

# Relating river change, biodiversity and land-use consequences: the Taquari River, Pantanal, Brazil

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## Introduction

The Taquari is a tributary of the Paraguay River in south-western Brazil (Fig. 1). One of the problems that has developed in the last thirty years is the permanent flooding of the savannah over an area of 11.000 km<sup>2</sup> on the Taquari alluvial fan in the Pantanal. In this area, an interdisciplinary research project was carried out (within the framework of the Partners for Water research program), which focused on: (1) the analysis and modelling of the ongoing process; (2) the consequences for biodiversity and land use of the lower Taquari floodplain; (3) capacity building for the organisation of integrated river management at the basin level including relevant stakeholders.

The upper parts of the Taquari catchment represent one of the major erosive areas of the highlands around the Pantanal, consisting of sandy soils. According to the local stakeholders this erosive character has resulted in the inundations of the floodplain of the lower Taquari because of silting up of the river channel.

Erosion in the upper catchment is believed to have strongly increased as a result of clearing of the natural vegetation (Fig. 1).

## Project approach

The project approach was to carry out joint Brazilian-Dutch research on river management focusing at understanding the Taquari system. Modelling of the river system and its land cover and land use involved construction of a Digital Elevation Model (DEM) and a river discharge model. Geomorphological analysis of remote sensing data and collection of new field data (sampling for <sup>14</sup>C dating and grain-size analysis) yielded an impression of river dynamics at various time scales. The DEM was constructed by the Institute for Geo-Information Science and Earth Observation (ITC) and was used by WL | Delft Hydraulics as a basis for a river flow model for the analysis of the river changes. The water input from the Planalto was considered as a given parameter ('black box'): the Taquari at Coxim (Fig. 1) is the only input of surface water into the plains. The DEM and the hydrological model, with important ecological knowledge of EMBRAPA-Pantanal made it possible to develop scenarios on the consequences of the ongoing processes for ecotopes, land use and species.

To provide river managers and stakeholders with insight in the consequences of planning and management options for the river system, it was necessary to analyse both the socio-economic and the eco-hydrological consequences of the changes in the river system. For the analysis of these impacts, socio-economic and ecological scenarios were developed for different hydrological and climatic changes affecting the river system.

The last, and for all institutes involved most difficult, aspect of the project was the integration of socio-economic consequences with the natural processes. Use was made of interviews with stakeholders and analysis of existing economic data. It is supposed that data and knowledge present in the institutions, with farmers and civil society are sufficient to make a first start with the construction of the Decision Support System. In a special workshop the principles of decision-making and the need for a decision unit were discussed as well as the principles of multi-criteria evaluation. Three scenarios (a dry,

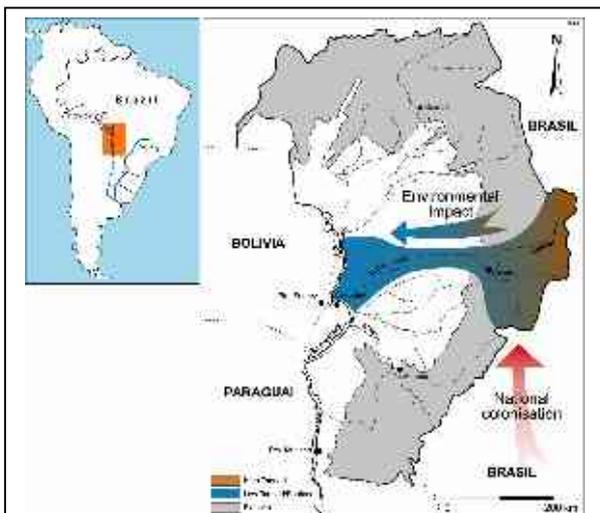


Figure 1. The Taquari River and the Pantanal basin in south-western Brazil. Forest-clearing following 'national colonisation' of the upper Taquari catchment was hypothesized to have environmental impact on the lower Taquari (increased flooding). Hydrological modelling in the present project, however, demonstrated only limited impact of land-use changes on Taquari discharge.

average, and wet scenario) were evaluated to demonstrate the principles of spatial multi-criteria evaluation.

## Results

The results of the project are various. A fundamental product is the DEM of the study area, with an altitude accuracy of 0.10 m (Fig. 2; Maathuis, 2005).

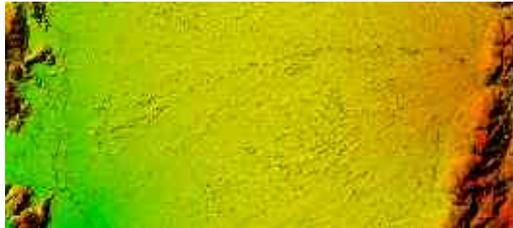


Figure 2. The final DEM of the Taquari River floodplain in the central Pantanal (Maathuis, 2005). Area shown measures ~300 km in width; north is up.

Other basic research products are the reconstructed geomorphological history, and the geomorphological map of the Taquari alluvial fan. The geomorphological analysis (Makaske, 2005) shows that the flooding problems in the area are associated with two major avulsions: the Caronal avulsion on the middle fan and the Zé da Costa avulsion on the lower fan (avulsion is defined as a diversion of river flow from an existing channel onto the floodplain, eventually resulting in a new river main channel). In addition to these two avulsions, many crevasses exist in the levees of the Taquari on the middle and lower fan (Fig. 3).

Our understanding of the hydrology of the study area has considerably increased. A groundwater map and a flooding map of the river basin were produced. Longitudinal and transverse hydraulic measurements were carried out and a discharge model was set up. It was demonstrated that increased discharge of the Taquari River, leading to avulsions and flooding, mostly results from increased precipitation and to a much lesser extent from changes in land use in the catchment (Querner et al., 2005).

As a result of research efforts in various fields, there is now an up-to-date ecotope map for the study area. Much existing ecological knowledge was organised in such a format that it could be included. These data were used for scenario development on the recognition of changes with impact analysis for biodiversity using the OSIRIS-LEDESS model and LARCH species models. Decision support scenarios were worked out in a special workshop in August 2005 and the results were presented and discussed in November 2005 with stakeholders and researchers.

Research can only have an impact on society when it presents a coherent vision on the future of the river basin and if there is a structure for decision making, and a management organisation. The objective of the project was to develop better understanding of the impact of human influences on the Pantanal basin and to be able to understand the functioning of the Upper Paraguay River Basin (UPRB) as a whole. This means that there had to be a strong link between research of ecological and land-use aspects, technology, management and policy. The project helped to identify opportunities for economically feasible use of the system, and for its management (Jongman, 2005). Three important lessons can be learned from this project.

- The erosion and sedimentation processes in the basin are so intense that technical solutions without a river basin management organisation attacking erosion and sedimentation processes are useless.
- Flood pulses are essential ecological processes in rivers for productivity and biodiversity. The comparison between disturbed and undisturbed rivers delivers important knowledge also for river management in Europe.
- Making water management work and sustainable depends on regional co-ordination and political commitment at supra-regional level. Co-operation between sectors and stakeholders appears sometimes difficult as each group is engraved into its own issues, priorities and views. This is not only true for policy makers and research groups, but also for civil society organisations.

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*Figure 3. A small crevasse in the natural levee of the Taquari River routing water from the main channel (left) to the floodplain (right). Note the remains of sandbags on the foreground, which were used by the local inhabitants to close the entrance of this small channel.*

# Assessing the relationship between river flows and human well-being; a case study in Bangladesh

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## Abstract

Environmental Flow Assessment methods, developed to assess what part of the flow regime should be maintained in a river to protect the river ecosystem, do not include the importance of this river ecosystem for human well-being. This paper discusses a conceptual model to take human well-being into account in Environmental Flow Assessments, and presents the results of applying the model in a case study in Bangladesh.

## Introduction

Water resources development may change the flow regime of a river. Changes to the flow regime affect the river ecosystem and subsequently the lives of the people depending on it. The negative effects of flow regime changes were recognised in the 1950s. Since then, methods to assess Environmental Flow Requirements are being developed.

Environmental Flow Assessments were recently recognised by many international organisations as a tool to ward off social conflict and environmental degradation due to the overexploitation of water in river basins of the world (IUCN, 2004). Environmental Flow Assessments first focussed on specific species and developed towards considering the entire natural ecosystem. People who depend on the goods and services provided by the river ecosystem did not receive much attention. How to take the needs of the people into account in assessing Environmental Flows is the subject of the research presented in this paper.

First, a conceptual model was developed which describes the links between human well-being and river flows (Fig.1). The second step was to test the model in a case study. The results of this case study, carried out in Bangladesh, are the main topic of this paper.

## Conceptual model

The conceptual model starts with the total well-being of the stakeholders, which may be partly related to water. The water-related aspects rely on certain river ecosystem goods or services which require a certain flow regime. The required internal flow regime can consist of discharge, water depth and flow velocity at

the location where the goods and services are available. The external flow regime is the flow regime at a location where this can be controlled, for example at a dam or a weir. At all levels the context should be considered to understand the importance of a certain flow requirement for people's well-being. The blocks on the right side represent the various people in different roles. A river manager should take the well-being of the stakeholders into account in a river basin plan and direct actors to maintain a certain flow regime.

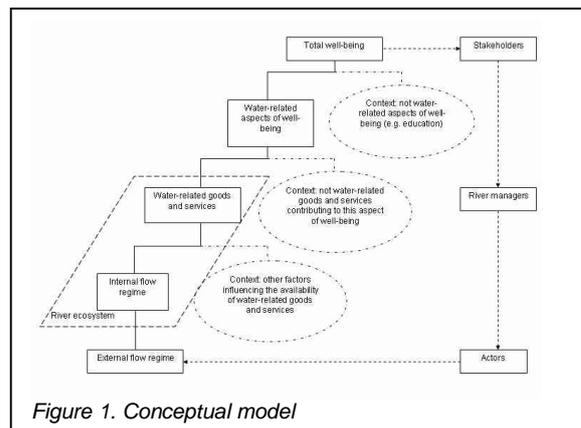


Figure 1. Conceptual model

## Case study area and methods

The case study was carried out in the Northeast of Bangladesh along the Surma river (Fig. 2). The Barak river which originates in India bifurcates at the border with Bangladesh into the Surma and the Kushiara. The area between the two rivers is low-lying and is flooded every year during the monsoon season (Fig. 3). The recession cultivation of rice and the fisheries, which are important income and food provision sectors in the area, are adapted to the rise and fall of the water level. In the selected floodplain area of 400 km<sup>2</sup> live approximately 285 000 people.

In the case study three methods were used: (1) interviews in four villages along the Surma River (Fig. 2); (2) study of reports about the Surma-Kushiara basin; (3) interpretation of 1-D simulation.