Review of alternative water allocation options

Task A4B of the BLUE2 project “Study on EU integrated policy assessment for the freshwater and marine environment, on the economic benefits of EU water policy and on the costs of its non-implementation”

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Executive Summary

This document aims to assess which would be the best alternatives for water allocation from an economic perspective, i.e. income and job generation, when water is relatively scarce, while pressure on water resources is maintained equal or lower. The review of implemented and available policy instruments for water allocation used in EU countries demonstrates alternative policy tools that can support water use reallocation to increase value creation and sustainable water use. Tools have been developed for reallocation of water under scarcity conditions and adapted to local circumstances and the historical context.

The economic effects of different water resources allocation criteria are evaluated with the support of the Economic Water Allocation model (EWA). The EWA model is applied to eight river basin districts representing different ecosystems in the EU. The model analyses existing water allocation rules and compares it with schemes maximizing Gross Value Added (GVA) or job creation. The estimation allows the assessment of the opportunity cost of current allocation system compared to a maximizing value strategy. The model draws exclusively from economic science and results should be considered in the light of its theoretical nature. Results show that there are two types of basins: those where agricultural use is predominant, i.e. agriculture abstractions higher than 50% of total abstraction and water scarcity affects mainly the irrigation sector (Guadalquivir, Jucar, Rhone and Arges-Vedea river basins). In these basins other economic uses are not affected, as they have higher priority in access to water in all alternative regimes. In other basins where agriculture is less dominant (low share of water abstractions), water reallocation is less flexible and water scarcity also affects high value sectors, such as manufacturing. The EWA model provides a useful first insight in the impact of water scarcity and the effect of alternative water allocation regimes at river basin level, even when data availability is low.

Water pricing may induce reallocation of water use and the analysis of this instrument is done with the support of a detailed hydro-economic model applied to the Guadalquivir basin, where data availability is high. Water pricing is adjusted by simulating an increased tariff that internalizes environmental and resource costs (ERC) as referred to in WFD (Art 9). In this Mediterranean basin agriculture uses 87% of abstracted water and water pricing increases induced water savings mainly in irrigation.

A detailed analysis of conflicting allocation between uses at water body level in two EU countries (Bulgaria and Spain) shows the convenience of a participatory approach between different stakeholders. Reallocation of scarce resources based on market instruments alone (such as water pricing) cannot guarantee an optimal allocation (for societal welfare maximization). Allocation of water resources must to be supported by public intervention as non-market values of ecosystem services need to be integrated in the decision making.
Preface

This report is one product of the “Study on European Union (EU) integrated policy assessment for the freshwater and marine environment, on the economic benefits of EU water policy and on the costs of its non-implementation” (BLUE2) commissioned by the European Commission (EC).

The overall aim of the BLUE2 study is to support the Commission in building up its analytical capacity and understanding of the economics and effectiveness of the EU water acquis.

BLUE2 is comprised of two parts, as shown in Figure 1:

**Figure 1 Overview of the BLUE2 study**

The overall objective of Part A of BLUE2 is to increase the understanding of the full (economic) value that water, and water services generate and how water resources contribute to economic development and citizens' well-being. The findings of BLUE2 will further assist in quantifying how the EU water acquis contributes to this value generation, using the most appropriate valuation techniques.

The overall objective of Part B of BLUE2 is to develop a method for the integrated socio-economic assessment of policies affecting the quality of the freshwater and marine environment, to be applied in connection with the water and marine modelling framework held by the Commission's Joint Research Centre (JRC). The method and accompanying tools will be used to support policy development. In particular, Part B aims to establish an EU pressures inventory and measures database. Additionally, Part B will increase the understanding of the cost-effectiveness of measures and the benefits arising from a reduction of pressures on the freshwater and marine environment through the application of two online modelling tools. A Scenario Generation Tool for defining and generating policy scenarios for JRC modelling and an Evaluation Tool for cost-benefit assessment of the created scenarios.

In this context, this report summarises the results of Task A4B. The study assesses alternative water allocation from an economic and a job creation perspective to be used at river basin level when water is scarce, while pressure on water resources is maintained equal or lower. Additionally, competing uses at water body level, including trade-offs between objectives and the impact on water pricing are analysed.
2.1 Relevance of this study

Europe’s water resources are under pressure from an expanding urban population, growing economic production and, in some regions, increasing environmental strain due to climate change (EEA, 2012/2017a and EC, 2017). Furthermore, water demand from main users is expected to increase up to 16% by 2030 (Dworak et al., 2007), and it must be harmonised with the environmental flows (i.e. minimum level of water in rivers that is needed to support freshwater and estuarine ecosystems) (EC, 2015a).

Europe’s water resources are on average abundant, as only 5% of renewable freshwater resources are abstracted every year, but they are particularly under pressure in specific regions. For instance, the share of water abstracted for agriculture in the EU as a whole in relation to the total water abstraction volume increases in the spring by 44% and in the summer on average 60%, and up to 75% in the Mediterranean (EEA, 2016). Over-abstraction affects 10% of the surface waters and 20% of the groundwater bodies, and problems related to adequate quantity of water affects many river basin districts across the EU.

The expected increase in demand and seasonality of water abstraction are further burdened by the effects of climate change, as climate change is expected to affect water availability and likely result in more extreme weather patterns and events, e.g. droughts and floods (EEA, 2017a). Climate change will exacerbate and widen the existing differences in water availability between the North and South in Europe. Southern Europe, and some Northern European areas, can be particularly affected by additional water scarcity. Research has shown that for some areas in the Mediterranean climate change is already an issue, e.g. on the Iberian Peninsula there is already a significant decline in precipitation (De Luis et al (2009)).

An increase in water scarcity events and trends calls for greater attention to- and improvement of water efficiency by users, e.g. through better monitoring, technological advancement, water banks or water pricing, etc. In any case, rethinking the current water allocation systems in the EU is urgently needed (see Annex A for a detailed description of water allocation systems in theory and in practice across EU).

When water scarcity leads to total allocation of water resources among alternative uses at river basin scale, the consequence is that new users can enter in the system only by reducing allocation of previous stakeholders, consequently, the solution is to proceed to a reallocation of resources. Reallocation of scarce water resources is also interesting from an economic point of view, as water is generally allocated according to historical distribution rights with no consideration to resource productivity. Most of the EU countries assign water use rights based upon “water entitlements”, defined as the right to extract a limited volume of water at a certain time (unrestricted or seasonal license) and location (point of abstraction and eventually point of discharge). This entitlement usually is granted with a limited time horizon (frequently 25 years). The most frequent allocation regime in EU does not consider a full ownership of the resource as water is generally defined as a public good ‘heritage of the nation’ and entitlement only give access to use water under the mentioned constraints. Consequence of the current water rights structure in the EU is the fact that water rights
cannot be traded in the majority of EU (as would be if water rights were a private property). Optimising water allocation is critical currently and it will become more strategic as water scarcity increases as:

- It can reduce pressure on water resources and help establish sustainable abstraction rates;
- It may contribute to EU policies promoting resource efficiency and support a shift toward a greener economy and more climate-resilient strategies for the water dependent sectors, e.g. agriculture and coke, chemicals and pharmaceuticals;¹
- It may improve aspects concerning the economic, environmental and social situation of the EU’s rural areas. Rural regions cover 57% of the EU territory and 24% of the EU population; and
- Improved resource allocation may contribute to EU goals of improving economic performance through jobs, growth and investment.

An analysis of allocation of water between alternative productive water uses, and an assessment of the effects of such allocation, is important as it gives insight into the economic implications of reallocating water use. This information will provide valuable support to policy makers that need to make decisions when confronted with water shortages in both the short- and long-term.

2.2 Scope of the study

Based on the water sectors identified in the BLUE2 Task A2 report (Spit et al., 2018), the results of BLUE2 studies in eight selected EU river basins under Task A3 (Russi and Farmer, 2018) and proposals for improving the water productivity index in Task A4A (Vladimirova et al, 2018), the present study (Task A4B) will:

- Develop an approach and methodology to assess the economic trade-offs and opportunity costs of alternative water allocation, under current and scarcity conditions, and the economic implications for job creation of optimal water allocation;
- Analyse the allocation regimes currently in place in selected river basins, to gain knowledge on best practices that can be replicated to achieve EU policy goals;
- Discuss conflicting water rights allocation at water body level, based on two case studies from Spain and Bulgaria, where different methods have been applied.

2.3 Road map for the report

The present report is composed of five chapters.

Chapter 3 presents an approach and methodology to analyse economic trade-offs of water allocation regimes at river basin level.

Chapter 4 presents findings on the opportunity cost of access to water under alternative water allocation regimes and scarcity conditions for eight selected river basins. This chapter

¹ As identified in Spit et al. (2018). The Economic Value of Water - Water as a Key Resource for Economic Growth in the EU. Deliverable to Task A2 of the BLUE2 project “Study on EU integrated policy assessment for the freshwater and marine environment, on the economic benefits of EU water policy and on the costs of its non-implementation”. Report to Directorate-General for the Environment of the European Commission
aims to increase understanding and insight into the economic (jobs and value added) trade-offs of water allocation between users.

**Chapter 5** presents a pilot hydro-economic model at river basin level and explores water reallocation under different policies, including water pricing and the impact of water scarcity on economic output and jobs.

**Chapter 6** discusses conflicting water use allocation at water body level, based on two case studies:

1) Fuencaliente aquifer (southern Spain), where there is competition for groundwater resources between productive commercial agriculture and traditional agriculture and recreational uses;

2) East Aegean River Basin District, a case of conflicting use between fish farming and agriculture where nutrient load is the limiting factor.

**Chapter 7** present some key findings and recommendations.

Additional to the main report, the **annexes** provide the following detailed information:

A. Water allocation policy instruments;

B. Detailed explanation of EWA model in eight RBs;

C. Competing uses at water body level: productive commercial agriculture, traditional agriculture and recreational uses in the ‘Fuencaliente’ groundwater system (Southern Spain);

D. Competing uses at water body level: fish farming and nitrogen load in the East Aegean River Basin District (Bulgaria).
3.1 Background on policy instruments for reallocation of water resources

The over-allocation of resources (i.e. excessive use with respect to available water) is a problem that needs to be addressed, especially in some specific regions and as regards the allocation and use of water in traditional economic sectors (agriculture, mining).

Some EU basins and aquifers are already over-allocated and existing water rights are based on historical trajectories leading to an economic sub-optimal state. In these regions, generally, irrigation has been the most important driver for water abstraction, but other economic sectors also played a significant role, e.g. the energy sector is the main water user in EU. The different water allocation systems in the EU are explored with greater detail in Annex A. Figure 2 illustrates four categories of tools for water allocation and reallocation (see also OECD, 2015):

1) **Public allocation**, where central government or some water agency allocate water rights to users under certain conditions;
2) **Water pricing**, where the government uses taxes, tariffs and cost recovery on water services as an economic instrument to induce water conservation (quality or quality);
3) **User-based allocation** where stakeholders (maybe irrigators only or including other sectors such as cities or industries) make a reallocation of the available volume with or without public support;
4) **Water markets**, where water rights are traded either on a temporal (seasonal) or permanent basis, buyers and sellers maybe individual stakeholders (water markets) or public administration (water banks).

**Figure 2 Water allocation tools**

![Water allocation tools diagram](image)

Source: Own elaboration.

Examples of policies under each of the four categories mentioned in Figure 2 can be found in the EU: [a] public allocation by centralized hydrological planning is used in water scarce
regions usually by implementing measures in a basin hydrological plan (e.g. France, Spain, Portugal). [b] water pricing is increasingly being implemented in all Member States encouraged by WFD-Art.9. [c] user-based allocation (e.g. ‘zones de répartition des eaux’ in France) and [d] water right trade and water banks are used in Spain (although legal also in Portugal and UK).

3.2 Irrigation water use efficiency increase and water resources reallocation

Governments often subsidize farmers for increasing irrigation efficiency on the premise that higher efficiency “save water” will be available for reallocation to other economic sectors (industry, cities) and the environment (see FAO review by Perry et al., 2017). Unfortunately, evidence worldwide shows that at basin scale water savings are negligible (Seckler, 1996). The analysis of cases where water saving investments has been implemented shows frequent existence of a ‘rebound effect’ of the subsidies aiming at improving irrigation efficiency. This means that increased water availability leads to increased use, and hence does not result in water savings. This paradox is explained by the fact that previously non-consumed water “losses” at a farm level, e.g. runoff is frequently recovered and reused later at basin level by users downstream.

This undesired effect can be avoided with careful policy measures (Grafton, et al. 2018), (Berbel and Mateos, 2014). A detailed analysis of the effects of irrigation efficiency enhancement at basin level has been carried out for the Guadalquivir river basin districts under Task A3 of the BLUE2 study.

3.3 Background for introduction of water use into economic models

The modelling of the economic impacts of water scarcity is still at an incipient stage (Liu et al., 2016). Two approaches can be found in literature: [1] hydro-economic models built upon previous hydrological and agronomic modelling approaches (worldwide, there are various hydrological models available) and adding to them an economic component. These models are usually developed at basin level and generally focused on water resources and crop production (Rosegrant et al., 2002), and [2] macroeconomic models built upon previous economic frameworks (Ledvina et al., 2018), either Computable General Equilibrium (CGE) (Wittwer, 2012; Nechifor and Winning, 2017) or input/output tables (Gomez et al., 2004). These models usually are utilized at country (region) level with a lower precision in the hydrologic compound.

After a careful review of available methodologies, we concluded that to analyse water reallocation under scarcity conditions at the EU river basin level we needed to develop a tailor-made model. We initially set up a detailed pilot hydro-economic model at river basin level and applied it to the Guadalquivir river basin (RB). Although successful, we found that it was not possible to build similar hydro-economic models for other RBs due to the lack of available data. Therefore, a simpler model was developed, the ‘Economic Water Allocation’ model presented below.

3.4 Presentation of the Economic Water Allocation model

The Economic Water Allocation model (the EWA model) simulates the economic impact of water allocation regimes at basin level, in terms of GVA or employment. The model indicates the water allocation resulting under alternative water allocation regimes: current, flat
reallocation, GVA maximization or job maximization. The main constraint for the use of the model is data availability at basin level, which in many cases is not enough to run the model.

The EWA model uses the Water Productivity Index (WPI) analysed in Task A4A of the BLUE2 study (Vladimirova et al. (2018))

The framework presented in Figure 3 shows different alternative water allocation regimes tested under scenarios of increasing water scarcity conditions. Decision criteria are the optimisation of GVA or of employment (jobs created). Results in terms of the maximization of GVA and job creation are compared to current local allocation to show the opportunity cost of different allocation regimes.

Figure 3 Graphical presentation of the EWA model, which calculates economic trade-offs from alternative water allocation regimes

Allocation regimes simulated by EWA are defined below:

- **[a] Current reallocation regime**: To determine the baseline for each river basin, the model optimises the value added of the economic sectors following current local water allocation regime\(^2\) rules.
- **[b] Flat reallocation regime**: In this regime, the model optimises the value added equally between the water dependent economic sectors in the river basin.
- **[c1] Water Productivity Index \(^3\) optimisation (WPI constant)**: In this regime, the model optimisation favours sectors whose water use generates the highest value added per m\(^3\). WPI remains constant under scarcity.

\(^2\) based on current legal framework and hydrological plan in the basins as detailed by expert information from selected river basins. Often allocation regimes will differ with river basins consisting of several sub-basins and water bodies.

\(^3\) WPI measures how water is converted into goods and is usually expressed as a ratio between a unit of output (in physical or monetary terms) and a unit of input of water (in volumetric terms) – for example kg/m\(^3\) of water.
• **[c2] Water Productivity Index optimisation (WPI variable):** In this regime, the model optimisation favour sectors whose water use generates the highest value added per m³. WPI may change under scarcity.

• **[d1] Jobs optimisation (WPI variable):** In this regime, the model optimisation favours the sectors whose water use generates the most jobs per m³. WPI may change under scarcity.

• **[d2] Constrained jobs optimisation (WPI variable):** In this regime, the model optimises the value added of the economic sectors generated under a ‘constrained alternative employment maximisation reallocation regime’. Employment in services, water supply and energy production sectors are preferred compared to other sectors. WPI may change under scarcity.

The optimisation model is based on a set of water scarcity scenarios that range from 100% water resources available (equal to a current situation) to 50% availability of water for abstraction (relative to the current situation), subsequently applied to each optimisation regime described above. For example, a water availability of 90% means implies a reduction of 10% relative to the current level of abstraction. The actual scarcity will differ per month, which could allow to partially mitigate its impacts. The next section explains the use of sector demand elasticities to simulate how each sector reacts to scarcity.

### 3.4.1 Sector selection and data gap-filling

To carry out the optimisation modelling exercise outlined in the previous sections, data on economic sectors for the river basins is required. The relevant economic sectors considered in the model are the same as the most water-dependent sectors identified in the BLUE2 Study Task A2, where applicable:

- **Agriculture**
  - Agriculture (livestock)
  - Agriculture (crop production through irrigation)
- **Water supply and sewerage**
- **Services**
- **Industry**
  - Food and beverages
  - Textiles
  - Paper products
  - Coke, chemicals and pharmaceuticals
  - Basic metals
  - Mining and quarrying
  - Energy production[^4]


[^4]: Due to lack of data, the sectors ‘other manufacturing’ and ‘construction’ have not been taken into account. Water use by these sectors is considered constant.

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or EUR/m³ of water. The resulting value is included in a Water Productivity Index that (should) allow for comparison of efficient (from an economic point of view) water use between sectors and regions. See BLUE2-A4A for further background on WPI (Vladimirova et al., 2018).

[^4]: Due to lack of data, the sectors ‘other manufacturing’ and ‘construction’ have not been taken into account. Water use by these sectors is considered constant.
sectors. This information is, however, often not available, as data is collected and reported at NUTS2 or even Member State level and not at water body or river basin level.

The baseline year 2010 was chosen after a comprehensive gap-filling exercise using three approaches: [1] using the data collected for Task A4A (either from the Eurostat database or reported in the River Basin Management Plans); [2] estimating water use and economic output (GVA) at the river basin level based on regional water use and output (in the current situation); or [3] estimating water use and output at the river basin level based on national WPIs. The first approach provides more reliable and robust results than the second and third approaches. For this reason, when possible, we used approach [1], but in cases when this was not possible due to lack of data, a less robust approach, i.e. [2] or [3], was used. In Annex B, we provide the data used for each river basin.

A specific gap-filling exercise was required to estimate water consumption and GVA of irrigated agriculture (crop production) and livestock. The two sub-sectors are grouped under NACE-A, which consists of (A1) agriculture (crop production and livestock), (A2) forestry and (A3) fishing. Information on GVA is available for total NACE-A at Member State level and for NACE-A1 subsectors at river basin level. To calculate the GVA for livestock and crop production at Member State level, we used information on total NACE-A, deducting forestry and mining prior to splitting between the two A1 sub-sectors. Information on the distribution of remaining NACE-A1 between livestock and crop output was used to further distinguish the GVA of agriculture at Member State level into the two NACE-A1 subsectors\(^5\). At river basin level, information on value added for NACE-A1 stems from Task A4-A, where these values were split into livestock and crop production using the share of livestock and crop output. In many cases, information on water use was only available for NACE-A as a whole both at river basin and Member State level\(^6\).

### 3.4.2 Impact of reductions in water supply on sector productivity

**Reallocation regime model and sector productivity**

Each allocation policy scenario determines resource distribution and as a outcome of reallocation rules, some sectors reduce the share of water resources meanwhile other increase according the priority ranking. Within the sector, the reduction in water resources determines an internal reallocation between the sub-sectors (e.g. high value and low value crops). Figure 4 explains graphically the process.

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\(^6\) As subsectors A2 and A3 are very small numbers or not part of the water use monitoring parameters, they are excluded. In general, figures on water consumption follow the above presented gap-filling logic.
When water supply is reduced, the irrigation sector is generally the first one to be affected, as it is always the less productive sector (lower WPI). The recent evolution of irrigated sector WPI (GVA/m³) in the Guadalquivir RB illustrates this effect (see details in Annex C). When the water supply is normal (100%), the average WPI (GVA/m³) is 0.60 EUR/m³, but during drought events (as happened in 2006, 2007 and 2008), water supply decreased by 50%, and WPI increased to 1.40 EUR/m³. Annex C shows the evolution of WPI as a function of water availability and the estimation of elasticity of average irrigation productivity, which is estimated at $\varepsilon = -1.284$ (i.e. each percentage point of water use reduction implies an increase of 1.284% in the average GVA per m³). According to the results of the EWA model for the Guadalquivir RB, when water scarcity is simulated the rules of allocation reduce water supply to irrigation (which is the lowest hierarchy use in all allocation policy regime tested). The new (reduced) water supply determines a new WPI, which, when multiplied by water volume, determines the sector GVA. This is done for the scarcity scenario (100%, 90%... 50%). This is also done for the rest of economic sectors if they are affected by water supply reductions according to water allocation rules. The supply WPI elasticity simulates the increased productivity per volume of water (EUR/m³).

**Information sources for elasticity estimation**

Water scarcity goes from 0% to 50% in our model. An increase in scarcity or decrease in available water for abstraction triggers an adaptation in the economic sectors. This adaptation concentrates resources in the most productive crops or tasks. This forces the implementation of water conserving equipment and techniques. Combined with a product demand, this mechanism has a positive impact on the average price of products due to elasticity (i.e. the degree to which demand changes in response to changes in prices).

We were able to estimate the elasticity for the irrigated agricultural sector of the Guadalquivir RB. In the present study, it was assumed that the other EU basins can use the same elasticity. This may be a rough assumption, highly depending on the economic role of the irrigated sector and the development of the sector in the economy.
The estimation of the rest of economic sectors (non-irrigation) WPI elasticity to water use assumes the price-demand elasticity as a proxy for the relationship between sector water saving and WPI response (it was not possible to find an estimation of this parameter).

Table 1 shows the demand elasticity per sector and the available source. From these sectors, the energy (cooling) sector has the highest elasticity factor. The amount of water used by this sector is very sensitive to changes in the price of water\(^7\).

**Table 1 Sectoral elasticities**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Elasticity Factor WPI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Livestock</td>
<td>-0.290(^2)</td>
</tr>
<tr>
<td>Households</td>
<td>-0.220(^3)</td>
</tr>
<tr>
<td>Industry (rest)</td>
<td>-0.290(^4)</td>
</tr>
<tr>
<td>Services</td>
<td>-0.380(^5)</td>
</tr>
<tr>
<td>Recreation</td>
<td>-0.290(^6)</td>
</tr>
<tr>
<td>Energy (cooling)</td>
<td>-0.894(^8)</td>
</tr>
</tbody>
</table>

Source: when a specific source is not provided, the elasticities are findings from the Guadalquivir RB. See Annex C for the estimation of irrigation sector and footnote for the reference source of elasticity.

The published range of elasticities\(^10\) is wide and strongly dependent on external circumstances (e.g. value for summer and winter are statistically different). Therefore, we have selected the more recent and general case and apply it to all the eight RBs so that results of the EWA model are comparable in this exercise.

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\(^7\) In many countries energy production is considered very important and water used by the energy sector is often prioritized over agriculture and industry users.  
\(^8\) Reynaud (2003)  
\(^9\) García-Valiñas et al. (2010)  
\(^10\) Urban water: Espey et al. (1997) estimated a mean water demand elasticity of -0.51 from a sample of 124 elasticities. Dalhuisen et al. (2003) obtained a mean elasticity of -0.41 after adding 172 observations to the Espey et al. Sebri (2014) obtained a mean elasticity of -0.37 from a sample of 638 elasticities. A complete review has been published by the JRC (Reynaud 2015).  
Industry: Renzetti (1992) study 2,000 firms finding that industrial elasticity is inelastic with an average of -0.38 (price elasticities for intake water range from -0.1534 (Plastics and Rubber) to -0.5885), although in a more recent Dupont and Renzetti (2001) found an elasticity of -0.77.  
Agriculture: A meta-analysis of irrigation water price elasticity has been reported by Scheierling, et al. (2016). European cases are also in great numbers, examples are: Spain: Berbel and Gómez-Limón, (2000), Gómez-Limón and Riesgo (2004); Italy: Bartolini et al. (2007), Bazzani et al. (2005), Galioto et al. (2013); Greece: Manos et al. (2006), Kampas et al. (2012), Manos et al. (2009); France: Chohin-Kuper et al. (2003), Rinaudo, (2013), de Frutos et al. (2017); Serbia: Ørum et al. (2010); Portugal: Pinheiro and Saraiva (2005) and UK: Vasileiou et al. (2014).
4 Alternative water allocation regimes and scarcity conditions for eight selected river basins

4.1 Selected basins and approach

The Economic Water Allocation (EWA) model was applied to eight EU basins to analyse the impact of water scarcity and water reallocation policies. This chapter summarizes the key findings on the effect of the six different allocation regimes on the GVA under water scarcity conditions in eight different River Basin Districts (RBD).

The River Basin Districts (RBDs) selected to test the EWA model were chosen to provide a good representation of RBDs across the EU, based on the following criteria:

- Wide geographical representation (i.e. RBDs from Scandinavia, the Mediterranean, Eastern and Western Europe);
- Different sizes (i.e. RBDs with large and small catchments);
- As far as possible overlap with the RBDs analysed under task A3; and
- Different levels of data availability (i.e. RBDs that were likely to have at least reasonable information and those which might be data poor).

Figure 5 below shows the river basins that were selected to test the EWA model. When key data ([1] water abstraction, [2] economic output (GVA) and [3] employment at sectoral and basin level) were not available for a basin, gap filling was carried out by using country data (national level or NUTS2 when available) as reference. Annex B summarises the resulting data at the river basin level, after gap filling was conducted.

**Figure 5 The eight river basin districts analysed in this report**

Source: own elaboration, Map source: Light Gray Canvas, sources: Esri, DeLorme,
The service sector is generally granted enough access to water, as it is the economic activity that generates more GVA (average 87% of basin total GVA, ranging from 76% in the Guadalquivir RBD to 93% for the Tidal Elbe RBD) and employment. In addition, it does not require large amounts of water. Therefore, the analysis of policy changes related to water scarcity is conducted with and without the service sector, in order to better show the impact of water scarcity on the most water-dependent sectors.

For each selected river basin, a short introduction of the basin is given, including key parameters. Insight into the economic and water abstractive structure of each sector is provided in Annex B. Results of the EWA model on change in value added is presented for each of the six allocation policy regimes tested under changing water availability conditions. 100 means that GVA is unchanged, whereas 95 means that GVA is 5 percent lower compared to a scenario without water scarcity.

The decision criteria for the allocation policy is based upon a sector hierarchy where the ranking is defined according to [a] the current allocation regime, [b] flat allocation (no hierarchy meaning that reduction in water use is distributed to all sectors evenly, i.e. that the water use of each sector is reduced by the same percentage), [c] sectoral WPI (GVA/m³) and sectoral jobs/m³ meaning that the sectors with highest GVA/m³ or jobs/m³ are prioritised by allocating water resources to the sectors according the hierarchy determined by these ratios: The ratio WPI (GVA/m³) and job/m³ are derived from the basin key parameters (see Annex B). Table 2 shows resulting sectoral WPIs that are used for the ranking of sectors to allocate water when scarcity is simulated. The table shows that the WPI of each sector varies considerably across river basins. A similar procedure is done for the ratio jobs/m³ that serves as criterion for allocating water when the criteria is to maximize job creation.
4.2 Detailed findings for the eight river basins

This section explains the application of EWA to the eight river basins. Key data and information on data quality and some additional river basin information can be found in Annex B.

4.2.1 Guadalquivir river Basin. Spain

The results of the EWA model show that in the [a] current allocation regime (i.e. local water regime) GVA only decreases by 2% even in the extreme 50% scarcity scenario (see Table 3). When a [b] flat reallocation regime (all sectors get an equal share reduction in their access to water) is imposed, the GVA decreased by 33%, mainly due to the large decrease in the value added of the service sector, including the service sector that contributes around 70% of the total GVA. The [c] WPI optimisation regime is executed with two alternatives: [c1] uses constant WPIs that results in the same ranking as the Current water allocation regime and [c2] that applies variable WPIs (taking observed or estimated elasticity into account). We find that when WPIs or jobs optimisation water allocation regimes are applied, the GVA is almost unaffected by scarcity conditions (e.g. drought event). Based on the model, the current allocation regime for the Guadalquivir river basin seems relatively well adjusted to scarcity conditions.\(^{12}\)

\(^{11}\) The water collection, treatment and supply sector has a low WPI due to its high demand for water compared to output. However, in the modelling exercise (and in reality) this sector will have priority access to water over electricity, other industry and agriculture due to its importance for human life. It is only preceded in importance by the environment (e-flow), which is not part of this analysis.

\(^{12}\) We compare the current water allocation regime with the WPI optimization with constant WPIs, because under current water allocation regime we do not impose variable elasticity. If we impose variable WPIs on the current water allocation regime the resulting loss in GVA would be similar to the WPI or jobs optimization regime with the variable WPI.

Table 2 Sectoral WPIs in the eight selected river basins

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture (livestock)</td>
<td>21.3</td>
<td>72.7</td>
<td>14.7</td>
<td>8.3</td>
<td>4.7</td>
<td>147.8</td>
<td>3.5</td>
<td>21.3</td>
</tr>
<tr>
<td>Agriculture (crops)</td>
<td>1.5</td>
<td>25.1</td>
<td>0.9</td>
<td>0.4</td>
<td>2.5</td>
<td>5.9</td>
<td>4.6</td>
<td>1.5</td>
</tr>
<tr>
<td>Mining and quarrying</td>
<td>36.9</td>
<td>12.6</td>
<td>550.2</td>
<td>6.2</td>
<td>6.2</td>
<td>136.1</td>
<td>315.5</td>
<td>25.6</td>
</tr>
<tr>
<td>Manufacture of food products; beverages &amp; tobacco</td>
<td>25.3</td>
<td>54.5</td>
<td>373.2</td>
<td>65.0</td>
<td>151.5</td>
<td>148.3</td>
<td>19.6</td>
<td>99.4</td>
</tr>
<tr>
<td>Manufacture of textiles, wearing apparel and others</td>
<td>61.2</td>
<td>126.9</td>
<td>739.8</td>
<td>18.8</td>
<td>257.6</td>
<td>404.1</td>
<td>148.3</td>
<td>221.9</td>
</tr>
<tr>
<td>Manufacture of paper and paper products</td>
<td>36</td>
<td>22.4</td>
<td>73.4</td>
<td>22.7</td>
<td>14.9</td>
<td>19.2</td>
<td>4.6</td>
<td>19.2</td>
</tr>
<tr>
<td>Manufacture of coke, pharmaceuticals and chemical</td>
<td>9.3</td>
<td>17.2</td>
<td>168.4</td>
<td>43.6</td>
<td>44.0</td>
<td>28.4</td>
<td>3.2</td>
<td>68.6</td>
</tr>
<tr>
<td>Manufacture of basic metals</td>
<td>5.6</td>
<td>25.4</td>
<td>118.3</td>
<td>40.8</td>
<td>40.8</td>
<td>29.9</td>
<td>93.6</td>
<td>34.1</td>
</tr>
<tr>
<td>Electricity, gas, steam and air conditioning supply</td>
<td>1.1</td>
<td>2.7</td>
<td>149.6</td>
<td>116.5</td>
<td>8.2</td>
<td>16.6</td>
<td>60.1</td>
<td>526.6</td>
</tr>
<tr>
<td>Water collection. treatment and supply(^{11})</td>
<td>2.0</td>
<td>1.0</td>
<td>1.5</td>
<td>0.8</td>
<td>2.2</td>
<td>1.1</td>
<td>1.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Services</td>
<td>625.1</td>
<td>62098.3</td>
<td>1204.7</td>
<td>6993.3</td>
<td>1761.2</td>
<td>2980.1</td>
<td>29574.8</td>
<td>406.4</td>
</tr>
<tr>
<td>Average</td>
<td>16.8</td>
<td>36.0</td>
<td>219.0</td>
<td>32.3</td>
<td>53.2</td>
<td>93.7</td>
<td>65.4</td>
<td>101.8</td>
</tr>
</tbody>
</table>
Table 3: GVA under scarcity and reallocation regimes in Guadalquivir RB

<table>
<thead>
<tr>
<th>Guadalquivir RB</th>
<th>Water availability for abstraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>[a] Current water allocation regime</td>
<td>100</td>
</tr>
<tr>
<td>[b] Flat reallocation</td>
<td>100</td>
</tr>
<tr>
<td>[c1] WPI optimisation. WPI constant</td>
<td>100</td>
</tr>
<tr>
<td>[c2] WPI optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>[d] Jobs optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>[e] Constrained jobs optimisation. WPI var</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GVA by policy scenario (excluding services)</th>
<th>Water availability for abstraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>[a] Current water allocation regime</td>
<td>100</td>
</tr>
<tr>
<td>[b] Flat reallocation</td>
<td>100</td>
</tr>
<tr>
<td>[c1] WPI optimisation. WPI constant</td>
<td>100</td>
</tr>
<tr>
<td>[c2] WPI optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>[d] Jobs optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>[e] Constrained jobs optimisation. WPI var</td>
<td>100</td>
</tr>
</tbody>
</table>

*100 means 100% of current GVA can be achieved. The numbers are rounded and the colours provide visual aid (green is highest GVA, red is lowest GVA).

When services are excluded from the GVA and jobs computation, the impact of water savings can be seen. In fact, [a] current allocation and [b] flat allocation shows a higher impact than changing the current allocation regime to a system that prioritizes WPIs or jobs creation. In the model that excludes services, with lower water scarcity irrigation has a lower WPI compared to energy production but when water becomes scarcer, the productivity of irrigation is higher (due to the increased water productivity implied by the elasticity effect) and water is allocated to this sector.

4.2.2 East Aegean River Basin. Bulgaria

The model results show that for the [a] current allocation regime in the extreme 50% scarcity scenario, GVA is reduced by up to 16% (see Table 4). Flat reallocation regime [b] results in a decrease of GVA of 32%, predominantly due to the large decrease in the value added of the service sector. When reallocation is done based upon [c] WPI optimisation regime and [d] job optimisation regime, using variable WPIs, GVA becomes higher than in the current regime. Thus, based on the model, [c1] WPI optimisation and [c2] job optimisation regimes may improve current regime for the East Aegean River Basin.
Table 4 GVA under scarcity and reallocation regimes in East-Aegean RB

<table>
<thead>
<tr>
<th>East Aegean River Basin</th>
<th>Water availability for abstraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>

**GVA by policy scenario (all sectors included)**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>100%</th>
<th>90%</th>
<th>80%</th>
<th>70%</th>
<th>60%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>[a] Current water allocation regime</td>
<td>100</td>
<td>99</td>
<td>97</td>
<td>86</td>
<td>85</td>
<td>84</td>
</tr>
<tr>
<td>[b] Flat reallocation</td>
<td>100</td>
<td>94</td>
<td>88</td>
<td>82</td>
<td>75</td>
<td>68</td>
</tr>
<tr>
<td>[c1] WPI optimisation. WPI constant</td>
<td>100</td>
<td>99</td>
<td>98</td>
<td>97</td>
<td>96</td>
<td>95</td>
</tr>
<tr>
<td>[c2] WPI optimisation. WPI var</td>
<td>100</td>
<td>100</td>
<td>99</td>
<td>98</td>
<td>98</td>
<td>96</td>
</tr>
<tr>
<td>[d] Jobs optimisation. WPI var</td>
<td>100</td>
<td>100</td>
<td>99</td>
<td>98</td>
<td>98</td>
<td>96</td>
</tr>
<tr>
<td>[e] Constrained jobs optimisation. WPI var</td>
<td>100</td>
<td>97</td>
<td>95</td>
<td>86</td>
<td>86</td>
<td>85</td>
</tr>
</tbody>
</table>

**GVA by policy scenario (excluding services)**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>100%</th>
<th>90%</th>
<th>80%</th>
<th>70%</th>
<th>60%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>[a] Current water allocation regime</td>
<td>100</td>
<td>92</td>
<td>76</td>
<td>34</td>
<td>29</td>
<td>24</td>
</tr>
<tr>
<td>[b] Flat reallocation</td>
<td>100</td>
<td>96</td>
<td>91</td>
<td>87</td>
<td>82</td>
<td>77</td>
</tr>
<tr>
<td>[c1] WPI optimisation. WPI constant</td>
<td>100</td>
<td>95</td>
<td>91</td>
<td>86</td>
<td>82</td>
<td>77</td>
</tr>
<tr>
<td>[c2] WPI optimisation. WPI var</td>
<td>100</td>
<td>98</td>
<td>96</td>
<td>93</td>
<td>89</td>
<td>84</td>
</tr>
<tr>
<td>[d] Jobs optimisation. WPI var</td>
<td>100</td>
<td>98</td>
<td>96</td>
<td>93</td>
<td>89</td>
<td>84</td>
</tr>
<tr>
<td>[e] Constrained jobs optimisation. WPI var</td>
<td>100</td>
<td>85</td>
<td>78</td>
<td>37</td>
<td>35</td>
<td>33</td>
</tr>
</tbody>
</table>

* 100 means 100% of current GVA can be achieved. The numbers are rounded and the colours provide visual aid (green is highest GVA, red is lowest GVA).

When reallocation excludes services the result is similar, although when only agriculture and industrial sectors are considered the model shows higher impact of water scarcity when allocation does not consider GVA or job hierarchy.

4.2.3 **Tidal Elbe River Basin. Germany**

The model simulates that in the [a] current allocation regime in the extreme 50% scarcity scenario, GVA decreases by up to 7% (see Table 5). The [b] flat reallocation regime results in a decrease of GVA by 34%, predominantly due to the large decrease in the value added of the service sector. The [c1] WPI optimisation regime, when constant WPIs are applied, results in a higher GVA compared to the current allocation regime (5% higher). GVA in the basin under [c2] WPI optimisation using variable WPIs is slightly higher, as only 1% of GVA is lost. Based on the model, optimisation of jobs is preferable compared to optimisation of WPIs. However, when considering the constrained jobs optimisation regime, the GVA will be similar to the current allocation regime as jobs will be maintained in sectors with a comparatively low productivity (e.g. energy sector compared to a manufacturing sector). The model that excludes services shows that a constrained jobs optimisation regime has much lower resulting GVA compared to a regime based on WPIs. Selection of the best allocation regime will likely be a mix of WPI and jobs optimisation, this however should be determined by future research using more detailed sectoral data.
When the service sector is excluded from the analysis, the overall GVA decreases sharply. While agriculture uses a small percentage of water, the energy (cooling) sector is the larger user in this basin and is affected directly by the scarcity, as the agriculture water less than 20% so that water scarcity impacts the sector with the second lowest WPI (energy cooling) . Based on these findings, the model would suggest increasing water use efficiency for electricity production (energy cooling) as an adaptation to future scenarios where water scarcity affects the Tidal Elbe River Basin.

4.2.4 Jucar River Basin. Spain

The model estimates that under the [a] current allocation regime (Hydrological Plan Normative) in the extreme 50% scarcity scenario GVA is reduced by up to 1% (see Table 6); the [b] flat reallocation regime will result in a decrease of GVA by 34%, mainly due to the large decrease in the GVA of the services sector. Under the WPI optimisation criteria when [c] WPI is constant (does not react to scarcity) and [d] variable WPI (average productivity grows as water decreases) GVA is higher compared to the current local regime [a]. Finally, when the criteria of optimisation are jobs (with/without constraint), the resulting GVA is similar to WPI optimisation. Table 6 also shows the result when service sector is excluded with results comparable to the full model.

### Table 5 GVA under scarcity and reallocation regimes (Tidal Elbe RB)

<table>
<thead>
<tr>
<th>Tidal Elbe River Basin</th>
<th>Water availability for abstraction</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GVA by policy scenario (all sectors included)</strong></td>
<td>100%</td>
</tr>
<tr>
<td>[a] Current water allocation regime</td>
<td>100</td>
</tr>
<tr>
<td>[b] Flat reallocation</td>
<td>100</td>
</tr>
<tr>
<td>[c1] WPI optimisation. WPI constant</td>
<td>100</td>
</tr>
<tr>
<td>[c2] WPI optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>[d] Jobs optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>[e] Constrained jobs optimisation. WPI var</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Allocation Regimes (excl. services)</strong></th>
<th>100%</th>
<th>90%</th>
<th>80%</th>
<th>70%</th>
<th>60%</th>
<th>50%</th>
</tr>
</thead>
<tbody>
<tr>
<td>[a] Current water allocation regime</td>
<td>100</td>
<td>63</td>
<td>30</td>
<td>23</td>
<td>19</td>
<td>15</td>
</tr>
<tr>
<td>[b] Flat reallocation</td>
<td>100</td>
<td>95</td>
<td>89</td>
<td>84</td>
<td>78</td>
<td>71</td>
</tr>
<tr>
<td>[c1] WPI optimisation. WPI constant</td>
<td>100</td>
<td>97</td>
<td>93</td>
<td>89</td>
<td>85</td>
<td>81</td>
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<tr>
<td>[c2] WPI optimisation. WPI var</td>
<td>100</td>
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<td>97</td>
<td>94</td>
<td>90</td>
<td>86</td>
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<tr>
<td>[d] Jobs optimisation. WPI var</td>
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<td>100</td>
<td>100</td>
<td>97</td>
<td>94</td>
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<tr>
<td>[e] Constrained jobs optimisation. WPI var</td>
<td>100</td>
<td>76</td>
<td>34</td>
<td>25</td>
<td>23</td>
<td>20</td>
</tr>
</tbody>
</table>

* 100 means 100% of current GVA can be achieved. The numbers are rounded, and the colours provide visual aid (green is highest GVA. red is lowest GVA).
Table 6 GVA under scarcity and reallocation regimes (Jucar RB)

<table>
<thead>
<tr>
<th>Jucar River Basin</th>
<th>Water availability for abstraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>GVA by policy scenario (all sectors included)</td>
<td></td>
</tr>
<tr>
<td>[a] Current water allocation regime</td>
<td>100</td>
</tr>
<tr>
<td>[b] Flat reallocation</td>
<td>100</td>
</tr>
<tr>
<td>[c1] WPI optimisation. WPI constant</td>
<td>100</td>
</tr>
<tr>
<td>[c2] WPI optimisation. WPI var</td>
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</tr>
<tr>
<td>[d] Jobs optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>[e] Constrained jobs optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>Allocation Regimes (excl. services)</td>
<td></td>
</tr>
<tr>
<td>[a] Current water allocation regime</td>
<td>100</td>
</tr>
<tr>
<td>[b] Flat reallocation</td>
<td>100</td>
</tr>
<tr>
<td>[c1] WPI optimisation. WPI constant</td>
<td>100</td>
</tr>
<tr>
<td>[c2] WPI optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>[d] Jobs optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>[e] Constrained jobs optimisation. WPI var</td>
<td>100</td>
</tr>
</tbody>
</table>

* 100 means 100% of current GVA can be achieved. The numbers are rounded and the colours provide visual aid (green is highest GVA. red is lowest GVA).

4.2.5 Rhone River Basin. France (& Switzerland)

The model results show that for the [a] current allocation regime (i.e. local water regime) in the extreme 50% scarcity scenario (average annual 50% reduction) GVA is reduced by only 2% (see Table 7). The [b] flat reallocation regime results in a decrease of GVA by 34% (66% vs baseline), predominantly due to the large decrease in the value added of the service sector. The WPI optimisation regime (both under [c1] constant WPI and [c2] variable WPI simulation) results in a higher GVA compared to the local regime (only 1% reduction or 99% vs baseline) in the extreme scenario. Choosing an optimisation with the aim to maximise employment shows a slightly lower result.

Table 7 GVA under scarcity and reallocation regimes (Rhone River Basin)

<table>
<thead>
<tr>
<th>Rhone River Basin</th>
<th>Water availability for abstraction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>GVA by policy scenario (all sectors included)</td>
<td></td>
</tr>
<tr>
<td>[a] Current water allocation regime</td>
<td>100</td>
</tr>
<tr>
<td>[b] Flat reallocation</td>
<td>100</td>
</tr>
<tr>
<td>[c1] WPI optimisation. WPI constant</td>
<td>100</td>
</tr>
<tr>
<td>[c2] WPI optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>[d] Jobs optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>[e] Constrained jobs optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>Allocation Regimes (excl. services)</td>
<td></td>
</tr>
<tr>
<td>[a] Current water allocation regime</td>
<td>100</td>
</tr>
<tr>
<td>[b] Flat reallocation</td>
<td>100</td>
</tr>
<tr>
<td>[c1] WPI optimisation. WPI constant</td>
<td>100</td>
</tr>
<tr>
<td>[c2] WPI optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>[d] Jobs optimisation. WPI var</td>
<td>100</td>
</tr>
<tr>
<td>[e] Constrained jobs optimisation. WPI var</td>
<td>100</td>
</tr>
</tbody>
</table>

* 100 means 100% of current GVA can be achieved. The numbers are rounded and the colours provide visual aid (green is highest GVA. red is lowest GVA).

The model without services sector show similar results to the full model.
4.2.6  Vistula River Basin. Poland (& Belarus. Ukraine and Slovakia)

Results show that for the [a] current allocation regime (i.e. local water regime) in the extreme 50% scarcity scenario (average annual 50% reduction) GVA is reduced to 93% (see Table 8). The [b] flat reallocation regime result in a decrease of GVA by 34% (66% vs baseline), predominantly due to the large decrease in the value added of the service sector. The WIPI optimisation regime (both with [c1] constant WPIs and [c2] variable WIPI) results in a higher GVA compared to the current regime. Optimisation of jobs and constrained jobs optimisation leads to a larger decrease in GVA compared to the WIPI allocation regimes.

Table 8 GVA under scarcity and reallocation regimes (VTRB)

<table>
<thead>
<tr>
<th>Allocation Regimes (excl. services)</th>
<th>Vistula RBD</th>
<th>Water availability for abstraction</th>
</tr>
</thead>
<tbody>
<tr>
<td>GVA by policy scenario (all sectors included)</td>
<td>100%</td>
<td>90%</td>
</tr>
<tr>
<td>[a] Current water allocation regime</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>[b] Flat reallocation</td>
<td>100</td>
<td>94</td>
</tr>
<tr>
<td>[c1] WIPI optimisation. WIPI constant</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>[c2] WIPI optimisation. WIPI var</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>[d] Jobs optimisation. WIPI var</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>[e] Constrained jobs optimisation. WIPI var</td>
<td>100</td>
<td>99</td>
</tr>
</tbody>
</table>

* 100 means 100% of current GVA can be achieved. The numbers are rounded and the colours provide visual aid (green is highest GVA. red is lowest GVA).

When the simulation is done excluding services, the economic losses in terms of GVA of the current water allocation regime are significantly lower than the WIPI (constant and variable) and jobs optimisation regimes. The current and (constrained) jobs regime is significantly less favourable to all other regimes when services are excluded from reallocation.

4.2.7  South Baltic Sea. Sweden

The model results show that for the [a] current allocation regime (i.e. local water regime) in the extreme 50% scarcity scenario GVA is reduced by up to 6% (94% vs. baseline) (see Table 9). The [b] flat reallocation scenario will result in a decrease of GVA by 34% (66% vs baseline). predominantly due to the large decrease in services value added. In the South Baltic River Basin, the WIPI or jobs optimisation regimes result in a higher GVA compared to the local regime.
The model excluding services shows that an optimisation favouring employment is again the best choice when aiming to maximise value added in the Arges-Vedea River Basin.
4.3 Key findings

The analysis of effects of increasing water scarcity scenarios combined with alternative water allocation regimes has been applied to eight EU river basins. The main findings of the simplified economic allocation model based on water productivity index are:

- The water scarcity affects initially to agriculture as the sector with lower WPI and sectors with higher productivity are only affected when water supply reduction is severe.
- Water scarce basins (Guadalquivir, Jucar, Rhone and Arges-Vedea) with an average agricultural water use around 70% have already implemented some allocation regimes with a definition of user hierarchy (agriculture is the first sector affected and industry and urban are the higher priority). These regimes give an allocation of resources similarly to a policy scenario based upon GVA and jobs maximization.
- Basins where water resources are more abundant (East-Eagean, Tidal Elbe, Vistula and South Baltic), agriculture typically plays a minor role (average use 17%). In case of severe water scarcity, the agricultural sector cannot act as a buffer for water saving (see previous paragraph) and therefore under severe scarcity economic losses affect to industrial sectors, mainly energy cooling that exhibit the lower WPI.
- The model (EWA) suggest that water re-allocation can improve economic output if water moves from low to high value activities either internally within the agricultural sector or between sectors (e.g. from agriculture or mining to higher value uses).

4.4 Limitation of the selected approach

As we have mentioned, the EWA basin model makes the most possible of the available data and can be applied to all other river basins in Europe allowing an evaluation of the current allocation regime from the economic point of view.

We compared the EWA model with the detailed and information-intensive hydro-economic model originally developed for the Guadalquivir River Basin (see next Chapter) concluding that EWA model provides satisfactory approximation to basin water allocation results compare to more data demanding hydro-economic models (see Annex C).

The EWA model may be improved in the future by integrating the economic analysis with a more detailed hydrological module or by incorporating WPIs estimated at the basin and sectoral level and finding sector specific WPI adaptation to water scarcity that improve the estimated elasticities used here.
This chapter presents an analysis of reallocation induced by water pricing based on a detailed hydro-economic model that is applied to the Guadalquivir River Basin. The model is used to assess the impact of water sue reallocation induced by scenarios of water pricing and Gross Value Added (GVA) maximization, both under increasing water scarcity.

5.1 Reallocation based on water pricing

The Article 9 of the Water Framework Directive (WFD) requires the use of water pricing to implement cost recovery. This is used according EEA (2013) as a mechanism for implementing the polluter-pays principle, and for improving efficiency in water use (minimising resource waste) and allocation (by allocating water to the most productive uses).

In principle, cost recovery should also include environmental and resource costs (ERCs), i.e. the costs derived from the environmental impacts caused by water use and the costs derived from the foregone opportunities due to the depletion of the water resources. ERCs are particularly difficult to estimate, due to a wide range of methodological challenges and data gaps. The work described in this chapter does not include an estimation of the ERCs, as this is out of the scope.

Some countries include at least part of the ERCs in their water tariffs. For example, France, Portugal and Italy have implemented a withdrawal ecotax applied to all economic uses of water and all water sources (groundwater or surface water), even though the level of water taxation is still low (World Bank-OECD, 2018):

- In France, a higher tariff is applied in water-scarce areas. In fact, the standard tariff for agricultural water abstraction in the Rhône Méditerranée is 0.001 EUR/m³ (year 2018) and it is duplicated (0.002 EUR/m³) in water scarce areas.
- Portugal has approved a tax for all water uses including irrigation at a level of 0.0032 EUR/m³ which is increased by 20% when abstraction is carried out in a water-stressed area.
- Italy has implemented a ‘resource tax’ for irrigation water use (0.001198 EUR/m3), which is increased by 300% in some circumstances (resources with drinking quality).
- Some EU states have implemented a water abstraction tax such as Germany (Baden-Württemberg) and the Netherlands have introduced water abstraction tax, yet they have both exempted the irrigation.

These tariffs and taxes are designed to induce water savings and to internalize some ERCs, although most of the tariffs are based on a political decision without a detailed economic analysis. In Spain some tariffs recover the cost of the water services such as storage, transport and other services associated to water supply and sanitation services, but regarding ERCs, there is not an abstraction tax that aims to internalizing ERCs (see Annex C for tariff description). However, in our model the water tariff currently in place for irrigation, which is the main user in the Guadalquivir RBD, is 0.012 EUR/m³.

Three scenarios of water pricing are proposed to induce water reallocation and water saving: [A] Current-baseline (2015); [B] Increase if water prices by 100%; [C] Increase of water prices
by 175%; [D] Increase of water prices by 300%. The water price in each scenario is calculated with respect to the current water price per each sector.

Table 10 summarizes the changes in GVA and the water savings that result from the above-mentioned water price increase. These scenarios assume that water pricing/cost is volumetric (i.e. water is priced by cubic metre), as it is required by legislation for both the irrigation and other economic sectors.

Table 11 Reallocation scenarios based on water pricing.

<table>
<thead>
<tr>
<th>Column &amp; price scenario</th>
<th>[A]</th>
<th>[B]</th>
<th>[C]</th>
<th>[D]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario Price (average) Agric.= farm gate Urban= supply + WWT</td>
<td>Baseline Agric.=0.06€/m³ Urban=1.90€/m³</td>
<td>Base +100% Agric.=0.12€/m³ Urban=3.80€/m³</td>
<td>Base +175% Agric.=0.16€/m³ Urban=5.22€/m³</td>
<td>Base +300% Agric.=0.24/m³ Urban=7.60€/m³</td>
</tr>
<tr>
<td>GVA irrigated agriculture (10⁶ EUR)</td>
<td>2,850</td>
<td>2,829</td>
<td>2,707</td>
<td>2,365</td>
</tr>
<tr>
<td>GVA remaining sectors (10⁶ EUR)</td>
<td>74,111</td>
<td>74,104</td>
<td>74,018</td>
<td>73,830</td>
</tr>
<tr>
<td>GVA of the entire RBD (10⁶ EUR)</td>
<td>76,961</td>
<td>76,933</td>
<td>76,725</td>
<td>76,195</td>
</tr>
<tr>
<td>Water use in irrigation (hm³)</td>
<td>3,085</td>
<td>2,997</td>
<td>2,349</td>
<td>1,601</td>
</tr>
<tr>
<td>Water use remaining sectors (hm³)</td>
<td>424</td>
<td>324</td>
<td>294</td>
<td>262</td>
</tr>
<tr>
<td>Total water use % vs. baseline</td>
<td>100%</td>
<td>95%</td>
<td>75%</td>
<td>53%</td>
</tr>
</tbody>
</table>

Source: Own elaboration; The baseline year is 2015.

The higher price scenario leads to water savings of 47% compared to the baseline. Water pricing policies induce savings in all sectors depending on their specific price-elasticities, and, as expected, the irrigation sector is the sector where an increase in the price of water induces greater savings (i.e. 87). Results also show that GVA losses are limited to a small percentage of total GVA (<1%) in the extreme case [D]. This can be explained with the fact that irrigation agriculture is the only economic sector affected (its GVA decreases by 17% with respect to the baseline, i.e. from EUR 2,850 million to EUR 2,365 million).

Response to water prices shows a reallocation of water uses within the agricultural sector (85% of water use at baseline). The price increase effect in agriculture implies that water is used for high-value crops and less water is used in low value crops (such as rice or other commodities). Additionally, price increase the share of crops under deficit irrigation, typically around 50% of maximum yield requirements). The impact of water pricing on the water use of non-irrigation sectors is significantly smaller in quantitative terms (in the range of prices that has been simulated).

5.2 Key findings hydro-economic model applied to Guadalquivir River Basin

The Guadalquivir river basin can be considered a representative Mediterranean basin experiencing resource scarcity and water stress, and for this reason the conclusions of this work can be applied to other Mediterranean RBDs. The key findings (see table 11 above) are:

- The low share of the GVA of agriculture (<4%) explains that the economic impact of the extreme scarcity scenario (50%) is small (<1% GVA), including direct impacts on irrigation and economy-wide effects on the service and industrial sectors).
- Water pricing induces water savings mainly in the irrigation sector, but in this basin the savings start once some threshold is surpassed. This is explained as most of the
crops are export-oriented high-value crops, and small increases in price do not induce changes in the farmers’ behaviour.

5.3 Main differences between the two modelling approaches

The application of the Hydro-economic model (HEM - see the previous chapter) and the Economic Water Allocation model (EWA) result in similar findings when applied to the Guadalquivir RBD (see Annex C for further explanations on both models). Table 12 summarizes similarities and differences.

Table 12 Main differences between the two modelling approaches

<table>
<thead>
<tr>
<th>Item</th>
<th>Economic Water Allocation (EWA)</th>
<th>Hydro-economic model (HEM)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Similarities in the results of the Guadalquivir RBD simulation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sectors affected by reallocation under extreme scarcity (water availability at 50% of current use)</td>
<td>Only the irrigation sector is affected, as it accounts for 87% of economic uses (*) in normal years.</td>
<td></td>
</tr>
<tr>
<td>Economic impact (on GVA) of water scarcity of up to 50% of present use</td>
<td>The reduction of the GVA is small as irrigation is the only sector affected (the baseline irrigation share of the GVA of the entire basin is 4%).</td>
<td></td>
</tr>
<tr>
<td><strong>Differences in the results of the Guadalquivir RBD simulation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact of water scarcity (savings) on non-irrigation sectors</td>
<td>No impact estimated</td>
<td>Reduced industry and service GVA, explained by the economy-wide indirect impact of reduced agricultural output</td>
</tr>
<tr>
<td>Impact of water scarcity (savings) on regulating ecosystem services (pollution removal)</td>
<td>No considered</td>
<td>Some impact, although negligible as the market value of regulating ecosystem services is less than 0.1% of the basin’s GVA</td>
</tr>
<tr>
<td>Water pricing</td>
<td>No included</td>
<td>Simulated</td>
</tr>
<tr>
<td><strong>Model characteristics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Model nature</td>
<td>Economic</td>
<td>Hydrological and economic</td>
</tr>
<tr>
<td>Agricultural sectors</td>
<td>Livestock, irrigated crops</td>
<td>Livestock, Irrigated crops, Rain-fed crops</td>
</tr>
<tr>
<td>Service sectors</td>
<td>Water supply and sewerage Services (general)</td>
<td>Households (domestic), Services, Navigation</td>
</tr>
<tr>
<td>Industrial sectors</td>
<td>Food and beverages, Textiles, Paper, Chemicals, Metals, Mining</td>
<td>Only general ‘manufacturing’</td>
</tr>
<tr>
<td>Energy</td>
<td>Energy production (cooling)</td>
<td>Energy (cooling), Hydropower</td>
</tr>
<tr>
<td>Ecosystem services</td>
<td>Not included</td>
<td>Nutrient (N) removal</td>
</tr>
<tr>
<td>Hydrologic variables</td>
<td>Not included</td>
<td>Abstraction, consumption and return flows</td>
</tr>
<tr>
<td>Basins analysed</td>
<td>Eight RBs</td>
<td>Only Guadalquivir RB</td>
</tr>
</tbody>
</table>

Source: Own elaboration. (*) Environmental flow is not considered as a water use and it is managed as a constraint that is always respected and not allowing trade-offs with economic uses.
In previous sections, alternative water allocation regimes were presented basin level assessing the socioeconomic impact. The goal of this chapter is to explore the conflicts between competing water uses at the water body level. Two examples will be presented: 1) ‘Fuencaliente’ aquifer (Spain), where the conflict is about the quantitative allocation of scarce groundwater resources; 2) the East Aegean River Basin District (Bulgaria), which is used to explore the allocation of nutrient load in surface water bodies.

6.1 Competition for groundwater resources. Fuencaliente aquifer

A groundwater body was identified in the Fuencaliente hydrological system (southern Spain). The case illustrates the economic value of water of the three conflicting uses and the trade-off between them.

The competing uses are [1] intensive horticulture located in the aquifer recharge; [2] recreational use of spring flow; [3] traditional farmers using spring water. These uses can be characterized as follows:

[1] Intensive horticulture generates 1.54 EUR of GVA per m³. It generates more value for the export sector. This use is conflicting with the other two that we define below.

[2] Recreational use of the spring, which is slightly thermal, and the associated pond by the citizens of the nearby municipalities. The site is open to the public all year round and has some facilities such as green areas, trees, bar and a rural hostel. This use is non-consumptive, but it requires a minimum spring flow. Based upon visitors’ valuation of recreational ecosystem services as an average of various techniques (travel cost and contingent valuation), (see Annex C), the value of the recreational use of the spring and the pond is estimated at around 0.35 EUR/m³.

[3] Traditional irrigation has been using this spring water since Arabic times (year 1500 by Queen of Castille decree). The water used for irrigation of traditional crops (maize, alfalfa, olive, almonds) generates a GVA of 0.50 EUR/m³.

As it can be seen, the GVA generated by commercial horticulture is significantly higher than the one generated by the other two uses, and for this reason the sector exerts pressure to increase its water allocation. However, in 2015 the Hydrological Plan allocation limited groundwater abstraction for commercial horticulture to guarantee compatibility with the other two uses. This consensus allocation between different stakeholders (traditional farmers, commercial farmers and rural population) has been facilitated by the intervention of the Basin Water Agency and the agreement has been incorporated into legal planning.

Key findings of this case are the following:

- Although commercial agriculture apparently generates a higher GVA per unit of water compared to recreational and traditional farming, the fact that stakeholders reached an agreement in 2015 shows that other non-market values were implicitly taken into consideration in the final decision. These include the cultural and historical values attributed to the Fuencaliente by residents and society in general.
Water pricing as a reallocation tool is not effective in \textit{Fuencaliente} system as the horticulture demand curve is very inelastic and the current tariffs need to be increased disproportionately (by 16 times the current tariff) to stop cultivation of high value crops\textsuperscript{13} (see Annex C).

Conflict cannot be optimally solved by markets alone, and a negotiating process among all relevant stakeholders is needed, as well as the involvement of a public body (the Water Agency in this case). In fact, market prices do not take into consideration a wide range of values, including those related to cultural ecosystem services.

6.2 Competition for load discharge. East Aegean River Basin District

6.2.1 Introduction

This case study analyses selected water bodies with competing uses that are part of the East Aegean River Basin District (EARBD)\textsuperscript{14}. The objective of this case study is to test whether it is possible to complement to the analysis of models EWA and HEM that have been focused on economic optimisation under water scarcity constrains. The approach has strong similarities to the WPI approach but replaces water quantity with a water quality aspect (nutrient load).

The economic activity, population density, nature objectives and water characteristics have been described by the FISHFARMING project (2014)\textsuperscript{15} and nutrient loads were detected as a main environmental issue impacting negatively in water quality. Three main sources of nutrient run-off are identified: [1] fish farming in reservoirs; [2] agricultural production in watersheds and [3] biodiversity ('fish-eating' birds). The nitrogen load in the sub-basins needs to decrease to achieve the water quality objectives in the WFD.

6.2.2 Approach and results

The case study explores the opportunity cost of reducing nutrient pollution by reducing the output of economic sectors mentioned above to allow for an increase in the number of 'fish-eating' birds without affecting current nutrient load. The optimisation objective is thus to achieve the Natura 2000 objective and achieve WFD goals at the expense of economic output.

First, the Nutrient Productivity Index (NPI) is calculated for each competing user, for each of the selected sub-basins. The NPI is calculated by dividing total sector value added by total nutrient pollution. The resulting sector’s NPI shows the value of 1 tonnes of pollution (nutrient load). The value added of one tonne nutrient load (1 NPI) equals for instance 1.000 EUR of value added in for the aquaculture sector and 500 EUR for the agricultural sector in sub-basin Kardzhali\textsuperscript{16}. Alternatively, in the Konush sub-basin one tonne of nutrient load (1 NPI) equals aquaculture value added of 750 EUR and agriculture value added of 1.500 EUR. Estimating

\textsuperscript{13} This case study presents also an example of the implementation of a tariff for groundwater users in Spain thus serving as pilot case for groundwater allocation in the country.

\textsuperscript{14} The sub-basins of the EARBD that are taken into account are stretches of the: Kardzhali-; Batak-; Koprinka-; Tskanov Kamak-; Konush-; Kavaka-; and the Shirikolashka river.

\textsuperscript{15} EEA Grant, project led by University of Plovdiv Bulgaria

\textsuperscript{16} Mock figures to explain the approach
the value added of 1 NPI for each economic sector for all sub-basins allows the estimation of the optimal allocation of nutrient load across these basins.

Second, the increase in nutrient load due to the increase in ‘fish-eating’ birds (Natura 2000 objective) is estimated. The increase in nutrient load by fish eating birds is the amount of nutrient load that economic sectors (competing polluters rather than competing users) need to pollute less.

Third, the amount of nutrient load that needs to be decreased in the basin to maintain a status quo nutrient load level is divided by the economic sectors across the six sub-basins. The economic sector and sub-basin with the lowest NPI will cease production, followed by the second sector with a low NPI up to the point that nutrient load reaches the status quo.

Fourth, the loss in economic activity of the various sub-basins is added up to determine the opportunity cost of achieving the Natura 2000 objective using nutrient load as economic optimization tool. Due to high uncertainty on data on economic value added per tonne of fish for the EARBD it was not possible to execute the proposed methodology in full.

In Annex D the above methodology has nonetheless been applied and rough calculations have been made: although uncertain it is found that in order to allow for an additional pollution of 1,96 tonne of nutrients (to increase bird population up to Natura 2000 objective), the Konush region should reduce fish production and the Kavaka region should decrease agricultural production.

6.2.3 Key findings

The case study shows how pollution can be reduced in a more cost-efficient manner by looking at opportunity costs of improving biodiversity using comparative nutrient productivity. The approach is applied to EARBD’s Natura 2000 objective but can be adopted to address WFD water quality issues in a similar manner. When executing the methodology, it was found that information is scarce and obtaining robust data is difficult, we however expect that information required to estimate a sector’s NPI is feasible for most river basins across Europe. This case study shows that estimating the opportunity cost of achieving WFD objectives could be through analysis of a sector’s NPI and that NPI might be an alternative to WPI as this indicator does not take water quality into account.

More detailed information can be seen in Annex D.
7 Key findings and recommendations

7.1 Key findings

Policy makers have available alternative instruments for water reallocation, including central allocation, water pricing, water markets and water banks. This study presents [a] an Economic Water Allocation (EWA) model aiming at simulating reallocation policies in eight river basins in the EU under increasing water scarcity. Furthermore, this study investigates two alternative approaches to optimise allocation: [b] a full hydro-economic model applied to the ‘data-rich’ Guadalquivir RB; and [c] an addition to the WPI method for optimization, by including nutrient load (and biodiversity objectives) as a parameter to be considered in the optimization process.

The aim of the EWA model was to increase understanding of the impact of water scarcity scenarios in economic output (GVA) and the impact of alternative water allocation regimes on a river basin’s value added compared to the current regime. The list below summarizes key findings:

- The review of existing water allocation and reallocation instruments in use in the EU indicates that all available methods (central allocation, water pricing, user-based, water markets and water banks) are used in the EU. The review found that EU member states have selected an instrument that is (often) best adapted to local circumstances. However, as water rights/allocation in some cases is ‘dated’, the allocation of water between economic sectors might not be optimal in the future when droughts become more common.

- The Water Framework Directive (WFD) establishes that economic information is collected ‘at least at industry, households and agriculture level’ (Art. 5, Art. 9 and Annex III). This report demonstrates the need to subdivide sector data collection further down at the level required for each basin (e.g. agriculture divided into irrigation and livestock, industry divided into energy and manufacturing, etc.). This information can be used to mitigate the impact on GVA and jobs of alternative water allocation regimes under scarcity conditions.

- Generally, as water scarcity reduces water supply below current levels, the reallocation based upon maximizing economic value (GVA) or job creation forces water saving in the agricultural sector before affecting the other economic uses.

- Water scarce basins (Guadalquivir, Jucar, Rhone and Arges-Vedea) have already implemented some allocation regimes with a definition of user hierarchy. These regimes operate similarly to a regime based upon GVA and jobs maximization with a scarcity scenario in our model. The average agricultural water use in the water scarce basins is 70% of the total water use, against an average use of 17% for the water-abundant river basins (see next bullet point).

- In basins where water resources are not scarce (East-Eagean, Tidal Elbe, Vistula and South Baltic), agriculture typically plays a minor role. In case of water scarcity, the agricultural sector cannot provide the entire required water saving (see previous paragraph) and therefore the simulation of a severe scarcity scenario produces higher economic losses (affecting industrial sectors).

- The theoretical model (EWA) suggest that water reallocation can improve economic output if water moves from low to high value activities either internally within the agricultural sector or between sectors (e.g. from agriculture or mining to higher
value uses). In the East-Aegean River Basin (the most extreme case), a change from the current water regime to a regime that maximises either GVA or jobs results in an increase of up to 12% of the GVA when water supply falls to 50% of normal abstraction levels.

The hydro-economic model (HEM) [b] analysis tested reallocation induced by an increase of the water price in the Guadalquivir RBD. Results show that **water pricing can induce water savings mainly by reducing water use in the irrigation sector**. The output of the non-irrigation sectors is not affected neither in the current allocation regime (as they have higher priority than irrigation), nor in a hypothetical reallocation based on GVA or job maximization. The explanation of this effect is the fact that scarcity up to 50% affects only irrigation (which is responsible of 87% of the total water use).

[c] Analysing conflicting allocation of water resources at water body level, including water quality (nutrient load) as an objective, allows to show the trade-offs among very specific economic uses (e.g. agriculture, biodiversity, fish farms). For a selection of East-Aegean sub-basins (those that had some data on nutrient load and economic value added) it was tested a) whether adding nutrient load to the WPI of economic sectors was feasible and b) what the opportunity cost are of achieving Natura 2000 objectives (which increase nutrient load), whilst keeping total nutrient load levels equal. Although data is very scarce, the analysis showed that estimating a nutrient productivity index (NPI) is feasible and that optimization of economic output including a water quality constraint provides useful findings. The NPI approach of optimization has promising aspects with regards to achieving WFD objectives.

The two reviewed cases ([a] Fuencaliente spring in Southern Spain and [b] East-Aegean reservoirs in Bulgaria) detect allocation conflicts that include market and non-market economic values. **Reallocation requires a consensus between stakeholders and the need of public intervention, as market forces alone cannot guarantee a social optimum.**

### 7.2 Recommendations

**Reallocation instruments**

Based on the results of the modelling exercises at basin level and at water body level, the following recommendations can be made:

- The EU countries have a variety of water allocation policy instruments that are the result of the respective institutional trajectory and natural conditions. EU countries may benefit from the exchange experiences with the goal of improving the collective know-how to advance in the choice of the alternative available instruments. This action is more opportune as climate change is associated with changes in precipitation regimes. Some examples of good practices are:
  - User-based allocation such as ‘zones de répartition des eaux’ in France can be used as a model for reallocation in over-exploited basins and aquifers that can be found mainly, but not exclusively, in Mediterranean regions.
  - Countries willing to introduce an eco-tax to internalize ERC may use the recent experience of Italian, French or Portuguese fiscal instruments to control abstraction in water stressed areas.
Improving robustness of findings

Based upon the experience gained developing the EWA model

- The information used to assess the gross value added (GVA), the water use and the employment per sector is based to a large extent on a gap-filling exercise. Data required at sectoral and river basin level are often not readily available. A critical review of input data would improve robustness of findings.
- The response of a sector to water scarcity conditions may vary considerably across the river basins. This is clear in agriculture which is determined by climate and location, but also the specific industrial sector and subsectors may affect the response to changes in water availability or cost. It is convenient to improve data and knowledge of different sub-sectors’ water use and response to scarcity.

Interpreting results of the EWA model

- The results of the water allocation model should be taken with caution, as the simplifications made regarding the response of the economic sectors to water scarcity may require further analysis. As such, the model results should be interpreted as the maximum impact that can be expected when a river basin becomes water scarce, as the adaptation to scarcity of each sector by increasing allocative or technical efficiency has been approximated with an elasticity factor.
- The EWA model is an economic model and it lacks the hydrological compounds and linkages as they need to be specifically tailor-made for each basin.
- Regardless of the limitations, the EWA model provides an insightful quick-scan of the need to reassess the water allocation regime of a river basin. River basins that in the near future will likely be affected by water scarcity conditions can benefit from application of the EWA model, as results increase the understanding of risks to value added or jobs. This insight can lead to an adjustment of the allocation regime in the river basin or increase investments that mitigate water scarcity.

Improving hydro-economic models at basin level and water body level

- The elaboration of a detailed pilot hydro-economic model for a basin (Guadalquivir) allowed an integration of economic and hydrological elements at sectoral level (i.e. irrigated crops, manufacturing, energy-cooling, navigation, services, nutrient removal, etc.) including water use, output value, price-elasticity, the efficiency of technology and water cost. The use of these models may give useful information but depends on detailed information at basin level and economic sub-sector behaviour.
- Water body conflicting water resources allocation between different uses should be addressed by facilitating consensus building between stakeholders supported by an active public intervention.
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List of acronyms

CGE: Computable General Equilibrium
EARBD: East Aegean River Basin District
EC: European Commission
EEA: European Environment Agency
ERC: Environmental and Resource Cost
ESS: European Statistical System
EUR: Euro
EWA: Economic Water Allocation model
GVA: Gross Value Added
HEM: Hydro- Economic Model
IE: Irrigation Efficiency
JRC: Joint Research Centre
NACE: Nomenclature statistique des Activités economique dans la Communauté Européenne
Natura 2000: Network of nature protection areas in the European Union
NPI: Nutrient Productivity Index
NUTS: Nomenclature of territorial units for statistics
RB: River Basin
RBD: River Basin District
WFD: Water Framework Directive
WPI: Water Productivity Index
### Annex A Water allocation tools and systems

See separate file

### Annex B Detailed results macro-model

See separate file

### Annex C Competing uses in Fuencaliente water body, Guadalquivir River Basin District, Spain

See separate file

### Annex D Competing uses between water bodies in East Aegean River Basin District, Bulgaria

See separate file