Reconnecting Iberian Rivers

Activity 3.5.2 Final Report

Quantitative analysis of water volumes to assist Partners’ MoU

Timeline: Apr 21 – Mar 22 (postponed to July 21 – September 22)
Partners: ANP|WWF (lead), WWF-ES, Wetlands Int., CEDOUA

1. Introduction

The purpose of this Activity is to carry out an assessment on water volumes and assignments to different users across the major Iberian shared river basins, taking into account climate change impacts, ecological objectives required by the WFD and the Albufeira Convention agreements. Under this frame, it is clear for WWF that we can expect greater uncertainties in water availability for the Iberian Peninsula in the coming decades, as the recent RIR report shown\(^1\).

Worldwide, existing policies and approaches to water resources management are consistently surprised and overwhelmed by the systemic nature of water scarcity and climate change impacts, which can spark and aggravate other ecological (e.g., pests, disease) and socioeconomic threats (e.g., commodity price fluctuations, migratory crises) via feedback loops and cascading impacts across systems (UNDRR, 2021).

These impacts are particularly relevant in transboundary basins, where water resources planning and management is typically fragmented and vulnerable to surprises. In this context, planning for the future is characterized by a high degree of uncertainty, or deep uncertainty, a situation where experts do not know or policy makers cannot agree upon: (i) the external context of the system (scenario uncertainty), (ii) how systems work and interrelate (parameter and structural uncertainties in models), and/or (iii) how to value the desirability of alternative and potentially conflicting outcomes (weighting) (Marchau et al., 2019).

The current context of climate change has made international cooperation in river management even harder. The international agreements in force, such as the Albufeira Convention between Portugal and Spain, were signed before the formal adoption of climate change laws and brings the issue of treaty renegotiation to the political foreground.

---

\(^1\) [Link to RIR report](https://www.wwf.es/?57520/Informe-sobre-los-efectos-del-cambio-climatico-en-la-Peninsula-Iberica)
Despite the policy discretion inherent to any international negotiation, there are limits to the free will of the parties established by European obligations deriving from applicable directives, as well as by legal principles enshrined in international conventions supporting international practice.

A values based approach to water volumes and assignments to different users should consider 8 major challenges:

1. **Territorial challenges (longitudinal):** Ethical challenges regarding fair and balanced access to the river, a shared natural resource providing benefits for the riverside populations (Newson, 1997). In contiguous rivers, that define the boundary line between two countries, as in the Guadiana river, sensitive issues of delimitation of the lowest line of a water course can emerge when the activities (like sand extraction) carried out on one side are likely to change the thalweg of the river.

2. **Territorial challenges (cross sectional):** Ethical challenges associated with the placement of the States in the course of the river flow (Falkenmark and Folke, 2002). In successive rivers the ethic challenges of preserving peaceful relations among neighboring countries sharing water resources is the inequality of the relations between upstream and downstream countries due to the de facto power of the upriver country and the correspondent vulnerability of the downriver country, as in the rivers Tejo or Douro.

3. **Geomorphology challenges:** Ethical challenges depending on how easy the physical access to rivers is in each country (Gregory et al., 2008). The landscape features on each river bank (for instance, with flood plains on one side and steep slopes and rocky cliffs on the other) can make it more prone to access the river resources on one of the sides. Beyond the geophysical features, the existing infrastructure can also make a difference.

4. **Development challenges:** Ethical challenges connected to the level of economic development of riverine regions (Hooper, 2005). Water-intensive industries or mechanized farming in one of the river margins can induce overexploitation of river capacity. Strong technological capacity to exploit the river resources and to use the river “services” on one of the river banks engenders further inequalities.

5. **Demographic challenges:** Ethical challenges correlate to diverse demographic dispersion on each riverside can as well lead to inequities (Jager et al., 2016). Population density can originate quite different levels of appropriation on both States (for instance more water abduction, waste water emissions, fisheries, fish farms, etc.)

6. **Cultural challenges:** Ethical challenges determined by the strength of the bonds between human communities and rivers (Jackson, 2010). The geomorphologic, socioeconomic and demographic dissimilarities are sharpened when the cultural differences lead to peculiar community practices associated with rivers collective symbols or identity markers. Unique visions and feelings towards the rivers accentuate the perceived unfairness of foreign uses, triggering social conflicts and potential legal disputes (Argyrou and Hummels, 2019).

7. **Interspecies challenges:** Ethical challenges regarding co-existence of humans and non-human species, dependent on river ecosystems in the same space and time (Whyte and Cuomo, 2016). Most
of the human activities likely to have impact on the rivers can trigger direct or indirect conflicts with species even if they are inedible or are not even known to man (Watters, 1996).

8. Intergenerational challenges: Ethical challenges regarding resource conservation and environmental quality of the natural resources that will be left for future generations (Fedra, 2015). Some activities that are necessary to allow the realization of all the potential uses of the rivers have irreversible impacts. Dams for hydropower production, for instance, cause huge and hardly reversible impacts in the area of the dam reservoir (European Commission, 2018).

Based on these premises, a thorough assessment of water allocations was conducted based on the draft proposals of RBMP’s for the 3 target basins (Douro, Tejo and Guadiana) in both Portugal and Spain. Furthermore, an applied research study was developed by the University of Salamanca, leveraged on recent advances in socio-ecological research and ensemble forecasting, to deliver a protocol-based modular framework that:

a. represents interactions between the climate and water system, assessing plausible future CO₂ emission scenarios and their impact on streamflow and water stock, which in turn condition water availability for environmental and economic uses (performed for all three case study areas);

b. explores interactions between the climate-water system and the socioeconomic system, assessing the impacts of changes in water availability under climate change on income and employment (performed in pilot areas of the Douro River Basin).

Each system/module considers multiple models (multi-model), including 4+ regional/global climate models and 4+ regional/global hydrological models, and explores multiple Shared Socio-Economic Pathways (SSP) scenarios (multi-scenario). The resultant multi-system, multi-model and multi-scenario ensemble is used to exhaustively sample uncertainties within and across systems (i.e., cascading uncertainties). The upshot is a database of simulations in which each simulation represents the environmental (and where possible, socioeconomic) performance under one specific scenario and ensemble setting.

This information is combined with information on water resources planning in each of the basins, so to identify futures where incumbent river basin management plans in the three case study areas meet or miss their objectives, and explore potential tipping points.

2. Portugal – assignment of freshwater resources

Unlike Spain, Portugal does not include water allocations as a core objective of its water planning policy.

---

2 In 2010, the project for one large dam in the Douro river basin (Padroselos dam, in Beça river) had a negative environmental impact assessment because of a small non-edible mussel. The monitoring report for three rivers shows the evolution of the Bivalves (Biosfera (2017) - Relatório de monitorização dos mexilhões-de-rio, available at https://siaia.apambiente.pt/AIADOC/PA402/mexilh%C3%B5es202078155454.pdf).
Quantitative analysis and/or assignment of water volumes to different users was not directly identified as a Significant Issue in the 3rd generation draft RBMP’s for all 3 basins considered – Douro, Tejo and Guadiana. Nevertheless, several other Issues closely related to this topic are identified and described, namely:

- Reduced inflows from Spain
- Insufficient/inefficient licensing and control
- Insufficient/inefficient monitoring and measuring of water abstractions
- Insufficient/inefficient implementation of e-flow regimes
- Changes to runoff regimes
- Water Scarcity (Tejo and Guadiana only)
- Droughts

The former clearly points out to the effect of increased water abstractions (mostly for irrigation purposes) and very high rate of water use in Spain, and of excessive river regulation in the whole of the 3 basins, thus reducing natural inflows across the whole territory covered.

In this context, measures foreseen in the draft RBMP’s proposals include several studies of great relevance and importance for water allocation and risk reduction. These include the calculation of scarcity indexes per sub-basin (presently unavailable), upon which current and new water abstraction permits should be revised and conditioned, promoting the use of alternative sources. The measure aims to reduce at least 7% of abstractions, and even restricting or forbidding abstractions, particularly in waterbodies in less than Good status and/or with a scarcity index above 40%. Such measure shall be supported by another one promoting water reuse (particularly from WWTPPlants), by the elaboration of Drought and Scarcity Management Plans at the river basin level, and by several specific measures on monitoring and metering.

Under the measures proposed in the draft RBMP’s for 2022-27 (next planning cycle), it is important that the implementation of e-flows (and preventively of minimum flow rates) is prioritized and ensured by the Public Administration, and not dependent on the submission of proposals by the permit holders (who should nevertheless be consulted). It should be noted that the European Commission’s assessment of RBMP’s (Feb. 2018) demonstrated the insufficiency of established e-flows and required action for a substantial improvement, including the need for the Plans to set e-flow regimes suitable for all water bodies incorporating five key components: maximum and minimum flow rates, seasonal variability, flood peaks, and variation rates.

In fact, although appropriate ecological flows are a key issue, and a cornerstone for the recovery of water bodies and for achieving and maintaining its good ecological status, initial studies still do not include a sound diagnosis and effective proposal for its implementation.

3. Spain – assignment of freshwater resources

Contrarily to Portugal, Spain does include in its draft RBMP’s a compilation of water abstractions and allocations per user type and supply system (and even per water body).
The draft proposals for RBMP’s in Spain continue to expand the water allocation for expanding irrigation schemes. This is particularly critical in the Ebro river basin (with nearly 50,000 ha of new irrigation plots planned, of which nearly 2/3 have no ensured supply), but also in the shared river basins with Portugal.

In the Guadiana for instance, 15,000 ha are planned in the new Tierra de Barros scheme, for which economic viability is dependent on public EU funding, as recognized in the Plan proposal documents (negative financial return rate plus high energy costs due to required pumping). Furthermore, it does not consider the documented reduced flows and water availability in the basin due to climate change effects, nor the impacts on associated groundwater bodies, already declared vulnerable due to nitrates contamination (which is expected to worsen under an intensified irrigation model).

The Tinto, Odiel and Piedras basins, managed regionally by the Junta de Andalucía, assume the increase and formalization of a permanent intake and transfer of more than 100 hm³/yr from the Bocachanza, on the confluence of the Guadiana with its Chanza tributary (and right on the edge of the Portuguese border). The existing intake was accepted by Portugal for emergency (drought) situations only, but it became a de facto option, as irrigation areas expand in the southwestern coast of Huelva. It does also build up on the conflict between regional and national water administrations, and potentially between the two riparian countries.

Increasing irrigation areas are also planned for the Tejo and the Douro river basins, albeit the draft plans recognize the uncertainty regarding the economic and environmental viability of additional irrigation schemes planned for in the 2nd cycle RBMP’s.

Overall, it should be mentioned that all Spanish draft RBMP’s consider the modernization of existing irrigation schemes as the cornerstone measure for adaptation to climate change. Such measures concentrate a large part of the planned investments, aiming to reduce relative water consumption (l/ha), and do represent a productive improvement for benefitting farmers. Nevertheless, supporting environmental impact assessments are biased, and fail to recognize:

- The reduction of returning flows to surface and groundwater bodies
- The increase on production contributing to an increased PET (and thereby, net consumption increase)
- The factual trend to intensify and expand existing schemes after modernization investments, based on assumed (and unmetered) water savings
- The increased concentration of contaminants in reduced returning flows

The above mentioned analysis clearly shows how the 3rd cycle RBMP’s proposals keep prioritizing demand allocations and satisfaction over the environmental objectives dictated by the WFD.

---

3 The Regional Administration, in charge of “internal” river basins, as opposed to cross-regional and international river basins which are managed by the Confederaciones Hidrográficas, under national authority.
4 Meaningfully, Portugal on its turn, instead of directly addressing its neighbor for noncompliance with EU legislation and with the Albufeira Convention, decided unilaterally to plan a direct intake on the Guadiana, just meters upstream of the Spanish intake, to reinforce the storage in the Odeleite reservoir (SE Portugal), which face a similar increase in demand due to expanding irrigation intensive schemes on the coast, mainly for greenhouses, avocado, orange and other sub-tropical fruits.
4. Modelling analysis

It is currently well known that under deep uncertainty, standard decision-making based on probabilistic description of future conditions and optimization of expected performance is no longer appropriate, since it artificially reduces uncertainty and risks providing unrealistically precise information that can lead to maladaptation. Instead, priority should be given to robustness, through the identification of policies that deliver a satisfactory performance under most plausible futures (UNEP, 2021). In this context, RIR partners (and particularly WWF-Spain) have developed a methodological exercise with the University of Salamanca in order to develop an actionable modular hierarchy that integrates interdisciplinary socio-ecological science and ensemble forecasting, so as to contribute to the design, and implementation of robust adaptation across Iberian transboundary basins.

The exercise shows the process of developing a modular hierarchy of Coupled Human and Natural System (CHANS) ensembles, which was used to assess the consequences of climate change (climate system, hydrologic system) and adaptation (human system) over time in three transboundary Iberian river basins: the Douro, the Tagus and the Guadiana.

The resultant framework couples multiple ecological and human systems building on ensemble experiments and CHANS hierarchical structures (so-called socio-ecological ensemble). Modules within the hierarchy include multiple models (multi-model ensemble) that are fed with alternative climate and global socioeconomic scenarios (multi-scenario ensemble). The resultant simulation framework (i.e. hierarchy of ensembles) can be used to explore the consequences of actions/policies under alternative future states/scenarios and models/model settings, while accounting for cascading impacts across ecological and human systems. This produces a large database of simulations in which each simulation represents the socioeconomic and environmental consequences of climate change under one specific scenario and combination of ecological and socioeconomic models—thus thoroughly assessing the fundamental sources of uncertainty and providing comprehensive data to inform robust decision-making.

Most models and scenarios used forecast a reduction in discharge for all 6 key locations, at the Spanish-Portuguese border and at the river outlets. The best estimate, both using a 12-month and 60-month moving average, also shows a reduction in discharge in all 6 key locations. Discharge reductions are more marked for the 2040-2070 period than the marginal increase experienced in the 2006-2040 period, as greenhouse gas concentrations peak and the impacts of climate change of the water cycle aggravate. Impacts are particularly severe in the central part of the Duero and Guadiana basins, where irrigation is very intensive. For most of the grids discharge reductions are estimated between -20% to -40%, and are more marked for the RCP6.0 and (particularly) the RCP8.5 scenarios as compared to the RCP2.6.

The modelling combines discharge forecasts from GCMs and GHMs with demand data and forecasts from the river basin authorities to calculate the WEI (Water Exploitation Index), finding a clear trend towards a worsening WEI. Most sub-basins across the Douro, Tagus and Guadiana basins exceed the water scarcity threshold (WEI>20%) by 2040, and less than a handful sub-basins do not experience scarcity by 2070.
One methodological conclusion that arises from the results of the analysis is that the integration of ecological (climate, hydrologic) and socioeconomic (microeconomic) systems/modules can provide additional information about the systemic complexity of human-water systems, and improve the design of water and climate adaptation policies, notably by accounting for the non-linear responses of economic agents and the cascading uncertainties across human and natural systems.

The framework developed is designed to be replicable and flexible, as well as capable of including alternative Decision Support Systems, climate, hydrologic, and microeconomic models that are better suited to represent water demand and/or supply challenges elsewhere. This is important because there is a large pool of different models in the literature that can fit better into varied regional or local conditions. As such, the framework developed can be applied widely and relatively easily given sufficient data availability.

The results of this exercise suggest also that there are several ways in which the proposed framework could be improved. First, it would be useful to develop multi-model ensembles that thoroughly sample parameter and structural uncertainties in the human system, as well as further exploring cascading uncertainties across socio-ecological systems. This possibility has been comprehensively explored in the climate and hydrological system but not in the human system explored for the moment. Also, the use of discovery methods that sample scenario uncertainty, will help the multi-system ensemble to build an (even) larger dataset of plausible futures, which can also help to detect new vulnerabilities to climate change and responses, and thus identify robust adaptation strategies that display a satisfactory performance under most plausible futures.

A second improvement identified is related with the current options of improving individual models within each module included in the simulation framework. As an example, recent developments in microeconomic modelling dislodge land use choices from water use choices, meaning crop portfolio choices need not be linearly related to water application (Sapino et al., 2022). This allows the representation and assessment of adaptation responses at the intensive margin (deficit/supplementary irrigation), beyond the extensive (shift to less water intensive crops) and super-extensive (shift to rain fed crops) margin adaptations studied in conventional microeconomic models. These new microeconomic models could be incorporated to our modular hierarchy with relatively minor changes in the simulation framework proposed. In a similar way, given the flexibility of this framework, additional modules could be added to the modelling framework, e.g., through the coupling with macroeconomic or crop models to assess climate change impacts on crop yields (crop models) and prices (macroeconomic models). All the above adds on are an effort to incorporate more variables to the analysis and that are a source of uncertainty, thus building on capacity of assessment of robustness which is the main objective of this work.

Another key part of the modelling exercise was to assess water allocation over time in the Douro River Basin using the DSS AQUATOOL, and explore the socioeconomic impacts of water (re)allocations on income and employment using a mathematical programming model that represents the behavior and responses of irrigators. Results predict a reduction in profit and employment, for all 3 management scenarios, periods (2006-2040 and 2040-2070) and statistical treatment (moving average 5 and 10 years). This suggests that irrigation expansion and modernization have a negative impact on profit and employment through the reallocation of water resources from downstream to
upstream users, which creates non-linear effects that reduce profit and employment overall. This general trend is observed in the Spanish Douro River Basin overall.

The analysis suggests that Agricultural Water Demands Units (AWDUs) in the Douro River Basin initially accommodate reductions in water allocations by substituting irrigated crops at the margin (e.g. wheat) by rain-fed crops, while trying to keep the surface of valuable irrigated crops (maize, sugar beet, vegetables and fruits) stable. When water allocations are further reduced, AWDUs are constrained to reduce the surface of maize, sugar beet, vegetables and fruits (usually in this order), and profit experiences more abrupt reductions.

Since water intensive crops are also the most labor intensive, employment may be subject to abrupt changes as well. This explains why while initial reductions in water allocation produce negligible impacts on employment and profit, marginally reducing water allocations under severe scarcity can sometimes result in significant, more-than-proportional reductions in profit an employment, leading to a substantial amount of surprise.

5. Iberian joint outlook

Common and specific issues emerge from the work conducted, which are summarized hereafter.

i. Portugal ought to incorporate water allocations per sector and waterbody on its planning goals, and include a quantitative assessment of waterbodies as a key component to determine its status (as already exists for groundwater bodies);

ii. Both countries face increasing pressure from irrigation expansion (particularly in the Guadiana and neighboring river basins), and should condition any further allocations to the scarcity and drought risk level of the supplying waterbodies;

iii. All the consulted RBMP’s drafts neglect the volume and significance of illegal abstractions – a recent study by WWF/Spain on the Upper Guadiana⁵ showed that over 50,000ha have been irrigated in 2019 in these conditions, mainly from (already quite vulnerable) local groundwater bodies, and critically impacting the overlying National Park of Tablas de Daimiel;

iv. “Business as usual” decision-making on such uncertain and variable systems as natural resources - and particularly water, so strongly affected by climate change - is no longer acceptable, given the availability of improved coupling models;

v. Continuous expansion of water-intensive agriculture cannot be expected, and current trends may have significant negative impacts on profit and employment, as opposed to most stakeholders’ expectations.

WWF has long defended the need to change our relation with water and the aquatic ecosystems. We are seeing an unprecedented loss of biodiversity, especially of those species that depend directly on healthy freshwater ecosystems (WWF, 2020). This is a consequence of degradation of habitats that

we are producing and the overexploitation of water sources that we have been doing for decades to support unsustainable economic development.

However, climate change and its impacts are posing an additional pressure to our natural and human systems. Still, we have some options to mitigate and adapt to this challenges if we assume that we need to do something different. To this matter, the results presented in this report shed light on how to change the way we manage our water resources, while accounting for uncertainties through cutting-edge modelling that can inform robust decision-making. This will surely help addressing the challenges in a more water scarce and uncertain world.
6. References


Authors:

Afonso do Ó (ANP|WWF, coord.)
Alexandra Aragão (CEDOUA)
Rafael Seiz (WWF/Spain)

© ANP|WWF, September 2022