THESES
on the consequences on the global change for water availability and water use conflicts in the Elbe River Basin (GLOWA-ELBE)

Head of project: F. Wechsung, Potsdam Institute for Climate Impact Research

Remarks
The following theses summarize important results from GLOWA-Elbe. A separate description of basic results and development of methods complements this summary.

1. The focus of the GLOWA-Elbe project is the question of the consequences of global change for water availability and water use conflicts in the Elbe River Basin. For the Spree/Havel region, which is particularly susceptible to the effects of global change, the project aims not only at identifying problems and conflicts, but also at working out integrated strategies to resolve these on a sustainable basis. The results of the project are founded on specific simulations made by climate, hydrological, eco-hydrological, economic and vegetation models and on a frame of calculation of the trends and effects an global change. In the first phase of GLOWA-Elbe, the emphasis was on the consequences of changing water availability. In the second phase, the effects of the greater probability of extreme events (i.e. both long dry periods and floods) will additionally be investigated.

2. The starting point for the GLOWA-Elbe analyses is given by scenarios of the future development of water discharge and water quality in the Elbe river basin under global change conditions (http://www.glowa-elbe.de/status_praes/wechsung/gesamt.html). These include not only changing climate, but also scenarios on the development of population and settlement structure, the development of the energy sector, agricultural policy and land use. Two main directions are postulated for the socio-economic scenarios of global change:

   a) liberalization / globalization
   b) "ecologicalization" / regionalization.

   The development of scenarios is based on discussion with stakeholders, available studies and model calculations. It takes into account also the visions of citizens, which had to be translated into scenarios. One result of this process is a citizens' scenario of future land use in the Niederlausitz region, which assumes that the share of land currently used for agricultural production declines sharply and large areas are allowed to "return to nature", since large-scale intensive forestry is no longer profitable here (http://www.glowa-elbe.de/status_praes/ipsen/gesamt.html).

3. Germany's climate has changed considerably in the last hundred years. We are no longer facing a change in our climate, but are already experiencing the change to a warmer climate. While the temperature trend of 0.6°C so far observed for the German part of the Elbe river basin is similar to that for other parts of Germany, the development of precipitation differs considerably. In the west, precipitation has increased by 95 mm, while in the Elbe river basin the annual mean precipitation sum has remained unchanged. But the distribution of precipitation over the year has changed. Precipitation in summer has declined and precipitation in winter increased. (http://www.glowa-elbe.de /status_praes/wechs/ gesamt.html).

4. Global climate models give varying results, particularly for the development of precipitation. Continuing model experiments with regional climate models are therefore essential.

5. According to scenario calculations with the model system ECHAM4/OPYC3, the Elbe river basin will experience a rise in temperature of 1.4°C within the next 50 years if no climate protection measures are taken. The plausibility of this extrapolation is demonstrated by the fact that the same model can reproduce well the observed regional temperature development of the last 100 years. . The mean regional temperature trend (+1.4°C in 50 years) forms the basis for the climate impact analysis in GLOWA-Elbe.

6. Two methods were used to derive regional climate scenarios. The regional circulation model REMO, driven by ECHAM4/OPYC3, was used to simulate climate change for the Elbe region between 2020 and 2049. With the aid of a statistical regionalization procedure (STAR), daily climate values up to 2055 were simulated using local observation data from 1951 to 2000 and with the pre-determined average temperature rise of 1.4°C up to 2050 (see above). REMO also calculate an average rise in temperature of 1.4°C and an in-

crease in precipitation for the whole region of up to 25% (http://www.glowa-elbe.de/status_praes/mpi/gesamt.html). STAR, on the other hand, gives 100 possible realizations of a future climate that warms by the pre-determined 1.4°C by 2055 and has various different developments for precipitation.

7. Initially, only the statistical method was used as the regional climate change scenario for the impact analyses in GLOWA-Elbe. It takes uncertainty explicitly into account and contains both realizations with decreasing precipitation (mean –10% for the driest scenario realization) and with increasing precipitation (+7.7% for the wettest realization) in the Elbe region (http://www.glowa-elbe.de/status_praes/gersteng/ gesamt.html). An extension of the analysis using REMO results is planned.

8. The STAR realizations comprehend daily values for temperature, precipitation, radiation, wind speed and relative humidity. The so-called "most probable realization" is particularly important. It was chosen from the simulations for the observation period 1951 – 2000 and after comparing observed and simulated precipitation trends. This realization with a rise in temperature of 1.4°C is the "most probable" if there is no change in atmospheric circulation over central Europe.

9. According to the most probable realization, precipitation in the Elbe river basin will decline (except in the Harz mountains and Thuringian Forest). Annual precipitation sums decline by up to 200 mm, according to region. There is a further altered change in annual distribution (strong decline in summer, slight increase in winter) and an increase in sunshine length in summer. The decline in annual precipitation in the "most probable" climate scenario leads to declines in evaporation, overland and below-ground flow, and groundwater recharge. The latter declines to 60% of the current level, averaged over all locations.

10. The decline in water availability leads to a decline in yields of winter grain-crops for the Elbe region. With the "most probable" STAR scenario, yields of winter wheat and winter barley decline by 14% and 11% respectively in the period 2046-2055 compared with the period 1991-2000. In the traditionally fertile regions of Magdeburger Boerde (a fertile plain) and the Thuringian basin, yields decline still more (by 20% and more). Losses in yields from winter wheat can be set against increased yields of silage maize (+15%). These however are concentrated in the northern part of the Elbe river basin, where yield increases of between 10 and 30% are possible (http://www.glowa-elbe.de/status_praes/valen/gesamt.html).

11. Changes in potential yields caused by reduced water availability and climatic warming require that farm structures are adapted accordingly. The direction and extent of such adaptation options depend essentially on the given political framework. Initial research in GLOWA-Elbe on the consequences of a change in policy in the coming 10 – 20 years showed that a partial liberalization (dismantling of subsidies) would lead to up to 30% of the land now used for agricultural production being left uncultivated. This applies especially to less favourable sites which have a low yield potential and are currently extensively cultivated (http://www.glowa-elbe.de/status_praes/goem/gesamt.html).
12. Through nutrient surpluses (nitrogen, phosphorous), agriculture determines an essential boundary condition for the water quality of the Elbe and the nutrient discharge into the North Sea. Simulations have shown that the current situation can only be improved through reduction of nutrient surpluses. The agricultural policy measures suggested by the EU commission in the framework of the half-time analysis of Agenda2000 do not lead to a significant change in nutrient surpluses. Changes in climate, too, initially have no immediate impact on the nutrient discharge from the Elbe into the Northern Sea. However, possible changes in use of fertilizers and temperature-related increased mineralization rates have not yet been taken into consideration (http://www.glowa-elbe.de/status_praes/behrendt/ gesamt.html).

13. In the Spree region, the water use conflicts between inland fisheries, agriculture, tourism in the Spreewald and in the Lausitz lakes area, nature conservation, prevention of water pollution, and lignite mining and between the interests of the federal states of Saxony, Brandenburg and Berlin will be intensified through enormous water requirements involved in flooding former open-cast mines. With these starting conditions, the impacts of the change in climate assumed by the STAR scenario (mean of 100 realisations) cannot be counterbalanced by the region's water management system (http://www.glowa-elbe.de/ status_praes/kalt/gesamt.html). Thus in a moderately dry year the minimum inflow of 8 m^3/s to Berlin can no longer be guaranteed, and could sink to under 5 m^3/s in the next decade, while from 2030, the inflow in such a dry year could practically cease. This is linked to the increasingly frequent failure of the Lohsa II reservoir system – the largest in the Spree region. At the end of the scenario horizon, the climate change scenario is such that even in years with average weather conditions, Lohsa II is unable to provide water to top up water availability in the lower reaches – and this has consequences for the main water users. The model results show, e.g., that for the flooding of disused open-cast mines, only half the anyway small amount of water would be available. For the inland fisheries sector, the annual deficit in their water requirements in

such a moderately dry year increases from around 5% in the immediate future to 35% in the period around 2050. Under these strained conditions, the water still being pumped from pits of the expiring / declining lignite industry is significant for water availability. Changed priorities as regards water supply in the regeneration of the former mining areas lead to a shifting of water use conflicts and associated costs and benefits. Thus even in a moderately dry year more than half of flooding requirements can be secured; water inflow to Berlin then amounts to around 4 instead of practically 0 m^3/s in 2050, while the deficit for inland fisheries rises by a further 10 to 20%, and small rivers could stop flowing. Bringing in water from other river basins, particularly from the Oder, could help alleviate water use conflicts. In this respect water quality aspects are particularly important

14. Wetland regions, such as the Spreewald, are affected by the impacts of changed climatic conditions both within the actual wetland area and in upstream catchment areas (http://www.glowa-elbe.de/status_praes/ dietricht/ gesamt.html). Declining summer precipitation, increased potential evaporation and reduced inflow from the upstream basin area mean that the additional water deficit for the Spreewald will continue to rise in future. Although water levels will fall only slightly, evapotranspiration in the Spreewald - in spite of still existing connection to groundwater - will continue to increase because of the changed climatic conditions. For the period 2048-52, this means in comparison with the period 1995-2000 a mean increase in calculated evaporation from May to September of around 40 mm. This corresponds with a 13 million m³ loss from the discharge of the Spree. The consequences of sinking groundwater levels are negative impacts on yields, on wetland vegetation and on moor resources (http://www.glowa-elbe.de/ status_praes/ wessol/gesamt.html). The existence of vegetation types reliant on wet or partially wet conditions will be endangered. Thus, e.g., the extent of endangered biotopes increases from 4% to 15%. Further, increased mineralization of peat, due to the assumed climatic changes together with sinking groundwater levels, causes increased leaching of substances from the area and thus a source of water pollution.

15. The economic consequences of global change were investigated for the upper Spree and the Spreewald for water sensitive sectors of the economy (http://www.glowa-elbe.de/status_praes/messner/gesamt.html). It was shown, among other things, that the climate change projection of the STAR scenario (mean of all 100 realizations) has clear but very varied economic impacts according to sector. Thus the inland fisheries sector, which is already suffering today under a partial lack of water, would additionally lose a sum of 2-3 years' annual profits (ca. 2.5 million euros) in the years up to 2052 given the climatic changes forecast by the climate change scenario. On the other hand, while the changes calculated for the groundwater levels in the Spreewald lead to a change in grassland yields, this has only a slight impact on farm incomes, which for many farms have more to do with area-linked transfer payments than with a shortage of basic fodder. Incomes from punting trips, which bring an annual profit of up to 10 million euros to the Spreewald, are limited by the spare capacities caused by stagnating visitor numbers. Since navigability is likely to be limited only periodically and locally, no great loss of income is likely, although some points of departure for trips may be affected disadvantageously. But climate change is only one aspect of global change. Looking at various socio-economic change scenarios, each with difference emphasis on the progress of economic globalization and liberalization and on national environmental politics, it became clear that the economic impacts of changes of this sort in the coming 50 years could count much more than the climatic impacts, which are still at in their early stages in this period. Thus under significant liberalization of the inland fisheries sector and corresponding reduction of subsidies, losses of 12-16 years' annual profits for the sector are to be expected in 50 years, while on the other hand, for example, the tourism sector in the Spree region could profit from the increasing globalization of tourist traffic.

16. An economic analysis of policy options to improve water management in the Spree/Havel region shows that considering the results so far, the accelerated flooding of the open-caste mines would bring – through the change to water distribution priorities – economic advantages of 5-6 million euros, which would be achieved by savings in providing water for the flooding and additional profits from an early re-use of the pits for tourism purposes. On the other hand, the inland fisheries sector alone would mainly carry the cost of this measure through reduction in profits of around 6 million euros.

17. The scenario analyses in the underlying bed of the Spree show that rehabilitation measures in mining areas in combination with climate change lead to a considerable reduction in the inflow to Berlin (http://www.glowa-elbe.de/status_praes/opperm/gesamt.html). At the same time, water availability from regional precipitation declines. In connection with this reduced water availability, the specific water quality problem of the Berlin area could be additionally aggravated. The increase in temperature alone will, e.g., lead to an increased length of layering in the Müggelsee lake. During this, decomposition of organic materials causes a reduction of the concentration of oxygen in the lake. This leads to the release of adsorptively fixed phosphorous and thus to an increase of eutrophication in the water.

18. The regional climate change according to the STAR scenario and its combination with other components of global change exacerbate water use conflicts in the regions along the Spree and between neighbouring regions. Multi-criteria analysis was used to build on the simulation results to give a comprehensive characterization of strategic policy options for water management in the Spree/Havel region (http://www.glowa-elbe.de/status_praes/wechs/ gesamt.html, http://www.glowa- elbe.de/status_praes/opperm/ gesamt.html). In this, decision-makers and affected persons use monetary and non-monetary criteria to make an overall judgement about policy alternatives. On the basis of this overall judgement agreed by all interest groups, a conflict analysis takes place in which differences of interest and points of agreement come to light.

19. GLOWA-Elbe has to do with a region which during the August floods suddenly came to the forefront of public attention. These floods damaged large tracts of land where previously too little water had been the predominant problem (http://www.glowa-elbe.de/status_praes/marc/ gesamt.html). The August floods and the following winter floods of 2002/2003 underline that even with regionally declining precipitation, the danger of flooding remains and can again become greater in future.
In the second, planned phase of GLOWA-Elbe, it is intended to look more thoroughly at this whole problem (http://www.glowa-elbe.de/ status_praes/wechs/gesamt.html).

Head of project:

F. Wechsung
Potsdam Institute for Climate Impact Research
Telegrafenberg, A 51
D-14473 Potsdam

Tel: (+49) 0331-288-2663
Fax: (+49) 0331-288-2600
e-mail: wechsung@pik-potsdam.de
www.glowa-elbe.de