CHR seminar Bregenz, Austria

Results after the international workshop March 2014

In November 2012 a project plan was drafted in order to investigate the influence of socio-economic influences on the low-flow regime of the Rhine. More specifically, the project aims to identify the current user functions within the catchment area of the Rhine and to analyse the possible influence of climate change scenarios and socio-economic developments on these user functions and consequences of the possible changes on the low-flow discharge of the Rhine. To collect existing knowledge on socio-economic factors and possible future socio-economic developments present within the different riparian countries, a first step was to organise a workshop in Bregenz, Austria in March 2014. During the workshop projects and research institutes from different riparian countries and sectors provided overviews of the latest insights and data available. In Annex A, the workshop programme, including a list of presenters and title of their presentation is provided. The presentations can be downloaded from the CHR website[1].

Observations and conclusions from the workshop

During the workshop several presentations were given on current water consumption and expected future developments in water use as a consequence of both climate change and socio-economic developments. Representatives of different organisations from Austria, Switzerland, Germany, France and the Netherlands demonstrated their latest insights and (selected) methods used on dealing with climate exposure and (socio-)economic challenges in the short and medium term.

The presentations demonstrated that all countries are dealing with questions concerning water consumption and socio-economic developments, particularly in the light of climate change. However, the type of data available and methods used amongst countries and sectors differ. Differences can be found in levels of scales, detail level of data, and focus. Generally speaking, Switzerland and the Netherlands have developed socio-economic scenarios for 50-100 years at a national level, with a few examples in which they are 'translated' to a local or regional level (city, region). In Germany scenarios are developed at a regional or federal level. Obviously, the German states are comparable in size with Switzerland or The Netherlands, but at this point it is unclear which scale is most useful for the analysis on catchment changes. Next to differences in approach, the way of presenting knowledge was different; either findings from model results were provided (Switzerland, The Netherlands) or the methods (Germany). All countries seem to have abundant hydrological and social data, for example on water consumption, GDP and discharge regimes, but the comparability and availability for current and future developments needs to be further investigated.

Besides national activities and interests, several sectors operate at a basin or international level or have cross-national influence. Particularly shipping – both for professional and recreational is a good example thereof, but also the use of (hydropower)reservoirs as an instrument for discharge management is an example of cross national influence. An overall schematic representation of the Rhine's socio-economic and hydrological system and relevant questions was made by Astrid Björnsen Gurung and depicted in Figure 1. It shows how the different sectors are dependent on the Rhine and influence changes in water

[1] www.chr-khr.org, About Us, Calendar, Spring Seminar - Socio-economic influences on the discharge of the River Rhine

availability of the Rhine, both now and in the future, and how scenarios could help understanding the functioning of these interactions.

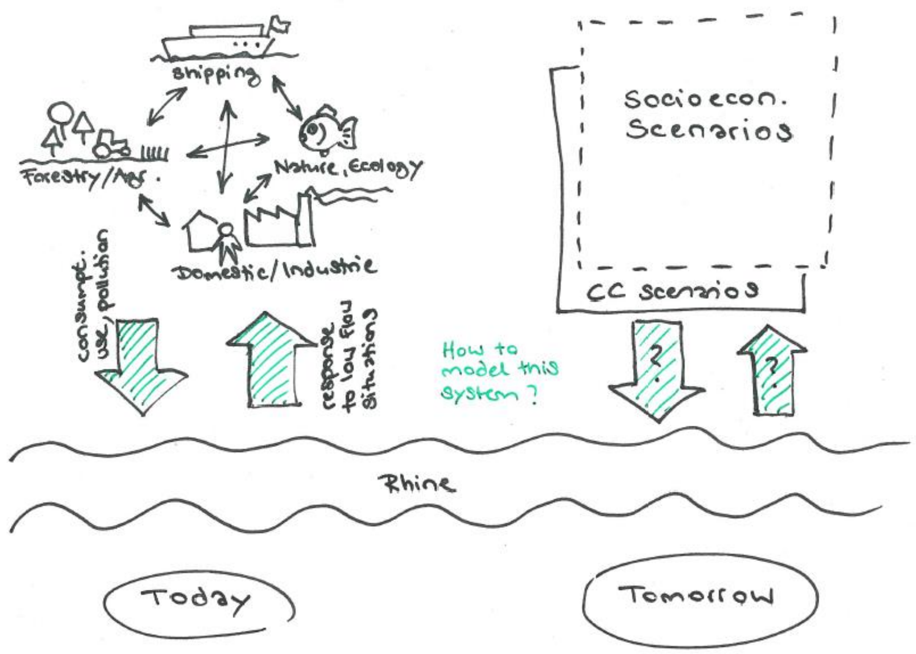

Figure 1: *schematic representation of the Rhine's socio-economic and hydrological system (by Astrid Björnsen-Gurung)*

All countries have developed multiple socio-economic scenarios, but not in a directly comparable or complementary way. The nature of many of the scenarios differ. For example, some socio-economic scenarios are combined with climate change scenarios, others are developed relatively independently. The level of scale may differ (e.g. national level, Ruhr-area or even city level), as well as the primary focus (e.g. water quantity or quality), and sector (agriculture, shipping, energy production).

In light of the abundance of data and methods in the riparian countries the recommendation would be to further develop and combine the knowledge already available in a process to translate this to the discharge of the Rhine and water consumption by the different sectors.

Depending on data availability and problem scope, the most useful level of scale (geographical and temporal) for the scenarios should be determined. Some presenters suggest focusing at the tributaries (e.g. Main, Neckar, Mosel, etc.) and making a preliminary water balance, based on available data, to determine relative importance of each of the tributaries.

Both from a climate change perspective and socio-economic perspective, uncertainties are high. For example, the Rhine is in between areas that get dryer and those that get wetter, so the influence of climate change on for example rainfall patterns is still uncertain. From a socio-economic perspective, developments such as changes in demography, changing types of economy, land use patterns and the role of energy production are only limited included and potential impacts highly uncertain. Additionally, expectations in the change of water demand of different sectors (e.g. agriculture, household, industry) are very different across the different countries. Factors like changing regulation and governance structures and their influence on Rhine management are not considered so far. Scenarios are a tool that could meet the demands of integrating a wide variety of possible developments. Through the use of scenarios an uncertain future can be presented in a coherent combination of coinciding developments, thus outlining a series of possible future outcomes.

Currently identified remarkable and high impact developments that will have an important effect on Rhine low-flow discharge are the disappearance of glaciers in the Rhine catchment, the changes in snow volume in the Alps, the closing down of the (lignite) mining industry, and the water demand of agriculture in the different riparian countries. Due to the disappearance of the glaciers there is in general a lower summer discharge and probably a shift from a nival (snow melt driven) to a pluvial (rain fed driven) discharge regime. The melting of the glaciers will lead to a temporal rise of the discharges. In combination with changing rainfall patterns with less rain in summer (and more in winter), and a larger variability, it is expected that extremes in winter high-flow discharges and summer low-flow discharges will increase. Due to the closing down of the lignite mines, low-flows will decrease. The mines currently 'produce' extra water by extracting ground water, which will stop when they are no longer operational. Additionally, the mine pits will be filled with Rhine water during a period of 40 years and so have a long-term potential impact on the (low-flow) discharge. With respect to agriculture the expectations are very diverse. However, despite the wide range of increase in demand, it is expected to be a particularly high-impact sector, because its consumption primarily takes place in the dry and warm summer months, when discharges are already lower. Changes in population density will lead to changes in electricity demand which will influence reservoir building in de Alps. Operation of these reservoirs has an impact on low flows and could lead to a seasonal redistribution of discharges.

Socio-economy and climate have impact on discharges. Floods and droughts however have impact on socio-economic behaviour. Socio-economic trends influence psychology of households and industry. How do sectors react on future hydrological changes? In order to assess the complete bandwidth of future scenarios the scenario outcomes should be assess without taking into account possible adaptation or mitigation policies. In The Netherlands this approach was used in establishing the deltascenarios[2]. Also the SCENES project, albeit at a different scale, looked at water demand and scarcity under different socio-economic scenarios for different sectors.

The complexity of the problem, with all the sectors, levels of scale and uncertainties, already reflected in the presence of different scenarios, leads to the recommendation that we need to think more in terms of exposure and vulnerability of different sectors and water users and decide from there on how to include this in current (hydrological) models. Figure 2 schematically shows how the different elements could link together. Within the current project context, it is not feasible to develop and all-encompassing model for all uses and sectors and scales. More specific challenges include:

- Link and quantify feedback mechanisms in relation to water use (e.g. influences of prices, regulation, land use, economic development, vested interests, etc.)
- Based on the approach followed in the deltascenarios and SCENES determine at what level socio-economic scenarios provide best insights for the questions asked

[2] (Bruggeman et al., Deltascenario's voor 2050 en 2100, 2013)

- Collect data on land use and water consumption of different sectors now and in the future at the most relevant level of scale, and in relation to the temporal differentiation (e.g. higher demand in summer has larger impact than in winter)
- Develop various scenarios (possibly by downscaling existing scenarios) in terms of the corners of a playing field in which diverse directions of demographic and economic change are explored, rather than extrapolated from current trends.
- How to deal with missing inputs from sectors and geographical areas for which data and information is currently lacking

Overview of available knowledge and data

Table 1 below provides a more detailed overview of the available data and knowledge on Rhine water consumption within the different riparian countries and sectors as presented during the workshop. Hence, the table also provides insight in knowledge and data gaps that need to be filled. However, it is not always clear whether these gaps resulted from the selection of presenters or are indeed non-existent. Obviously, this would be a first step in the follow up of the project to further identify the availability of knowledge and data.

Proposed Follow-up activities

Based on these outcomes of the workshop we propose the following steps to be included in the description of the project plan in order to further the analysis of the impact of societal activities on the discharge regime of the Rhine:

1. Assessment of the current situation, based on availability of knowledge and data, which will be used to define the reference situation for the scenarios that will be developed in the next steps.
2. In parallel with the previous step distinctive development scenarios should be developed, based on short "story-lines" for each of the riparian countries, outlining development scenarios on economic growth, demographic developments combined with climate change scenarios based on existing studies
    a. Determine most appropriate level(s) of scale for scenarios, based on data availability, input needs for hydrological models and desired detail level in outcomes. A first step could be to focus at tributaries and make a preliminary water balance to determine relative importance of each of the tributaries
    b. Further identification and specification of knowledge and data gaps; propose methods to identify or estimate the needed knowledge and data.
    c. Develop a shared approach for the development of socio-economic scenarios,
    d. Develop new storylines and/or translate national scenarios to regional/ sub-catchment scenarios in which impact on discharge can be estimated
3. Assess impacts of different scenarios on the Rhine discharge
    a. Feed scenario data into existing hydrological models to assess effects of socio-economic developments on Rhine discharge
    b. Identify relative importance of different sectors on water consumption in the different socio-economic scenarios for all riparian countries/sub-catchments throughout the year

The scenarios that will be developed this way are used to detail water consumption of the different sectors and this should consequently be included in existing hydrological models in order to assess their influence on the low-flow discharge of the Rhine, possibly along the lines as indicated in Figure 2.

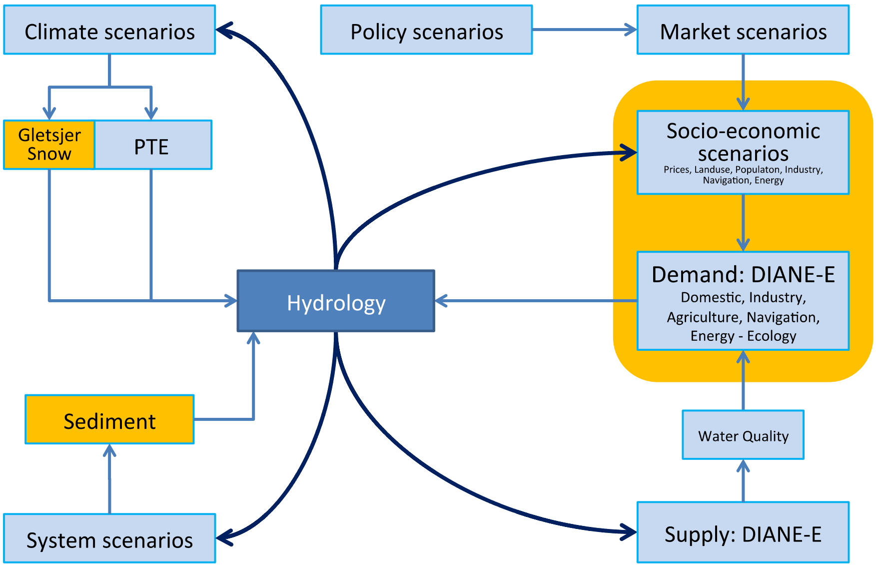

Figure 2: *Relations between socio-economic and hydrological models (by Erik Ruijgh)*

Planning

It is proposed to implement the activities as described in the previous paragraph through the use of a coordinating group with representatives from each of the riparian countries. These members should collect all the existing relevant data for each country and differentiated for the pre-decided sub-catchments. Through review of the data and interviews with representatives from the different sectors the coordinating group should develop storylines and consequent scenarios with sufficient detail for these to be incorporated into the existing hydrological models.

Table 1: Knowledge availability on Rhine water consumption, socio-economic developments and challenges in the different riparian countries

		Switzerland	Germany	Austria	France	Netherlands
Availability Scenarios and Models,		- Climate scenarios (CH2011) - SE Scenarios (income, population, urbanization) 2050 (EAWAG) - Impact CC on agriculture and adaptation possibilities - Strategy development/ DSS for water quality (EAWAG) - iWAQUA (EAWAG) - Method for multi-scale scenarios, based on storylines and trends (ETH Zurich)	'WIRE' (up to 2030) CC-SE Ruhr area (dynaklim) Forecasts energy production methods (# water power) (VIA) Drinking/Waste water scenarios for the Ruhr area KLIWAS (BfG)	CC-SE scenarios at city level in Austria (Joanneum Research)		Deltascenarios/ land use (to 2050)/ demography (12-24 mln) (Deltares, CPB, PBL, KNMI) Kennis voor Klimaat Scenes
'Basic' data		- Water consumption (2.2 km3/yr) - Consumption per sector - Energy industry water use for cooling - Demography - GDP - Energy consumption - Reservoirs volume 727 Mm3 in alpine Rhine CH, AT, FL - Seasonal distribution of flows - Discharge: 40-3100 m3/s (HQ100) - Water balance CH - Reduction water storage in glaciers and seasonal snow	- Water consumption per sector (household, industry, agriculture, energy, mining – 380Mm3/yr = 1.2% of average low discharge)) - Demography - Drinking water - Industrial use - Precipitation - Energy production and mix - GDP	- Energy production in Austrian Alpine Rhine (hydropower and storage) - Reservoir volume 727 Mm3 in alpine Rhine -		- Water consumption per sector (household, industry, agriculture) - Demography - GDP - Land use - Discharges (MQ=2200 m3/s at Lobith) - Precipitation

		Switzerland	Germany	Austria	France	Netherlands
Data and scenarios at Rhine level		- Hydrological scenarios (Rheinblick) - GDP, rainfall, discharge - Sensitivity to temperature: drinking water, electricity, irrigation (Joanneum Research policies) - Strategic importance of Rhine for shipping (raw material and oil – volume doubled since 200), including river cruising - Relevance of CC for Rhine shipping (central commission navigation of the Rhine): after 2050 higher costs are expected due to lower water levels. Cruising is less affected. Strategy: smaller vessels, change in stock keeping. Now: low water levels increase price, but may lose market shares. - Learning from/ inspired by Danube studies? GLOWA Danube and Danubia models (coupled agro-economic and hydrological models – university of Cologne): Danubia generally applicable to Rhine catchment				
Expected changes in consumption		- Irrigation: steep increase from 2020 on. 1.5-4x more in 2050 (600-2000 Mm3) versus: - Overall impact irrigation expected to be small (uni Bern)	Households & Industry demand will go down in all scenarios	-		Growth for almost all sectors in all scenarios
Drivers for change	*Physical*	- Disappearance of glaciers - 55% has already disappeared over last 150yrs - Temporarily more melt from glaciers - Smaller snow storage - Precipitation change? - MQ/yr +2.73% over the last 100yrs > in summer -8.7%, winter +22%				- Precipitation change

		Switzerland	Germany	Austria	France	Netherlands
	Socio-Economic	- Reservoirs having a smoothening effect. Capacity 1.9 BCM - Cross-catchment supply (e.g. for drinking water) - Population, urbanization, economic growth - Energy demand	- Disappearance 3 large mining pits , that a) demand water during 40 yrs (new lakes) and b) no longer 'produce' extra water - Reduction in water use households and industry - Energy demand and production methods - EU regulation: WFD> national water plan			- Population change - Changing economic structure (e.g. bio-based) - Changing urbanisation/agricultural patterns
Strategies		- Change business model of hydropower dams and reservoirs (from power generation to buffering/ compensation) - Adaptation only locally needed - Integrated analysis and decision framework (EAWAG) - Increase in water level reservoirs	- Buffering - Inter-catchment diversion of discharge - Filling up reservoirs during winter> less pressure on groundwater during summer	- Hydropeaking		
Major Challenges		- Sufficient water needed for hydropower plants - Discharge modelling of the future difficult due to flexibility energy market - Impact of hydropower plants on fish - Changing discharge: more extremes	- Buffering capacity is small (0.7 km3) compared to discharge (40-4200 m3/s) - Fulfilling peak requirement s only limited - Changing discharge: more extremes	- WFD objectives versus CC mitigation and energy security		- Large water needs for salt water intrusion - Scenarios in which increasing drought is combined with economic pressure - Changing discharge: more extremes

Annex A

CHR Workshop programme 26-27 March 2014, Bregenz, Austria (in alphabetic order)

"Socio-economic influences on the discharge of the River Rhine"

1. **Belz, J.U.** *Manifestation of Socio-Economic Influences in Discharge Patterns.* Bundesanstalt für Gewässerkunde (Federal Institute of Hydrology), Germany.
2. **Bruggeman, W.** *Delta Scenarios NL.* Deltares, Netherlands
3. **Flörke, M.** *Socio-economic scenarios incorporation into hydrologic modeling*. Center for Environmental Systems Research- Universität Kassel, Germany.
4. **Kersting, M.** *Scenarios for drinking water and waste water in the Ruhr area.* RUFIS (Ruhr-Forschungsinstitut für Innovations – und Strukturpolitik) , Germany.
5. **Kwadijk, J.** *Discharges in the future (from a Dutch perspective).* Deltares, Netherlands.
6. **Matt, P.** *Benefits and Impacts of Modern Pumped Storage Plants in the Austrian Catchment of the Alpine Rhine.* Voralberger Illwerke AG, Austria
7. **Moser, H.** *Socio-economic influences on the discharge of the Rhine.* Federal Institute of Hydrology, Germany.
8. **Prettenthaler, F.** *Building value data for normalizing damage data and develop socio-economic scenarios.* Joanneum Research Policies, Austria.
9. **Reichenau, T. and Krimly, T.** *Integrating decision making in the agriculutral sector into ecohydrological simulations: the GLOWA-Danube approach.* University of Cologne, Germany
10. **Schädler, B.** *The Alpine water tower –past, present, future.* Universität Bern, Switzerland.
11. **Schädler, B. et al.** *Water and Swiss agriculture.* Universität Bern, Switzerland
12. **Schuwirth, N. et al.** *Prediction, valuation and ecological effects of future stream water quality based on socio-economic scenarios and climate change predictions for 2050.* EAWAG, Swiss Federal Institute of Aquatic Science and Technology, Switzerland.
13. **Seidl, R.** *Socio-economic scenarios in interdisciplinary integrated modelling projects.* ETH Zurich, Switzerland.
14. **Van der Werf, H.** *Shipping on the Rhine – developments and prospects for the demand and supply side, with consideration of the climate change.* Central Commission for the Navigation of the Rhine
15. **Wächter, H.P**.*Discharge forecast for the Alpine Rhine river – the influence of the hydropower plants.* Internationale Regierungskommission Alpenrhein. Switzerland.
16. **Wagner, A and Hüsener, D**., *Flooding of the residual lakes in the Rhenish lignite area by use of the river Rhine.* RWE power AG and Landesamt für Natur, Umwelt und Verbraucherschutz NRW (LANUV), Germany.