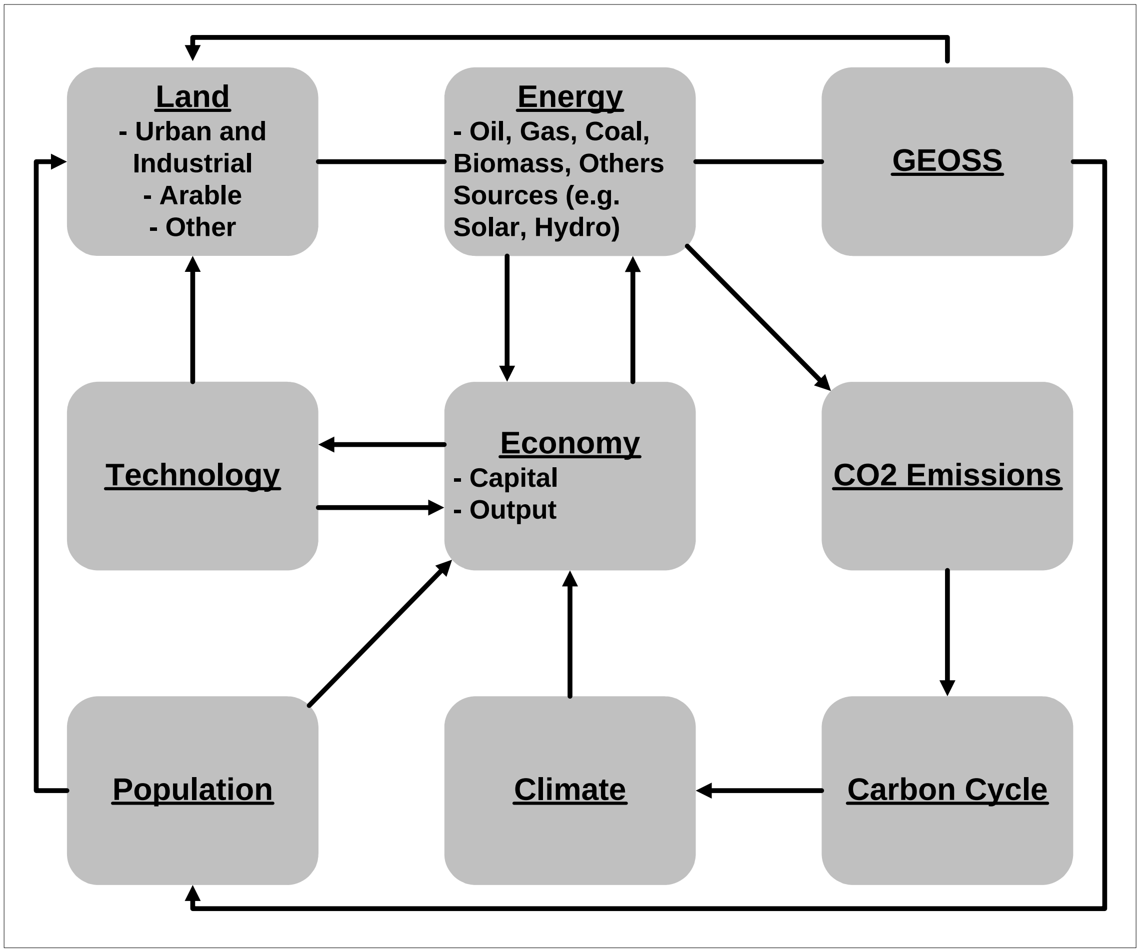


Figure 1 Preliminary structure of the FeliX model

The work on the model started with the Economy module. It is based mainly on established DICE model (Nordhaus 1992, 1994). DICE, originally constructed as optimization model, was translated into System Dynamics technique (see Fiddaman 1997). The structure of the Economy sector in FeliX is already completed. Similarly to the DICE, FeliX model addresses CO2 Emission, Carbon Cycle, and impact of Climate on Economy. All these sectors – Economy, CO2 Emission, Carbon Cycle, and Climate – are already completed but they still require integration with other parts of the FeliX model. The interrelations between these sectors are presented in Figure 2. The dynamics in this area is determined mainly by two feedback loops – *reinforcing* (responsible for translating capital, labour and technology advancement into Economic Output a part of which <Savings> are reinvested to result in more Capital) and *balancing* (the Economic Output is associated with CO2 Emission, which determines carbon cycle in atmosphere and ocean and later have impact on the output – greater amount of CO2 in ecosystem leads to greater reduction of economic output).

In the course of integration of this part of the FeliX model there will be addressed further issues like Population, Technology and CO2 Intensity of Production (mainly dependent on energy sources choice and technology development issues) – marked in yellow, but also further development of the Carbon Cycle to include for instance storage of CO2 in biomass and thus the impact of deforestation on the Economic Output (to be completed while integrating Carbon cycle with Land and Energy sectors).

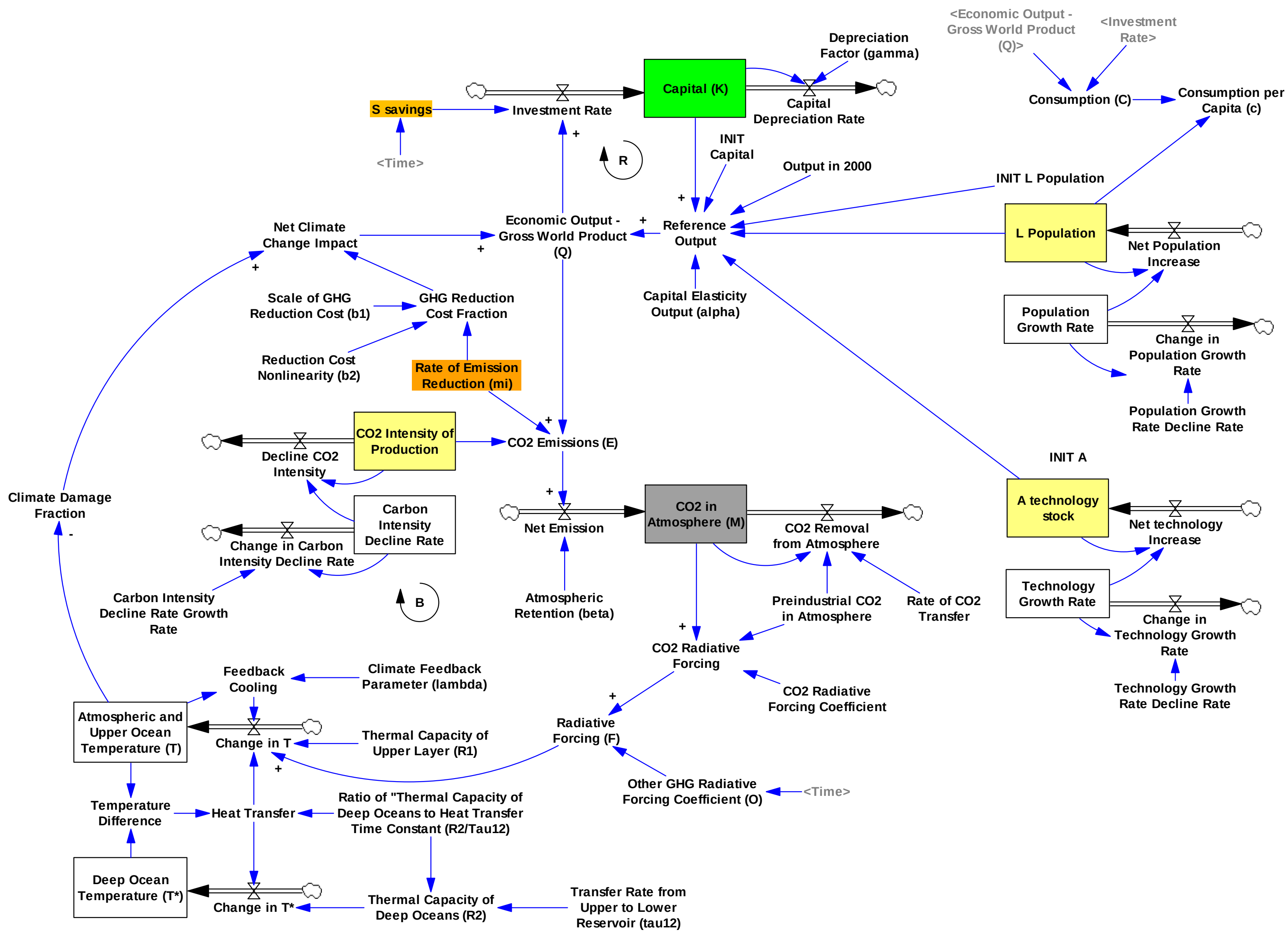


Figure 2 Already existing structure of the Energy, Economy, CO2 Emission, Carbon Cycle, and Climate sectors in FeliX model

Currently under development is the Energy sector. Since the energy production from various raw materials has different impact on economy and environment the FeliX model considers energy production form oil, gas, coal, biomass, and also other sources of energy, like wind hydro, solar and geothermal.
The energy production from oil, similarly to gas and cola, assume limited global resources of raw materials (there is no inflow to 'Undiscovered Oil Resources' in Figure 3) (Sterman, Richardson, and Davidsen 1988). Only a fraction of them can be explored, the fraction of which can be produced (depending on advancement in extraction and production technology).

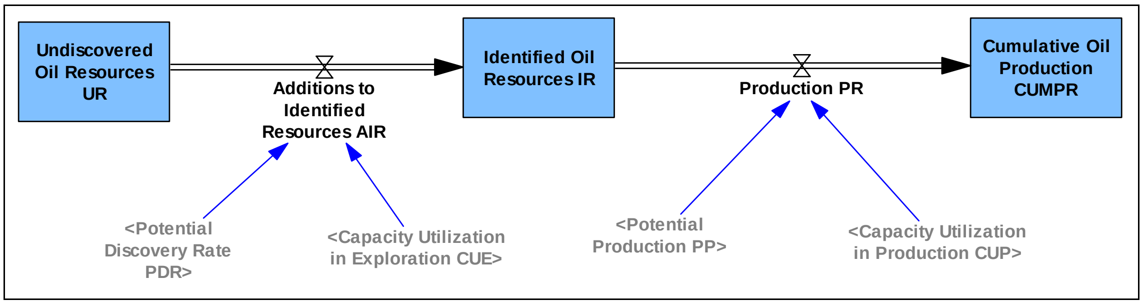


Figure 3 The core structure of oil extraction and production

The situation is different as far as biomass is concerned. The renewable resources (i.e. trees, crops) have a certain regeneration rate. However, the regeneration is constrained by carrying capacity (in that case available land). The core physical flow structure of the renewable resources is presented in Figure 4.

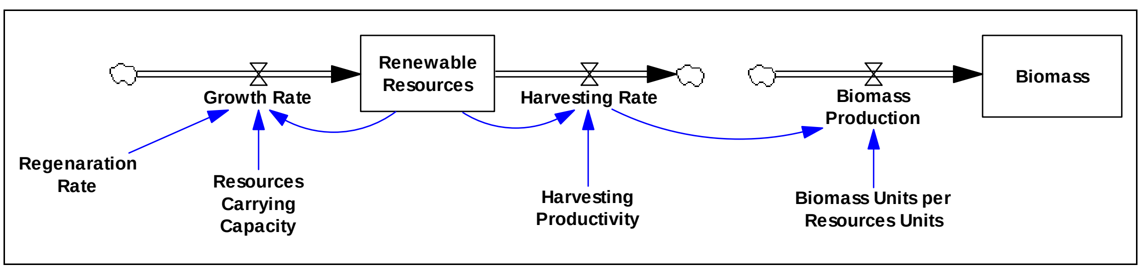


Figure 4 The core structure of the biomass production

As far as other sources of energy are concern the production of energy is dependent on available infrastructure (i.e. solar panels, windmills, turbine dam construction). Investment in infrastructure development will increase the available infrastructure. Over time the infrastructure is expiring (i.e. breaking and aging). The simple structure of this dynamics is presented in

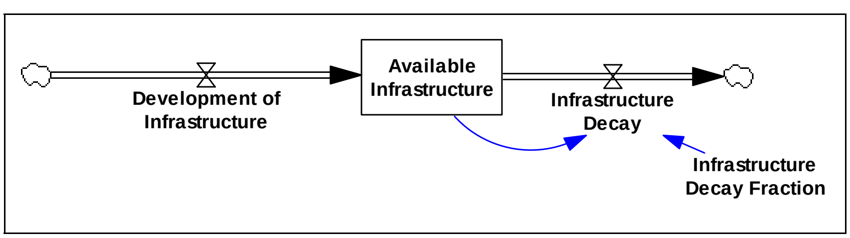


Figure 5. The core structure of other energy sources

An example of the gas sub-sector is presented in parts in Figure 6, Figure 7, and Figure 8.

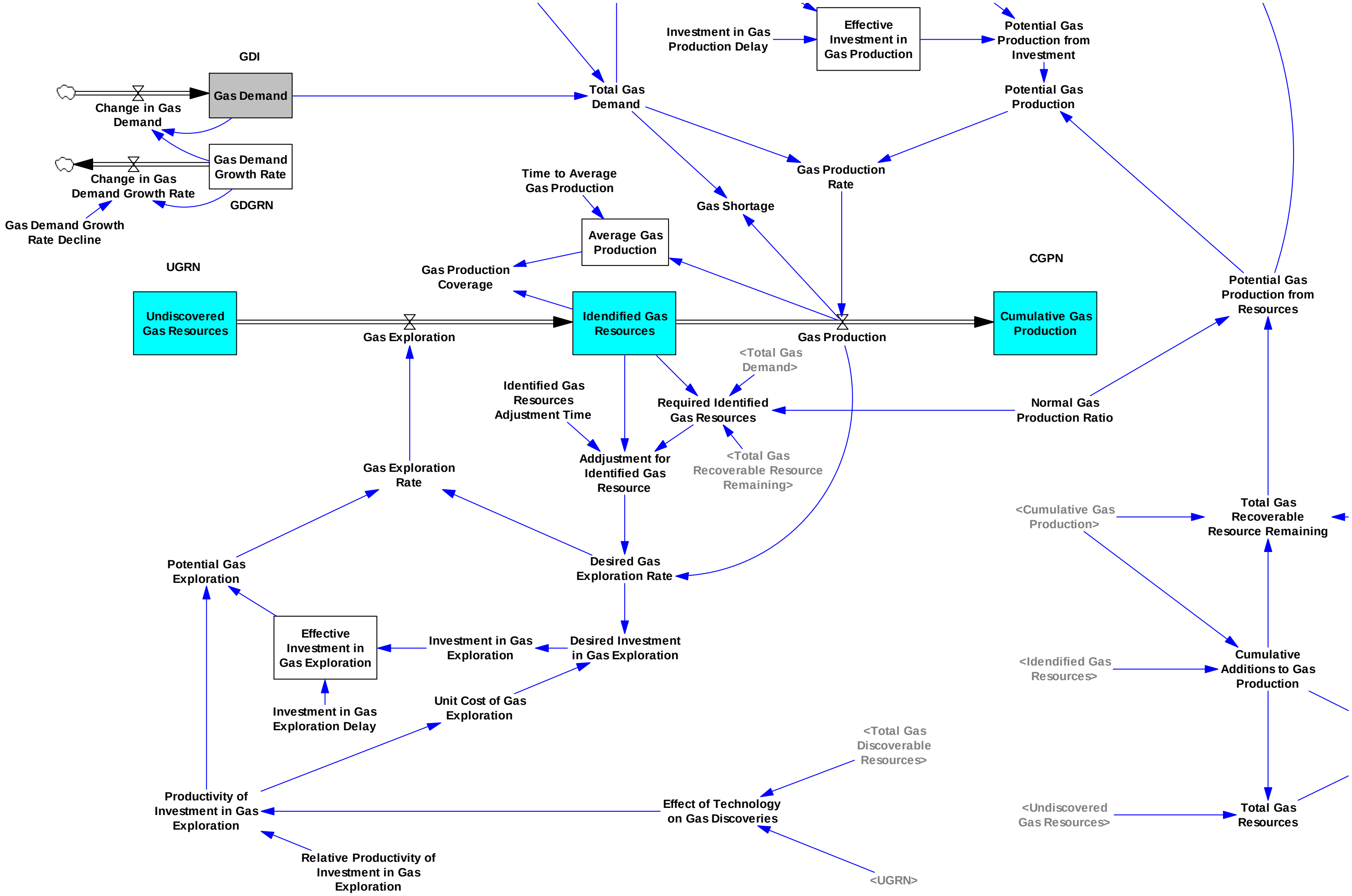


Figure 6 Gas sub-sector – exploration and production

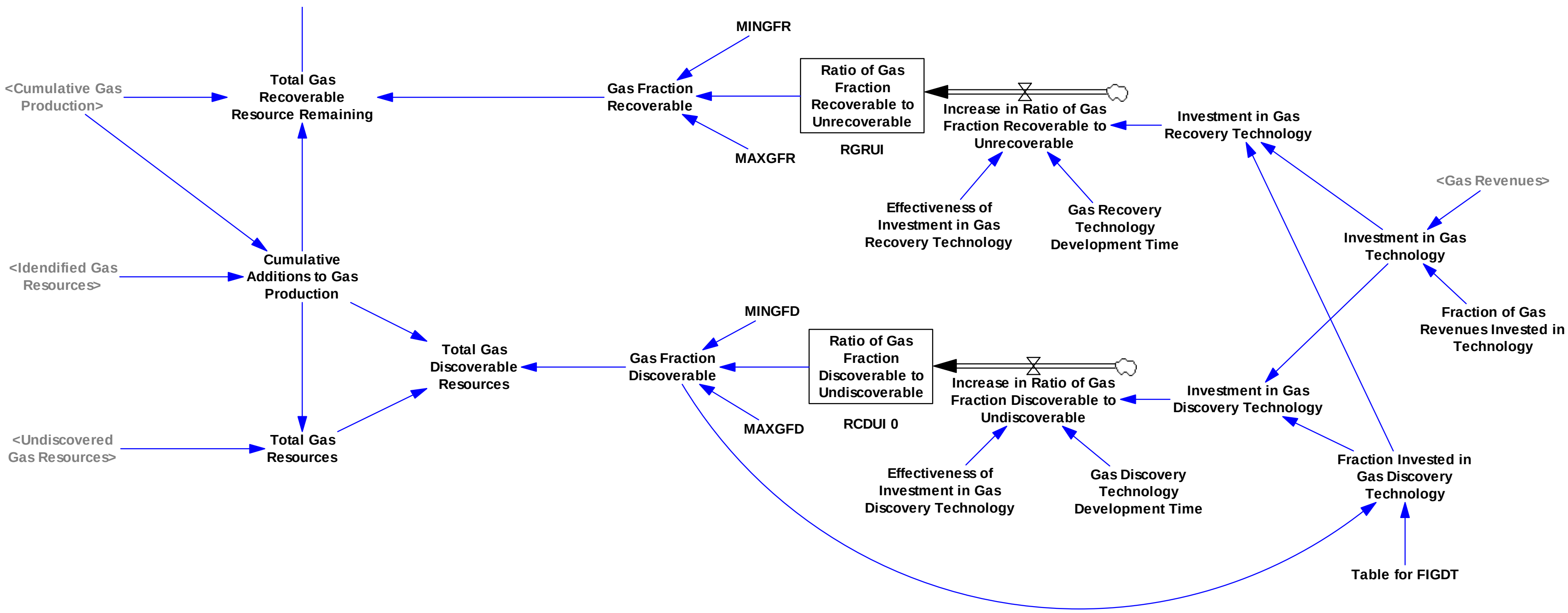


Figure 7 Gas sub-sector – investment in exploration and production technology

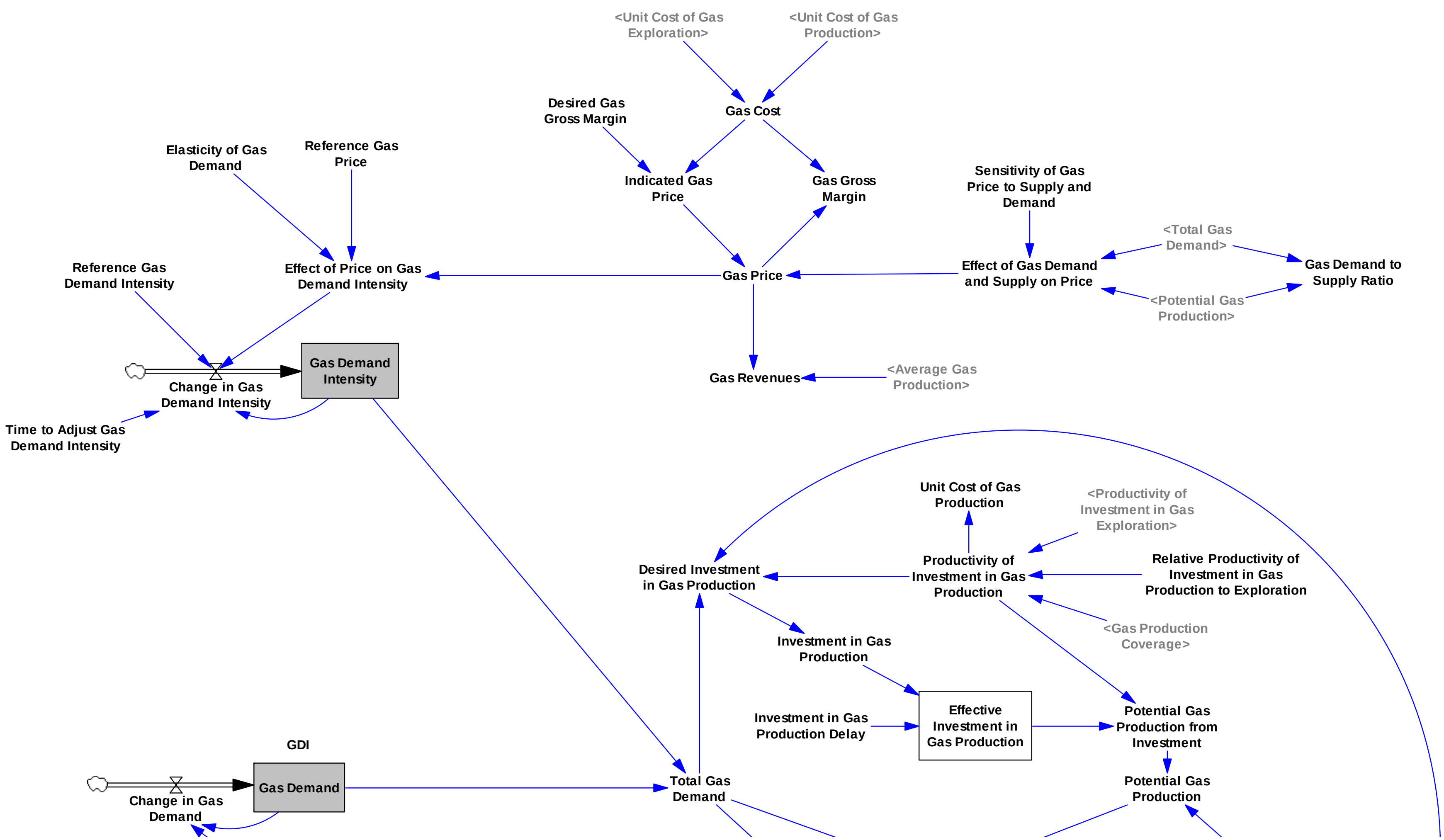


Figure 8 Gas sub-sector – demand and revenue

The renewable resources sector needs still be further developed. All energy sub-sectors needs to be integrated with other parts of the FeliX model.

The next sectors to be developed, once the current work is finished, will encompass Land, Technology and Population sectors. Fragments of these sectors have already stared to appear in the model, i.e. the renewable resources regeneration is constrained by available land, extraction and production capacities are dependent on advancement of technology, and population determines the economic output. Despite of this, more work is required in these sectors.

Once all sectors of the FeliX model are completed they will be integrated and the model will be calibrated according to available data and also more focused research projects, undertook as a part of the GEO-BENE project.

Model Simulation

The advantage of the System Dynamics technique, used to build FeliX model, is very clear structure and presentation of results. Once the model is simulated all results are presented over time. It allows the analysis of the dynamics of particular variables and their interdependencies. Furthermore, multiple runs allow for comparison scenarios during which the impact of GEOSS can be investigated in various sectors in short and long-time range. Based on the simulation results the policies in use can be modified or even new policies can be constructed and tested.

An example of the simulation scenarios results are presented below. Scenario 1 is a base run (no impact of GEOSS is investigated). Scenario 2 takes into consideration the impact of GEOSS on CO2 Intensity of production – finding a proper place for alternative energy infrastructure is one possibility of GEOSS application. (Please note that dynamics of variables is the main focus at that stage; since the model requires further calibration no quantitative accuracy is claimed here.)

The results of the base run (Scenario 1) for four variables, 'Capital', 'Population', 'CO2 Emissions' and 'CO2 in Atmosphere' are presented in Figure 9. The assumption made for this scenario is that the population net increase rate will decline over time.

The results of the Scenario 2, targeting the CO2 Intensity of Production, are presented in Figure 10 (in blue) compared to the base line (Scenario 1) results (in red).

Comparing two scenarios we can observe CO2 emissions decline leading to reduction of CO2 in Atmosphere by 7% over 100 years. Some may claim that the results are not significant considering the time scale. However, GEOSS in that case is used only to help in selection of places for alternative energy related infrastructure (e.g. windmills) – another issue would be efficiency of the new infrastructure (a subject to technology development). Furthermore, the new infrastructure development would require investment, having the impact of the economic output and later Capital (no impact on Capital is visible in Figure 10 since the particular model sectors are not integrated yet).

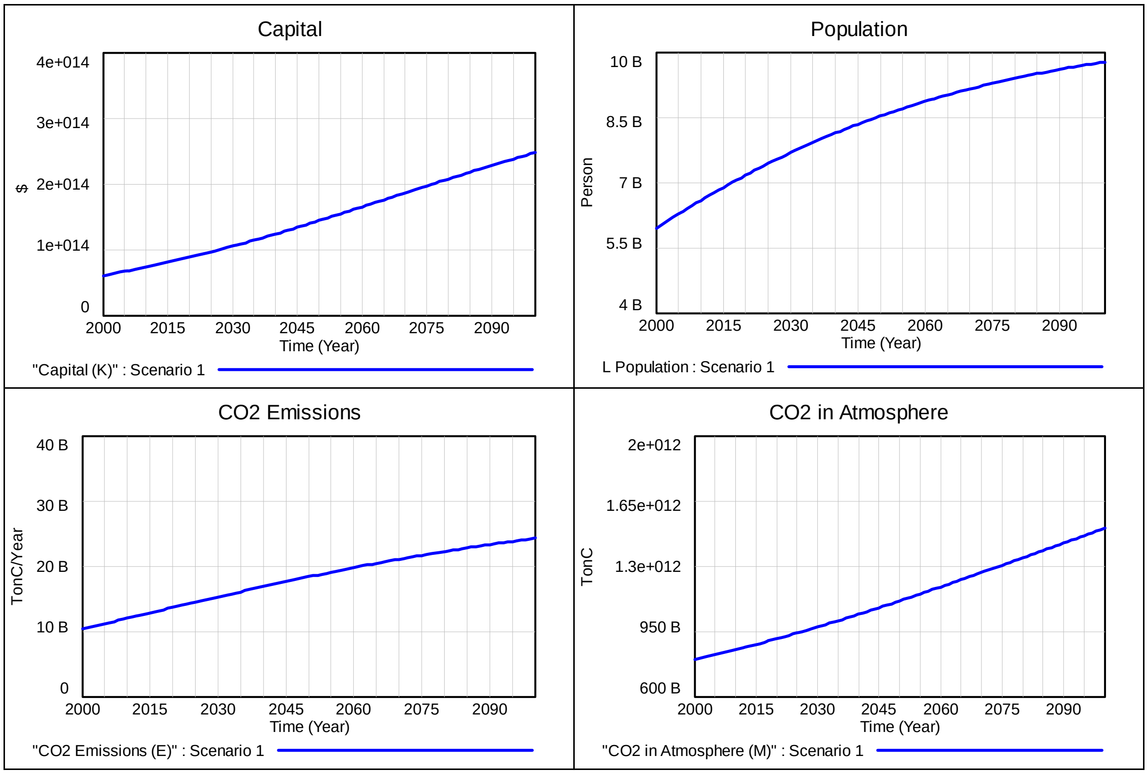


Figure 9 Scenario 1 simulation results

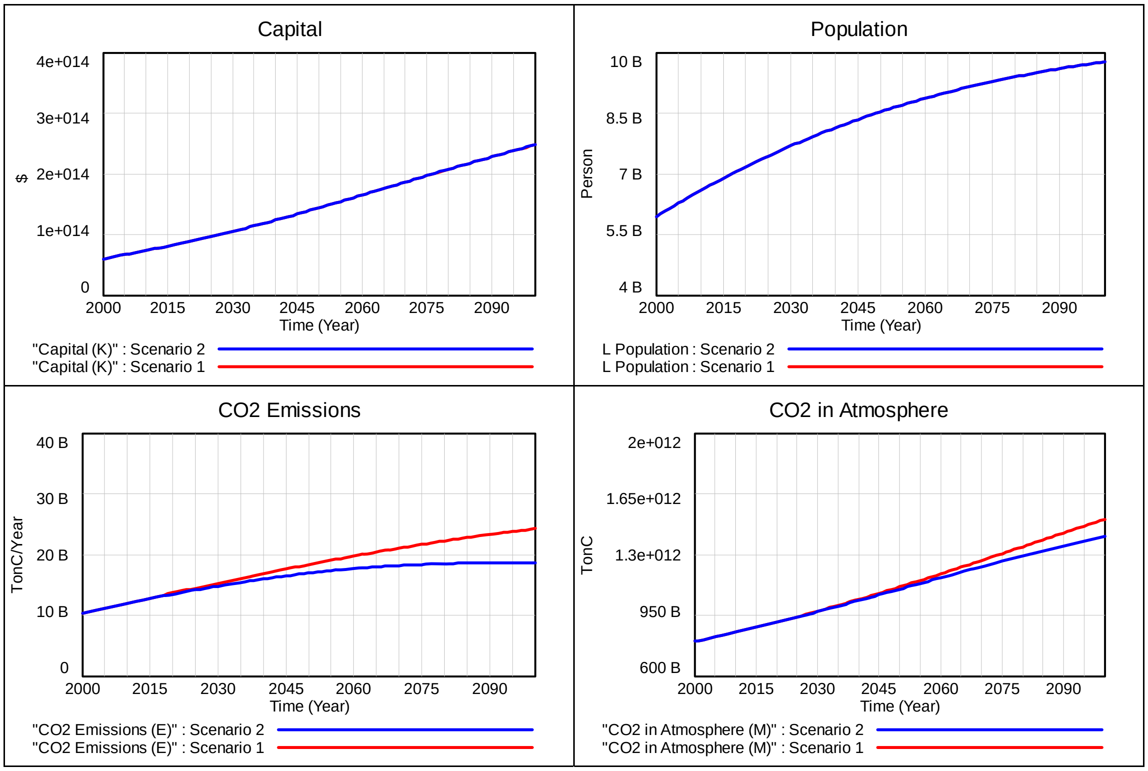


Figure 10 Scenario 2 simulation results

The aim of these scenarios was to illustrate the potential of the model as a tool for testing various assumptions and designing policies and strategies for the future. The question is how GEOSS can be designed to have the greatest impact on the dynamics of the system, we all live in?

References

Fiddaman, Thomas. 1997. Feedback Complexity in Integrated Climate-Economy Models, MIT Sloan School of Management.

Nordhaus, William D. 1992. The "DICE" Model: Background and Structure of a Dynamic Integrated Climate-Economy Model of the Economics of Global Warming Discussion. Paper No. 1009 Cowles Foundation for Research in Economics at Yale University.

———. 1994. *Managing the Global Commons*. Cambridge, MA: MIT Press.

Sterman, J. D., G. P. Richardson, and P. Davidsen. 1988. Modeling the estimation of petroleum resources in the United States. *Technological Forecasting and Social Change* 33:219-249.

WP 5200 GEO-DIM benefit assessment and geo-spatial mapping

GEOBENE has further developed a number of global geographic explicit models in order to account for spatial heterogeneity when performing aggregate global analysis through up-scaling geographic explicit units. Furthermore, the spatially explicit analysis allows for direct assimilation of EO data. Geographic explicit global modeling (GEO-DIM) at this stage is performed for the SBAs Water (in agriculture), Weather (in agriculture, climate and ecosystems), Climate (in agriculture and ecosystems), Ecosystems, and Agriculture. Global GEO-DIM analysis in the energy SBA is up and running for bioenergy and underway for solar and wind energy. GEOBENE is also currently producing a data set of all major existing energy generation units (power plants) of the world. Cooperation on geographic explicit energy modeling is also ongoing with DLR in Germany and ISPACE research studios in Austria. GEO-DIM global modeling in the health area has been initiated by cooperation with the EU FP6 project EDEN. The GEOBENE partner KTL has started collaboration with Oxford University, an EDEN consortium member, to model contagious diseases. GEODIM modeling in the Disaster SBA is currently in the planning phase where GEOBENE is considering either direct cooperation with the Earth Institute of Columbia University in New York or alternatively through cooperation with the UNEP Office in Geneva producing global hazard maps. The latter might be the preferable option as there are close contacts between the GEO-SEC and UNEP.

According to current plans GEO-DIM modeling will cover all SBAs and in some SBAs GEOBENE will attain almost full coverage of all sub-SBAs. The GEOBENE consortium has decided to make GEO-DIM results available through the GEOBENE website using GoogleEarth as the publishing medium (see sample visualization below)

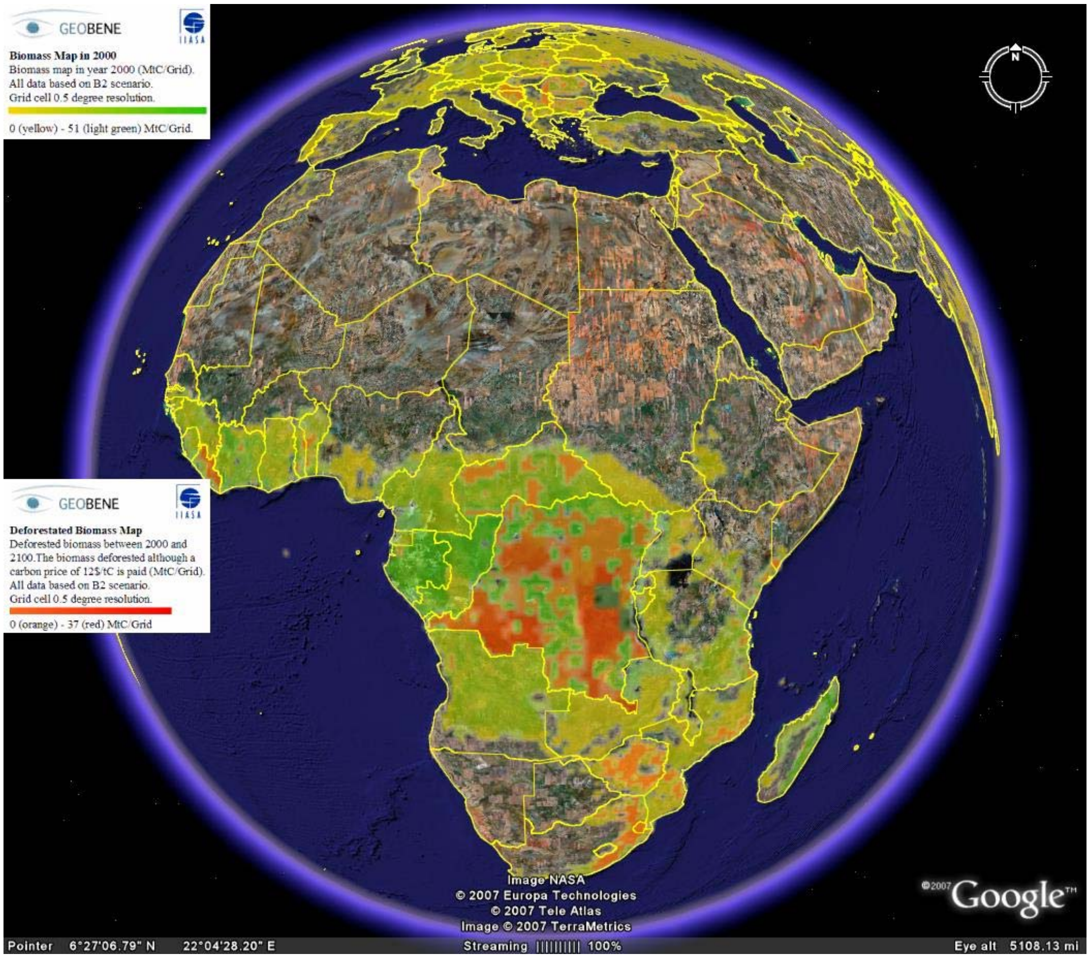


Figure 5200.1: Deforested biomass (red) between 2000 and 2100 given an avoided deforestation policy of 12$/tC and socio-economic development assumptions according to the IPCC B2 scenario. Biomass density (green) of remaining forest in year 2000 (Kindermann et al. 2008 forthcoming).

The existence of GEO-DIM models and respective scenarios illustrate the benefit of global earth observations (benefit of improved planning and policy planning). Targeted scenarios to quantify other benefits have up to now only be quantified for avoided deforestation scenarios. GEO-BENE is currently preparing a suit of scenarios to quantify the global benefits of GEO in other SBAs. In cooperation with the GEOSEC a number of scenario application areas have been identified including scenarios for e.g. GEO-BON and Harron. Further communication with the GEO-SEC and the respective GEO Tasks will be needed to exactly define scenario parameters.

WP 5300 GEO-SIM overall assessment of sectoral and secondary benefits

Global GEO-SIM assessment can be roughly be subdivided into three clusters of sector impact assessment models. The first is cluster is centered around GLOBIOM (Global FASOM type model) which is feed by the GEPIC model and G4M model. The second cluster which is currently emerging covers the SBAs Disaster and Health and are stochastic GEO-DIM type models. For the Energy SBA a detail GEO-MACRO model is built and at the same time a GEO-DIM type model in cooperation with DLR and ISPACE studios is underway. In addition, the Real Options and Portfolio model results will be used to inform the energy part of the GEO-MACRO model. Furthermore, a multitude of specialized models were developed in GEO-BENE for specific case studies. These case studies can be understood as shot-gun analysis which are used to inform parameters of GEO-MACRO. In the following we will short sketch the outcome of the case studies carried out so far.

Table 5300.1 Overview of Individual Case Studies Using the GEO-BENE Tool Cluster currently feeding into the aggregate benefit assessment

Institutions	Model Name	Observations Explicit	Real Data Used	Quantitative Result	EO Baseline-Benefits	Model Validation	EO Cost-Benefit	Global Model
IIASA FOR, KTL, UBR	Forest Fires							
IIASA FOR, KTL	Earthquake							
IIASA FOR, Univ. Zurich	Landslides							
IIASA RAV & FOR	World Risk Maps							
IIASA RAV	Malawi Micro-Insurance							
CSIR	Biodiversity in South Africa							
KTL	Acute Myocardial Infarction							

Legend and description

Model characteristics

Observations Explicit Does the model use as input variables any observable (from the ground, air, or space) quantifiable parameters (e.g. temperature, water in the soil content), which *accuracy and resolution* may be improved to improve the system's performance?

Real Data Used Does the model use any (real) *historical data set* of the

	above parameters?
Quantitative Result	Is the result of the modeling expressed in numbers (mainly *euros* and/or *lives* saved)?
EO Baseline-Benefits	Does the model assess the result of improvement currently available data (expressed mainly in *euros* and/or *lives* saved)?
Model Validation	Does the model reproduce the reality, so that the results of the model can be *verified* against some historical data?
EO Cost-Benefit	Does the model answer the question: how much should be invested in EO to get the best cost-benefit ratio?
Global Model	Is the model global?

Legend

Yes
No
Other (somewhere between yes and no)

<u>SBA: Disasters</u>

<u>Project Title</u>: Impact of Weather Observations on Efficiency of Fighting Forest Fires

Collaborating GEO-BENE partners: IIASA (leader), KTL /Finland/

Background: Being able to correctly predict the location and scale of a possible forest fire is an integral part of fire management. A Nesterov index, based on the daily weather history, is one of the existing measures, which allow quantifying the risk of a forest fire. The air patrolling schedule, e.g., in the Russian Federation is based on this index. Therefore, better information on daily weather in terms of both, measurement accuracy and refinement of spatial scale, may lead to better fire management, by preventing or significantly limiting losses due to ignition.

Data: The dataset used for this study is gridded daily weather data for the year 2000 for the area covering parts of territory of Spain and Portugal located approximately between -7.5W, 42.0N and -0.5W, 38.0N. The grid size in the analysis is 50x50 km for the 'fine' grid and 100x100 km for the 'rough' grid.

Methods: Forest fire history is simulated autoregressively based on the Nesterov index and the associated fire patrolling regime. The resulting resource expenditure and fire losses are then assessed.

Results: Generally, information obtained for the finer spatial resolution results in slightly larger number of patrols (+3.62% according to the simulation) and considerable loss prevention (-20.64% respectively). The model revealed the possibility of optimizing the system's performance by combining and integrating different observation systems (System of Systems effect). According to the simulations, the refinement of the weather data on about 20% of the total area in selected most critical sub-areas may deliver about 80% of the total possible improvement of the system's performance.

Status: A manuscript on 'Valuing Weather Observation Systems for Forest Fire Management' by Nikolay Khabarov, Elena Moltchanova, and Michael Obersteiner has been submitted for publication in IEEE Systems Journal (as of February 2008).

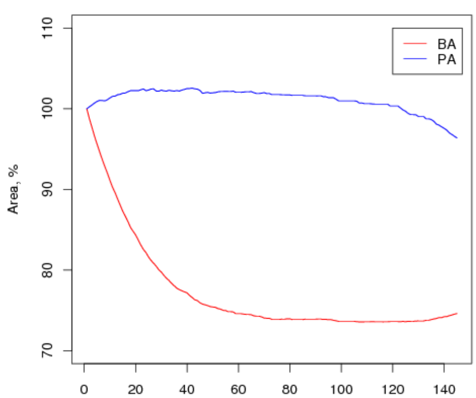


Figure: Reduction of burned area (BA) by adding extra weather stations (144 in total). By doing that, the patrolled area (PA) is slightly increased at initial stage.

Project Title: Value of Observations for the Earthquake Risk Management

Collaborating GEO-BENE partners: IIASA (leader), KTL /Finland/

Background: The complexity of an earthquake as a geophysical phenomena and the lack of understanding of deep underground processes causing it do not allow the humankind at the current state of technology and science to reliably predict earthquakes. Nevertheless, the consequences of the disaster may be substantially reduced through proper preparation and rapid response to the event. We consider a model of an aftermath response, the main purpose of which is to save as many lives as possible immediately after the earthquake.

Data: This is a simulation study; the parameters of the simulation are based on the previous research in the field.

Methods: The utility of information is assessed by varying the following parameters: (1) the severity of an event, (2) the sensor network resolution, (3) resources availability, and (4) population density.

Results: One of the study's main outcomes is the analysis of the stochastic rescue efforts efficiency function defined in the 4-dimensional space. This function's properties characterize a tight relationship between preventive and proactive measures and quality of observations. The optimal strategy for risk reduction should be based upon the trade-off between the costs of rescue resources, investments into preventive measures and observation systems, and admissible level of risk.

Status: Manuscript in preparation (as of February 2008).

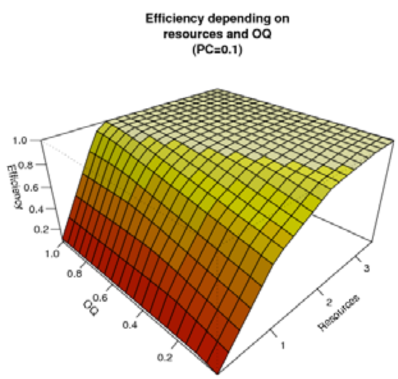


Figure: Rescue efficiency after an earthquake depending on available rescue resources and density of a sensor network.

Project Title: Integrated Assessment of a Landslide Early Warning System

Collaborating partners: IIASA, University of Zurich

Background: Early warning systems (EWS) for natural disasters such as landslides consist of different components including monitoring instruments, physical models, and decision making rules. EWS are rather complex systems, and it is quite difficult to quantify the impact of different factors on the overall system's performance.

Data: We used a historical 6-hour rainfall data set from Colombia, which was utilized for a local disaster prevention project.

Methods: The landslide occurrence is simulated based on the historical rainfall data and triggering thresholds. The early warning issuance is based on observed precipitation that includes modelled error in measurements.

Results: The evaluation of the EWS against observed rainfall data containing up to 200% measurement error and computation of the probabilistic damage functions showed that small errors in measuring rainfall do not significantly affect the overall damage, but errors greater 50% have serious consequences.

Status: Results to be presented on the EGU conference, Vienna, 13-18 April, 2008.

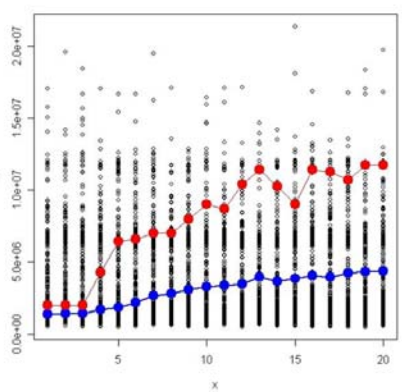


Figure: Average damage and 95% quantile for 20 levels of the rainfall measurement error (starting from 10% to 200%).

SBA: Health

Project Title: Epidemics and Vaccination Modelling

Collaborating GEO-BENE partners: IIASA (leader), KTL /Finland/

Background: In epidemics, such as those of meningitis in the Sahel region of Africa, the vaccination starts once the observed number of cases exceeds the level, defined by the WHO. Earlier vaccination could, in principle, prevent more cases and thus reduce the burden of disease, but it could also be unnecessary or of the wrong type. Additional information, such as seasonal patterns, spatial relationship and correlation with natural phenomena, e.g., dust storms, may provide better information and ultimately lead to more efficient decision making. Acting now vs. waiting for more information is another interesting aspect to be studied.

Data: TBD

Methods: TBD

Results: TBD

Status: Brainstorming (as of February 2008).

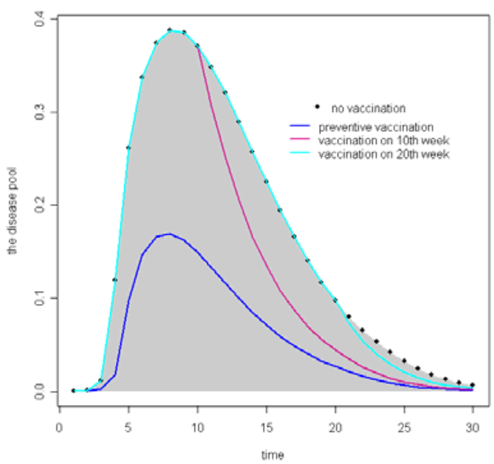


Figure: Conceptual framework: comparison of the burden of disease associated with different vaccination initialization times.

Project Title: **Case study in the use and application of GEO data in disaster recovery and reconstruction**

This document outlines the rationale behind a 10 day field visit to Banda Aceh by GEO-BENE partner IIASA, to assess the use of Earth Observation data (satellite imagery, aerial orthophotographs, in-situ measurements, etc.) in response to disasters and their application in the subsequent restructuring process.

Partners:

(1) BRR NAD-Nias, Spatial Information & Mapping Centre, SIM-Centre of Badan Rehabilitasi dan Rekonstrucksi (BRR) NAD-Nias, Banda Aceh, Indonesia.
(2) Remote Sensing and GIS Centre Syiah-Kuala University, Banda Aceh, Indonesia.
(3) Vrije University Amsterdam-IVM, Netherlands.

Figure: Visiting local users of EO data in Banda Aceh, Indonesia.

Objectives

(1) To survey with help of local partners, use of GEO data among agencies in Banda Aceh and across the province of NAD;
(2) To determine sources of this GEO data, its quality/usefulness and areas for improvement; and
(3) To identify (perhaps quantify) value that GEO brings to relief/reconstruction effort by identifying past, present and future role and worth of this information.

Methodology

(1) With the help of local partners identify users of GEO data (including use of search tools such as the RAN Database: http://rand.brr.go.id/RAND/);
(2) Develop survey (with help of Vrije University Amsterdam-IVM, Netherlands);
(3) Implement a two phase user survey. Phase 1- remote contact with GEO users (phone/email). Phase 2 - dedicated field survey with in-person contact with GEO users in Banda Aceh;
(4) Compile results;
(5) Analyze; and

(6) Report.

Field Survey

A field visit to Banda Aceh was carried out from 3rd - 12th December, 2007; coinciding with the 2nd International Workshop on Disaster Mitigation hosted at Syiah Kuala University. During the field survey the GEO-BENE representative visited a number of agencies including:

Table 1: Organisations visited in Banda Aceh, Indonesia.

Org. Type	Organisation	Contact
Nat. Gov	BRR, Pusdatin	Mr. E. Darajat
Nat. Gov	BRR, Bakosurtanal	Mr. Darmawan
University	UNSYIAH, GIS & RS	Mr. M. Affan
University	UNSYIAH, Vice Rector	Mr. Dhalan
University	UNSYIAH, TDMRC	Mr. Dirhamsyah
Local Gov	BPN	Mr. G. Suprato
Local Gov	AGDC	Mr. S. Gan
NGO	ABD - ETESP	Mr. E. Van Der Zee
NGO	Sea Defence Cons.	Mr. J. Kraaij
UN	UN ORC	Mr. H. Busa
UN	UNICEF	Mr. B. Cahyanto
UN	UNFAO	Mr. Sugianto
NGO	LOGICA	Mr. D. Hurst
NGO	GTZ-SLGSR	Mr. M. Widodo
NGO	ManGEONAD	Mr. T. Rehman
NGO	Leuser Int. Fnd. (YLI)	Ms. D. R. Sari
NGO	Flora Fauna Int. (FFI)	Mr. Syaifuddin
NGO	Sogreah	Mr. B. Coiron

Results

The results of the interviews with the organisations in Table 1 are currently being analysed. Additionally, specific cost-beneift examples were analysed from the region showing the growing use of EO data and the benefits acrued. Especially in disaster regions where timeliness is crucial, it appears that the benefits from the application of EO data are numerous. More analysis is planned in the near future as new data is obtained. It is expected that trends found here from this questionnaire-based study will be applicable in other post-disaster regions and if applied would improve the response of the global community to similar disasters in the future.

Specific Case Study Deliverables

- A report showing results of the assessment - delivered to all participants; and
- A journal article (peer reviewed) to be placed in an on-line or standard journal.

SBA: Disasters

Project Title: World Risk Maps

Collaborating GEO-BENE partners: IIASA (leader), RAV, FOR

Background:
To inform and improve decision making on disaster risk management and adaptation to climate change on the country, regional and global level, world natural disaster risk maps are needed which incorporate the inherent randomness of the phenomena. Through the use of loss distributions the full information of possible direct and indirect losses can be better assessed and new risk management strategies developed.

Data: The dataset used for this study is gridded data on various scales from various sources, including the ones used in other large scale assessment studies such as the Hotspots studies or UNDP's *Reducing Disaster Risk*.

Methods: In a stochastic framework the CatSim and CatView model assesses the financial and economic consequences of natural disasters, showing their impacts on indicators such as national economic growth (in terms of averages and volatility), indebtedness and other important variables. A key concept here is the translation of direct/financial risks (stock effects) into economic/indirect risks (flow effects).

Results:
Phase I: While CATSIM assessments have been based on aggregate country-wide assessments of asset risks, a more spatially explicit approach for Geo-Bene was developed, namely the CATVIEW module. The CATVIEW module tries to combine the hazard, elements at risk and the physical sensitivity of the exposure by integrating different estimation techniques (Maximum likelihood estimation as well as Monte Carlo Simulation) to get an overview and approximations of different direct risk levels, e.g. through loss distributions.

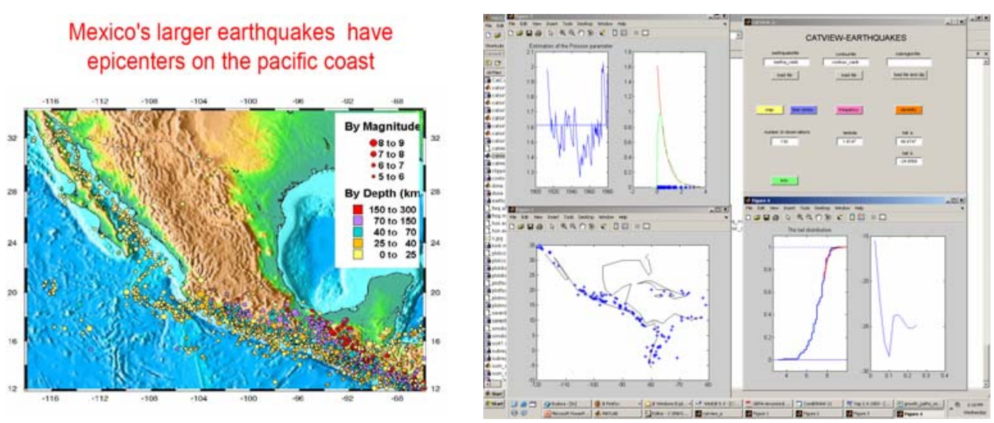


Figure: Left: Earthquake occurrences (intensity and frequency) and (right) loss approximation via the CatView module.

The goal of this approach is to represent natural disaster risk in more detail and more accurately than in existing studies, such as the Hotspots studies or UNDP's *Reducing Disaster Risk*. The foreseen output would be probabilistic asset risk maps, which also can be used to assess economic flow effects.

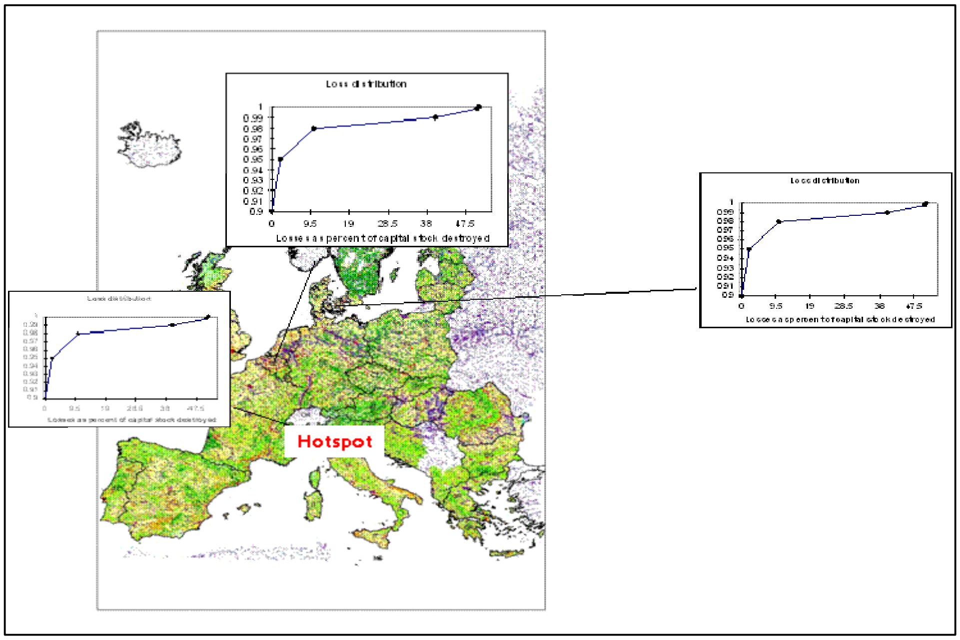


Figure: Foreseen representation of disaster risk for Europe

The CatView output is seen as the basis for the overall process development, which also can be used for scientific assessment of natural extreme events on various scales.

Phase 2:
Due to various problems encountered in phase 1, the ongoing analysis, will focus now at the beginning of phase 2 on hotspots regions and countries with good datasets. While the overall motivation is to provide at the end global risk maps, some methodological challenges have to be tackled first, especially, the lack of data in very important regions of the world, which make it very difficult to use the presented probability based approach for all countries.

<u>SBA: Disasters</u>

<u>Project Title</u>: EO and Micro-insurance in Africa

Collaborating GEO-BENE partners: IIASA (leader), RAV

Background: Risk management is at the heart of insurance. Yet, as insurance uptake particularly in developing countries is low due to among other things the substantial costs of insurance, novel products are being developed utilizing index-based approaches, where the claim payment is not based on the individual losses, but on physical signals, such as rainfall and the lack thereof. Microinsurance is one of insurance, which aims at managing risks for the poor through increased stakeholder coordination and information sharing between donor organisations, multilateral agencies, NGO's etc. To make this instrument cost-effective, index-based microinsurance is currently being developed in Asia, Latin America and Africa. The event triggering the payment of loss compensations is an easy-to-observe objective event, such as measurements of atmospheric or seismic activities by an independent observatory exceeding some threshold. While this kind of event triggering is easy to implement, cheap and not subject to moral hazard, it might be ineffective, if the real loss is not highly correlated to the triggering event. There is a fundamental tradeoff in such kind of instruments: Easy-to-observe events are not highly correlated to the real loss, but well correlated events are not easy to observe. The question is whether new technologies of remote sensing may alleviate this dilemma: By observing smaller areas with better resolution, the triggering event for a certain region may be very local and therefore better correlated with the damages in that region.

Data: Daily Rainfall amount from 1961 till 2005 from Chitedze station. PRECIS rescaled projections (monthly rainfall) of the control and future period. Control is January1960 to December 1979. Future is January 2070 to December 2089. MM5 rescaled projections (monthly rainfall) of the control and future period. Control is from January 1975 to December1984. Future is January 2070 to December 2079

Methods: Monte Carlo simulation, dynamic financial analysis.

Results: Phase 1:
Based on rainfall data as well as climate scenarios up to 2100 for a village in Malawi various possible problems of micro-insurance were tackled. For example, the figure below show the catastrophe risk of insurers in this region, if climate change signals are not taken into consideration.

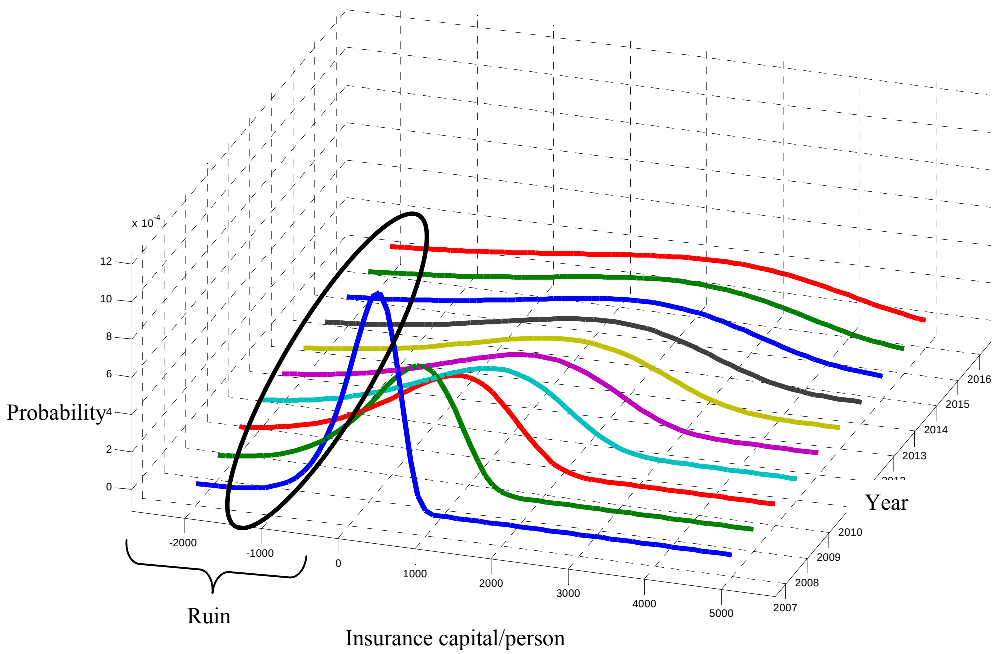


Figure: Simulated trajectories of insurance pool's capital in the near future

Based on extreme value theory the benefits in the case of extremes were assessed. In conclusion heavier tails are likely to be expected in the future, which in turn would lead to higher probabilities of an insurers ruin, due to the underestimation of the direct risk.

Phase 2:

In phase 2 other benefit areas will be assessed in a quantitative manner too. The benefits of additional data or more detailed data is investigated on the country level as well. Furthermore, the very important "basis risk" for microinsurance is looked at. Here, it is assumed that the basis risk can be decreased due to better land use information and incorporating El Nina and El Nino effects.

SBA: Ecosystems

Project Title: Predicting the deforestation trend under different carbon prices

Background: Global carbon stocks in forest biomass are decreasing by 1.1 Gt of carbon annually, owing to continued deforestation and forest degradation. Deforestation emissions are partly offset by forest expansion and increases in growing stock primarily in the extra-tropical north. Innovative financial mechanisms would be required to help reducing deforestation. Using a spatially explicit integrated biophysical and socio-economic land use model we estimated the impact of carbon price incentive schemes and payment modalities on deforestation. One payment modality is adding costs for carbon emission the other is to pay incentives for keeping the forest carbon stock intact.

Data: Main data drivers of the model are a land cover map, net primary productivity, population density, gross domestic productivity, buildup- and cropland, agricultural suitability, corruption, discount rate, carbon price and their development over time.

Methods: The decision whether afforestation or deforestation will happen in a specific region is done by comparing the net present value of forestry and agricultural land. Beside, agricultural suitability, net primary productivity, population density the carbon price has much influence on the net present value of forestry. Information of where the deforestation will be and how much will stop deforestation, allows specifying the payment from paying all forest owners the same amount per t/C over pay only in affected regions the amount which will stop deforestation there to pay only in presently affected forests.

Results: Baseline scenario calculations show that close to 200 mil ha or around 5% of today's forest area will be lost between 2006 and 2025, resulting in a release of additional 17.5 GtC. Today's forest cover will shrink by around 500 million hectares, which is 1/8 of the current forest cover, within the next 100 years. The accumulated carbon release during the next 100 years amounts to 45 GtC, which is 15% of the total carbon stored in forests today. Incentives of 6 US$/tC for vulnerable standing biomass paid every 5 year will bring deforestation down by 50%. This will cause costs of 230 billion US$/year if paid for all forests, 34 billion US$/year if paid in affected regions and 10 billion US$/year if paid only for affected forests. On the other hand a carbon tax of 12 $/tC harvested forest biomass will also cut deforestation by half. The tax income will, if enforced, decrease from 6 billion US$ in 2005 to 4.3 billion US$ in 2025 and 0.7 billion US$ in 2100 due to decreasing deforestation speed.

Outlook: Improvement of the model by including additional datasets and increasing the special resolution.

SBA: Agriculture and other land uses

Project Title: Establishing a relational database for global EPIC modelling

Collaborating GEO-BENE partners: SSCRI, BOKU, IIASA

Background: EPIC is a bio-physichemcial process model and requires data on weather, soil, topography as well as land use and crop management. These type of data need to be available for global analysis. There are basically to types of data, (i) geo-spatial data and (ii) non-spatial data. The spatial data usually is available in different resolutions and non-spatial data often refer to country statistics. In building such database, we have to (i) review and collect the data, (ii) process and harmonize the data, (iii) fill the data gaps and the EPIC data requirements, and (iv) store the data in a relational database.

Data:
Topographical data:
- GTOPO30 (data authority USDA EROS),
- SRTM (data authority NASA).

Soil data:
- DSMW (data authority FAO),
- WISE (data authority ISRIC).

Weather/Climate data:
- East Anglia climate data from 1901–2002 (Tyndall),
- 18 climate change scenario data for 2001–2100 (Tyndall),
- ECMWF weather variation data.

Land cover/use data:
- GLC2000 (data authority EC-JRC),
- GLU (data authority IFPRI).

Administrative units data:
- GAUL (data authority EC, FAO),

Crop management data:
- literature review (irrigation map, fertilization map, etc.).

Methods: Relational databases.

Results: The data has been collected, processed, harmonized, completed and stored.

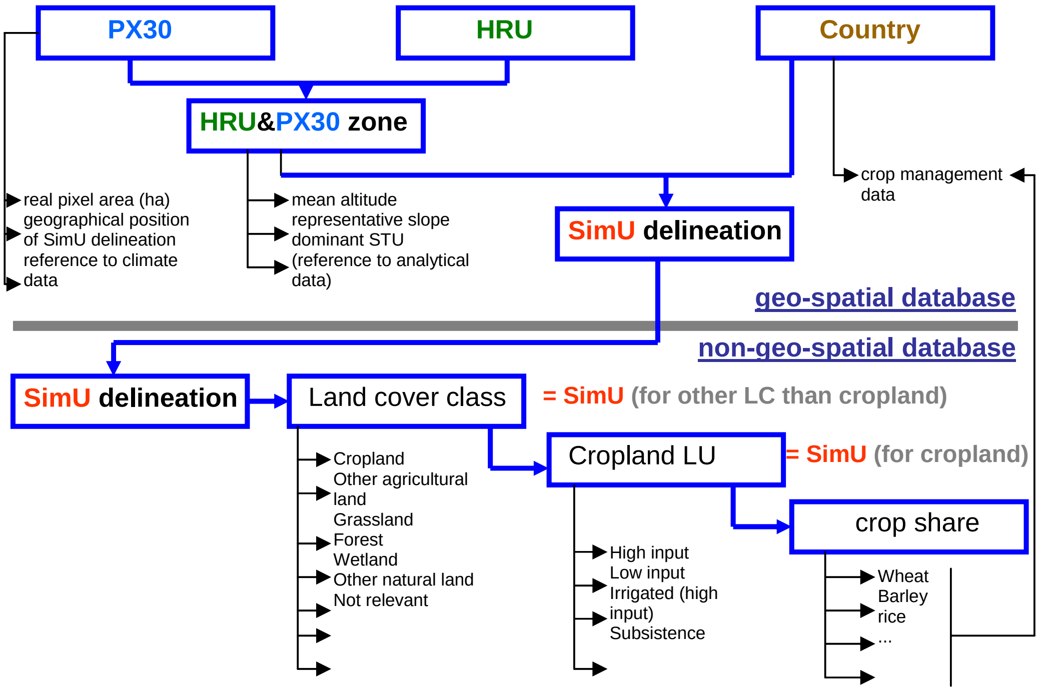


Figure: The global EPIC database logic: an overview

Status: finished.

Project Title: Delineation of Homogenous Response Units (HRU) at global scale.

Collaborating GEO-BENE partners: SSCRI, BOKU, IIASA

Background: EPIC requires plot-scale data, where weather, soil, topography and crop management systems are assumed to be homogeneous. Therefore, the data (see above) has to be processed to delineate a global HRU layer This HRU concept assures consistency in integrating the biophysical impact vectors from EPIC in an economic land use optimization model (e.g. Global FASOM, GLOBIOM, BeWhere, etc.). A two-step hierarchical process has been developed to delineate the HRUs (Schmid et al., 2007):

- In the first step, parameters of landscape are merged (e.g. altitude, slope, soil texture), which are relatively stable over time (even under climate change) and hardly affected by farm management.
- In the second step, the HRU layer obtained in the first step is merged with land cover categories, weather, crop rotation and management, and boundary information to derive individual simulation units (ISU).

Each ISU represents a certain share in a spatial unit, which is simulated with EPIC to deliver spatially and temporally explicit biophysical impact vectors. These ISUs along with their physical characteristics (crop yields, emissions) and their specific other attributes (area, management) are treated as an activity in economic land use optimization models. If all potential alternative ISUs are simulated with the biophysical process model then one can construct a production and / or emission possibility set that an economic land use optimization model can choose from.

Data: data listed above.

Methods: GIS.

Results: The global HRU layer (see the following figure) has been constructed and combined with all relevant data to derive individual simulation units (ISU). Each ISU contains information on weather, soil, topography, land use, and crop management. Currently, we are working in construction spatially explicit crop rotations.

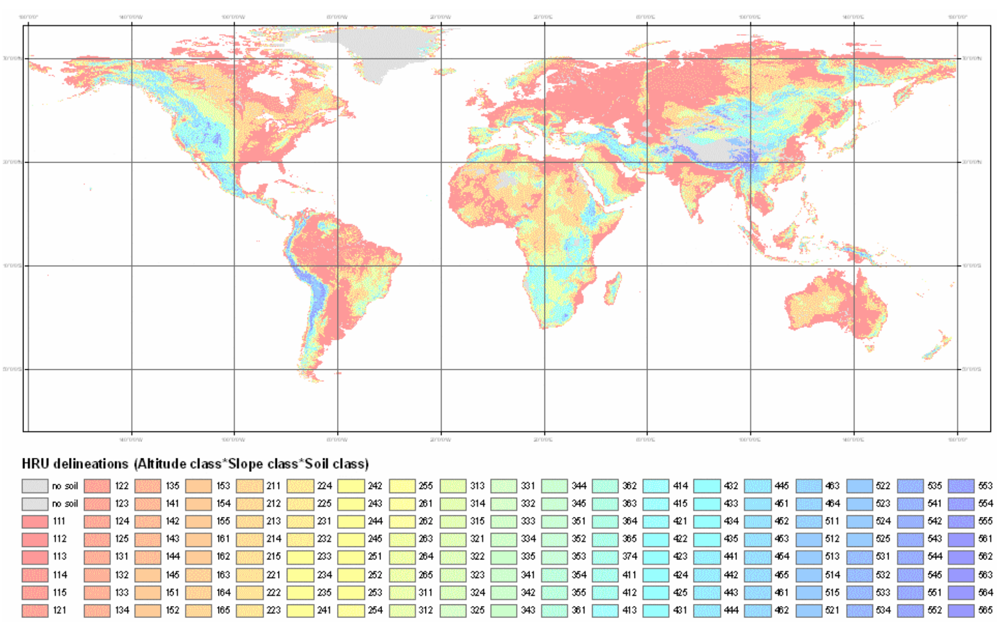


Figure: The global HRU layer

Status: HRU and ISU finished, contruction of crop roation in progress.

Project Title: Extension of the EPIC model for greenhouse gases.

Collaborating GEO-BENE partners: BOKU, IIASA

Background: EPIC is a daily time step model capable of simulating many agro-ecosystem processes including crop growth, tillage, wind and water erosion, runoff, soil density, leaching and soil organic matter dynamics. Recently, the EPIC model was extensively modified with algorithms describing C and N transformations in soil following concepts and equations used in the Century model (Izaurralde et al., 2006). The incorporation of greenhouse gases effects is the current and near future into EPIC modeling. The microbial denitrification is modeled on an hourly basis following the concept that oxidation of C releases electrons thereby driving a demand for electron acceptors such as O_2 and oxides of nitrogen (NO_3^-, NO_2^-, and N_2O). Diffusion of O_2 or CO_2 and N_2O respectively, to and from microbial sites is described using a spherical diffusion model. A cylindrical diffusion model is used to describe O_2 transport to root surfaces and CO_2 and N_2O from the root surfaces. Oxygen uptake by microbes and roots is described with Michaelis-Menten kinetic equations. If not enough O_2 is present to accept all electrons generated, then the deficit for electron acceptors may be met by oxides of nitrogen if they are available. The movement of O_2, CO_2 and N_2O through the soil profile is modeled using the gas transport equation solved on an hourly time step.

Data: EPIC source code.

Methods: Simulations in Fortran. Development of process algorithm for greenhouse gases diffusions.

Results: An refinement and integration of all greenhouse gases into the EPIC model is necessary to investigate the impact of climate policy on the agricultural economics. CO_2 is already implemented and validated, N_2O is implemented but not yet validated, CH_4 is planned to be implemented for the next year

Status: in progress.

SBA: GEOSS Cooperation – all SBAs

Project Title: Designing of research coalitions in promoting GEOSS. A brief overview of the literature

Collaborating GEO-BENE partners: BOKU (lead), IIASA

Background: Despite of the common aim to implement GEOSS and provide better information for better decision making, the public good character of these national endeavours remains. Even though the national data and information contributed to GEOSS is nationally owned and hence excludable, the policies which are implemented due to the improved data concern the utilization and conservation of the environment and natural resources and are of public good character. Similar to a research coalition, contribution to GEOSS entails positive information spillovers on GEOSS-participants and non-participants alike, which reduces the incentive to contribute to the GEOSS platform and jeopardizes cooperation and the emergence of a socially optimal coalition.
This discussion paper reviews literature of the game theoretic branch coalition theory with regards to the formation of research coalitions. The aim is not only to portray the process and challenge of research coalition formation, but also to introduce a set of incentives which could help to overcome the obstacle of spillovers and favour the formation of large and socially optimal coalitions.

Methods: Literature survey with focus on two stage non-cooperative, linear-quadratic Cournot games.

Results: The results suggest that large coalitions clearly maximize social welfare and that the size of the coalition depends on the extent of information spillovers. Equilibrium coalitions are usually smaller than the optimal size coalition unless the spillover rate equals one and the involved countries are willing to fully share their data and information. This happens at a trade off for private benefits, which are decreasing for high spillover rates. The proposed incentive system to broaden participation to GEOSS includes the formation of multiple coalitions, which allows countries with specific interests (desertification, rain forests, marine ecosystem observations etc.) to flock together, and the linkage of negotiations, which compensates countries for their efforts to be part of the coalition.

Status: This literature survey has been finished.

Project title: How high quality contributions of data and information to GEOSS can promote cooperation.

Collaborating GEO-BENE partners: BOKU (lead), IIASA

Background: Even though countries commit to participate in GEOSS the problem of voluntary compliance to the GEOSS targets, which are to contribute high quality data and information to the portal, is not solved yet. This project aims to analyse whether the contribution of high quality data is necessary to ensure integrity of GEOSS and long-lasting and successful cooperation. The decisive question is hence not whether to participate in GEOSS or not, but whether to shirk and contribute low quality data or not.

These considerations lead to subsequent questions: Which ways and mechanisms are there to ensure contribution of high quality data. Which mechanisms can be integrated to secure quality standards? Could quality be ensured by the presence of a standard setting technological leader, who is constantly monitored and evaluated by the peer agents? What should the resulting GEOSS governance system look like to ensure contribution of high quality information (endogenous institution formation, monitoring by peers or external planner)?

Methods: Theoretical investigation.

Status: In progress.

SBA: Weather

Project Title: Integrating statistically generated weather data with climate change in EPIC—a case study analysis

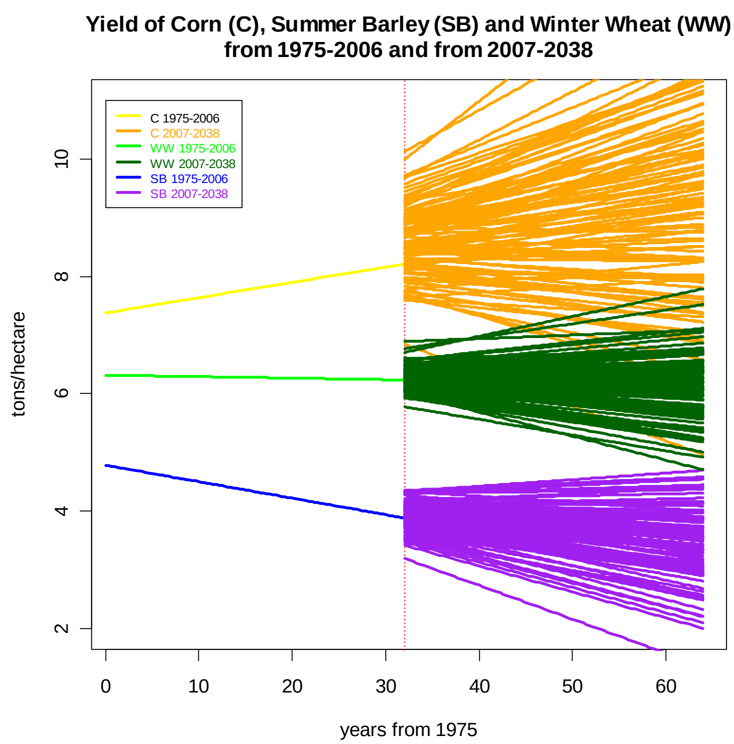
Collaborating GEO-BENE partners: BOKU (lead), KTL, SSCRI, IIASA

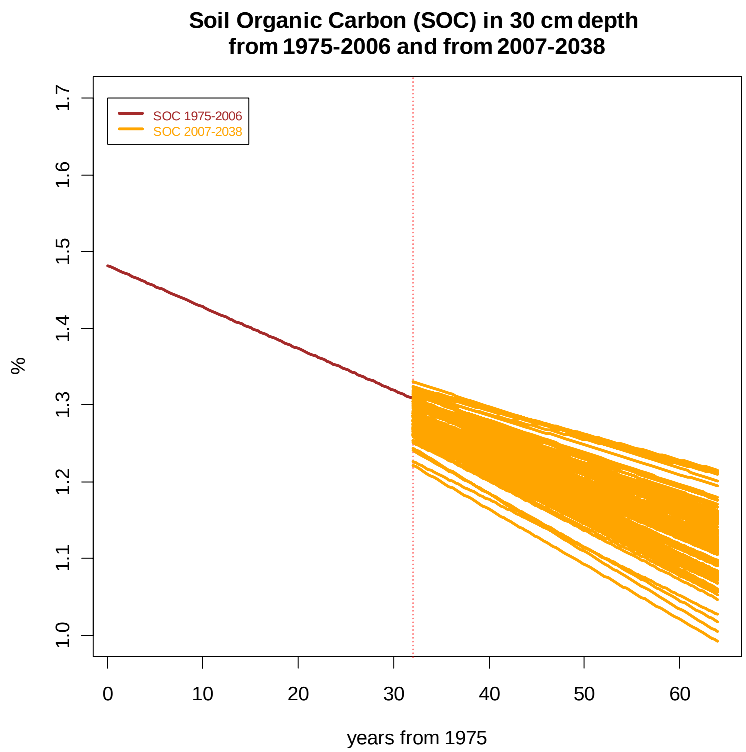
Background: Global climate evaluations show at varying initial conditions (e.g., economic growth, development of the world population and the use of renewable energy) different climate scenarios in the next 100 years. The uncertainty of the climate in the coming 20 to 30 years is relatively small, given that the characteristic time span of significant economic changes and innovations is around 30 years. Therefore, we have developed a statistical model based on the weather observations from 1975 to 2006 to generate weather data considering climate change for the next 30 years. The daily weather observation data are from a weather station in the Austrian region Marchfeld.

Data: Daily weather data from Groß Enzersdorf (Marchfeld / Lower Austria) for the years 1975 to 2006. Representative site, soil and crop management data for Marchfeld.

Methods: The EPIC model and linear regression including linear variables and seasonal covariates; redistribution of data to get random predictions. Stochastic bio-physical impact analysis.

Results: First, we have investigated the impacts of climate change on the crop yield and soil organic carbon (see following pictures).





Only one trend is shown for the period 1975–2006, because we use observed weather data. For the next 30 years, we have randomly selected months from the past period and generated a new weather by respecting the monthly sequences (e.g. the weather in March of the past period is also the weather of March in the new seeds) and the trends in daily Tmin and Tmax temperatures and monthly rainfall amounts. This process has been repeated to construct 100 random weather seeds.

	Corn	Summerbarley	Winterwheat	Soil Organic Carbon
Trend 1975-2006	n.s.	s.	n.s.	s.
Trends 2007-2038	16%	34%	17%	100%
Difference Past / Future	n.s.	n.s.	n.s.	s.

Only the crop yield trend of summer barley and the trend of soil organic carbon are significant (see table above) in the period 1975–2006. The table also contains the percentage of significant trends for the period 2007–2038. There is only a significant difference between the two periods for ‘soil organic carbon’.
Next steps will focus on the impacts of climate change in the period 2007–2038 on the profitability of different crop production systems and other environmental indicators.

Status: in progress.

Project Title: European Bioenergy and Wetland Targets—An EUFASOM Illustration

The main purpose of this study is to document the mathematical structure of EUFASOM. However, in this section we will briefly illustrate the use of the model through a small scenario experiment. Bioenergy production and wetland preservation constitute two major political objectives of the European government. While the first goal includes managed dedicated energy crop plantations, the second one usually requires the establishment of rather undisturbed nature reserves. Moreover, both options are mutually exclusive with food production. This raises an important questions for policymakers: how does the competition between food, bioenergy plantations, and wetland reserves for scarce land affect the competitive economic potential of these environmental goals? EUFASOM is well suited to address this question. The following scenario setup is used. First, bioenergy policies are represented by biomass targets up to 300 million wet tons. This amount of biomass would roughly be required to generate about 20% of the current total electricity consumption in the European Union. Second, to avoid negative ecological spillovers, existing wetlands and forests are protected and cannot be used for agriculture or bioenergy plantations.

Aggregated economic potentials of wetland restoration are displayed in
Figure 11 1. The 100% biomass target corresponds to a European wide requirement of 300 million wet tons. As shown, with such a constraint, wetland subsidies as high as 800 Euro per ha are insufficient to induce restoration. For reduced biomass targets, restoration potentials are higher. In all cases, increasing opportunity costs lead to increased marginal costs of restoration.
Figure **11** also illustrates that the competition between bioenergy production and wetland restoration does not increase linearly. While the difference between no and a 25% biomass target is small, a relative large gap exists between the 25% and 50% targets.

The interaction between food production and environmental goals is shown in
Figure 12. The line labeled "EU25wide" shows the wetland restoration potential for wetland subsidies established in all European countries. The second line, labeled "national" forms the sum of 23 independent assessments. In each of these national assessments, the wetland subsidy is only established in the respective nation. For both setups, a 50% biomass constraint is enforced jointly over all countries.
Figure **12** shows that starting from a subsidy level of 300 Euro per ha, the two lines drift apart. The sum of national assessments gives a higher restoration potential because bioenergy and agricultural production simply shift to those countries without wetland subsidy. At the highest shown subsidy level, the sum of national assessments overestimates the economic potential by almost 10 million ha.

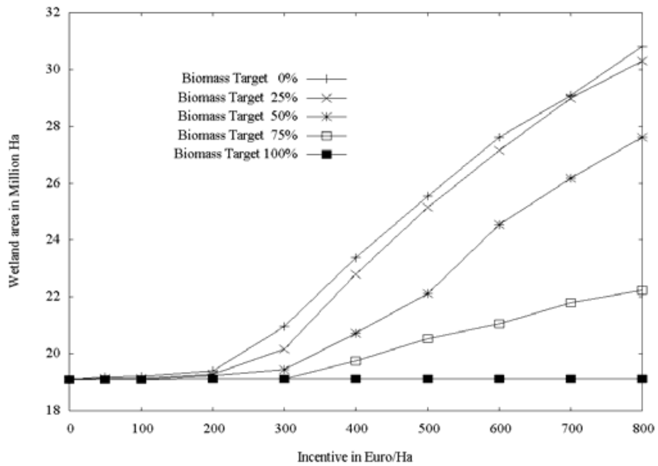


Figure 11: Competitive economic wetland restoration potentials for different biomass targets and different wetland subsidies (horizontal axis).

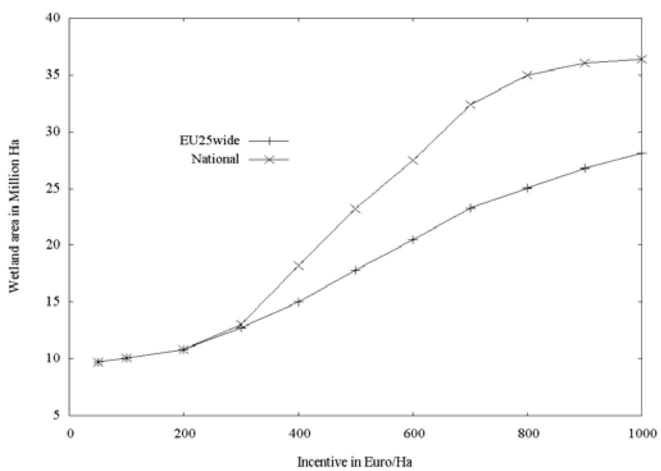


Figure 12: Economic wetland potentials for (a) simultaneous wetland subsidies in all EU countries and (b) sum of independently obtained national potentials assuming that subsidy is only established in the respective country

Project Title: **I**mproved monitoring & evaluation systems (trends) and Improved management decisions (responses)

Improved monitoring of biodiversity

Several national, regional and global conventions and policies now existed requiring the regular and accurate monitoring on the state and trends of biodiversity (e.g. the Convention on Biological Diversity's 2010 target and its subprogram Streamlining European 2010 Biodiversity Indicators). Several of these indicators will depend on GEOSS for accurate data on for example land use, degradation. To test the role of GEOSS in this context we applied the benefit chain to improved data on biodiversity, land use and condition in Europe and South Africa. These results showed significant differences in the results when using good data similar to that produced by GEOSS and poor resolution data without a GEOSS (see Figure 1).

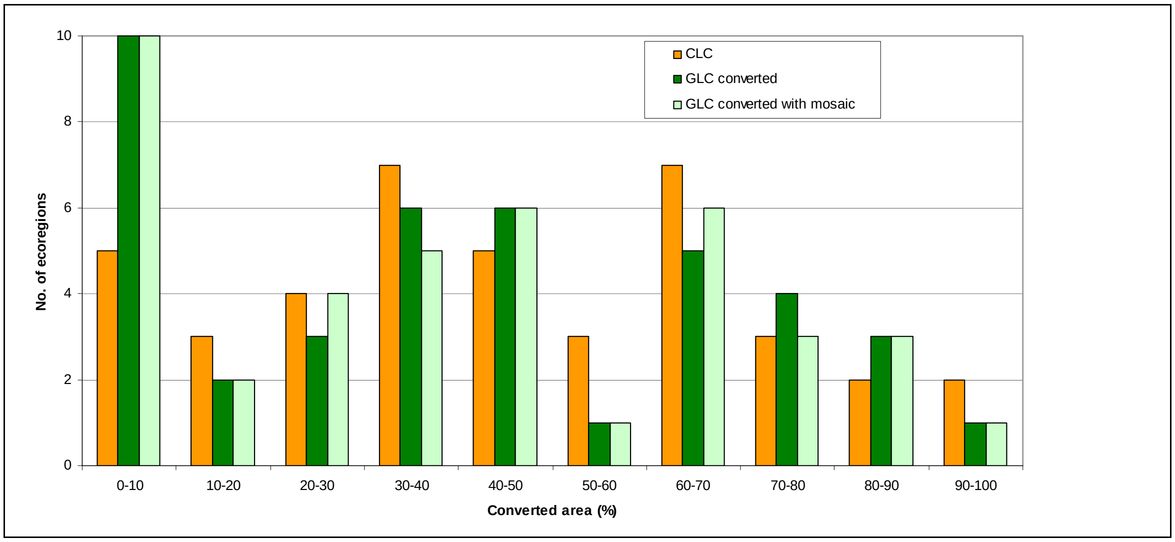


Figure 1: Number of European ecosystems (WWF ecoregions) per converted area category. Converted area is measured as natural vegetation cover converted to agriculture, forestry, urban areas and artificial surfaces. The data-poor scenario is represented by relying on Global Land Cover data, while the data-rich scenario is represented by the CORINE data.

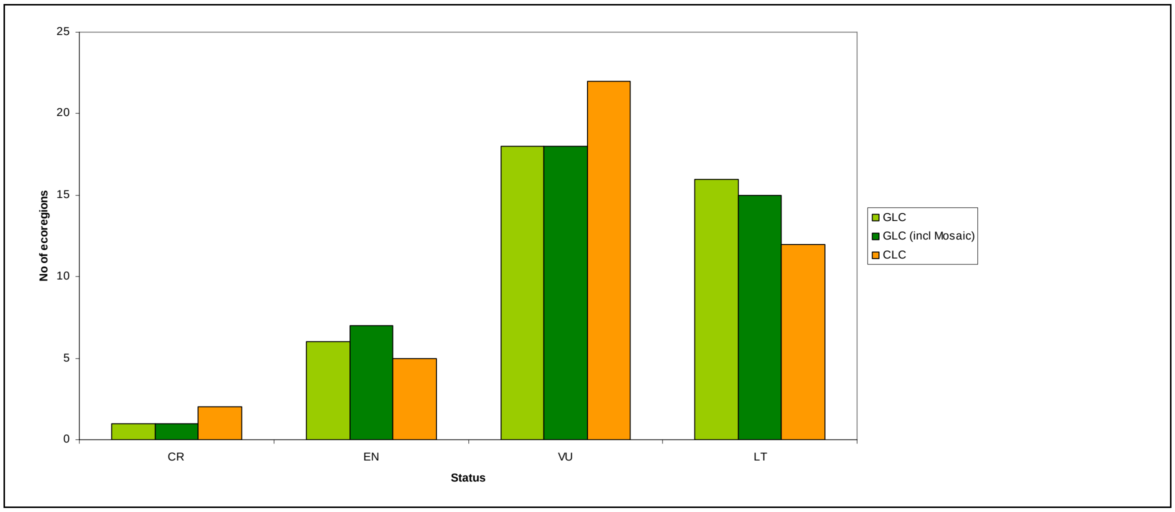


Figure 2: The number of European ecosystems in different threat categories (CR = critically endangered, EN = Endangered, VU = vulnerable, LT = Least threatened) based on conversion relative to thresholds proposed by Rodriquez et al. (2007). GLC = Data poor, CLC = Data rich.

A problem with these results is that although they show the improvements of GEOSS in bidoievrsity monitoring these benefits are not quantifiable and comparable with the costs of GEOSS. We propose to take this forward in the next section in the next phase.

Similar work in a semi-arid region of South Africa has demonstrated the value of good data on land cover and degradation (Payet. 2007).

Improved management decisions

In a preliminary study (included in the IEEE submission) we used the results of a national scale study on data-rich and data-poor scenarios in South Africa (Jonas et al. In Prep). This showed that when it comes to making decisions on the location of new conservation areas poor data overestimated by about 10% the land needed. This works out at an extra cost of 1.2. billion euros in once off costs plus management costs. This can be compared to the costs of the good data (which costs about 100 times more than poor data to collect ~ 200 million euros in this example). This makes clear the cost-benefit approach and results. We plan to apply this thinking and method to European examples.

References

Payet, K. (2007) The importance of data and scale in making conservation assessments. MSc Thesis. University of Stellenbosch

Rodrıguez, J.P., Balch, J.K. and Rodrıguez-Clark, K.M. (2007) Assessing extinction risk in the absence of species-level data: quantitative criteria for terrestrial ecosystems. Biodivers Conserv. 16:183–209

SBA: Water

Project Title: Global consumptive water use for crop production

Collaborating GEO-BENE partners: Eawag (leader), ETH-Board, IIASA

Background: Despite the progress made in water use assessments, previous studies either lack spatial details and resolutions, or merely emphasize on blue water uses, or focus on water withdrawal while ignore consumptive water uses. We estimate consumptive water use and proportion of green water in the production of 17 major crops with a spatial resolution of 30 arc-minutes on the land surface.

Data: The crop distribution maps are obtained from the Center for Sustainability and the Global Environment (SAGE) at the University of Wisconsin-Madison. Irrigation map is collected from the Food and Agriculture Organization of the United Nations (FAO). The amount of fertilizer applied per country and crop is derived from the statistical report by the International Fertilizer Industry Association.

Methods: Crop yield, crop evapotranspiration and crop water productivity of 17 major crops are simulated with a spatial resolution of 30 arc-minutes with a GIS-based EPIC model (GEPIC).

Results: The results show that the global annual consumptive water use (CWU) of the crops considered was about 3651 km^3 yr^{-1} for the period 1998–2002. Over 80% of this amount was from green water. Globally, almost 90% of the virtual water trade among countries had its origin in green water. This is partly related to the low opportunity cost of green water as opposed to blue water. High levels of net virtual water import generally occur in countries with low CWU on a per capita basis, where a virtual water strategy can be an option of water management to compensate for domestic lack of water resources for food production.

Status: A manuscript on 'Global Consumptive water use for crop production: the importance of green water and virtual water' by Junguo Liu, Alexander J.B. Zehnder and Hong Yang has been submitted for publication in Water Resources Research.

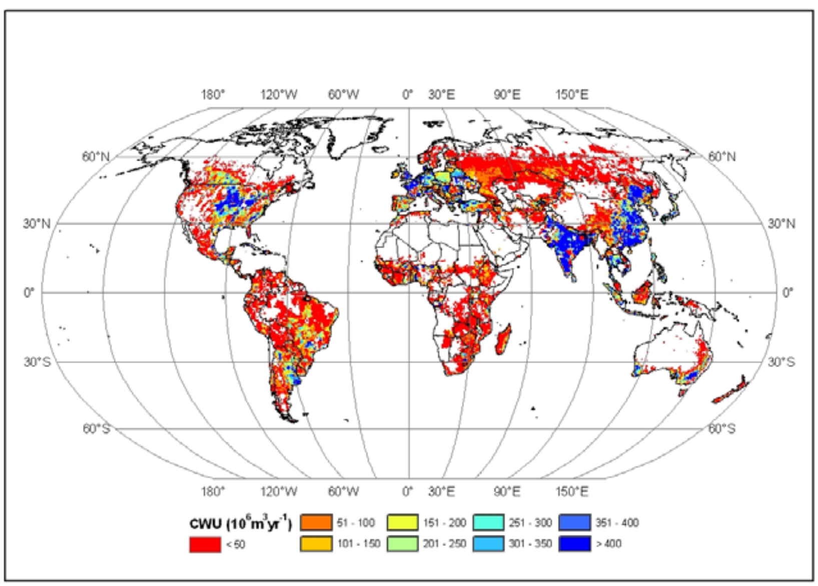


Figure: Spatial distribution of consumptive water use (CWU) for crop production per grid cell of 30 arc-minutes (average over 1998-2002)

SBA: Agriculture

Project Title: Global nitrogen flows in cropland

Collaborating GEO-BENE partners: Eawag (leader), IIASA, IFPRI, SSCRI

Background: Crop production is by far the single largest cause of human alteration of the global nitrogen cycle, thus raising global sustainability concerns. Previous research on global nitrogen flows in cropland has not made full use of the spatially explicit databases available. Studies generally treat a country or region as a whole, and rarely pay attention to the spatial variations within a country or region. We conduct an assessment in global nitrogen flows in cropland with spatial resolution of 5 arc-minutes for the year 2000. The results are aggregated into national level to analyze nitrogen balance in different countries.

Data: This study involves extensive use of spatially explicit databases. We only list the most important ones here. The spatial distributions of harvest area and production of 20 major crops are simulated with a spatial resolution of 5 arc-minutes with a spatial allocation model from IFPRI. The livestock density is from FAO's Gridded Livestock of the World. Crop-specific fertilizer data are collected from the International Fertilizer Industry Association. Soil parameters are obtained from ISRIC-WISE derived soil properties.

Methods: Each of the six nitrogen inputs and five nitrogen outputs is calculated either based on regression models or commonly used methods. The high resolution results are integrated into national averages to assess global nitrogen balance.

Results: We calculate a total nitrogen input of 145.3 Tg N yr^{-1}, of which almost half is contributed by mineral nitrogen fertilizer; and a total nitrogen output of 137.2 Tg N yr^{-1}, of which 55% is uptake by harvested crops and crop residues. High resolution maps are provided to quantify the spatial distribution of nitrogen inputs and outputs, soil nitrogen balance, and surface nitrogen balance. The results show almost 80% of African countries were confronted with nitrogen scarcity or nitrogen stress. The calculation also show a global average nitrogen recovery rate of 52%, indicating almost half of the nitrogen input was lost in ecosystems.

Status: Manuscript in preparation.

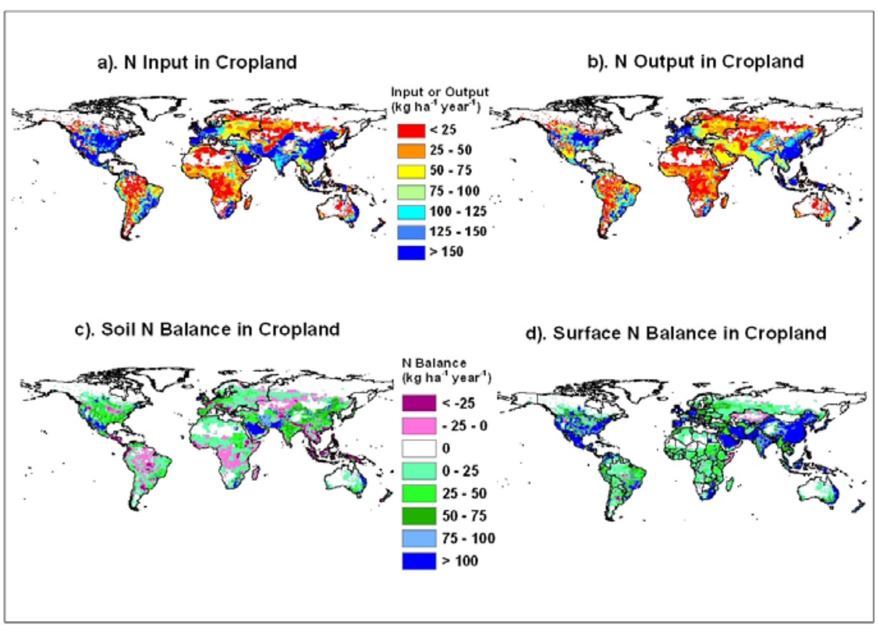


Figure: Maps of global nitrogen input, output, soil nitrogen balance, and surface nitrogen balance

SBA: Agriculture, Water

Project Title: Impacts of global climate change on food production and agricultural water use

Collaborating GEO-BENE partners: Eawag (leader), IIASA, IFPRI, SSCRI

Background: In recent years, an increasing number of studies have been found in literature to assess the impacts of global climate change on food production and agricultural water use. The impacts are mostly assessed on small scales, while whenever global-scale studies exist, they are often conducted with low spatial resolutions. We conduct an impact study with a spatial resolution of 30 arc-minutes on the entire land surface. Hotspots with high adverse effects of climate change are highlighted for analysis.

Data: Past and projected future monthly climate data are collected from the Climate Research Unit (CRU) in the University of East Anglia. The ISRIC-WISE derived soil properties are used. The livestock density data are collected from FAO's Gridded Livestock of the World. Crop-specific fertilizer data are collected from the International Fertilizer Industry Association.

Methods: The GEPIC model is used to simulate the impacts of climate change on food production and agricultural water use of the major crops. A MODAWTHC model is developed to convert the monthly climate data from CRU to daily climate data.

Results: A MODAWTHC model is being developed to convert monthly climate data to daily climate data.

Status: The project is at an early stage. The MODAWTHC model is being developed and tested.

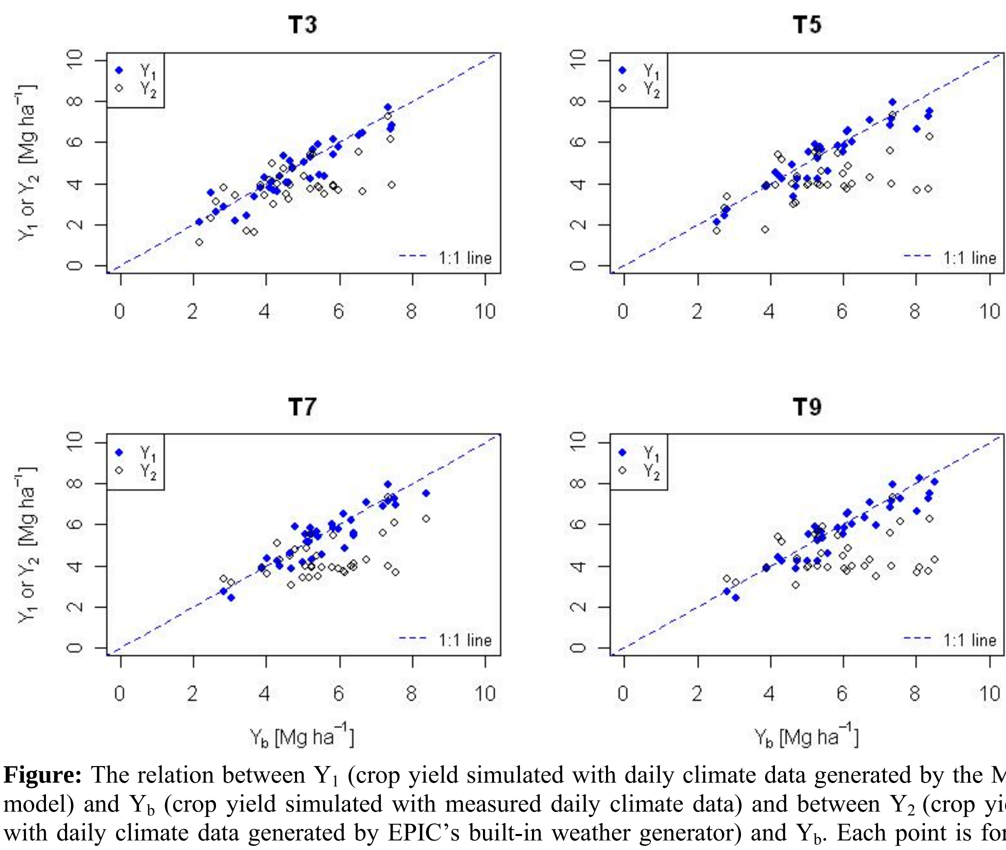


Figure: The relation between Y_1 (crop yield simulated with daily climate data generated by the MODAWTHC model) and Y_b (crop yield simulated with measured daily climate data) and between Y_2 (crop yield simulated with daily climate data generated by EPIC's built-in weather generator) and Y_b. Each point is for one specific year between 1958 and 1991 at the Arlington Agricultural Research Station in Wisconsin. T3, T5, T7, and T9 are four treatments.

SBA: Health

Project Title: Prediction of daily acute myocardial infarction incidence based on the weather forecast. A case study of Finland.

Collaborating GEO-BENE partners: KTL, Finland (leader) + IES, The Netherlands

Background: The effect of the daily weather, in particular, ambient temperature on the aetiology of cardiovascular and respiratory disease is now widely known and researched. The most important single cardiovascular disease is coronary heart disease (CHD), including acute myocardial infarction (AMI). The morbidity and mortality of AMI in Finland is among the highest in the world despite the significant recent reduction trends. Together with high quality patient and population registers Finland provides a good platform for detailed study. The ability to use weather forecast for AMI incidence prediction can lead to better resource allocation and reduced disease burden, which, according to WHO 2030 projections for CHD, is expected to grow considerably worldwide.

Data: Geo-referenced first AMI incidence and population data for subjects aged 25-74, for the years 1983, 1988, and 1993, and the daily weather data.

Methods: Statistical modelling: Poisson regression with weather effects and seasonal variation included¤ cross-validation checks performed for the forecast potential.

Results: The information on weather does not allow to significantly improve incidence prediction. The methods developed within this study can be applied to other similar diseases in other geographical locations.

Status: The article "Prediction of daily acute myocardial infarction incidence based on the weather forecast. A case study of Finland." by Nadja Schreier, Elena Moltchanova, Onno Kuik, Niina Lammi and Marjatta Karvonen to be published shortly in the Proceedings of the 6th International Conference on Health Economics, Management and Policy, Athens, Greece.

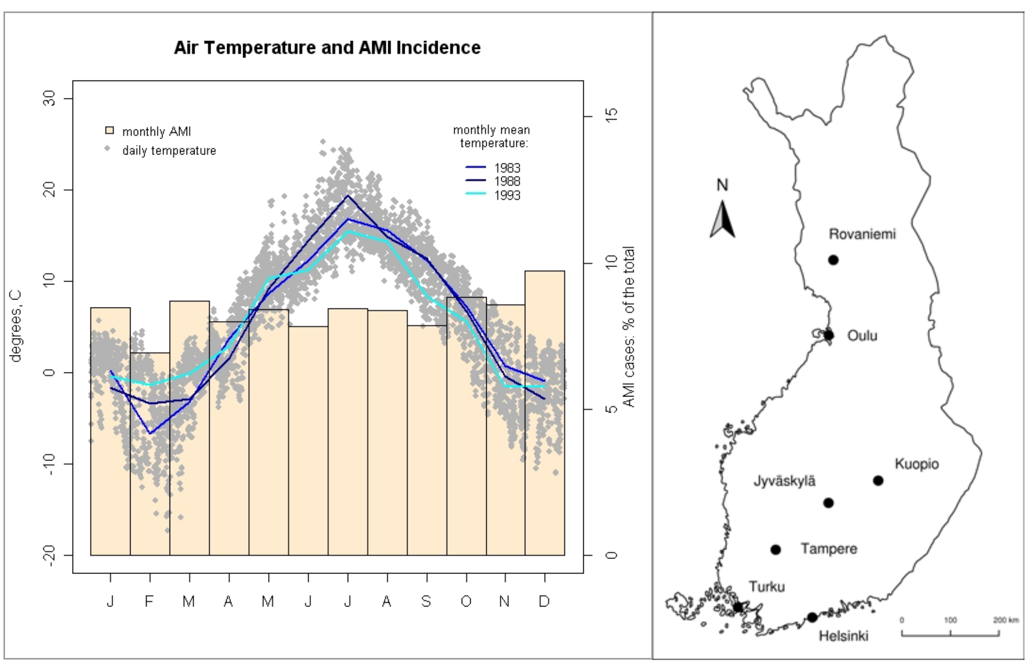


Figure. Air temperature and monthly AMI incidence distribution in Finland.

<u>Project Title</u>: The seasonality and effect of daily weather on daily case fatality of the acute myocardial infarction incidence. A case study of Finland.

Collaborating GEO-BENE partners: KTL, Finland (leader)

Background: The seasonality and the effect of the daily weather on AMI case fatality, i.e. the probability of dying for a patient, has not been well researched. Better understanding of underlying risk factors may lead to better allocation of hospital resources thus saving human lives.

Data: Geo-referenced first AMI case-fatality and population data for subjects aged 25-74, for the years 1983, 1988, and 1993, and the daily weather data.

Methods: Statistical modelling: Binomial regression with weather effects and seasonal variation included¤ cross-validation checks performed for the forecast potential.

Results: Preliminary results suggest seasonality in case-fatality. The observed seasonal pattern does not differ significantly by age and/or sex.

Status: The analysis is at its final stage. The manuscript is in preparation to be submitted to an epidemiology journal by the end of February 2008

Project Title: The seasonality in type 1 childhood diabetes incidence wordlwide.

Collaborating GEO-BENE partners: KTL, Finland (leader)

Background: The seasonality in diabetes incidence is a well-known and widely researched phenomena. However, most studies focus on a single period in a single geographical region. The worldwide Diabetes Mondiale (DIAMOND) project has collected incidence data on type 1 childhood diabetes from all over the world for the period 1990-1999. Such a wide spatio-temporal window may allow to get a better view of geographic aspect of seasonality.

Data: Monthly diabetes incidence data from 105 DiaMond centers for children under 15 years of age for the period 1991-2000, and the corresponding census data.

Methods: Bayesian statistical time-series modelling: Poisson regression with a possible autoregressive component included.

Results: TBD

Status: Under analysis. The preliminary results are to be ready in February 2008.

SBA: Climate

Project title: Conceptual Models for the Role and Benefits of EO and Modelling

Background: We investigate the role of future learning about the climate system (by global earth observation and modelling) and about climate thresholds in timing abatement policies. Learning plays a crucial role when irreversibilities or rigidities and large uncertainties are present in the system as in the case of climate change. For computational reasons most multi-stage models have simplified the learning process to an autonomous, perfect one-time learning. We focus on the implications of sequential, potentially active resolution of uncertainty in a simple multi-stage model with a climate threshold. Thereby, the concept of 'value of information' and 'future value of information' can be extended to the value of different sequential learning processes. Thereby, it is hoped to gain qualitative insights into questions like: How do first period optimal decisions with anticipated sequential learning compare to decisions for one-time learning? What is the benefit from resolving uncertainties over time in terms of improved abatement policy? What would the value of tipping point early warning systems be? How does this value depend on the flexibility in abatement and on other system properties? When is anticipation of learning essential?

Method: (Approximate) stochastic dynamic programming.

Results: In a first step, the probably simplest sequential decision model possible representing irreversibility, time-lags and a threshold (modified version of the model presented in Maddison(1995)) was used to gain first insights into the questions above. Learning was represented in a simple parametrized form taken from Kolstad (1996) and modified to represent active learning. Besides the sunk-cost – climate-irreversibility trade-off well known from the literature, additional tradeoffs are observed between learning velocity and threshold location and impacts, and between learning velocity and flexibility in abatement. Whether there is a clear correspondence between one-time learning and sequential learning in terms of first period recommendations is yet to be determined.

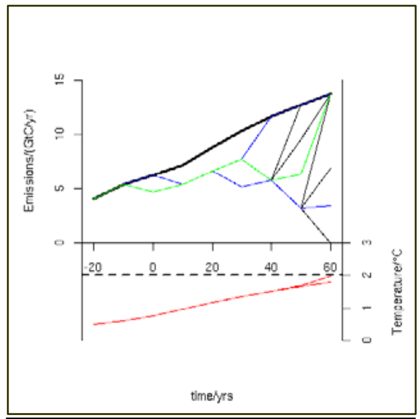


Figure 1: Adaptive strategies and corresponding temperature increase for climate threshold at 2°C. Green: no learning; blue: most probable learning paths (leading to shown temperatures); black: improbable learning paths.

Outlook: Planned is a similar investigation in a more realistic model.

SSCRI relevant and recent research under GEO-BENE project (phase 1)

SSCRI research is focuses primarily on SBA agriculture. The particular task of SSCRI is to support various SBA agriculture analyses carried out by other consortium members (BOKU, UHH, IIASA) with relevant global data on topography, soil, land cover, land use and agricultural management. SSCRI activities within the GEO-BENE project are identification of the best global data sources and the development and implementation of the global database primarily for bio-physical modeling (EPIC model) but also for LC/LU optimization modeling (FASOM, Forest/Deforestation model). Global database is also supposed to identify the most serious gaps in global data availability for data-model fusion based interpretations defined by Group on Global Earth Observations (GEO) "*Developing a Strategy for Global Agricultural Monitoring in the Framework of GEO Workshop Report*" document for SBA Agriculture (ftp://ftp.iluci.org/GEO_Ag/GEO_IGOL_AG_Rome_2007_Workshop_Report_v2.pdf).

The logical data structure and content of the developed global database mirrors three general aspects taken into account in the database designing process:

- **Requirements of the models (conceptual level)**—concept of spatial units defined on the basis of the most stable landscape characteristics (altitude, slope and soil texture)—homogenous response units (**HRU**)—was adopted as a spatial frame for setting up the base-run and alternative LC/LU scenarios and as an interface for communication of input/output information between bio-physical model EPIC and optimization models. Moreover, the concept of elemental simulation units (**SimU**) based on the selection of the areas homogenous with respect to topography (altitude, slope), soil (soil chemical and analytical properties), land cover and land use (cropland or grassland management type and amount of human inputs to the agro-ecosystem) was defined to satisfy the EPIC model input data requirements while applied in geographical context;
- **Global data availability and quality**—data required by EPIC model or other data necessary for setting up the LC/LU scenarios are available in the different quality. Some of the essential data is absolutely lacking and have to be interpreted or estimated from other data sources. The general quality of the available data (spatial and temporal resolution, attribute depth, thematic accuracy) and data validity or confidence vary significantly. This influence mostly the extent to which the input data can be interpreted or enhanced to satisfy the requirements of bio-physical or optimization models and via data interpretation possibilities it influence also the quality of the global database content—spatial, attribute or temporal resolution of the data, confidence level of the information derived from the global database and a relevance of the data to the particular needs (detailed requirements of EPIC model versus broad and general data available);
- **Spatial and attribute unification of the data coming from various sources -** because various thematic global datasets have been developed for various purposes and it differs seriously in spatial representation (if spatial), spatial, attribute or temporal detail, spatial or temporal resolution, geographical extent, etc. the spatial unification was necessary. Based on the least spatial resolution of the essential data inputs required for HRU and SimU definition the global coverage grid of 5 arcmin resolution pixels was selected the basic spatial frame for representation various source data (global digital elevation model, digital soil map and soil analytical properties estimations, land cover and land use data). Global coverage grid of 30 arcmin resolution pixels and country-level administrative units coverage (spatially represented via 5 arcmin resolution grid) serve the supplemental spatial reference for meteorological and agricultural census data, respectively.

Global database has been organized in three separate datasets addressing different aspects of global modeling in agronomy or forestry sector and specific data requirements (both the data type and data organization) of bio-physical model EPIC and LC/LU optimization models:

- **EPIC input data dataset** store the data on topography, soil and climate mandatory for the bio-physical model runs;
- **Land cover (LC) and land use (LU) statistics** store the data on the relevant LC/LU classes for agricultural and forestry modeling and serve the data source for setting up the global base-run LC/LU scenarios for bio-physical and optimization modeling as well as it creates a basis for estimation of possible LU/LC change scenarios;
- **Agricultural management dataset** store the data on crop and crop management calendar (irrigation, fertilization and tillage) and data on irrigation water amounts and fertilization application rates interpreted from available agricultural census data.

Actually, first version of the global database is available for the test simulations. In phase 2 of the GEO-BENE project the most important task will be therefore the refinement of the database to fit all the mandatory requirements of bio-physical and optimization models as well as to get it in the best accordance with general goals of SBA Agriculture activities.

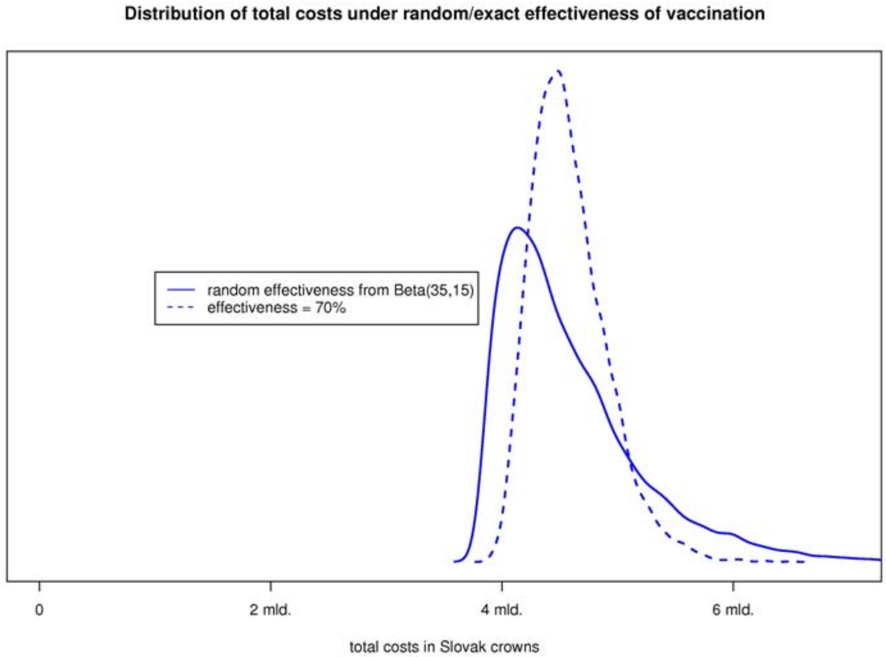
Partner: UBR

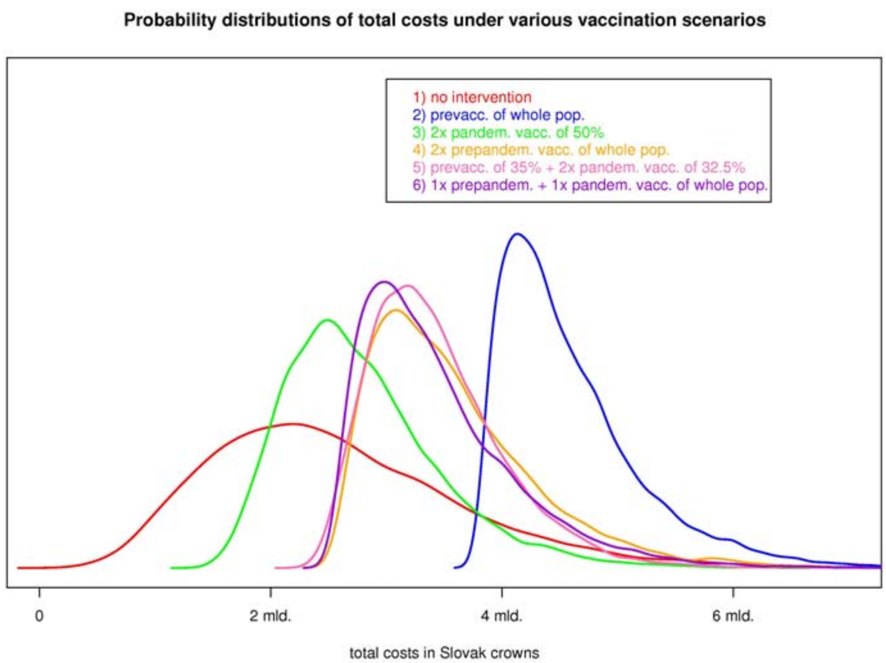
The leading idea of the work of the Comenius University (UBR) team is reduction of loss risk by analyzing optimization problems on Markov chain models. To construct the latter conditional probabilities based on observations have to be computed. Parallely, methods of information value assessment are being developed. Particular models concern several social benefit areas.

Disaster: In cooperation with the IIASA team its model of forest fire prevention is being further developed by:

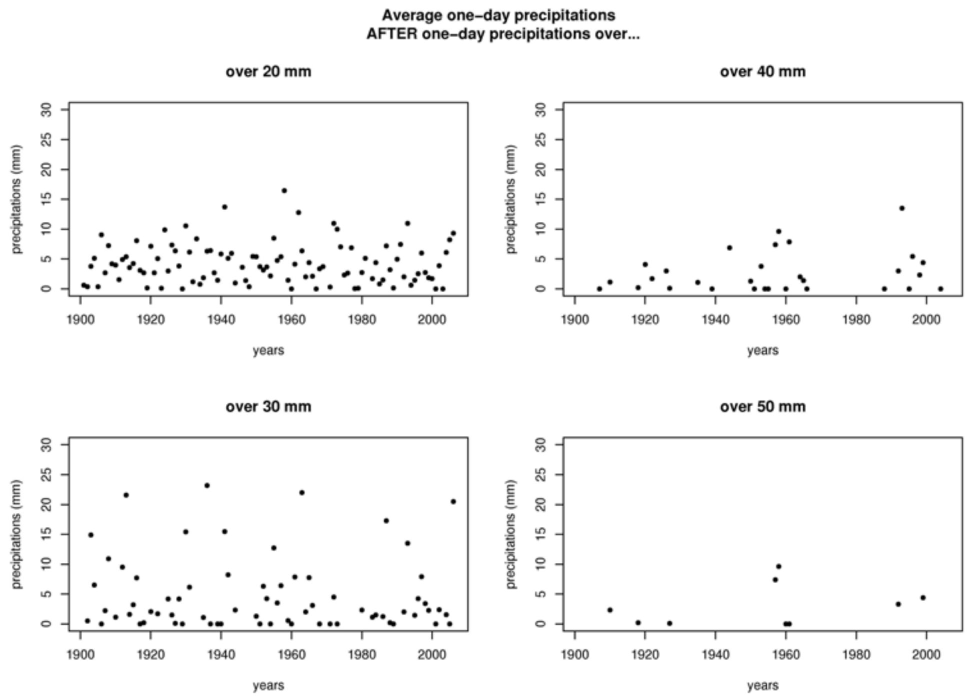
- Calculation of optimal thresholds for the fire danger classes. The existing model uses fixed thresholds without any justification of their values. Optimization of thresholds leads to cost reduction.
- Application of the risk-based approach. So far, only the average values of the distribution have been considered. Therefore, the analysis of the properties of the distribution tails was impossible. The application of VaR and CVaR techniques appears to be promising.

Health: In cooperation with GlaxoSmithKline researchers a basic assessment of losses caused by a pandemic influenza has been worked out and is being further developed. The material will be submitted to the National Pandemic Committee of Slovakia. The first picture shows probability distributions of total costs under various vaccination scenarios. The second picture depicts a decrease of the variation of total costs provided using more precise data (pre-vaccinaton effectiveness in particular). It serves as an example of benefit from related observations and research.

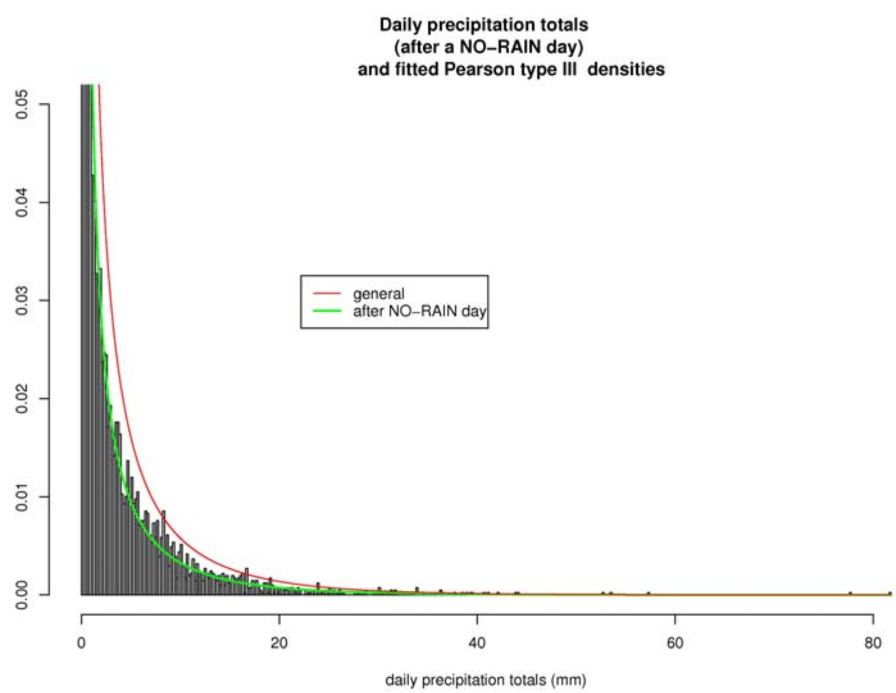




Climate, Weather, Ecosystems: Decades long chains of data of daily precipitation, temperature and humidity values have been obtained from the Slovak Hydro-Meteorological Institute. To develop adaptive estimates of flood danger we developed a methodology of computing conditional probability of continuing rainfall after heavy rainfall days



We also studied conditional probability distributions of rainfalls after specific events (e.g., after a no-rain day).



Currently we are working on an identification method of continuing extreme weather events, in particular of long periods without rainfall, high temperature and low humidity. From the results we expect to obtain some information on climate change and support of adaptive decision making based upon observations with help of an index similar to the used by the IIASA team for forest fire prevention.

In cooperation with the Institute of Hydrology of the Slovak Academy of Sciences a stochastic model of long-term prediction of the Danube river monthly discharge has been developed (Fig. P).. As a part of the project a similar autoregressive model of daily discharge is being developed. In combination with a transition matrix the model will enable to predict probability of flood events and their duration.

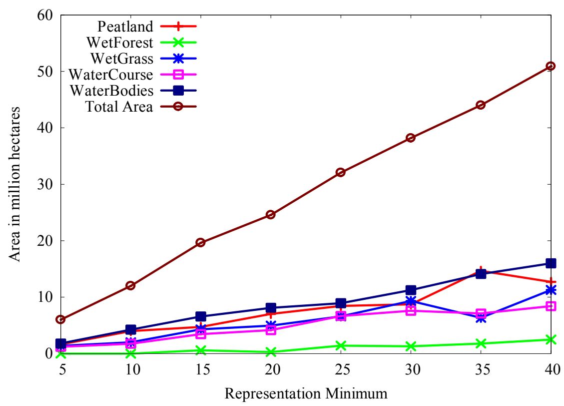
Partner: UniHH
Research Unit Sustainability and Global Change
University of Hamburg

SBA Biodiversity

Results and Outlook

Biodiversity loss takes place at unprecedented rates. Habitat loss and habitat fragmentation resulting from human land use are among the most important threat factors for biodiversity. Integration of biodiversity conservation into economic land-use models like FASOM is therefore necessary.

A biodiversity conservation module is developed that will be interlinked with FASOM. It estimates habitat allocation under several objectives and different biodiversity policies in Europe. We employ a deterministic, spatially explicit mathematical optimization model. Objectives involve minimizing the total area needed for conservation as well as minimizing the cost for setting aside land for conservation purposes. Exogenous biodiversity policies include a conservation target.



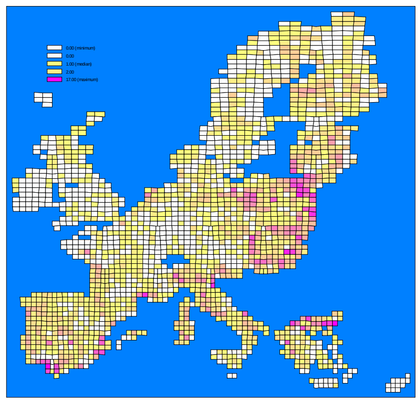


Figure 1: Habitat allocation resulting from area minimization over 68 animal species

Figure 2: Covered animal species per cell for target 40 (dark colours indicate high numbers; maximum: 17)

Accounting for conservation requirements in land use modelling affects opportunity costs.

The implementation of the conservation module into FASOM allows evaluation of competition and complementarities between traditional agriculture and forestry, bioenergy and biomaterial plantations, and nature reserves.

We can furthermore explore synergies and trade-offs between conservation, climate, energy, and other policies which affect land use and agricultural and forest markets.

SBA: Solar energy

Project Title: Optimize solar PV plant place and transportation for Europe and Africa

Collaborating GEO-BENE partners: FELIS (Freiburg University), IIASA

Background: with the significantly increasing population and greatly consuming of energy, the conversion energy can not provide enough energy commodities for people living. The renewable energy, such as solar, biomass and wind, shed a light for this situation. The satellite's launching can provide the global simultaneous data, especially for Geo-reference. Therefore, using these data can optimize the best place to install the renewable plant and the best transportation in order to get the maximal profit.

Data: The solar irradiation data comes from NASA website, which has the 0.5 *0.5 resolution degrees. The solar PV module price data and electricity demand data are obtained from IEA. Some of them are obtained from internet. The PV transportation efficient data are obtained from DLR.

Methods: Solar plant size and solar transportation of 29 Europe countries are simulated with simple solar bewhere model.

Results: The results show that for researched Europe countries, Germany is the best place to install the PV plant, with the plant size 137124.89 GW/y. The transportation is center on Germany and every researched country' electricity can be satisfied. The total cost, including PV plant cost and transportation cost, is 1.023197E+15 dollar.

Status:

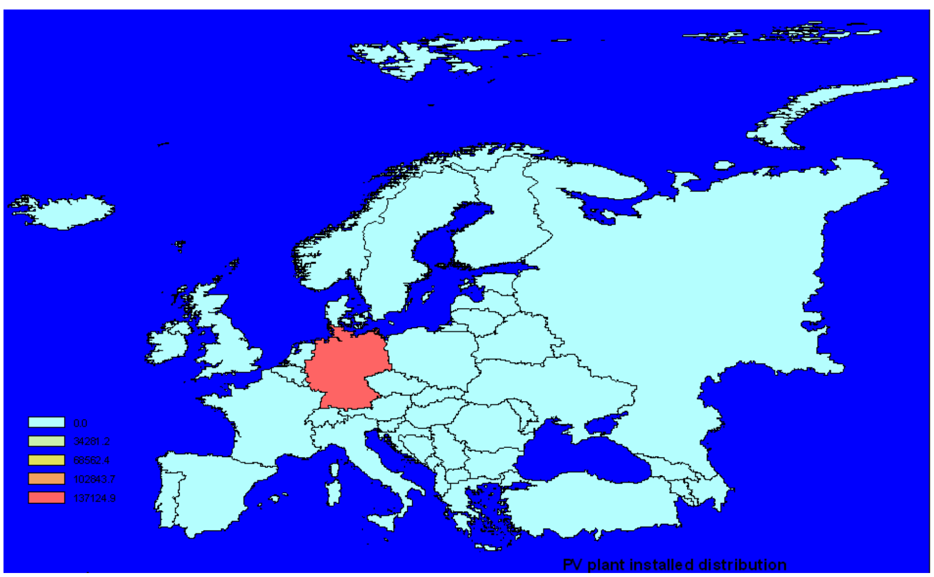


Figure: PV plant installed distribution

Framework: Geobene Geodata management

Project Title: Developing a Geodata infrastructure to be used within the Geobene Project

Collaborating GEO-BENE partners: FELIS (Freiburg University), SSCRI, BOKU, IIASA

Background: The GEO-BENE project deals with large amounts of geo-referenced data and also produces models and simulations that are also geo-referenced. In order to be standards compliant we are utilizing geomatic standards that were issued by ISO/TC211 and the OGC.

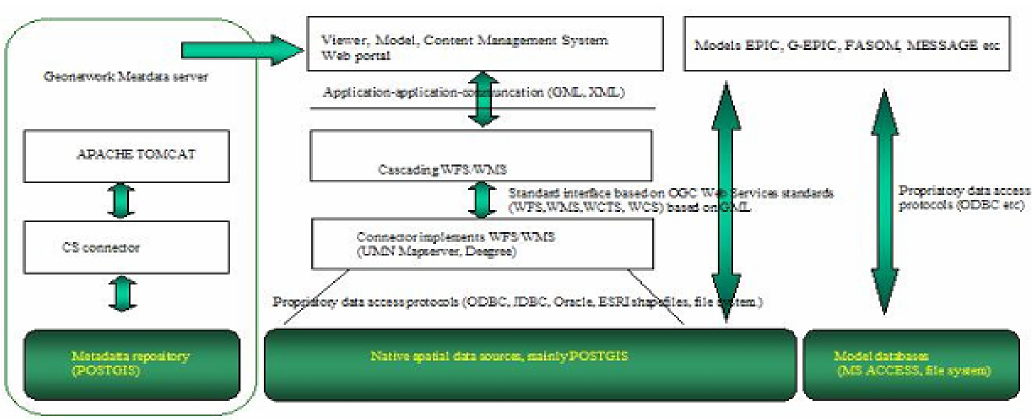
Nearly all global initiatives are adopting the ideas from OGC to form an interoperable worldwide community of geodata and services.

OGC and ISO make use of standard web technologies like web services and thus defines services for the transmission of raster data like Web Mapping Service, Web Coverage service as well as for vector data (like Web Feature Service), and also a Catalogue Service. Furthermore it defines metadata data that were adopted by ISO and culminate in the definition of metadata according to ISO 19115, which describes geospatial datasets.

In order to follow the INSPIRE principles and in order to clearly catalogue and make available these data we have developed a Geobene system architecture based on OGC web services and standards from both the OGC and ISO/TC 211. We are running a standards compliant Open Source Metadata server used to serve both the modellers and interested researchers who can search the Geobene data pool via a standardized meta data interface based on ISO 19115 (and FAO's open source geonetwork server).

We are describing the data models used within our simulation software (like EPIC,G-EPIC, FASOM, MESSAGE etc) and we then publish our results in WMS layers that can easily be integrated in online 3D globes.

The Geobene system architecture:
We also describe the GEOBENE high level system architecture that we have developed and that we are implementing at the moment. The client frontend is based on the aforementioned OGC- and ISO standards to guarantee broad acceptance and,. more important, best interoperability. The backend is based on open source software like geonetwork and postgis as well as on propriatory data sources were the used models demand it and where it is not feasible to write connectors (like EPIC).



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