

SITE: A generic framework for integrated modelling

Abstract

The SITE framework (Simulation of Terrestrial Environments) is a generic modelling platform supporting spatially explicit land-use modelling. Compared to most existing land-use modelling environments, the functionality of SITE is not confined to managing the execution of land-use models, but additionally integrates (i) interfaces to link new models to study different processes e.g. in hydrology or changes in biodiversity, and (ii) tools for simultaneous multi-model calibration and testing (via various map-comparison algorithms) into its generic framework. SITE can easily be employed for and adapted to climatically and socio-economically very different study regions and research foci.

One of the most important aspects is that the framework greatly simplifies the coupling of different models, by defining a generic interface that allows the linkage of sub models including the implementation of feedbacks between different framework components. It was decided to include additional infrastructure to facilitate the typical land-use modelling workflow.

In particular, emphasis was laid on the integration of model calibration and model test components by developing a map comparison toolkit for categorical maps, implementing state of the art spatial statistics like Kappa, Figure of Merit and moving window approaches. Calibration is performed using optimization algorithms, e.g. a genetic algorithm, to encounter a solution for a model parameter set, based on user defined criteria.

The software design of SITE follows a modular approach to reduce software complexity and to facilitate further development of the computer program, as well as the adaptation to new research questions and/or regions. As far as possible, existing technologies and software libraries were used. For the definition of simulation rule sets and other case study specific code, the Python scripting language is employed. Calibration by means of genetic algorithms is based upon the GALib software library (Wall 1996). Input and output data are managed in MySQL databases.

Rule Set Implementation

SITE is based on an extended Cellular Automata concept i.e. employing a rule-based approach, which is simulating land-use decisions in annual time steps. Simulations are carried out in the sequence

1. Multi-criteria suitability assessment: including ecological, economic and cultural and demographic factors as well as neighbourhood effects (spatial auto-correlation)
2. Decision making: based on the suitability assessment as well as regional constraints and rules, regulations & regional preferences.
3. Land allocation: driven by demands for spatially relevant commodities
4. Calculation of vegetation & crop growth/production: based on the DAYCENT model (a process based (agro-)ecosystem model) working with daily time steps and including crop management such as fertilization, irrigation, tillage,
5. Calculations of other ecosystem services: e.g. such as pollination involving additional component-models and/or using output from 3-4 (land-use pattern, soil fertility, GHG),
6. Calculation of land-use related changes in biodiversity: based on IUCN criteria.

Note that the SITE framework may employ other models / model types to represent decision making (CA à ABM?) or biophysical processes (DAYCENT à DNDC?, empirical functions?) or add new functionality to account for other processes of interest if needed (erosion?, hydrology?).

SITE: A generic framework for integrated modelling

Case Studies

SITE-Sulawesi

The main objective of SITE-Sulawesi is to study and simulate land use in a highly dynamic tropical landscape, focussing on socio-economic and environmental effects of different strategies of resource use. SITE-Sulawesi is developed in the context of STORMA, a multidisciplinary research project, located in Central Sulawesi – Indonesia and funded by the German Research Foundation (DFG) until 2008.



SITE-Mongolia

The SITE-Mongolia model was developed to study regional land dynamics with a strong focus on the linked impacts on water resources, due to the main focus of contributing to integrated river basin management. The modelling approach supports coupling the socio-environmental system combining agriculture & forestry, demography and other economic sectors such as, industry & mining and the private sector. The study is funded by the Federal Ministry of Education and Research (BMBF) 2006-2009.



SITE-Karnataka

The SITE-Karnataka project is addressing research topics related to (i) the production of bioenergy and (ii) to land use change. The project is focussing on the state of Karnataka in South India. Part of the area includes the Western Ghats region, which has been identified as an important Biodiversity Hotspot. Primarily an agrarian economy, the area is experiencing sharp increases in pressures on environmental resources (land, soils, water) to meet rising food and energy demands. The project is funded by the German Academic Exchange Service (DAAD), 2007-2010.



SITE-Central Germany

The SITE-Central Germany (SITE-CG) project is embedded in a large multidisciplinary research programme 'Terrestrial Environment' by the Helmholtz Research Community. SITE-CG will address regional land-use drivers, constraints and options, such as urban-rural dynamics, demographic transition, adapted management & crop production, bioenergy crops, etc. SITE will embed new components designed to optimize land use with respects to the provision of ecosystem services (or other goal functions). The project is funded by the Helmholtz Association until 2013.



Links

Website: <http://www.ufz.de/index.php?en=19080>

Contacts

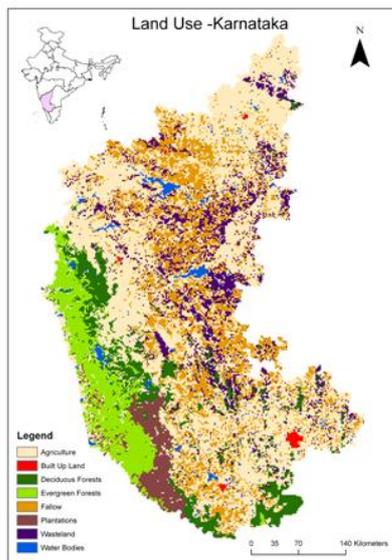
Dr. Jörg Priess
Tel.: +49-341-235-1879
Email: joerg.priess@ufz.de

SITE: A generic framework for integrated modelling

SITE-Karnataka

The **SITE-Karnataka** project is addressing research topics related to (i) the production of bioenergy and (ii) to land use change. The project is focussing on the state of Karnataka in South India. Part of the area includes the Western Ghats region, which has been

identified as an important Biodiversity Hotspot. Primarily an agrarian economy, the area is experiencing sharp increases in pressures on environmental resources (land, soils, water) to meet rising food and energy demands.



Continuous land degradation has emerged as a grave environmental issue in the area. Bioenergy from non-food crops such as oilseeds is a major focus of alternative energy programmes aimed at energy generation and amelioration of marginal and degraded areas (=wastelands). The modelling approach aims at the spatial quantification of the potential of the oilseed, *Jatropha*, on wasteland parcels and analysis of the competition for limited land for food and/ or fuel production, dynamics caused by changing population, urbanisation trends, globalisation and climate as major drivers.

The project (2007-2010) is funded by the German Academic Exchange Service (DAAD) and forms the framework for doctoral dissertation of Subhashree Das, supervised by Joerg Priess and Ralf Seppelt. Collaborations with Indian partners at various levels amplify the regional significance of the study.

Related Publications

Peer reviewed journals and book chapters:

1. Das S. and Priess J.A., 2008. Local land use change impacts and opportunities- contributory case study on India, in Gallagher Review on the indirect effects of biofuel production, UK.
2. Das S., Priess J.A., Schweitzer C., , 2009. Biofuel Options for India- Perspectives on land availability, land management and land-use change, Journal of Biobased Materials and Bioenergy, under review (11/2008)
3. Das S., Priess J.A, 2009. Shedding some light on Karnataka's blind date with *Jatropha*, submitted to Journal of Environmental Management (10/2009)

Other publications:

4. Das S., Schweitzer C., Lapola D.M., Priess J.A., Simulated Potential Yields of *Jatropha* and Oil Production in Southern India, poster presented at Climate Change: Global Risks, Challenges And Decisions, 10–12 March 2009, Copenhagen, Denmark

Links

Website: <http://www.ufz.de/index.php?en=19104>

SITE: A generic framework for integrated modelling

SITE-Sulawesi

The main objective of **SITE-Sulawesi** is to study land use in a highly dynamic tropical landscape, focussing on socio-economic and environmental effects of different strategies of resource use. SITE-Sulawesi is developed in the context of STORMA, a multidisciplinary research project, located in Central Sulawesi – Indonesia and funded by the German Research Foundation (DFG) until 2008.



The simulations incorporate many of the socio-economic and natural science aspects of the various subprojects of STORMA into a single modelling framework. Other objectives are: to provide new insights into the current landuse-biophysical system in the forest margin, and to serve as a tool for scenario analysis of strategies to enhance socio-economic and environmental stability in the forest margin area.



PI: Jörg Priess
Project Scientists: Matthias Mimler (until 2007)
Christian Schweitzer (since 2007)
Scientific Assistant: Michel Helms

Publications

Peer reviewed papers in journals and books:

- Schaldach, R.; Priess, J.A. (2008). Integrated Models of the Land System: A review of modelling approaches on the regional to global scale. Living Reviews on Landscape Research, 2008 - 1 (URL: <http://landscaperesearch.livingreviews.org/Articles/Irlr-2008-1/>)
- Erasmi S. and Priess J.A. (2007) Satellite and survey data: a multiple source approach to study regional land-cover / land-use change in Indonesia. Dickmann, F. (ed.): Geovisualisierung in der Humangeographie. Kartographische Schriften, vol. 13, Kirschbaum (accepted)
- Oltchev A., Ibrom A. , Priess J.A., Erasmi S., Leemhuis C., Twele A., Kreilein H., Gravenhorst G.: 2007. Effects of land use changes on evapotranspiration of tropical margin area in Central Sulawesi (Indonesia): modeling study with a regional SVAT model, Ecological Modelling doi:10.1016/j.ecolmodel.2007.10.022.

Conference papers and invited lectures:

- Priess J.A. (2009). El Niño and land-use change – an attempt to simulate farmers' reactions on climate variability and climate change in Indonesia. CLIMATE Change Conference, Copenhagen; IOP Conf. Ser.: Earth Environ. Sci. 6 342005. doi: 10.1088/1755-1307/6/34/342005
- Priess, J.A. (2008). Invited lecture - Integrated Modelling of Landsystems. European Science Foundation Exploratory Workshop - Europe's Green Backbone – Post-Socialist Land use Change in the Carpathian Region (EuCaRe). 9-10 October 2008, Berlin
- Priess, J.A. (2008). Invited lecture – Global and Regional Environmental Simulations. 30.6.2009, University of Greifswald, Germany.
- Priess, J.A. (2008). Invited lecture - Global Change Scenarios. IWRM workshop – May 20-21 2008 Ulaan Baatar, Mongolia.

Links

Website: <http://www.ufz.de/index.php?en=19105>