EuroWasser

Model-based assessment of European water resources and hydrology in the face of global change

Bernhard Lehner, Thomas Henrichs, Petra Döll, Joseph Alcamo

Center for Environmental Systems Research
University of Kassel

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Center for Environmental Systems Research,
University of Kassel, 34109 Kassel, Germany
Tel. 0561 804 3266, Fax.0561 804 3176
Internet: http://www.usf.uni-kassel.de

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Executive Summary

In this report we assess the possible impact of climate change on Europe's water resources. We also include the complicating factor of growing water withdrawals and their influence on water stress. Since there is no standard yardstick to measure these impacts, we use the concept of "critical regions", meaning regions where the extent of changes to water resources (according to different measures) is larger than in other European regions. The thinking behind this concept is that the regions facing the most rapid changes (in the direction of higher risk) may have to devise the most drastic adaptation measures. Conversely, regions with slower changes may be able to gradually, and without special effort, adapt to the changes in their water resources.

As the basic spatial unit of our analysis we take the river basin and grid cell because water withdrawals, availability, or drought and flood frequencies cannot, in our opinion, be meaningfully averaged over larger scales like countries. Within each of the approximately 550 first order river basins and 6500 grid cells making up Europe, we estimate several measures of changes in water resources because it is unclear which measure is best suited for assessing impacts on society and ecosystems. Indeed, an urgent task for the research community is to identify relevant and measurable indicators of impact. This task requires multi-disciplinary studies of the vulnerability of society to changes in water resources, and such studies must in particular include social scientists who up to now have played only a small role in water resource studies. Despite the challenge of this task, it needs to be done.

As one measure of changes in water resources we examine the change in "water stress" – here taken as an indicator of the pressure put on water resources by water withdrawals. We show that today's severe water stress regions in Europe include not only expected areas such as arid Southern Europe, but also heavily populated watersheds of North-Western and South-Eastern Europe because of their high water withdrawals. Under future changes in population, economy, and climate change we shown that Eastern Europe will be an especially critical region for water stress because of the sharp increase in water withdrawals for households and industry, but also because of climate-related decreases in water availability. As compared to other regions, the pressure on aquatic ecosystems may increase faster, and the competition between water users may be greater. The need for intensive river basin management is likely to increase.

Another measure of change is the change in the frequency of drought. The critical drought regions (defined as a decrease in the return period of the current 100-year drought to 50 years or less) include much of Southern Europe and parts of Central Europe. In these calculations the increase in water consumption in the domestic and industry sectors again play an important role, especially in South-Eastern Europe. During periodic dry spells, this water consumption will deplete river discharge to a level below a critical reference flow. Drought planning in these critical regions may need to be revised in the light of these impacts and additional adaptive measures may be needed.

Consolidating the results for water stress and drought frequencies, South-Eastern Europe might be the area with the greatest increase in pressure on its water resources in the coming decades. Here large areas fall under the critical regions definition regarding both water stress and drought frequencies, in total accounting for about a quarter of Europe's land area. This region might require the highest degree of adaptive measures to ensure adequate water supply and protection of aquatic ecosystems.

Future changes in the occurrence of low flows and droughts may also affect the output of hydroelectric power plants. To address this issue we compute both an indirect measure of this impact, namely the change in the gross hydropower potential (i.e. the potential if all runoff at all locations were to be transformed into energy) and a more realistic measure, namely the developed hydropower potential of current hydroelectric facilities. For the latter analysis we assume that most of Europe's future hydroelectricity will be generated at current hydroelectric sites because they are already good sites, and because it is difficult to develop new sites in Europe. Under these assumptions, the critical regions (defined as where the developed potential of hydroelectric facilities will drop by 25% or more)

will be similar to the critical regions for droughts of Southern and South-Eastern Europe noted above. But not all countries are equally affected because some are more reliant on hydroelectricity than others. Of the 40 European countries investigated, 14 will experience a decline of more than 25% in developed hydropower potential. Nine of these countries are in Eastern Europe and they may be particularly affected by the decrease in hydroelectric potential because they are undergoing a rapid increase in the demand for electricity.

Although we emphasize the negative impacts of climate change, it is also notable that 15% of Europe will have decreasing water stress under the long-term scenario investigated in this study. Where water stress decreases, water quality may improve (depending on the degree of wastewater treatment and many other factors), and aquatic ecosystems and biodiversity may recover. Also, according to this scenario, the current 100-year drought will occur less frequently in approximately half of Europe's land area, implying less frequent water shortages. In addition, the potential for generating hydroelectricity will increase in about the same areas, along with its evident economic benefits.

But the above benefits have an important caveat – although increasing precipitation could bring positive effects, it could also bring more intense and frequent floods. Critical flood regions (defined as a decrease in the return period of the current 100-year flood to 50 years or less) include much of Northern Europe, and smaller parts of Central and Southern Europe. These regions cover many of the same areas that may benefit from decreased occurrence of drought. Here new strategies may be needed to prevent an increase in damaging river flooding. Preliminary modeling results indicate that some parts of Southern and Central Europe may even be in a special category where both droughts and floods become more frequent, e.g. the Wisla basin in Poland. This may be due to a change in the seasonal variability of precipitation and temperature in these areas, but the results are still very preliminary.

Finally, we compare critical flood regions with critical drought regions. Here the two sides of the climate change coin become evident. Critical regions of either floods or droughts (or both) cover a total of two-thirds of Europe's land area. This result suggests that adaptation to more frequent extreme climatic events should be a major concern of European water resources management.

But what should the adaptation measures be? The long list of possibilities can be clustered into two categories: "demand side" measures that aim to reduce exposure to the impacts of climate change, and "supply side" measures in which actions are taken to directly counteract these impacts.
An example of a demand side measure is the reduction of water use through conservation or through changes in lifestyle or economic activity, which reduces the dependence of society on large volumes of water during periodic water shortages. Another demand side measure is reducing society's exposure to flooding by prohibiting development in flood plains.

An example of a supply side measure is counteracting more frequent or intense droughts by improving reservoir management or altering water distribution systems. Another supply side example is adapting to more frequent floods by creating natural inundation areas or by building dikes. These are just a few of the many adaptive measures available to European water managers in the face of increasing impacts of climate change.

The selection of these measures will depend on the type of new risks, the current adaptive measures being taken, the costs of new measures, the availability of land, and many other factors. Since these and other factors are mainly specific to the country and river basin, it is appropriate to evaluate these measures on these scales.

Yet although action should be taken on the national and river basin level, some intervention is also justified on the European Union level because of the large total European area that may experience either more frequent droughts or floods. It is also consistent with the findings of this study that droughts or floods could occur more often in different parts of Europe within a relatively short time of each other – Among other impacts, this could lead to the overtaxing of European emergency relief services. It is also conceivable that the financial burdens of dealing with two catastrophes within a short time span could lead to cascading financial problems between the tightly-knit economies of Europe. In any event, we recommend that the European Union review the adequacy of its planning for coping with water-related catastrophes in the face of climate change.

In conclusion, this study shows that climate change will have mixed positive and negative effects on water resources in different parts of Europe, but that we should be especially alert to where it may cause new risks and require new adaptive strategies.

Table of Contents