Climate change impact assessment and adaptation options in vulnerable agro-landscapes in East Africa

Resilient Agro-landscapes to Climate Change in Tanzania

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Description and results of ongoing research activities
-Climate Change Scenarios-

Initially, a thorough data survey explored the availability of meteorological data in terms of their type, quality, and spatial and temporal resolution. These data would serve as the basis for the intended validation of the planned present-day climate reconstruction. Secondly, the regional climate model CCLM was applied for the first time to perform a couple of climate simulations for the specified region (i.e. Tanzania). In order to validate and adjust CCLM for the region of interest, a prioritized list of required reference data was prepared including the necessary meteorological parameters, their spatial and temporal resolution. Already available data at PIK and from other sources have been investigated in terms of consistence and coverage. Several serious data gaps were identified. Especially daily precipitation and temperature data could only be found for a few Tanzanian stations paired with insufficient critical temporal coverage. Consequently, a request to the Tanzanian Meteorological Agency was formulated and handed to our partners in Tanzania and Kenya for passing this query to TMA. In addition, datasets from global climate model simulation were obtained for later use.
The regional climate model CCLM was implemented and tested with a configuration covering a simulation area, which completely covers the African continent. This also implied the testing of the CCLM-preprocessor tool. For the continental-scale simulations a horizontal resolution of 0.5° (about 50km) was chosen. Later high-resolution model-runs for the Tanzanian region will most likely be performed in a 0.0625° (about 7 km) resolution. After these tests, we set up a 30 year reference simulation on the compute cluster at PIK to get an estimation of CCLM's ability to simulate the African climate and to have a base dataset for subsequent sensitivity runs. Despite the fact that CCLM in this reference simulation performed better than expected there are some deficiencies in modelling East African rainfall. Therefore, we started a suite of sensitivity experiments to detect the causes of the underestimation of the long rains. Until now, we finished about 14 experiments.

-Hydrological and Agro-ecosystem modelling-

A number of state of the art hydrologic water balance models were evaluated. Important requirements are: (1) the inherent accuracy of the model; (2) robustness: degree to which model can perform in different climatic and hydrologic conditions particularly African conditions; (3) compatibility with the available input data; (4) model flexibility, ease of use; and (5) compatibility or ability to use regionally downscaled data from regional climate models; and (6) adequate consideration of different land use types and agricultural adaptation options among others. This activity is still on going, and final results will be available in January 2009.

A range of crop growth models have been reviewed and a short list proposed based on suitability and familiarity to local partners in the study region of Morogoro in Tanzania. The models under serious consideration include:

1. HERMES (Kersebaum 1995)
2. DSSAT[1] (International Benchmark Sites Network for Agrotechnology Transfer)
3. WOFOST[2] (Supit et al. 1994)

Arguments for the models under consideration include the following:

1. HERMES is a ZALF in-house model developed by one of the principal investigators of the project and its source code is available for further modification and/or development;

[1] ***D**ecision **S**upport **S**ystem for **A**grotechnology Transfer*
[2] **Wo**rld **Fo**od **St**udies

2. As mentioned earlier there is a need for generic crop growth systems especially giving the current situation on the ground in study region of Morogoro, HERMES as well as WOFOST which are based on the same basic crop growth approach aptly fulfills this role and;
3. Key potential partners on the ground in the Morogoro region have parameterized a number of systems for tropical crops; researchers at SUA have experience with crop growth models including DSSAT and APSIM[3].
4. WOFOST has fundamental crop parameter sets for 10 annual field crops in Europa and 12 crops for tropical regions, which can be used also for HERMES parameterization.

A number of criteria were developed for the selection of a suitable study site at the beginning of the project from the point of view of hydrological and agro-ecosystem modelling. Main points are the availability of data (GIS data, historical time series for meteorological and hydrological data, especially discharge in rivers) and agricultural land use systems as dominating land use type.

-Socio economics-

Socio-economic work focused so far on the development of approaches and concepts in ReACCT. A large number of "state of the art" approaches on vulnerability and sustainability were revised and screened for applicability in ReACCT. Furthermore, an inventory of participatory methods was elaborated and discussed. The concept of multifunctionality specifies Sustainable Development for a certain landscape (Wiggering et al. 2003). Social, economic and environmental effects of land use are considered interactively in this concept. The multifunctionality of any land use action can be described as the degree to which land use affects the ability of land to contribute to various functions. In this context, land use functions reflect the societal demand to land in general. Sustainable Development of land use, if understood as a discoursed based process (WCED, 1987), will be therefore assessed taking the multifunctionality concept as basis (Helming et al. 2008). In contrast to the supply driven ecosystem function approach, defining functions as "the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly" (De Groot et al. 2002), the land use functions approach focuses on human land use activities and the demand on land.

The concept links
a) Economic, environmental and social demands to land use and guaranties therefore a balanced view on three sustainability dimensions.
b) The concept provides a smaller and clearly defined spatial resolution (avoiding the discussion about landscape definitions).
c) Additionally, it identifies different functions on one hand and simultaneously considers trade-offs and side effects.

The land use function approach additionally serves as a visualisation aid of land use changes. Through the assessment of land use functions related to different land use sectors (agriculture, forest, transport, etc.) land use changes get a graspable connotation for stakeholders. Land use functions can therefore be applied for vulnerability and scenario assessments.

ReACCT has chosen the mentioned approaches, as especially for rural Africa the consideration of Sustainable Development as a negotiation process and a balanced mixture of the three sustainability dimensions taking into account ReACCT's holistic view. As data and

[3] ***A****gricultural* ***P****roduction* ***S****ystems s****IM****ulator*

indicator availability is sometimes weak, this approach, based on expert knowledge, demonstrates a feasible and adapted approach to rural Africa.

The results from computer-based simulation activities, through integration with other modeling and socio-economic work within the project, will form the basis for the development of storylines or scenarios.

-Agroforestry-

Tree suitability modelling and mapping will be based on statistical modelling of historical maps of natural vegetation and species presence-absence data obtained from gradient-oriented transect surveys in the case study region. Modelling approaches will include maximum entropy modelling and boosted regression trees, given that these models have recently been demonstrated to be more effective in habitat distribution modelling compared to more traditional approaches of constructing species suitability maps from presence-only or presence-absence occurrence records (Wisz et al. 2008). The modelled climatic preferences of preferential tree species will feed into suitability models responding to proposed climatic scenarios. Historical vegetation maps and descriptions of Tanzania (especially the Eastern Arc region) have been identified (e.g. Pócs 1976a,b) and are currently being evaluated to create a local database of occurring tree species. It is expected that many of the preferred tree species will be featured among the 201 tree and shrub species selected as useful to farming and pastoral communities of Tanzania (Mbuya 1994), hence information on management and potential use of these species will be readily available. Readiness for adoption of the recommended species, adapted to the relevant climate scenarios, will be explored among smallholder farmers by socioeconomic surveys. Results contribute to the selection of suitable indigenous tree species in the development of the good practices.

The added values of including trees into the farming systems will be investigated using the Water, Nutrient and Light Capture in Agroforestry Systems (WaNuLCAS) model, which has been developed at ICRAF and which is also to be employed within the ALUCCSA Project in Burkina Faso which can serve as an additional bridge of integrating results within the BMZ funded Climate Change Adaptation research projects. To date, literature review has been performed and the field trips facilitated the identification of sites of past and rather contemporary Agroforestry inventions in the Morogoro Region which are suitable as research sites.

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