Transboundary Water Management Under Global Change

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1. Defining the scope:

First, the terminology "transboundary water management" and "global change" needs some clarification. Under this term we understand management across borders that might be constituted by catchment boundaries, administrative boundaries or by national borders. **Water management** is the activity of planning, developing, distributing and managing the use of water resources according to principles and rules. In general, it includes all the human activities intervening into the natural water cycle. In our case, **global change** refers to impacts of direct human activities on water resources, such as excessive abstraction of groundwater, as well as impacts of climate change. Further, growth patterns in population and the pressure on water resources should be also considered.

2. Historical approach to manage transnational water issues

Historically, transboundary water issues were often managed in a bilateral manner. Ministerial commissions from neighbouring countries met regularly to discuss hydraulic construction works and water management plans that might have impacts on the neighbouring country. International water related agreements/treaties resulted often from political dominance and hegemony. A few examples from the Nile, the Rhine and the Danube underline this fact.

Nile:

Some agreements about water allocation in the Nile basin date back to 1891 and were subsequently updated. In colonial times, these agreements had the aim to ensure sufficient water for Sudan and Egypt that were under British control. The allocation should support irrigation and mainly cotton production. The interests of countries like Ethiopia were widely disregarded. Until today, any upstream projects, like dam construction or large-scale irrigation, requires Egypt's consent (Kameri-Mbote, 2007). With the construction of the Great Renaissance dam (2011-2020) in Ethiopia, located at the Blue Nile just upstream of the border to Sudan, new tensions among these countries emerged. Reservoir filling started in 2020 without the consent of Egypt and Sudan and will last for several years. Since 1999 the Nile Basin Initiative (NBI, 2022) tries to establish a basin wide consensus on joint water use.

Rhine:

According to the treaty of Versailles in 1919, France received the exclusive right to divert Rhine water for hydropower utilization along the common river section. 50% of generated energy should be remitted to Germany. In 1950, the International Commission for the Protection of the Rhine (IKSR) was established to harmonize monitoring strategy among the riparian countries and to improve the water quality data with the objective to reduce pollution load. Later, drinking water utilization, ecosystem preservation, sound flood and sediment management strategies were additionally integrated as objectives. The IKSR became a prototype for other European river basins, such as for the Elbe, the Maas, Schelde and later the Danube river basin.

Danube:

After the Crimean War (1953-1856), in a period of growing industrial production and international trade, the western powers Italy, Prussia, England, France and the Austro-Hungarian Empire tried to stimulate the navigation along the Danube and in 1856 several commissions of the Danube River were established. After the First World War and several re-organisational steps, the International Danube Commission was

established with the main goal to promote navigation and trade along the Danube. In 1948, after the Second World War, the Danube Commission was re-established in Belgrade and later on the headquarter was moved to Budapest, where it is located until today. Its main goal is to develop and implement technical standards along the Danube to support international navigation.

3. The recent state of transboundary water management at the global scale

About 263 international river basins cover, almost 50 % of the Earth's surface (UNECE/UNESCO, 2015) and 145 States have territory in these basins. About 40% of the world's population is living in transboundary basins. There are approximately 300 transboundary aquifers, helping to serve the 2 billion people who depend on groundwater. Lubner (2015) identified 1 600 transboundary lakes worldwide. The most international river basin is the Danube River including parts of the territory of Germany, Austria, Czech Republic, Slovakia, Hungary, Slovenia, Croatia, Bosnia-Herzegovina, Serbia, Montenegro, Bulgaria, Romania, Ukraine, Moldova, and small parts from Italy, Poland, Montenegro, and Albania.
Between 1990 and 2013, 53 international water conflicts occurred with the primary focuses of water quantity and border issues (Lubner, 2015). 28 of the 53 conflicts that occurred after a treaty was implemented were not related to the content of that treaty. The majority of the international lake treaties lack vital components for successful compliance including enforcement, conflict resolution, and monitoring. An analysis of water conflicts and resolution tools is given in Wolf (2002). International water treaties include all formal documents such as treaties, agreements, conventions and protocols among countries addressing issues related to quantity and quality of water, and various water uses (Oregon State University, 2022; FAO, 2022; Water Encyclopedia, 2022). Beyond these direct consumptive water uses, some agreements refer also to navigation, ecosystem preservation, and fishing permits (Lubner, 2015). For the period from 806-1984 the FAO has identified more than 3 600 agreements addressing international water resources issues.
The Transboundary freshwater dispute data base (Oregon State University, 2022) was initiated by Wolf in 1998 and it contains 450 international treaties. The FAO Water Treaties Database (FAO, 2022) includes all treaties related to water and its uses.

4. The recent state of transboundary water management in Europe

In the Europe, transboundary water management is either based on the conventions of river basin commissions (Rhine, Schelde, Elbe, Danube, Tisza and others) and/or on EU wide directives. In European Union the EU Framework Directive on Water and the Flood Risk Directive are most relevant. Of course, the various basin conventions have to follow the EU directives, even when a commission has been already established before the directives became effective.
The **EU-FDW** (Directive 2000/60/EC), which came into force in December 2000, represents a new framework governing the water policies of the member states of European Union. The goals defined in the directive are aiming at sustainable management and protection of freshwater resources including inland surface waters, transitional waters, coastal waters and groundwater. The ultimate goal is to achieve good ecological and chemical status of all water bodies. Priority hazardous substances should be eliminated and concentration levels in the marine environment should be reached that are near to background values for naturally occurring substances. The control of water quantity is an ancillary element in securing good water quality and therefore measures on quantity are considered. The WFD is not usage-oriented but has an ecological focus based on the assessment of the aquatic ecosystems with the objective of restoring or preserving the habitat for water type-specific biotic communities (ecological focus).
In transboundary basins, programs for measures should be coordinated among riparian states, also in the case of non-member States (catchment-related approach). The achievement of a good status of water bodies will provide economic benefits by contributing towards the protection of fish populations, including

coastal fish populations. However, it can be also concluded that numerous benefits due to ecosystem services can be expected (ecosystem services).

The execution of the EU-WFD is based on jointly agreed principles and standards and started with the characterization and assessment of the state of river basins; it defined a set of actions to improve environmental state and it led to the development of river basin management plans. The progress, improvement of the state, had to be monitored and documented. These results were assessed and the whole cycle is repeated every six years. The main features are: basin wide approach, public participation at all levels, transparency in planning and implementation, evidence based planning with regular updating. Obviously, this directive contains several features of an integrated water management approach.

The **Flood risk directive** (Directive 2007/60/EC) has the main target to reduce existing flood risk and to avoid the emergence of new flood risks. The directive focuses on the reduction of adverse impacts from flooding on human health, the environment, cultural heritage and economic activity.

In a first step, a preliminary flood risk assessment, based on the RBMP elaborated for the framework directive and on documents of past flood events available at the national level, had to be executed providing preliminary flood hazard maps and flood risk maps. Flood hazard maps have to cover the geographical areas that could be flooded according to the following scenarios:

(a) floods with a low probability, or extreme event scenarios;

(b) floods with a medium probability (likely return period ≥ 100 years);

(c) floods with a high probability, where appropriate.

For each scenario the flood extent, the inundation depth and, if required, the flow velocity have to displayed.

Flood risk maps show the potential adverse consequences associated with flood scenarios characterized by the indicative number of inhabitants potentially affected any by the type of economic activity of the area potentially affected. Based on these maps, the riparian states established flood risk management plans coordinated at the level of the river basin. Flood risk management plans focus on prevention, protection and preparedness. Flood risk management plans shall address all aspects of flood risk management focusing on prevention, protection, preparedness, including flood forecasts and early warning systems and taking into account the characteristics of the particular river basin or sub-basin. Flood risk management plans may also include the promotion of sustainable land use practices, improvement of water retention as well as the controlled flooding of certain areas in the case of a flood event.

In several sections of the EU-FRD, non-structural measures are emphasized, such as giving more space to rivers, the maintenance and/or restoration of floodplains, as well as measures to prevent and reduce damages. The elements of flood risk management plans are periodically reviewed and if necessary updated, taking into account the potential impacts of climate change on the occurrence of floods. This strategy clearly recognizes the dynamic features of flood risk that is due to changes in the flood frequency, may it be due to human interventions in the water cycle or climate induced changes, and changes in the damage potential, which can be due to modified land use and/or to the increase of property values.

Summarizing, the EU-FRD has a basin wide perspective, demands for public participation at all levels, and is updated every six years.

The **Danube River Protection Convention** (The Convention on Cooperation for the Protection and Sustainable Use of the River Danube, 1994) was signed in 1994 in Sofia but legally ratified later. It became effective in 1998 and it constitutes the basis for a basin wide collaboration that is steered by ICPDR, based in Vienna. The main objectives are included in Article 2 (1): *The Contracting Parties shall strive at achieving the goals of a sustainable and equitable water management, including the conservation, improvement and the rational use of surface waters and ground water in the catchment area as far as possible. Moreover, the Contracting Parties shall make all efforts to control the hazards originating from accidents involving substances hazardous to water, floods and ice hazards of the Danube River. Moreover, they shall endeavor to contribute to reducing the pollution loads of the Black Sea from sources in the catchment area.*

Considering these objectives, at an early stage the state of environment in the Danube basin had to be documented (Maltby et al., 1994) and then the main hot spots (polluters) had to be identified and assessed, see the first Strategic action plan (PCU, 1995). An overview of goals, principles and strategies of cooperation during the early phase is given in Nachtnebel (2000).
Similar to the Danube convention, the **Convention on the Protection of the Rhine (1999)** was signed 1999 by the representatives of the riparian states replacing several previous agreements related to water quality and water protection. Despite the fact that the river is intensively used for navigation, the main objective refers to preservation, improvement and sustainable development of the Rhine ecosystem.

5. Critical review of transboundary water management in Europe

Water flow in surface and groundwater systems, is always associated with transport organic matter and pollutants. In surface waters the sediment transport has to be added.Thus, any water management strategy has impacts on the transported material and solutes and additionally on the water dependent ecosystem. Vice versa, any change of land use in a catchment has impacts on released substances. In Europe, land use changes are driven by economic growth associated with higher income and internal migration. In other regions population growth is an important driver.

Integrated management
The EU-FDW has the emphasis on the linkage among land and water uses and preservation and rehabilitation of the ecosystems. The EU-FRD combines socio-economic development with water related risk. In both directives non-technical measures are included which support ecosystem services to mitigate impacts on the society.

Adaptive Approach
Both directives envisage an adaptive approach, which is based on jointly developed (EU member states) long-term objectives. The achievements have to be documented and reported regularly (every six years) and based on gained experiences the measures can be adapted. This approach considers economic development, societal changes as well as possible impacts from climate change. Perhaps it may be criticized that a prospective approach is missing. It means that forecasts about socio-economic processes, such as population growth and migration towards densely populated areas, could be integrated into land development plans considering water related risks.

Institutional aspects
The consequences of the directives with respect to institutional development are also worth to be considered. The EU-WFD requires water management institutions, which emphasize the catchment scale, also for transboundary basins. The EU-FRD demands for a close cooperation among different administrative units. Implementing both directives requires collaboration at the river basin level between many parties, such as upstream and downstream water managers, land-use planning authorities, organizations involved in crisis management, different sections of the public and different types of experts. This raises a number of issues that social science research can help to address (Mostert & Junier, 2009).
It should be also considered that the water sector is still segmented into different domains of intervention. For instance, in the Danube basin, there is the International Commission for the Protection of the Danube River Basin (ICPDR), which is responsible for environmental protection, and then there is the Danube Commission, exclusively responsible for navigational issues. It should be noted that the international agreed standards about navigation depth and width have shaped the river course as well its bed over the last 100 years leading to substantial losses of morphological variability and dynamics.

Climate change impacts

Impacts of climate change are included in ICPDR activities but a coherent picture about future water related changes for the whole basin is still missing. Several national and regional studies are available (Stolz, et al., 2018; Bisselink et al., 2018) as well as an updated version of an adaptation strategy (ICPDR, 2018).
The International Commission for the Hydrology of the Rhine Basin (KHR/CHR) started in 2012 a project about possible impacts of climate change on the hydrology of the Rhine River. The emphasis was on snow and glacier contribution to runoff under climate change. First results were published in 2017 (Stahl et al., 2017) and a detailed version is expected in the beginning of 2022.

Deficits in directives

Besides water, sediments are an essential and integral part of river basin management plans but this topic is not explicitly addressed, neither in the EU-FWD nor in the EU-FRD. It became evident after the last major flood events that economic losses are strongly dependent on the concentration level of sediments. This is not only the case in Alpine torrential flows usually carrying huge amount of course material but it hold also for large river which may deposit thick layers of sediments in the inundated areas. This fact is reflected in SedNet's recommendations (SedNet, 2007, 2009) to integrate sustainable sediment management into the EU-WFD policy.
In the EU-FRD, three different scenarios have to be analyzed. Only one is precisely defined which refers to a flood with a hundred years return period. The other two scenarios are imprecisely characterized as they describe a frequent and a very rare event (extreme event scenario). This may result in further discussion among riparian states using different return periods in their scenario analysis. However, this fact has been already observed in some countries where internally different criteria are used for risk analysis along torrents and rivers.
The EU-FRD specifically demands for designation of the areas endangered by a very rare flood event together with the expected potential damage. This means that a worst-case scenario is considered in flood risk management plans. Thus, it is difficult to communicate these uncertainties to a broader public as expert judgement may contradict to individual risk perception.

6. Critical review of transboundary water management at the global scale

The global economic development resulted in increased pressure on water resources demanding for an intensive transboundary management strategy.
A few examples are discussed describing river basins outside Europe. In the last decades, we observed the shrinking of large lakes, like Lake Chad in Central Africa, or Aral Sea in Central Asia, both located in endorheic transboundary basins. Similar trends were reported from Lake Urmia (Iran) and the Dead Sea in Near East. Of course, climate change has an impact but the most relevant driver is related to overexploitation of water resources in all these cases. In the Aral Sea basin and in the Lake Chad region a quickly growing population is observed. In the case of Lake Aral, the lack of a basin wide responsible commission aggravates the pressure on water and environment. Since 1989, the water management in the basin was under central power, mainly supporting large-scale irrigation. With the collapse of Soviet Union, the institutional collaboration faded out. Several international initiatives were launched to improve transboundary water management. As an example, the Aral Sea Vision has been elaborated (UNESCO, 2000) but no success could be achieved in establishing a basin wide institution. While upstream countries are rich in water but suffer from other energy sources, the downstream countries consume most of the water resources and are rich in oil and gas. The various national development plans are not harmonized and will not be able to restore the former lake Aral. Simulations of different development paths indicate (Nachtnebel, 2009) that in the optimistic case some smaller water bodies, the Western part and some ponds in the Pre-Aralie region could be maintained. In the Northern part a smaller water body of the former lake Aral could be already re-established.

In addition, in the Nile basin increasing pressure on the common water resources, originating from growing population, is observed and the implementation of the Great Renaissance dam has increased tensions among Ethiopia and the downstream countries, Sudan and Egypt. The Nile basin initiative (NBI, 2022) is an intergovernmental partnership of 10 Nile Basin countries, namely Burundi, DR Congo, Egypt, Ethiopia, Kenya, Rwanda, South Sudan and tries to support riparian co-operation but no basin wide agreement has been yet achieved.

7. Summary and conclusions

Pressure on water resources is increasing due to socio-economic development, population growth and climate change. The direct human interventions into the water cycle have shown the most severe impacts on both, quantity and quality of water resources. The need for integrated water management is obvious.
In European Union several directives, the Framework Directive on Water and the Flood Risk Directive, provide an essential basis for integrated and transboundary water management. Further, in some major river basins, like in the Rhine and the Danube, commission were established to implement environmentally sound strategies with the tasks to protect water and environment, thus serving human needs for save drinking water, to reduce environmental risks such as floods, and to support water based recreation.
Based on these experiences from the last twenty years, it can be concluded that this legal and institutional framework worked successful and could serve as a prototype for other regions.
Still, it should be mentioned, that some water related aspects, such as sediment transport, and regional development planning, should also be harmonized with water management strategies.

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