

**WAVES: Water Availability, Vulnerability of Ecosystems and Society in
Northeast Brazil
- An Overview of the Interdisciplinary Project and Integrated Modelling -**

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Abstract

In WAVES (Water Availability, Vulnerability of Ecosystems and Society in the Northeast of Brazil), possible paths towards a sustainable common development of nature and society are investigated for the semiarid region of the Brazilian states Piauí and Ceará, covering an area of about 400000 km². This region is characterised by water scarcity and vulnerability of natural resources, pronounced climatic variabilities and social stress situations such as migration. The key issue of the project is the interdisciplinary analysis and integrated modelling of the relationships between water availability, quality of life and migration and the reaction to global change processes.

Keywords: global change, integration, modelling, semi-arid, water scarcity

Introduction

As a result of the economic and industrial development of the world, in particular the utilisation of fossil energy sources, an increasing concentration of greenhouse gases in the atmosphere leads to changes in the global climate. A global climatic change could affect semi-arid regions much stronger than other regions. These areas cover one third of the earth, and they have about 20% of its population. Socio-economic indicators point out living conditions much below the world's average. Arise in mean temperature, prolonged drought periods and increasing climate variability will have an impact on hydrological processes, vegetation and land use, hence on the base of human living conditions. If land use systems are not adapted, these changes may accelerate desertification and soil degradation and promote massive migration from rural areas into urban centres or more favourable areas. If potential consequences of a climatic change in semi-arid regions are to be assessed, a cross-cutting analysis of the interactions between the climate, the geosphere, the hydrological cycle, the biosphere and, last but not least, human activities must be made. Integrated studies involving hydrology, ecology, meteorology, climatology, pedology, agronomy, and social and economic sciences are required not only for improving socio-economic conditions but also to make the semi-arid regions less vulnerable to possible climatic changes.

Figure 1: A local water reservoir in a remote rural part of Northeast Brazil during the dry season



Project Objectives

It is assumed that the phenomena of global changes could severely affect the semi-arid area of Northeast Brazil. Northeast Brazil is characterised by recurrent drought periods, vulnerability of the natural resources and of the social structure, causing an exodus from the rural areas either to the more humid forests of the Amazon basin or to the urban centres in the South. Figure 1 shows an example of the rural water supply in the informal sector during the dry season: a small pond which serves as a source for drinking water (both human and husbandry), irrigation water, and finally is used as sewage pond, too. Being aware of a possible global climate change, the objectives of the WAVES project are:

- Identifying possible pathways towards a sustainable common development of nature and society in the Northeast of Brazil, taking into account future climatic changes
- Developing methods of integrated regional modelling to identify sustainable management strategies on a regional scale.

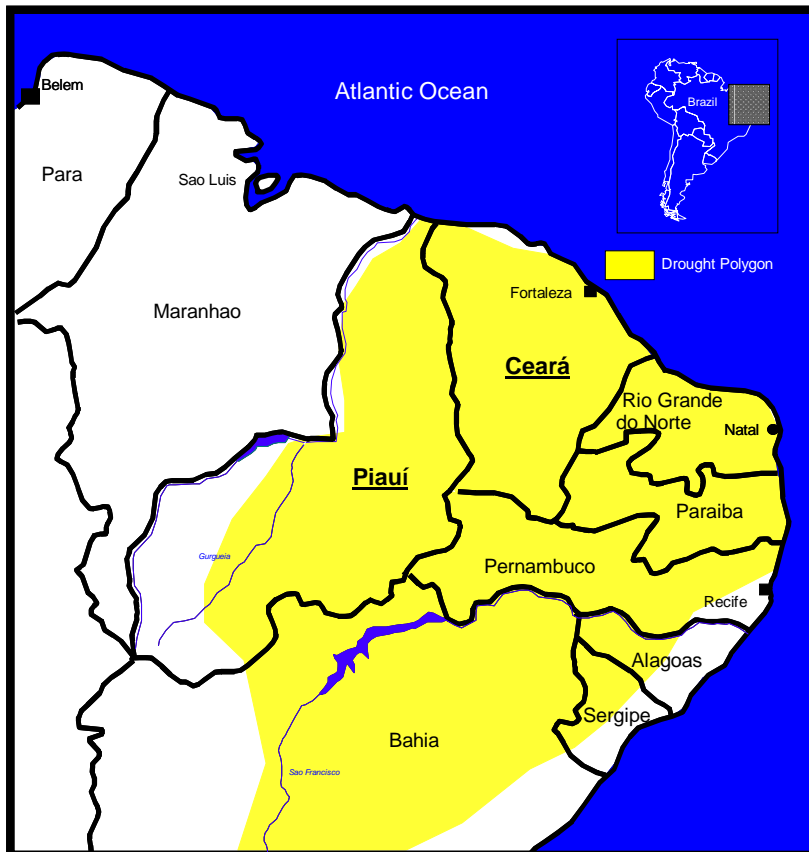
For this purpose, the fundamentals of the existing system have to be analysed in an interdisciplinary approach, strategies for a sustainable system control have to be developed and - under consideration of the interactions - the potential effects of alternative development strategies of social and natural systems have to be evaluated. This challenge can be fulfilled by combining the work of each discipline and the results produced by the individual disciplines (local results, optimisation, budget and regional models) in an overlying "integration" level. Complex interrelations overlapping the individual disciplines are handled by combining the results of each sub-area.

Study Area

In NE Brazil, three reference areas were selected along a climate gradient (mean annual rainfall between 600 and 900 mm) in the states of Ceará and Piauí. The reference areas are

located in the "Drought Polygon" of NE Brazil, see Fig 2. They differ in their ecological and socio-economic characteristics, which may lead to a good transferability of the obtained results to other regions in the Northeast of Brazil.

Figure 2: The states of Ceará and Piauí located in the "Drought Polygon of Northeast-Brazil



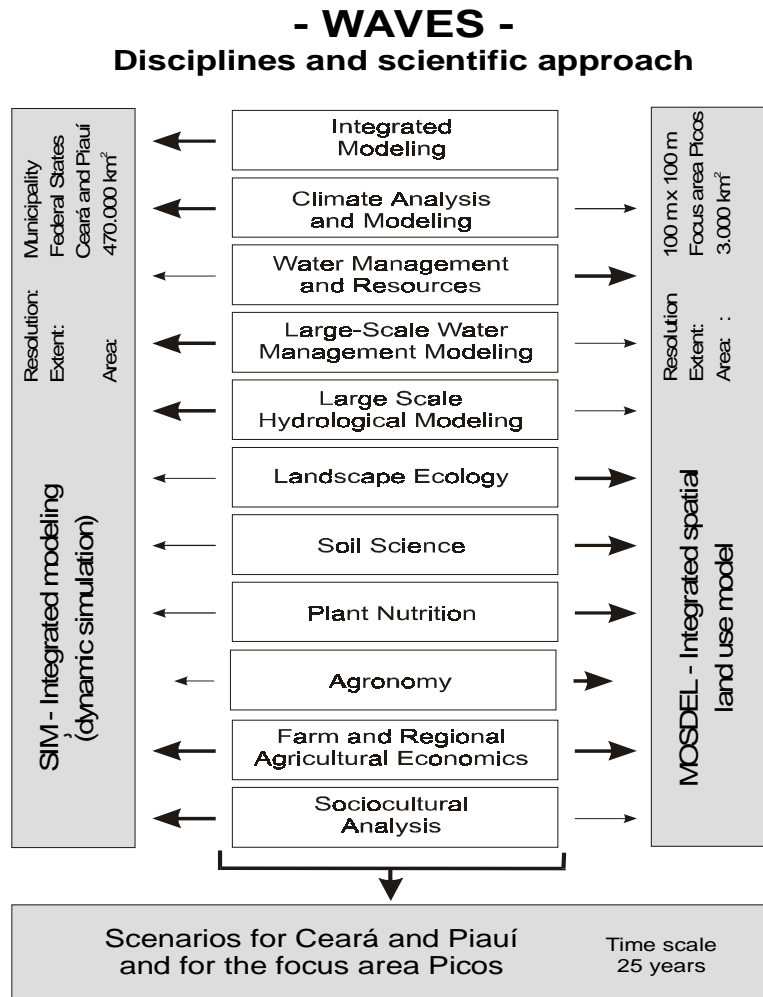
Disciplines Involved and Working Scope

Due to the complexity of the task, six working groups were established:

- Climate Analysis and Climate Modelling
- Water (Water Management Resources, Water Management Model, Large-Scale Hydrological Model)
- Agroecosystems (Soil Science, Plant Nutrition, Crop Farming, Animal Farming)
- Socio-economic and Socio-cultural Analyses (Economy, Socio-cultural Analysis)
- Landscape Ecology
- Integrated Modelling

The working groups are responsible for the analysis of a total number of eleven system components and/or for the integration of the results of the disciplines involved and work closely together, as shown in Figure 3. Figure 3 indicates also the scales involved in this study and the integration components, such as integrated modelling and the set-up of integrated scenarios for the two states.

Figure 3: Discipline involved in the WAVES-project



In every discipline, a substantial part of its work capacity is scheduled for the exchange with other disciplines. The adjustment and development of joint results between the disciplines is conducted by regularly holding national and bilateral workshops.

Within the framework of the consortium project, three working groups (Climate Analysis and Modelling, Water and Agroecosystems) investigate the area as regards its potential capacity, based on its natural resources. At the same time, the socio-cultural and economic dimension is analysed by a fourth working group. These results are put together in a supra-disciplinary picture by two other working group (Landscape Ecology and Integrated Modelling). The working group Integrated Modelling is creating an integrated regional model in co-operation with all other disciplines, covering the entire investigation area and combining the partial models of the different disciplines on a municipio level. The basis for this is a Geographical Information System (GIS) that is supervised by the working group "Landscape Ecology" and will be available for all project participants.

Meteorological data and precipitation data in particular are required by almost every discipline. The discipline Climate Analysis and Modelling requires support from other disciplines for the creation of climate models, scenarios and for the determination of boundary conditions.

The discipline Water focuses on the modelling of water supply and water management (working group Large-scale Water Budget Model and working group Water Management Model) supported by investigations on the quality and quantity of surface and groundwater at the catchment level (working group Water Management/Resources). There are important interfaces with the discipline Climate Analysis and Modelling and with the working group Soil Science (discipline Agroecosystems) which complement the large-scale modelling of water supply by groundwater budget measurements on the microscale. Furthermore this discipline depends on the supply of topographical and geomorphological information from the discipline Landscape Ecology. Regarding demand for drinking water and irrigation water, there are interactions between the water management model and the models of the discipline "Socio-economic and Socio-cultural Analyses".

The discipline Agroecosystems is concerned with the listing of site-related production potentials and the verification of the transferability of simulation models of plant production and animal farming to the ecological and technical situation in the investigation area. Its goal is to evaluate the local suitability and the sustainability of production under present and changing climate conditions. The discipline depends on a co-operation with other groups (Climate Analysis and Modelling, Landscape Ecology and Integrated Modelling). The yield models are closely connected with the economic production models and, as far as irrigation agriculture is concerned, also with the water management model and water evaluation of the discipline "Water".

The Socio-economic and Socio-cultural Analyses are methodologically treated in different ways. While indicator spaces, which enable an evaluation of social and economic living conditions and of the objective dimension of the quality of life of human beings, are identified on the meso- and macroscale, investigations at the site should serve to identify, categorise and put into the context of the mesoscale indicator family and family types, production systems, economic efficiency and the individual perception of problems. These indicators in their spatial context are a decisive interface to other disciplines and have to be further developed in interdisciplinary co-operation. The discipline "Socio-economic and Socio-cultural Analyses" will closely co-operate with the disciplines "Water" and "Agroecosystems".

"Landscape Ecology" is a spatially orientated and interdisciplinary working group with interfaces to all other working groups. The working group will divide the research area into landscape ecological system units e.g. by means of remote sensing. Furthermore the working group will draw up ecological standards. The results of the other working groups will be integrated on different spatial levels. The capability of scaling will be examined in co-operation with each discipline. The relevant spatial data will be transferred into the Geographical Information System (GIS). The GIS results and representations will be available for all project partners.

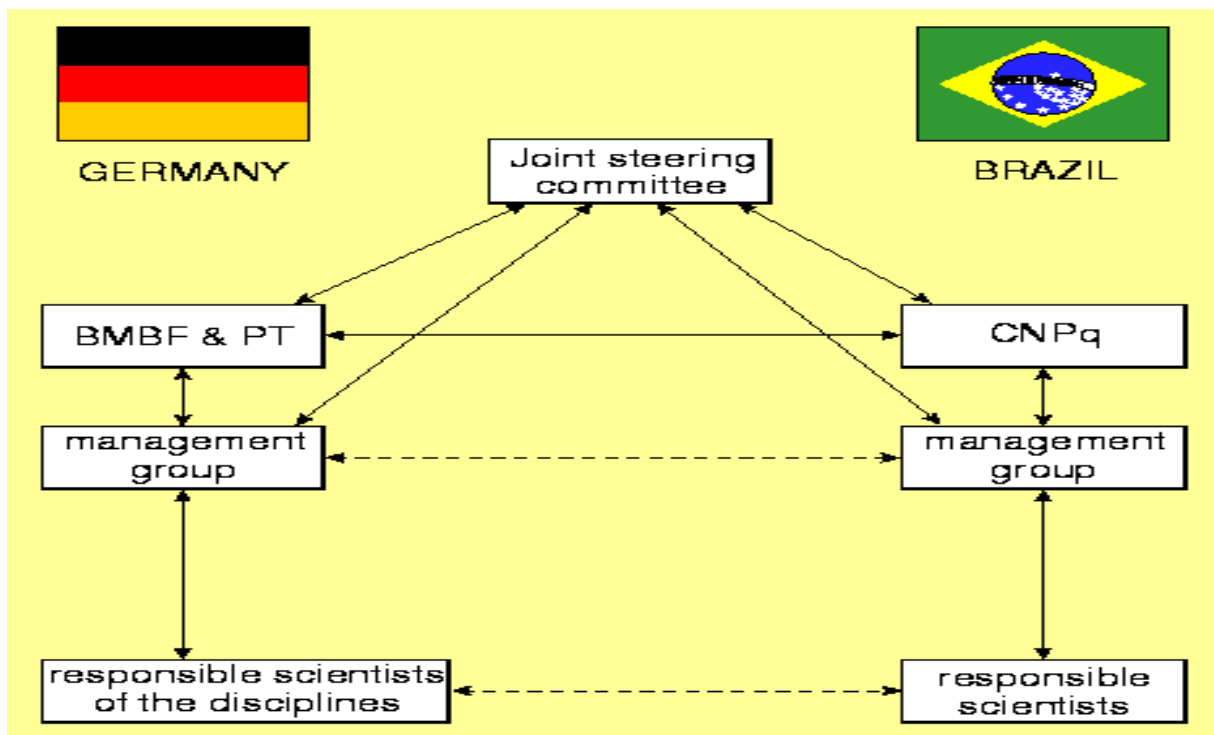
The discipline-specific partial models and the GIS form the basis for the development of the integrated regional model in the discipline "Integrated Modelling". The integrated model can be developed in iterative steps from already existing partial models or also from submodels to be newly developed by the disciplines, which are connected with each other in an appropriate open model framework. Regarding the application of the entire model or also partial models,

it is of special importance to create sectoral and/or overall scenarios in view of possible climate changes for the federal states of Piauí and Ceará, which requires expert knowledge from all disciplines.

Organisational Structure of the Project

The WAVES-project is a joint contribution of Brazil and Germany to the global change research program. The organisational structure of WAVES is outlined in Figure 4.

Figure 4: Organisational structure



A German-Brazilian Joint Steering Committee is charged with the scientific supervision of the project with respect to research objectives and methodology. It gives scientific direction and approves the project framework. The Steering Committee is formed by two governmental representatives and one independent scientist of each country.

A German and a Brazilian Management Group is to follow up and control the research activities in the two countries. It has to guide and harmonise the work with the respect to the objectives. The groups take decisions in agreement with the project framework. The management groups consist of responsible scientists of the project and cover the whole disciplinary range.

An extension of the institutes involved may be possible in future project phases. The present main partners of co-operation are listed below.

Brazil

- Universidade Federal do Ceará - Fortaleza
- Universidade Federal do Piauí - Teresina

Deutscher Tropentag 1999 in Berlin

Session: Research and Management of Ecosystems and Natural Resources incl. Forests

- Fundacao Cearense de Meteorologia e Recursos Hidricos (FUNCEME) - Fortaleza

Germany

- Technical University Munich
- University of Stuttgart-Hohenheim
- University of Kassel
- Potsdam Institute for Climate Impact Research (PIK)
- Hydroisotop Schweitenkirchen (private consulting group)
- University of Applied Sciences Cologne (UAS)

At the Brazilian side, the federal universities of Ceará and Piauí have a variety of working groups which are involved in the disciplines of hydrology and water management, agro-ecosystems, agro-economy, landscape ecology, socio-economic analysis and scientific computing/integrated modelling. The FUNCEME is incorporated in the fields of climate analysis, large scale hydrology, and landscape ecology.

At the German side, the above listed institutions are involved in the project as follows: Technical University of Munich: Landscape ecology; University of Stuttgart-Hohenheim: soil science, plant nutrition and production, agro-economy; University of Kassel: socio-economic analysis and modelling, water management; PIK: climate analysis and modelling, large scale hydrology, integrated modelling; Hydroisotop: hydrological analysis; UAS: regional agro-economy.

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