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Outlook on Water Use in Europe in 2030

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Abstract

One of the major objectives of this study was to improve our water use models by using country-specific historical data and to produce quantitative estimates of the future water use in Europe-30 up to 2030, including the impact of climate change. In order to assess the future water use situation in the Europe-30 region, a scenario and a modeling approach were combined. In this paper, we present the results of a baseline scenario reflecting a continuation of current trends over the time horizon from the base year 2000 to 2030. Depending on this scenario, the trend of total European water withdrawals is expected to decrease by 10%, and a change of the main sectoral water use in Europe is observed. At present, the most important sector in Northern Europe is the electricity production, but in the future it is assumed to be the manufacturing sector. In the new EU Member States, the most important sector is the electricity production, but this is expected to be replaced by the domestic sector. Water withdrawals in Southern Europe and in the EU Candidate States are currently dominated by agricultural water use and are expected to remain so.

1. Introduction

One of the key responsibilities of the European Environment Agency (EEA) is to assess the current and future state of the environment in Europe. This assessment is contained in a comprehensive ‘State of the Environment and Outlook’ report published every five years (EEA, 2005). Next to other environmental areas the state of Europe’s freshwater is of special interest. Besides satisfying basic needs for drinking water and sanitation, water plays a vital role in Europe’s economy. It is needed as cooling water in the electricity production in thermal power stations and is a necessary input for the manufacturing industry. In addition, much of Europe’s agricultural production growth on irrigated fields which requires extensive withdrawals of freshwater. The future of Europe’s water use will be influenced by a combination of important environmental, social, economic, political, and technological factors. What are the prospects for the next decades? To answer this question, a scenario approach and a modeling approach were combined.

2. Methodology

2.1 Overview of Scenario

In this study we evaluated the impacts of the EEA’s baseline ‘Long Range Energy Modelling’ scenario (LREM-E). The baseline assumptions follow demographic, socio-economic, and technological trends as developed for the assessment of future energy and transport options given in ‘European Energy and Transport – Trends to 2030’ report (European Commission, 2003). The demographic transition continues with a modest population growth in the EU15 and a decreasing population in the new EU countries

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whereas in the candidate countries an increase is expected to occur. Overall, a further increase of Europe-30 population of 0.14% per year is projected. The economic growth in the EU-30 region is not uniformly distributed across countries, but the gradual convergence of new and candidate countries is expected to continue over the time period. In the EU-30 region, the economy grows at a rate of 2.3% per year between 2000 and 2030 as compared to 1.5% per year in the 1990s. One of the pillars of the new economic expansion is the increased production of manufactured products. The economic expansion and population growth also affect the agricultural sector which leads to an extent of irrigated areas in some Europe-30 countries. While economic activity becomes very lively, no assumptions are made on the development and implementation of additional climate and environmental policies. As a consequence, the EU-30 region as a whole is not expected to meet its Kyoto targets to reduce its GHG emissions.

2.2 Water Use Modeling

To compute the impact of climate change and socio-economic drivers on future water resources, we use the WaterGAP model (Alcamo et al., 2003). WaterGAP consists of two main components: a global hydrology model to simulate the terrestrial water cycle and a global water use model to estimate future water withdrawals and consumption. The global water use model is composed of five sub-models to determine both water withdrawals and water consumption in the domestic, electricity production, manufacturing, irrigation, and livestock sectors. In this context, water withdrawals depict the total amount of water used in each sector while the consumptive water use indicates the part of withdrawn water that is lost by evapotranspiration or consumed by industrial products or humans.

WaterGAP: Domestic Water Use

The domestic water use model calculates the annual water withdrawals and consumption of water by households and small businesses. The basic approach of this model is to first compute the domestic water use intensity [m^3/cap-year] and then to multiply this by the population of water users. Changes in water use intensity can be expressed by structural changes and technological changes (Alcamo et al., 2003). The structural change is represented by a sigmoid curve which reflects the per capita water use changes with income (GDP/cap). The relationship between water intensity and income is derived for each country by fitting a sigmoid curve to historical data (provided by the EEA, Eurostat, and other national statistical agencies). Figure 1a gives an example of the fitted curve for Germany. Note that the water intensities show the adjusted data from which the estimated effect of technological improvements in water use efficiency have been subtracted (minimum water use of 18 m^3/cap-year).

However, the sigmoid curves could not be used for the eastern new EU Member States (the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, the Slovak Republic) and Turkey. For these countries the trend shows a rapid reduction after 1990 because of drastic changes in the water market. In the Czech Republic, for example, before 1990 water distribution was organized according to the administrative structure of the CSSR. Today, more than 70% of the Czech water market is owned by multinational companies. The extension of water privatisation in the Czech Republic is much higher than the European average and even higher than in Great Britain or France (Naumann, 2003). The large price increases reflect the effects of significant reductions in water related subsidies, considerable increases in infrastructure improvements, and reduction in domestic water use resulting in higher charges to cover the total costs of the system.

In order to estimate future domestic water use in these countries, two extreme assumptions representing a trend in future per capita water use were made (Figure 1b). The bottom flat curve in Figure 1b assumes that domestic water use will remain at the current level (year 2000) despite a possible strong economic growth, and the upper steep curve assumes that per capita water use will converge by 2030 with the average value of the other EU-30 countries.

The index of agreement (Willmott, 1984) varies from 0.47 for Romania to 0.99 for the United Kingdom and Italy. For 70% of the countries considered in this study (EU 30 region), the index is higher than 0.8, for 50% the index is higher than 0.9.

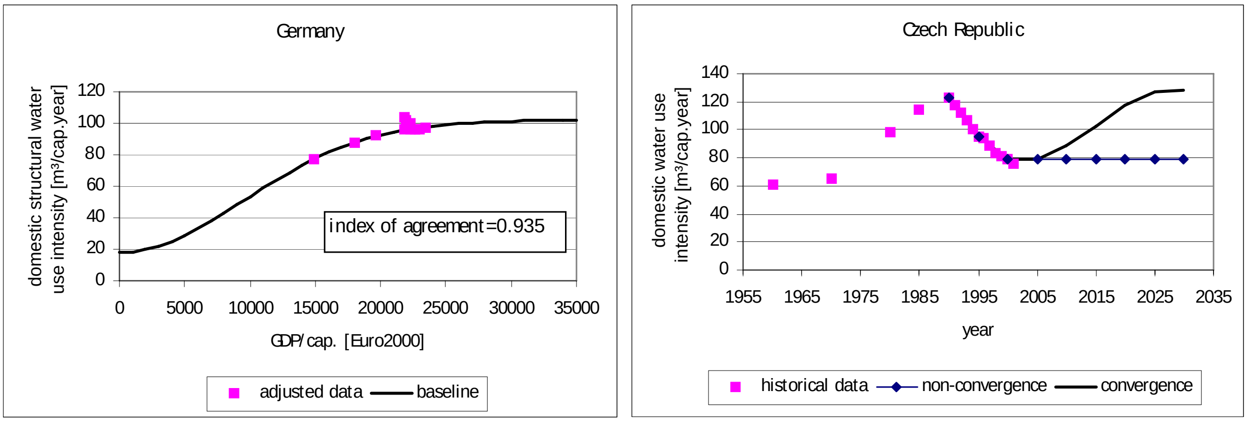

Fig.1: Structural change in water intensity in the domestic sector in Germany (Fig.1a, left) and the Czech Republic (Fig. 1b, right).

WaterGAP: Water Use for Electricity Production

The objective of this sub-model is to compute the volume of water used as cooling water in the electricity production. Since thermal power plants use freshwater for cooling, we calculate location-specific annual values for water withdrawals and consumption. The water withdrawn by each plant is computed by multiplying the annual electricity production [MWh/year], which is the main driving force, by the water use intensity of the power station [m³/MWh] (Vassolo and Döll, 2005). Technological changes that will lead to a reduction in water use are considered as a factor. To validate the estimated water withdrawals, the values computed for the year 2000 are compared to statistical data for almost all countries considered in this study (EU-30). The overall model results show a model efficiency of 0.99, indicating that the applied methodology leads to an adequate evaluation.

WaterGAP: Water Use in the Manufacturing Industry

Within this project we developed a sub-model to calculate the annual volume of water used per country by the manufacturing industry. This manufacturing water use model distinguishes between six different sectors, which account for more than 80% of the total manufacturing water withdrawal. the Gross Value Added (GVA) is the sector-specific driving force to estimate future values. As for the other sub-models, technological improvements are taken into account by a sector-specific technological change factor.

WaterGAP: Agricultural Water Use

The volume of water used in the agricultural sector is defined as the sum of irrigation and livestock water use. The irrigation water use sub-model computes net and gross irrigation water requirements which reflect an optimal supply of water to irrigated crops. Net irrigation requirements refer to the part of water that is evapotranspirated by plants, gross irrigation requirements refers to the total volume of water that is withdrawn (Döll and Siebert, 2002). In contrast to the other sub-models, the irrigation model computes monthly rather than annual results. The model calculation is based on a global map of irrigated areas with a spatial resolution of 0.5° by 0.5° (Döll and Siebert, 2000). The computation of the net irrigation requirement is a function of climate, cropping intensity, crop type, and extension of irrigated area. Then, the ratio of net to gross irrigation requirement is called irrigation water use efficiency.

The livestock water use sub-model calculates the volume of water used by animals which is in most countries very small compared to the other water use sectors. In WaterGAP, ten different varieties of livestock are distinguished (Alcamo et al., 2003) and it is assumed that the water withdrawals for livestock are equal to their consumption. Then, the water withdrawals for livestock are calculated annually on a global grid (0.5° by 0.5°) by multiplying the number of animals per grid cell by the livestock-specific water use intensity [m³/head-year].

3. Results

Figure 2 gives an overview of the volume of water used by the different sectors for the base year (2000) and as calculated by the WaterGAP sub-models for the year 2030 for the baseline scenario. Here, the water withdrawals are aggregated for the EU-30 region. From the results of the study, several conclusions can be drawn: Water withdrawals in the Europe-30 region decrease by approximately 11%, from 310.6 km³ to 274.3 km³.

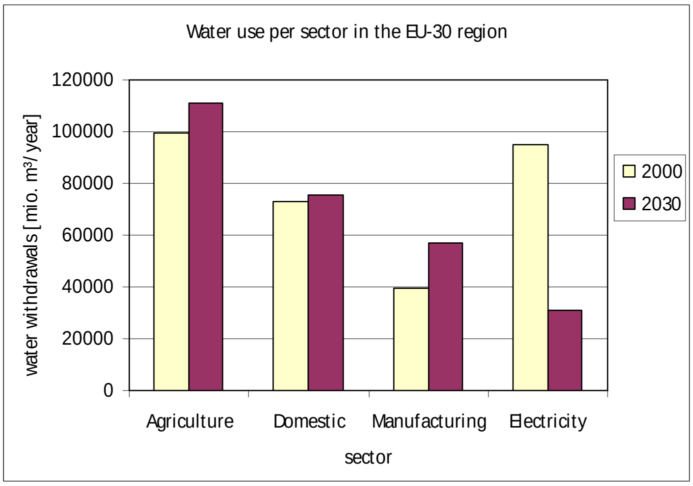

Fig. 2: Sector-specific water withdrawals in the Europe-30 region for the years 2000 and 2030.

Gross irrigation requirements increase by 8% because of both an expansion of irrigated area and a warmer and drier climate in southern parts of Europe. Water withdrawals in the domestic sector increase up to 3% by 2030, here, the decline in domestic water use in the EU-15 countries dampens the increases in this sector in the new EU Member States and Candidates Countries (see Fig. 3a, b). A strongly increase in water withdrawals is calculated for the manufacturing sector, which is mainly the result of the increasing economy. The projected annual growth in gross value added is somewhat above the annual rate of the per capita GDP. In this sector 43% more freshwater are expected to be used in 2030 compared to the base year. Water withdrawals for electricity production show the largest changes. However, water withdrawals sharply decrease as older power stations with once-through cooling are replaced by stations equipped with cooling tower which require much less water. Altogether, we expect that continuous improvements in technology make water use appliances and industrial processes more water efficient and contribute to reductions in water use.

The results show that different water sectors dominate total water withdrawals in different parts of Europe and the importance of these sectors is likely to change up to 2030. Water withdrawals in the EU-15 countries are currently dominated by water use for electricity production, but by 2030 we expect, that the agricultural and domestic sectors will be the two dominant water use sectors (Figure 3a). A combination of drier/ warmer climate and an expanding irrigated area will increase water withdrawals for agriculture in Southern Europe. In the new EU Member States, electrical production is the largest water-using sector as in the EU-15 countries, but it is expected to be replaced by water use in the domestic and manufacturing sectors (Figure 3b). A major unknown is the domestic water use in the new EU Member States. If per capita water use rises to the level of other EU countries by 2030 (2030 conv.) then water use in the domestic sector will substantially increase to become the most important water-using sector in this region. In the case of convergence, domestic water withdrawals increase from 5025 mio. m³ to 8753 mio. m³ between 2000 and 2030. But in the case of non-convergence, domestic water use decreases to 4340 mio. m³.

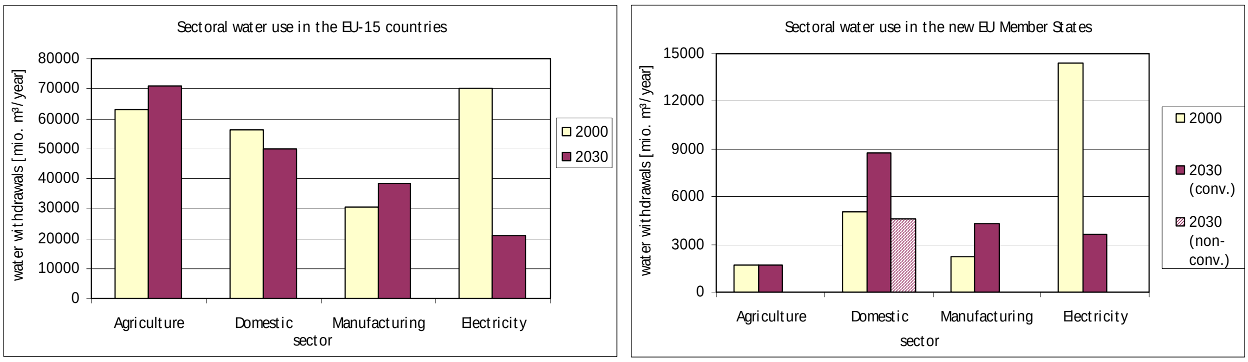

Fig. 3: Sector-specific water withdrawals in the EU-15 countries (Fig. 3a, left) and the new EU Member States (Fig. 3b, right) for the years 2000 and 2030.

4. Conclusions

Within the scope of this study we have improved our domestic water use model by including country-specific historical data on water withdrawals and GDP per capita. For 70% of the 30 countries, the index of agreement is higher than 0.8, for 50% the index is even higher than 0.9. However, this approach does not apply for the eastern new EU Member States and Turkey, due to sudden political and economical changes that lead to a rapid decrease in domestic water use. In the Czech Republic, for example, more than 70% of the water market is now owned by multinational companies and the water prices have increased eightfold since the beginning of the nineties. Following the two different approaches used in this study, the domestic water use in the new EU Member States varies between 4340 and 8753 mio. m³ in 2030 (from 5025 mio. m³ in 2000). Next to this improvement, the industrial water withdrawals were differentiated between cooling water for electricity production and manufacturing water use.

Besides model improvements, this study explored a quantitative scenario of future water use up to 2030 in 30 European countries. From the results of the study, several conclusions can be drawn: Total water withdrawals in the Europe-30 region are expected to decrease by approximately 11%, from 310.6 km³ to 274.3 km³. Since no single sector dominates water use in Europe, a multi-sector approach is needed to focus on water conservation efforts. A major unknown is the domestic water use in the new EU Member States. If per capita water use rises to the level of other EU countries by 2030, then water use in the domestic sector is expected to substantially increase to become the most important water-using sector in this region. Water use in the electricity production is expected to significantly decrease up to 2030 because of the assumption that all new power stations are assumed to be equipped with cooling tower rather than once-through cooling. Finally, a combination of drier/warmer climate and an expanding irrigated area lead to an increase in water withdrawals for agriculture in Southern Europe. Altogether, we expect that technological improvements in the different water use sectors will continue to lead to improvements in the efficiency of water use.

Bibliography

Alcamo, J., P. Döll, T. Henrichs, F. Kaspar, B. Lehner, T. Rösch, and S. Siebert (2003). Development and testing of the WaterGAP 2 global model of water use and availability. *Hydrological Sciences*. 48 (3), 317-337.

Döll, P. and S. Siebert (2000). A digital global map of irrigated areas. *ICID Journal* 49 (2), 55-66.

Döll, P. and S. Siebert (2002). Global modeling of irrigation water requirements. *Water Resources Research*, 38 (4), 8.1-8.10.

EEA (2005). European Environment Outlook, EEA Technical Report.

European Commission (2003). European Energy and Transport: Trends to 2030. European Commission, Directorate General for Energy and Transport (LREM project).

Naumann, M. (2003). Current Status of Water Sector Restructuring in the Czech Republic. Intermediaries, Working Paper.

Vassolo, S. and P. Döll (2005). Global-scale gridded estimates of thermoelectric power and manufacturing water use. *Water Resour. Res.*, 41, W04010, doi:10.1029/2004WR003360.

Willmott, C.J. (1984). Spatial Statistics and Models. In L. Gaile and C.J. Willmott (Editors), *On the Evaluation of Model Performance in Physical Geography*, Dordrecht, The Netherlands, pp. 443-460.