Impacts of Complex Land Use Change Measures on the Regional Water Balance

Water and Material Retention in the Elbe River Lowland

WaStor ELBE - TIEFLAND

FORSCHUNGSVERBUND ELBE-ÖKOLOGIE

Introduction

Land use is one of the main boundary conditions which directly or indirectly influences many hydrological processes. The analysis of land use changes in a region is a rather complex task, since many different aspects must be taken into account. Which areas of the actual land use should be converted into which other type depends both on the **physical properties** of the specific location and on various **socio-economic aspects** evolving from the regional, national and European legislation (i.e. **Agenda 2000**). Arable land should be converted when it is used unprofitably and the existing natural conditions (soil, slope, climate etc.) do not fit the actual use. In general, the form of the land use change scenarios developed for a region strongly depends on

- the **specific aims** of the investigation (i.e. ecosystem or flood protection),
- the **model** used (kind and extent of physical and non-physical boundary conditions that can be taken into account, model sensitivity),
- the **spatial scale** (resolution of the available temporal and spatial data) and
- the specific **natural and socio-economic characteristics** and constraints of the study region itself.

In the present study a concept is described, which allows to assess the impacts of land use changes (as an important aspect of global change) on the regional water cycle. One basic aim of the simulation calculations is to investigate whether and how land use changes or alternative management practices may induce positive effects on the **regional water balance**.

Scenario Development

The development of land use change scenarios is performed according to the following steps:

1. Comprehensive hydrological modelling and **analysis of the current state** of the river basin
2. Analysis of the impacts of **extreme land use changes**
3. **Identification of sub-regions** which – due to various landscape characteristics – are primary candidates for a changed land use (multi-criterial analyses)
4. Development and analysis of **complex scenarios** based on several natural indicators
5. **Inclusion of socio-economic aspects** like management planning of the local government, concerns of various stakeholders and interest groups, and projections of the national and international legislation.

Based on these steps, a **catalogue** of land use change scenarios is developed and applied, which covers a considerable range of alternatives induced by the natural and economic-ecological constraints of the region.

Study Regions

In the framework of the Elbe-Ecology project special studies are performed in **vulnerable sub-regions** where more detailed data are available. Two of these sub-regions are the Stepenitz and the Stör basins which are part of the pleistocene Elbe lowland (see **Fig. 1**). Due to the changing political and economic conditions after 1989/1990, the **Stepenitz** river basin is characterized by a series of complex hydrological and ecological problems, which mainly result from the intensive agricultural practices in almost 80 % of the total basin area and a loss of natural retention areas in the past.

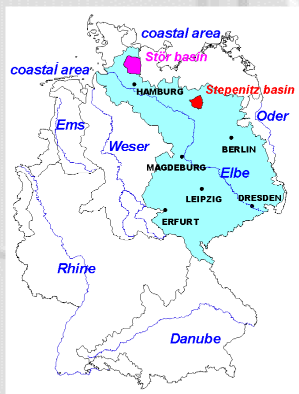

***Fig. 1**: The **Stepenitz** (575 km²) and the **Stör** (1.100 km²) basins, part of the pleistocene Elbe lowland.*

Complex landuse change scenarios

Though 'realistic' land use change scenarios must include socio-economic aspects, primary emphasis must be on scenarios based on the natural characteristics of the study region. Besides the physical parameters provided by the basic maps for hydrological modelling (land use, soil, groundwater table depth, topography), also the so called **soil number** is used in identifying areas which are preferred areas for a change of the actual land use. **Fig. 2** shows the spatial distribution of this indicator for soil quality. Though it is based on rather old investigations (1934), it represents an important indicator for the derivation of more complex and realistic scenarios and, therefore, should be used as additional selection criterion in simulating the regional hydrological cycle for a changed land use. In the following, some more complex scenarios including the indicator soil number will be described.

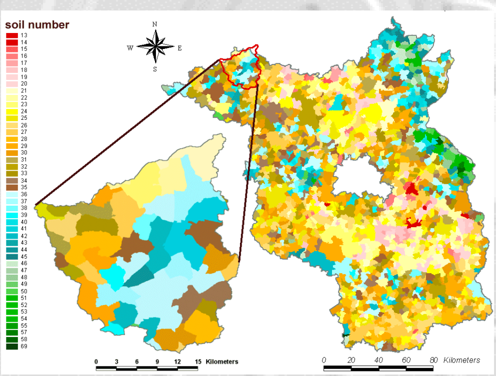

***Fig. 2**: Spatial distribution of soil numbers in the Country of Brandenburg and the Stepenitz river basin.*

Table 1 gives an overview on 4 conversion modes based on the indicators groundwater table depth (GWTD), topography (slope) and productivity (soil number SN), from which 4 scenarios were derived, including more and more affected areas. The conversion modes fit the following general principles:

conversion mode	scenario	conversion of arable land	area [km²]	percentage of arable land [%]	percentage of catchment area [%]
1	1 2 3 4	with slope >= 4% into **dry pasture**	16,8	4,4	2,9
2		with GWTD <= 0.75m into **meadow**	100,6	26,5	17,5
3		with SN <=29 and GWTD >= 4.5m into **forest**	39,7	10,5	6,9
4		with SN <= 29 and 0.75m < GWTD < 4.5m into **open land**	36,3	9,6	6,3
		sum	193,4	51,0	33,6

***Table 1**: Overview on the conversion modes and the derived scenarios for changing arable land into 4 other land use types. The scenarios are based on the indicators groundwater table depth (GWTD), topography (slope) and productivity (soil number SN).*

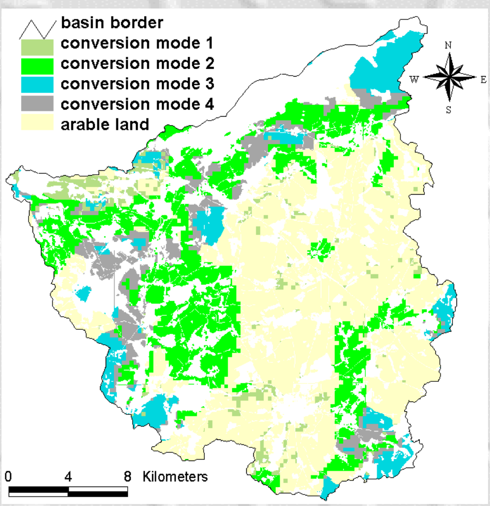

***Fig. 3**: Arable land in the Stepenitz basin which was converted into 4 alternative land use types.*

The conversion of arable land into **grassland** ('dry pasture') is favoured on areas with larger GWTD and considerable slope (erosion protection). The conversion into **meadows** is restricted to areas with low GWTD. **Forestation** is the preferred land use change mode on areas with deep GWTD and bad soils (small soil numbers). Due to the bad sandy soils, the conversion of arable land into **open/bare land** is the favoured conversion type in the Stepenitz basin, especially for heterogeneous or low productivity areas. **Fig. 3** demonstrates the spatial distribution of the affected areas.

Simulation calculations on a daily time step were performed for the reference scenario (actual land use) and the 4 scenarios for the period 1981 to 1993. The results for the mean annual sums of the **water balance components** evapotranspiration, groundwater recharge, surface runoff and basin discharge are shown in **Fig. 4**.

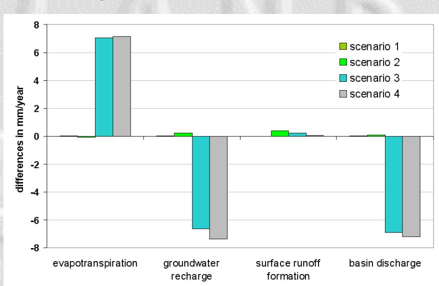

***Fig. 4**: Changes of the mean annual sums of various water balance components calculated for the period 1981-1993 in case of converting arable land into 1 to 4 alternative landuse types.*

Obviously, moderate changes of the actual land use result in only small changes of these components. The changes calculated for scenario 4 amount to +1.50%, -7.31%, 0.12% and -4.15% as compared to the actual land use. While the conversion of arable land into dry pasture, meadows or open land does not result in considerable changes of the water balance components, larger reductions of the basin discharge (increase of the basin water retention potential) are possible by **forestation** of larger areas, which dominates the scenarios 3 and 4. This, however, seems to be questionable in view of the already existing water deficit in the region.

Future Activities

- The **scenario catalogue** will be complemented by various 'simple' and more complex scenarios. For example, the impacts of land cover changes restricted to the upper or lower river course will be analysed.
- Instead of changing the land cover type, agricultural areas may be less intensively used as well. Therefore, the **extensivation** of arable land might represent an alternative in increasing the water retention potential, which must be studied in detail.
- The methodology of land use change studies developed in the Stepenitz river basin will be applied to the **Upper Stör basin** which in various respects differs from the Stepenitz basin.

Werner Lahmer and Alfred Becker; email: lahmer@pik-potsdam.de

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POTSDAM INSTITUT FÜR KLIMAFOLGENFORSCHUNG E.V. • POSTFACH 601203 • 14412 POTSDAM
Telefon (0331) 288 2500 • Fax: (0331) 288 2600 • Email: pik@pik-potsdam.de • Web: www.pik-potsdam.de

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