



# SUSTAINABLE LAND MANAGEMENT

## SUSTAINABLE RESERVOIR USE





View of the reservoir in the town of Petrolândia.

- The Itaparica Dam on the São Francisco River in North-east Brazil was finished in the 1980s. The embankment dam was built with the intention of improving the living conditions of the local people, but subsequently gave rise to many ecological problems. German and Brazilian scientists are now working together to reduce the negative effects of the dam through the research project INNOVATE.**

**F**orest regions are preserved in Germany as so-called green lungs to make the air of the cities cleaner for the population. In North-east Brazil, German and Brazilian research scientists are relying on a green liver for water purification. They aim to use certain aquatic plants to purify the waters of the dammed São Francisco River of toxins from antibiotic residues and nutrients such as phosphates and nitrates so that it again becomes usable for anthropogenic purposes. The method is also intended to halt the increase in algal blooms and the eutrophication of the reservoir. And with good reason: the many nutrients in the water stimulate the growth of cyanobacteria, which produce liver toxins and other noxious substances and are suspected of causing diseases such as Alzheimer's or Parkinson's disease.

The principle of the green liver was developed by Dr. Stephan Pflugmacher Lima, Professor of Ecological Impact Research and Ecotoxicology at



The reservoir close to the embankment dam – with typical Caatinga vegetation.

the Berlin Institute of Technology (TU Berlin). The method sounds simple: impure water from the reservoir is drawn off into a sunken basin in which native aquatic plants grow. The plants absorb the toxins and nutrients and incorporate them into their cell structures. »After two days, 85 percent of cyanobacterial toxins have been removed and the clean water can then be ducted back onto the fields«, says Pflugmacher Lima, who has already implemented this principle successfully in China.

**»After two days, up to 85 percent of the cyanobacterial toxins have been filtered out«**

The green liver method is currently being put to the test in the research project INNOVATE, a joint German-Brazilian project sponsored with 5.1 million Euros in funding by the German Federal Ministry of Research and Education. Funding of the Brazilian researchers is provided by the Brazilian Ministry of Science, Technology and Innovation, along with scholarships from the National Council for Scientific and Technological Development. The research scientists are working together in 22 study groups until December 2016 to draw up proposals and recommendations for the sustainable use of the large water catchment area of around 630,000 square metres of the São Francisco, focusing mainly on the Itaparica Dam in the semi-arid state of Pernambuco in North-east Brazil. The scientists' aim to develop



The dam wall of the Itaparica Reservoir with six hydro-electric turbines, each with a capacity of 250 megawatts.

detailed concepts to improve the quality of the reservoir water, reduce emissions of the greenhouse gas methane, prevent salinisation of the soil and above all enable the people living around the reservoirs to have greater involvement in regional development.

»We are seeking to develop models, solutions, action strategies and technologies which take account of climate change and which also promise a solid economic basis for the local population«, explains German project spokesman Professor Johann Köppel, Head of Environmental Assessment and Planning Research Group at TU Berlin.

### **Closing cycles, connecting material flows**

It is Köppel's view that a comprehensive solution to this complex task can only be found by taking an interdisciplinary approach. For this reason, more than 100 scientists from a total of 12 universities and research institutes in both countries are participating in the project – from areas such as water management, landscape economics, plant ecology and soil science. Köppel considers certain aspects of the project to be scientifically innovative: »We want to close the cycles in the management of the reservoir and thus connect the material flows in the water and on land in such a way that the pressures on the lake are reduced and at the same time the region's natural potential is better exploited«. This means for example that if water from the São Francisco is used for agricultural irrigation and fish farms, it should be clean and hygienically safe afterwards.



A farmer with his sheep and goat flock in Itacuruba.

The São Francisco was dammed to form the Itaparica Reservoir in 1988. The Brazilian government undertook this ambitious project, for which it relocated 40,000 people, with the intention not only of securing electricity supply to nearby towns but also of improving the living conditions of the local people and combating poverty. It has only been partly successful in this aim however. »The consequences of the dam for the local people and the landscape were not thought through properly«, says Köppel. The question of soil quality was overlooked, for example, and the enormous water losses through surface evaporation from the reservoir were underestimated. New homes with small-scale irrigation systems were built for the relocated people. But many of these dwellings were built on soils containing too much sand or too

**»The consequences of the dam for the local people and the landscape were not thought through properly.«**

little clay, or with poor drainage, and consequently the fields were unproductive or quickly became salinised. Nor has any solution yet been found to the problem of the water quality of the São Francisco River and Itaparica Reservoir, which continues to deteriorate. The reservoir managers provide the rehomed farmers with free water for irrigation, and they use it in great quantities. »If the water is piped



The food plant *Opuntia ficus-indica* (foreground) and coconut palms in the Apolônio Sales irrigation project.

back into the reservoir afterwards, it is so contaminated that really it is no longer usable for drinking water«, says Köppel. Initiatives such as Pflugmacher Lima's Green Liver should help this situation. However the ecotoxicologist's aim is not just to purify the water; he is also seeking to close the cycle by utilising the plant material. »When the absorption capacity of the aquatic plants is reached, we want to convert them into bioethanol«, explains Pflugmacher Lima. Enquiries have already been received from Brazilian companies willing to try this.

#### **Sediment on the fields**

In two further INNOVATE sub-projects, study groups led by Professor Joachim Sauerborn, agricultural ecologist at the Hohenheim University in Stuttgart, and Professor Martin Kaupenjohann, soil scientist at TU Berlin, are working on another approach. The scientists and their teams are investigating agricultural productivity in the region. For example, one doctoral student is seeking to establish whether the agricultural ecosystems along the river reduce greenhouse gases and store carbon. »In an irrigation zone, terrestrial production is of key importance«, says Kaupenjohann. The TU scientist is seeking ways to improve soil quality in the region. His German-Brazilian team is investigating the use of biochar (likewise charcoal) in field trials on local farms, based on the model of the so-called terra preta do indio, an extremely fertile anthropogenic soil in Amazonia.



Self-financed installation of improved irrigation infrastructure (drip irrigation) in Icó-Mandantes.

He explains their objective: »We want to improve the adsorption capacity of the soil so that it can store more water and nutrients in a form readily available to the plants«. The soil scientist also wishes to test whether sediment from the reservoir is suitable for use on agricultural fields, and whether such use could be economically viable. He also wants to try out new crop rotations: »In tropical ecosystems, it is often the case that

**»We want to grow perennial and annual crops on the same land in rotation.«**

permanent crops such as coconut palms and mango or banana plantations are grown in the same space as annual crops such as tomatoes and pumpkins«. The INNOVATE project now wishes to take a new direction: »We want to grow perennial and annual crops in rotation on the same land«. The intention is first to grow a long-term crop for 10 to 20 years. This makes the soil fertile, Kaupenjohann explains, as it enriches the humus content and increases carbon and nitrogen reserves; moreover, it prevents salinisation. After the harvest, the land is ploughed and annual crops are planted. »In this way we make more efficient use of the nitrogen and need less mineral fertilisers, which are very energy-intensive to produce«, he says. The German scientists are currently testing out this approach on a fifteen-year-old coconut plantation.



[Source: V. Rodorff]

Fish farming in the Itaparica Reservoir – nearly always with Tilapia (*Oreochromis niloticus*).

In another INNOVATE sub-project, a bi-national research team led on the German side by Dr. Fred Hattermann from the Potsdam Institute for Climate Impact Research (PIK) is engaged in a study of local land use. Working alongside scientists from the Brazilian Federal University of Pernambuco in Recife, the team is investigating how land use in the São Francisco catchment area could change over the next few decades under changing climatic and market conditions. The aim is to find out for example where and how renewable resources might be grown if there are changes in temperature, the amount of precipitation or the carbon dioxide content of the air, or if global demand for products such as bioethanol from sugar cane increases. To allow them to analyse these connections, the scientists are

**»The pressure on the available water resources is increasing.«**

creating a computer model of the trial region and feeding in for example regionalised scenario data from the Intergovernmental Panel on Climate Change (IPCC). They have already established that in the northern part of the project area, precipitation has decreased over the past 60 years. In the same period the temperature across the whole catchment area has risen by between 0.5 and 1 degree Celsius. This trend is likely to continue in the future. PIK scientist Hattermann describes the consequences:



[Source: M. Guscha]

Tucunaré (*Cichla* sp.) from the Itaparica Reservoir.

»The pressure on the available water resources is increasing, and the question of water availability is likely to become more and more pressing in the future«. The research group is investigating the flow of the São Francisco, the most important river in the dry North-east of Brazil, to establish how much water will be available for agricultural land in the future. »We are examining water levels, the distribution of toxins and nutrients in the reservoir and also methane production«, Hattermann explains. This research is still in its early stages. However, the INNOVATE scientists have already established that there could be major changes in water availability in the trial region in the future.

#### **Authorities changing their way of thinking**

The research carried out by the German scientists in cooperation with the Brazilian universities forms the central basis of the INNOVATE project. »However, the transfer of this knowledge into practice is also very important«, emphasises Brazilian project spokesperson Professor Maria do Carmo Sobral from the Federal University of Pernambuco in Recife. The project must not be merely an academic exercise; rather the scientists should make common cause with politicians, government representatives and interest groups in the region. »We hold joint workshops to work out scientifically based solutions for the region«, she explains. A major plus point here is the input from Germany. As Sobral says: «People from other countries contribute their own ideas and research



Small Caiman from the trial region (later released).

approaches. This intercultural exchange alters the authorities' way of thinking.« In her view, however, the project will also benefit the whole German-Brazilian scientific cooperation. »Some of the scientists will certainly continue the bi-national cooperation in further projects.«



Resettled woman in her new house in Itacuruba.



Production systems researched in the region are: agricultural systems (industrial and extensive), livestock, fish

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### ■ Funding: 5.1 million Euros (BMBF) plus Brazilian funds

### ■ Funding period: January 2012 to December 2016



»INNOVATE« is one of twelve regional projects funded by the Funding Measure »Sustainable Land Management« (Module A) provided by the Project Management Agency (PT-DLR) on behalf of the German Federal Ministry of Education and Research (BMBF).

Science Portrait 12 is published in the context of the Funding Measure »Sustainable Land Management« of the German Federal Ministry of Education and Research (BMBF).

[www.sustainable-landmanagement.net](http://www.sustainable-landmanagement.net)

Publisher:

- Scientific coordination and synthesis (GLUES)  
Helmholtz Centre for Environmental Research – UFZ  
Department of Computational Landscape Ecology  
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Translation: Green Ink ([www.greenink.co.uk](http://www.greenink.co.uk))

Author: Benjamin Haerdle, November 2013

Layout: Metronom | Agentur für Kommunikation und Design GmbH, Leipzig

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