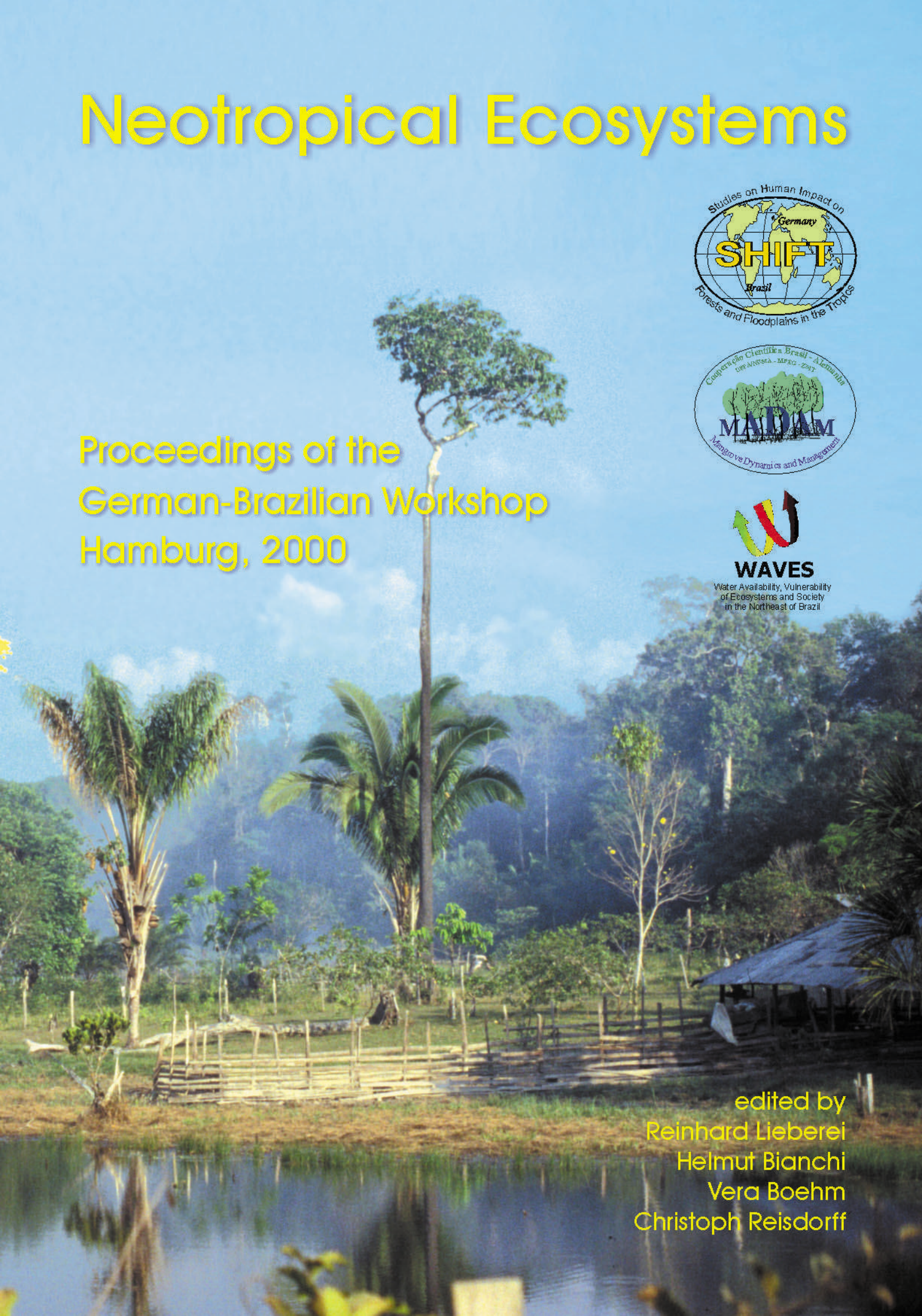
Neotropical Ecosystems



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WAVES
Water Availability, Vulnerability of Ecosystems and Society in the Northeast of Brazil

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The Semi-arid Integrated Model SIM

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The central question of the WAVES project is the analysis and modeling of the relationships between climate (change), water availability, agricultural and societal processes (specifically migration) including the aspects of global change processes in the Brazilian federal states of Ceará and Piauí.

A co-ordinated integration of knowledge in the individual disciplines of WAVES is a precondition for obtaining these goals. For this purpose, the dynamics of the system and the external forces are implemented and interconnected in the Semi-arid Integrated Model (SIM) considering all relevant processes of the mentioned disciplines.

The model SIM gives a systematic, dynamic, quantitative and spatially resolved description of the causal relationships between climate - water availability – agriculture - quality of life - migration. The context of the descriptions is the internal dynamics of the regional processes and the reaction to global change processes, e.g. climate change. The discipline-specific partial models form the basis for the development of the integrated regional model, which is structured in a modular way.

The model describes both of the federal states Ceará and Piauí, using municipalities as explicit simulation units. Subunits within municipalities (e.g. based on soils or vegetation) are not georeferenced in the model. The time horizon of the model is 50 years, allowing global change influences to reach appreciable levels. Time resolution ranges from one day to one year, depending on the process described. Potential effects of differing development strategies of social and natural systems will be evaluated by means of this simulation tool.

The results show that a regional integrated model can be a very suitable tool for complex and interdisciplinary studies.

The Response of the Smallholder Farm to the Introduction of Cattle in Eastern Amazonia: The Case of the Bragantina Region

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Farming systems in the Bragantina region are highly dynamic and changes in farm organization occur rapidly. The early slash-and-burn systems established one hundred years ago were based on annual crops in an apparently balanced cycle of cultivation and fallow. The introduction of (semi-)perennial crops and pastures, mostly as mono-cultures, has resulted in a reduction of fallow time and the exclusion of some plots from the fallow cycle. The relatively large areas used for pasture threaten the functioning of the agroecological cycle by reducing the land reserves needed for adequate fallow periods. Moreover, conventionally managed pastures show a decreasing productivity. However, experiences from other parts of the world show benefits from the integration of cultivation and animal rearing. The situation in the Bragantina region is unclear because detailed information about management strategies and economics of farms combining cultivation and animal husbandry is scarce. This study will make good this deficit, and seek to demonstrate how the agroecological system (the farm) responds to the introduction of a new component (cattle).

Three study sites with different characteristics were selected, namely: Bragança/Tracuateua with small farm size and emphasis on annual crops, Igarapé-Açu with perennial crops, and São Miguel do Guamá, where there is a high proportion of pastures plus an active extension service. Within each municipality about 15 smallholder farms keeping livestock were selected representing the prevailing

types of land use associated with pasture. Subsequent selection criteria included: farm administration by the farmer or his family, residence on the farm or nearby, reliance on family labor, farm size<100 ha. Data on all inter- and intra-flows of cash, labor, capital and products are collected every month over one year.

The analysis aims to identify the factors favoring or inhibiting the introduction of cattle, according to the forms of integration of crops and livestock and in the context of the economy of the whole farm. Integration can occur when products are exchanged or when the same production factors are used for both activities. Examples of direct positive integration include the use of the cattle by-product, manure, for pepper cultivation, which removes the need for purchased inputs. Negative examples are: cattle keeping demands continuous cash purchase of salt and drugs, and ties up capital. Also pasture restoration and crop cultivation compete for manpower at the same time of the year. The conflict is usually resolved in favor of crops, but either crops (manioc flour) or animals can be sold to pay for pasture restoration.

These interactions will be described in detail for one annual cycle and then transformed into conceptual models of flows for different farm types as the first step towards quantification.

Potential of EPIC and ALMANAC to Estimate Crop Yields Under Erratic Rainfall in NE Brazil

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Crop models consist of an equation or a set of equations, representing qualitatively the assumptions or hypotheses that have been made about the real system. They can be applied as a research tool for providing interactive responses to "what if" questions related to an improved understanding of the influence of season, location and management on growth processes of plants, for deriving recommendations concerning crop management and for investigating environmental and sustainability issues. Models can be used as a policy tool for yield and area forecasting and land use planning. Finally, they are important tools for gaining a better understanding of how ecosystems interact with a rapid changing environment as they can synthesize existing knowledge in a common framework and explore the consequences of known or hypothetical mechanism at higher levels of integration. The interdisciplinary Brazilian-German joint program WAVES focuses on analyzing and predicting the impact of human activities on water availability, vulnerability of ecosystems and society in semi-arid regions of Northeast Brazil. Among 13 crop models, the Environmental Policy Integrated Climate (EPIC) model and its follow-up version the Agricultural Land Management Alternatives with Numerical Assessment Criteria (ALMANAC) model were selected for the simulation of crop production in Northeast Brazil. The crop files of both models allow to simulate the growth and yield performance of about 80 crops, half of them can be grown in the tropics. Furthermore, both models consider Al toxicity and the availability of nitrogen and phosphorus in the soil. Apart from that, ALMANAC is able to consider up to ten plants in a single simulation run and, thus, it reflects both competition by weeds and mixed cropping. Major constraints of crop production in Northeast Brazil are erratic rainfall distribution, limited availability of plant nutrients, restricted field capacity, low pH, toxic levels of aluminum, and salinity. The daily rainfall distribution has been well simulated by the EPIC/ALMANAC weather generator from recorded monthly data. The occurrence of dry spells within the rainy season was also well predicted by the weather generator of the models. With regard to solar radiation, a good correlation between simulated and measured data was found for the rainy season only whereas solar radiation during the dry season was underestimated, leading to reduced yields in the simulation runs of both models. In 1996, the harvested area of crops represented by EPIC/ALMANAC crop files were 20% for the Litoral, 74% for the Sertão, 76% for the Meio-Norte, and 83% for the Cerrado in the states of Piauí and Ceará. Simulation runs with rice, maize, lettuce, and cowpea in various environments by using traditional and improved crop varieties showed promising results, particularly when traditional crop management was used. However, improved crop management was only well estimated on the more fertile test sites. Both models partly failed to simulate crop growth and yield performance with regard to burning, mulching, increased planting density and fertilizer applications on less favorable sites which represent about 40% of the agricultural area cultivated in Piauí. In conclusion, the structure of both models is appropriate for simulating crop production in Northeast Brazil but model calibration is urgently recommended and in progress.