Organisation for Economic Co-operation and Development

# Background note: The economics of water scarcity

**April 2022**

For the thematic workshop on 26 - 27 April 2022

This background note aims to inform and support discussions at the third thematic workshop, co-convened by the OECD and the European Commission's Directorate-General for Environment. The workshop is part of a series aimed to facilitate the implementation of the economics of the Water Framework Directive in European Member States. The background note builds on existing literature and experience of EU Member States. It may not reflect the opinion of the OECD, the European Commission or their Member States

Acknowledgements
Xavier Leflaive (OECD) coordinated this paper. A preliminary draft was authored by Stephanie Lyons (then OECD). Paul Arnoldus (DG Environment), Pierre Strosser and Gloria Depaoli (Acteon), Aude Farnault, Helen Laubenstein and Delia Sanchez Trancon (OECD) provided valuable inputs.

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# 1 Purpose of this background note

To inform the workshop on the economics of water scarcity, this background note examines the challenges and policy imperatives involved in addressing water scarcity, water demand and climate change in the context of the Water Framework Directive (WFD).

It has been increasingly recognised that the proper consideration of climate change and its impacts on water availability and demand would require that the programmes of measures to implement the Water Framework Directive (WFD) need to improve their coverage of water scarcity and quantity issues (Climate-ADAPT, 2021[1]; European Commission, 2019[2]; European Commission, DG Environment, 2021[3]). The WFD strives for good quantitative status for groundwater bodies and it calls for sound quantitative management of all freshwater resources as supporting conditions to deliver e-flows and achieve good ecological status for surface waters.

This also determines financing needs and capacities, as supply augmentation and water use efficiency or demand management can have distinctive requirements when it comes to investments and operation and maintenance costs[1]. Moreover, demand management can affect financing capacities of service providers (when volumes of water sold decrease) and the recovery of (fixed) costs of operating water services (think of domestic water supply or irrigation).

In early 2019, the European Commission’s fifth Implementation Report on River Basin Management Plans (RBMPs) highlighted that accounting for climate change impacts would be an important challenge in the next cycles of WFD implementation (Climate-ADAPT, 2021[1]). Later that year, the Fitness Check of the WFD and the Floods Directive (FD) found that, while the directives’ phrasing and flexible provisions are able to support the management of “significant pressures” affecting water bodies and emerging issues, the WFD does not adequately cover water scarcity and quantity challenges (European Commission, 2019[2]). In particular, the Fitness Check noted that a lack of clarity regarding water abstraction and water use (particularly in relation to the use of exemptions) could affect the achievement of good quantitative status (European Commission, 2019[2]). There is also a lack of knowledge on related financing and investment needs: for example, many members states do not yet know the total costs of achieving the policy goals under the WFD while accounting for future climate and other emerging socio-economic global changes (European Commission, DG Environment, 2021[3]).

Climate change is recognised for the significant uncertainty it imposes on water-related decision-making. A recent EC-commissioned study found that currently decisions under the WFD are “made within a context of cascading uncertainty, not only stemming from global climate models and scenarios or the downscaling to regional climate models, but also from the assessment of potential impacts and in socio-economic modelling” (European Commission, DG Environment, 2021, p. 23[3]).

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[1] It should be clear from the outset that one (supply augmentation) is not necessarily more expensive than the other (demand management). Demand management requires investments (think of leak detection and repair) and can increase operation and maintenance (O&M) costs ; hence the notion of economic level of leakage. From an economic and financial perspective, the decision about supply augmentation and demand management is a balancing act, which should be done on a case-by-case basis.

To support the workshop discussions, this note examines the following topics:

1. Current status of water availability, water demand, and influences from climate change in Europe
2. State of play of economic policy instruments to address water scarcity and manage water demand
3. Policy options and considerations for addressing water scarcity and meeting WFD objectives, including issues related to:
    - balancing demand management and supply augmentation
    - managing water scarcity through robust allocation regimes – including the principles and features of effective regimes; drivers and incentives for allocation reforms; the hierarchy and sequencing of water use; abstraction charges; and ensuring return flows and ecological flows
    - increasing use of agro-environmental measures and practices
    - improving the coherence of WFD measures and climate change policies.

## Proposed discussion topics for the workshop

Allocation regimes as tools to enhance water use efficiency:

- Definition of return flows (or net abstraction limits) and e-flows (Germany, Hungary). Do they meet environmental purposes? Are they enforced in practice, at basin level? How the WFD fits in?
- Reflecting flexibility in the definition of water entitlements (including through collective entitlements). How to factor in climate change?
- Experience with the reform of water allocation regimes and accompanying measures.
- The relationship with pricing policies (accounting prices; scarcity premium; social tariffs)

Incentives to use water efficiently and to increase demand for reclaimed water (where appropriate). Implementation of new regulation on reclaimed water.

Scaling up nature-based solutions (NbS) to enhance water retention. The role of water authorities in water retention measures

How to reflect water scarcity risks in broader policy agenda (regional economic development, food security, energy security, recovery packages)?

# 2

# Status of water availability, water demand and impacts of climate change in Europe

Various European regions face mounting water scarcity[2] and competing demand challenges – particularly but certainly not only in southern Europe, where seasonal water shortages are expected to increasingly require interventions such as efficiency improvements in water use (Eurostat, 2020[4]). According to the PESETA IV study (JRC, 2020), many European regions are already facing more frequent, severe, and longer lasting droughts due to climate change.

More severe sustainability challenges are anticipated in the regions that experience low rainfall, intensive agricultural or industrial activity, and high population density, and are likely to be further exacerbated by the impacts of climate change. Water demand and climatic conditions are the two main factors that drive or exacerbate water stress[3] in Europe, which currently affects over 100 million European citizens (EEA, 2018[5]). Another driver is pressure on soils that use to store water: sealed surfaces, deforestation, and reduction of wetlands exacerbate water stress as they accelerate run-off, prevent groundwater recharge, or shatter mitigation of water scarcity risk. Water stress has obvious potential to jeopardise member states' compliance with the WFD via detrimental effects to both freshwater resources quantity (e.g. through over-exploitation, drought) and quality (e.g. through pollution, lack of dilution capacity, eutrophication) (EEA, 2018, p. 1[5]).

The European Environment Agency (EEA) has estimated that about 30 % of Europe's population is affected by water stress during an average (EEA, 2021). Indeed, 10% of the European territory is under permanent water stress as a result of socio-economic and climate change pressures on renewable freshwater resources, and up to 30% of additional European territory experiences seasonal water stress (EEA, 2020[6]). Water scarcity associated with agricultural activity shows strong seasonal variations that are especially notable in southern European countries including Spain, Greece and Italy, but are also evident in multiple sub-basins in western, eastern and northern Europe (EEA, 2020[6]).

Sometimes, a lack of adequate infrastructure or services is the primary barrier to access to water, rather than limited availability of the resource – a situation referred to as economic water scarcity. The UN notes that around 1.6 billion people worldwide face economic water scarcity, in that water is physically available but they do not have the necessary infrastructure in place to access that water (UN Water, 2021[7]). It is

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[2] Water scarcity exists "when the climatologically available water resources are insufficient to satisfy long-term average water requirements, leading to a structural imbalance" (UNDRR, 2021, p. 24[54]). The OECD defines water scarcity as "an imbalance between the supply and demand of freshwater as a result of a high level of demand compared to available supply, under prevailing institutional arrangements (including price) and infrastructural conditions" (2015, p. 130[46]). According to the European Commission (2012[55]), water scarcity means that water demand exceeds the water resources exploitable under sustainable conditions.

[3] Water stress is a measure of the total annual average water demand of a river basin (or sub-basin) compared with the annual average water available (precipitation minus evapotranspiration) in that basin (OECD, 2015, p. 130[46]).

worth recalling that in 2020, in the European Union, 1.5% of the population was in households without basic sanitary facilities (such as bath, shower, indoor flushing toilet). This is more of an issue in select countries such as Romania (21.2%), Latvia (7%) or Lithuania (6.4%) (Eurostat, 2022[8]).

As water availability, water demand and the impacts of climate change vary both regionally and seasonally across Europe, they require tailored, contextually appropriate policy solutions. This section reviews the current "state of play" for these three interlinked issues to better illustrate the water scarcity challenges faced in the EU and pertinent to the achievement of the WFD's objectives.

## 2.1. Water availability in Europe

Although there is a relative abundance of freshwater (surface water and groundwater) resources in many parts of Europe, these resources are unevenly distributed, creating considerable differences in levels of water stress between regions and seasons (EEA, 2018[5]). The amount of total available freshwater in a country[4] is primarily determined by the climatic conditions and transboundary water flows (external inflows). Factors such as country size and geography also influence the total amounts of the available resource for inhabitants (Eurostat, 2020[4]).

Measured by population (rather than country size), most EU member states' available water resources generally range from 1 000 cubic metres to 10 000 cubic metres per inhabitant, though resources per-inhabitant are notably higher in such countries as Croatia, Finland, Norway and Sweden, (Eurostat, 2020[4]). According to a United Nations indicator, Cyprus, Czech Republic, Malta and Poland are the four EU countries considered to be experiencing water stress (i.e. they have annual water resources of below 1 700 cubic metres per inhabitant) (Eurostat, 2020[4]).

Some member states have no or negligible external inflows of freshwater, including Cyprus, Denmark, Malta and Spain. In other member states, transboundary water resources play a critical role in water availability. Certain countries receive a major proportion of their freshwater resources as external inflows, including Hungary, the Netherlands and Serbia (i.e. high percentages as a share of their total inflows) and some Danube Basin countries such as Bulgaria and Croatia (i.e. high percentages in terms of total volume of water received) (Eurostat, 2020[4]).

Member states vary in their levels of reliance on surface water, groundwater, and non-freshwater sources (such as seawater, transitional water, or recycled water). Many European member states rely primarily on surface waters for abstraction, though Malta and Denmark are two countries that abstract more groundwater than surface water (Eurostat, 2020[4]). As a country with limited surface water availability, Denmark is the only EU member state that uses untreated groundwater for more than 99% of its water use (OECD, 2017[9]). In most places globally, groundwater and surface water systems are closely interlinked, and human activities including water abstraction (notably for irrigation) and artificial drainage have intensified these interactions (OECD, 2017[9]). Sweden, the Netherlands and France are the highest non-freshwater abstractors in the EU (Eurostat, 2020[4]).

Seasonal variations in water availability and peaks in water scarcity are particularly pronounced in Mediterranean countries, where water demand peaks during summer, which is usually the driest season (EEA, 2017[10]). For example, in the summer of 2015, a 10% drop in precipitation compared with the year before led to a 20% reduction in renewable freshwater resources (EEA, 2018[5]).

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[4] Note that country level data fail to reflect significant disparities at sub-national level. A further level of disaggregation (at basin or catchment level) is required for sound and policy relevant analyses

However, dry periods and drought are not the only factors affecting water availability: as an example of reduced supply due to pollution pressures, in Denmark, pesticide pollution causes 20% of well closures and nitrate pollution causes 10% of well closures (EEA, 2017[10]).

## 2.2. Water demand in Europe

Global freshwater use increased by a factor of six over the past 100 years, and it is estimated that global water demand[5] increased twice as fast as population growth over the 20th century (OECD, 2012[11]; UN Water, 2021[7]). In Europe, water demand also has steadily increased over the past 50 years, partly as a result of population growth, leading to an overall decline in renewable water resources per capita of 24% across the continent – this decline is particularly marked in southern Europe, driven by lower precipitation levels (EEA, 2018[5]).

### *2.2.1. Abstraction rates and trends in Europe*

Though overall demand for water has been growing in Europe, the introduction of water management policies and measures has driven reductions in overall abstraction over recent decades. As a result of various improvements in water supply management and efficiency, Europe has experienced a decrease of 19% in total water abstraction since 1990, and most economic sectors' water use has fallen (EEA, 2018[5]). These declining overall abstraction rates have resulted from various policy changes in different sectors in combination with other factors, including reduced water losses through network maintenance and improvement, the introduction of water-saving appliances at the household level, and higher awareness of the costs and value of water (Eurostat, 2020[4]).

Overall rates of abstraction vary considerably among European countries. From 2008 to 2018, Denmark and Turkey were European countries in which the total volume of freshwater abstracted rose at the fastest pace (+54% and +45% respectively), while the largest decreases were seen in Lithuania (-87%), Germany (-25%) and the Netherlands (-24%) (Eurostat, 2020[4]). In Lithuania's case, the decline occurred because of reduced cooling water needs for electricity production.

As of 2019, over 7 600 (or seven per cent) of Europe's surface water bodies were affected by significant water abstraction pressures, and 16% of groundwater bodies were affected by over-abstraction (European Commission, 2019[12]). The European Commission has indicated that the over-abstraction of water is the second most common pressure on water bodies' ecological status. Its 2019 report on WFD implementation noted that there had been progress in some member states in extending metering, water abstraction controls, reviewing licences, and improving water abstraction datasets. However, it highlighted that some member states still needed to fulfil previous European Commission recommendations to improve their management of water scarcity (namely Spain, Portugal, Italy, Malta, Sweden and Slovenia) (European Commission, 2019[12]). The European Commission also underlined that most member states continue to exempt small abstractions from controls and/or registering, despite the contribution they make to the failure to meet good ecological status under the WFD.

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[5] Water demand refers to demand for water from different water users. Water demand can be met from freshwater withdrawn from the environment (a river, lake or aquifer) or from other sources of water (e.g. recycled water) (OECD, 2012, p. 213[11]).

### 2.2.2. Water demand by sector

Economic activities in Europe use an average of around 243 000 cubic hectometres[6] of water annually (EEA, 2018[5]). The majority of this water (over 140 000 cubic hectometres) is returned to the environment, but commonly contains pollutants and impurities that can contribute to the poor water quality of water bodies and affect ecosystem functions. Figure 2.1 shows water demand by sector and freshwater abstraction by source.

#### *Demand from agriculture*

Agriculture is the largest water user in Europe: while around 6 % of EU farmland was irrigated in 2016, the sector was responsible for 24 % of all water abstraction., accounting for around 40% of total annual water use in Europe (ECA, 2021) (EEA, 2018[5]).

Agriculture is projected to remain the largest water consumer in Europe over the coming decades, and increased demand for irrigation will add to water stress, particularly in southern Europe (EEA, 2018[5]). Most of the water abstracted for agriculture is consumed by crops or lost as evapotranspiration, which distinguishes it from water use in other sectors (such as energy or households), which return most of the abstracted water as waste water discharges; as a result, agriculture is the largest net water user in the EU (EEA, 2020, p. 41[6]). From 2008 to 2017, around 37% of agricultural water abstractions were from river water bodies, with almost as much being abstracted from groundwater (36%) and a further 27% coming from reservoirs (EEA, 2020[6]).

Water abstraction is one of the main pressures imposed by agriculture on Europe's water resources, along with diffuse nutrient and chemical pollution and hydro morphological pressures (EEA, 2020[6]). These pressures are expected to grow as a result of climate change, and are associated with farming practices such as the use of fertilisers and pesticides, intensive livestock farming, and hydro morphological river modifications resulting from structures for drainage, water storage, flood protection or livestock overgrazing (EEA, 2020[6]). Although agricultural water abstraction has decreased over recent decades, it is considered to be at unsustainable levels in many European regions, and climate change poses additional pressures and challenges (EEA, 2020, p. 46[6])[7].

#### *Demand from other sectors*

Aside from agriculture, the other major water users in Europe include energy, mining and manufacturing, and households (municipalities). Energy production – mostly for cooling in power plants, but also for hydro-electricity production – accounts for around 28% of annual water use. In the next decades, transition towards renewable energy sources is likely to increase water use in energy, as some of these energy sources are water intensive (e.g. concentrating solar thermal). Mining and manufacturing accounts for 18% and household water use accounts for around 12%. (EEA, 2018[5])

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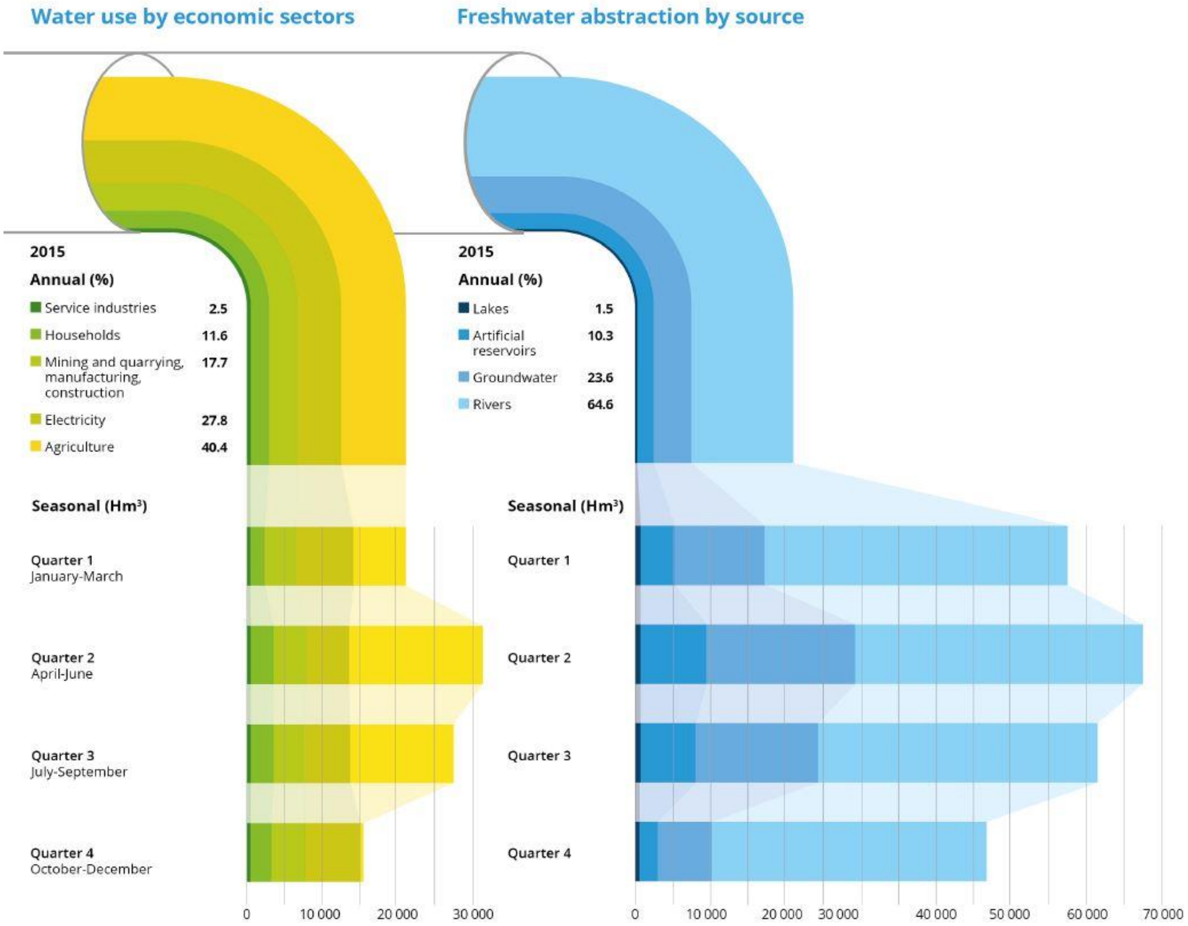
[6] One cubic hectometre is equal to 1 000 000 cubic metres (EEA, 2018[5]).

[7] Note that mounting emphasis on food security triggered by the war in Ukraine can only exacerbate these challenges.

Figure 2.1. Water demand by economic sector and freshwater abstraction by source in Europe



Source: EEA, 2018. *Water use in Europe - Quantity and quality face big challenges*. (EEA, 2018[5])

The largest water-using sectors in Europe vary between regions and among individual member states: agriculture is the largest user in southern Europe; cooling for power generation is the greatest source of pressure in western and eastern Europe; and manufacturing is the largest user in northern Europe (EEA, 2018[5]). Between member states, the share of water consumed by manufacturing as compared to households varies; for example, the manufacturing industry uses a comparatively larger share in the Netherlands, Sweden and Belgium, while the reverse applies in countries with smaller manufacturing and industry sectors (Eurostat, 2020[4]). Overall, the levels of household water use across Europe are more uniform than those of manufacturing, and data reported by member states indicate that levels of household water use from public water supplies was relatively stable over the decade 2008–2018 (Eurostat, 2020[4]).

Overall, water demand is projected to continue to rise in Europe over the coming decades[8], driven by demand from agriculture, energy and households (where population grows) as well as increased demand from particular sectors such as tourism – particularly in certain regions and during key periods (think of remote locations, or places where tourism will compete with agriculture or other uses) (EEA, 2018, p. 4[5]).

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[8] It should be noted that aggregate demand projections can be misleading, as figures at the national level can mask regional or local scarcity and temporal issues. The location and timing of demand relative to supply determines the scarcity conditions, and hence, the risk of shortage. (OECD, 2015, p. 22[46])

For example, tourism (primarily accommodation and food service activities) currently accounts for around 9% of total annual water use, and will put increased pressure on water supplies.

It is worth noting that shifts in agricultural water demand are considered some of the most difficult to forecast, given the need to account for projected increased demand for food and irrigated food production, both at global level (UN Water, 2021[7]) and for the EU. The United Nations Food and Agriculture Organization has stated that global agricultural water withdrawals can only increase by 10%[9] given water availability, pointing to the need for major improvements in water use efficiency in irrigated and particularly rain-fed systems, alongside other non-water centric measures such as reducing consumption and food waste (UN Water, 2021[7]). As regards the EU, there are clear limits to irrigation, in particular where it is hard to reach and maintain good quantitative status for groundwater and ecological status for surface water.

### *The role of ecological flows*

Most member states and river basin districts have undertaken water balance assessments as a foundation for determining sustainable abstraction levels given available renewable freshwater resources and requirements for ecological flows (also known as environmental flows or e-flows) (EEA, 2020[6]). Water balance assessments summarise the volume and flow of water within a hydrological unit (e.g. a river catchment or basin), occurring both naturally and due to human-driven water abstractions and return flows (EEA, 2020[6]). The water balance concept is the foundation on which to build “water allocation regimes” (see section 3.2)

In the EU and elsewhere, dedicated ecological flows are considered a form of water user (IUCN, 2021[13]) and factored into water allocation regimes, given that ecological flows are a basic requirement for aquatic ecosystems to thrive and provide services (European Commission, DG for Environment, 2016, p. 2[14]). The EU water acquis requires that e-flows are set and implemented; hence, an appropriate water allocation mechanism should put e-flows on equal footing with other users. The 2012 Blueprint to Safeguard Europe’s Water Resources stressed the need for member states to better address the over-abstraction of water as the second most common pressure on water bodies’ ecological status, and proposed the development of a common understanding and guidance on the calculation of ecological flows. The subsequent guidance document under the Common Implementation Strategy (European Commission, DG for Environment, 2016[14]) provided a working definition of ecological flows along with information on methodologies, monitoring, measures and evaluation methods. The guidance did not provide binding standards on ecological flows, but rather encouraged their consideration within WFD planning processes by providing a common understanding of their definition and practical implementation.

The fifth implementation report on the second RBMPs in 2019 indicated that most member states were still working to define and implement ecological flows during the second cycle of RBMPs, with the exception of Hungary and the Netherlands, which had completed the process (European Commission, 2019[12]). According to the 2021 Report on the Implementation of the Water Framework Directive: “The information subsequently reported for PoM reporting in 2018 shows that 7 Member States have derived ecological flows objectives in all or some of the water bodies. This is similar to what was reported in 2016, indicating no apparent progress. For the others, work is ongoing, but the reported indicators do not make it possible to assess detailed progress”. In terms of measures implemented to reach ecological flow, 20 Member States reported on KTM7 for surface water, while only five reported on KTM 7 for groundwater (European Commission, DG Environment, 2021, p. 15ff[3]).

In most member states, there is a need to better connect abstraction levels and ecological flows in practice, and the action plan of the recent EU biodiversity strategy for 2030 calls for the European Commission to

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[9] It is noteworthy that additional water uses for irrigation may not be feasible in areas where the infrastructure is already in place and water resources are already fully allocated. Some relocation may be required.

provide technical guidance by 2023 on measures to review water abstraction and impoundment permits and to restore ecological flows in the revised RBMPs (EEA, 2020[6]; European Commission, 2020[15]).

At a global level, estimates of requirements for ecological flows are being integrated into indicators of progress towards the Sustainable Development Goals, to support the creation of national datasets for monitoring water stress (UN Water, 2021[7]).

## 2.3. The impacts of climate change on water availability, demand and related challenges

Water is fundamental to the climate regulation cycle, and climate change poses severe and far-reaching challenges for water management in the form of increased water scarcity, drought risk, flood risk and increased precipitation, declining water quality, and broader ecosystem degradation (EEA, 2020[6]; Eurostat, 2020[4]; IPCC, 2021[16]). While this note focuses on water scarcity, it is important to note the potential influence of climate change impacts such as increased precipitation and evaporation as well as the increasing occurrence extreme water-related events and how they can interact to affect both water quantity and water quality (Box 2.1).

### Box 2.1. Intersecting climate change impacts affecting water quantity and quality

The 2019 Fitness Check of the WFD and FD notes that water quantity and water quality problems are interlinked, and that climate change will exacerbate existing and emerging water-related challenges including water scarcity, floods, water pollution and degraded ecosystem functions.

“The principal drivers of surface water quantity issues related to climate change include precipitation and temperature changes. Annual river flow rates are expected to decrease throughout the majority of southern European regions whilst conversely increasing in northern regions due to changes to precipitation and snowmelt rates. Extreme temperatures, which are projected to rise over the 21st century, are expected to result in large increases in meteorological and hydrological droughts in most of Europe, with the greatest increase in drought conditions projected for southern regions.

“The impact of climate change on groundwater resources is less understood, due to spatial variabilities in soil, evapotranspiration and aquifer properties. Nevertheless, models have projected average groundwater recharge rates to decrease throughout Europe due to climate change. The aforementioned impacts of climate change on water quantities can also induce negative feedbacks, due to human interactions through water abstractions. For example, in prolonged high temperature periods a heightened requirement for water resources is often witnessed – for public water supply, cooling waters for increased energy use, and crop water requirements. Abstractions at such times when water levels are typically already at low levels can maximise the detrimental impacts on freshwater ecology.”

Source: European Commission, 2019. *Fitness Check Evaluation of the Water Framework Directive and the Floods Directive: Final evaluation report*. (European Commission, 2019, p. 221[2])

In 2020, the European Commission published projected impacts of climate change, land use change, and changes in water consumption on future water resources in Europe (JRC, 2020, p. 8[17]). The analysis underscores that, because of climate change, periods of water scarcity in Europe will generally be longer and more intense. The projections for Europe reflect a “North-South pattern” of diverging water availability across the continent, with southern European countries facing decreasing annual water availability (especially Spain, Portugal, Cyprus, Malta, Italy and Turkey), and central and northern European countries facing increasing annual water availability (JRC, 2020[17]). These aggregate and average figures mask changing water availability over the years and increasing seasonal variability. For instance, in Nord Sweden the pattern of precipitation has been changing: the peak of rainfall comes before the crops' growth season while the geography and soil are ill suited to retain water.

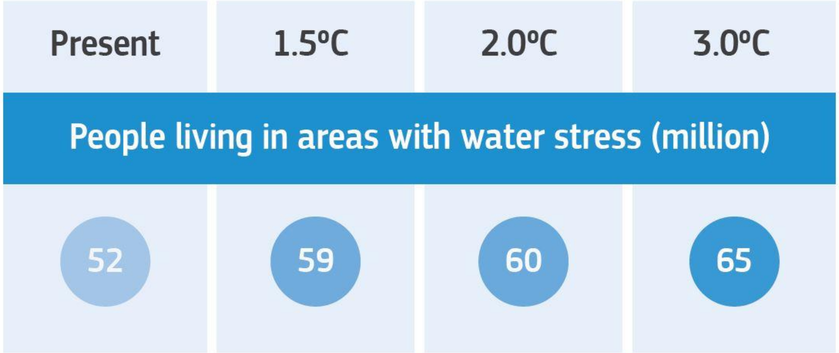
The European Commission analysis indicates that climate change is the main driver of exposure to water stress in southern Europe, with other factors such as changes in water demand, land use and demographic change having comparatively minor effects on exposure (JRC, 2020[17]). Climate change will worsen many existing water scarcity challenges in southern Europe. Mediterranean countries will experience longer and more intense water scarcity, with the widening gap between potential evapotranspiration and precipitation projected to lead to drier summers (Gelati et al., 2020[18]; JRC, 2020[17]). If water demand remains at current levels and significant water saving efforts are not taken, climate change and reduced precipitation in the Mediterranean will lead to extreme increases in water scarcity (JRC, 2020[17]).

Outside of southern Europe, seasonal analysis also predicts notable differences between stream flows in summer and winter, particularly in France, Belgium and the UK, which are projected to experience drier summers and wetter winters (JRC, 2018[19]).

It is estimated that, in the EU and United Kingdom, close to 52 million people and EUR 995 billion in economic activity are currently exposed to water scarcity, with 3.3 million people and EUR 75 billion in economic activity exposed to *severe* water scarcity (JRC, 2020[17]). European Commission modelling underscores the significant uncertainty member states face given the different scenarios of global warming over the coming decades. The analysis shows that under scenarios of 2-degree and 3-degree Celsius global warming within this century, water scarcity will be exacerbated in currently water scarce areas, while new water-scarce areas will emerge in countries such as Germany, Bulgaria and France (JRC, 2020[17]).

Modelling of a 1.5-degree Celsius warming scenario indicates that under such conditions, exposure to water scarcity could increase by 7.4 million people and EUR 134 billion in economy activity compared with the present day (see Figure 2.2). In a 1.5-degree warming scenario, the numbers of people and share of economic activity exposed to severe scarcity would remain constant yet be subject to longer and more intense periods of water scarcity. A scenario of unmitigated climate change with 3-degree Celsius warming by 2100 (reflecting the estimated current global emissions trajectory) suggests a further additional 7.7 billion people and EUR 99 billion could be exposed to severe water scarcity (JRC, 2020[17]).

## Figure 2.2. Projected population in the EU and United Kingdom living in water stressed areas



| Present | 1.5°C | 2.0°C | 3.0°C |
|---|---|---|---|
| People living in areas with water stress (million) | | | |
| 52 | 59 | 60 | 65 |

Note: Water Exploitation Index+ >0.2 for different levels of global warming
Source: European Commission, 2020. *Climate change and water resources*. (European Commission et al., 2020, p. 2[20])

In member states, the number of people exposed to water scarcity is anticipated to vary in line with either projected population growth (e.g. in France: increasing population exposed) as well as projected population decline (e.g. in Greece and Spain: constant or declining population exposed, though notably still with more severe and longer-lasting periods of water scarcity) (JRC, 2020[17]).

The European Commission analysis provides a number of other relevant predictions of how climate change will affect water scarcity and current water management challenges in a 2-degree warming scenario. For example:

- Spain, Portugal and Greece are forecast to experience significant reductions in groundwater recharge (JRC, 2018[19]). The potential reduction is greatest in Spain, where it is equal to 15% of the reported annual amount of abstracted water for irrigation.
- For energy production, the analysis variously predicts both decreases and increases in hydropower annual inflows for different regions, reflecting that both water scarcity and water oversupply will present challenges (with the risk of local dam safety issues in the latter case). For cooling, projected major decreases of low flows in the southwest and southeast European regions could lead to limited availability of cooling water for thermal power stations as well as higher temperatures of cooling waters (JRC, 2018[19]).
- Other projected pressures include increased local runoff production in many cities vulnerable to pluvial flooding as a result of climate change and urban expansion, and increased soil moisture stress in large parts of Europe, including France, the UK, and parts of the Mediterranean that are already experiencing high stress (JRC, 2018[19]).

### *2.3.1. Interconnections with broader ecosystem functions and services*

Both water scarcity and climate change threaten the healthy functioning of ecosystems and critical natural resources (such as soils). Ecosystems and their services are fundamentally interlinked with water resources, as they are water-dependent and cease to function without water (regardless of their role in hydrology) (UN Water, 2021, p. 31[7]). Longer, more intense periods of water scarcity have potentially severe detrimental effects on ecosystem services. At the same time, ecosystems provide water-related services and their degradation can have severe consequences for water resources – sediment regulation is one (often overlooked) example of a water-related ecosystem service that helps regulate water quality and erosion, supports land stabilisation, and contributes to disaster risk reduction (UN Water, 2021, p. 32[7]). The 2019 global assessment by the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) found that 14 of the 18 categories of “nature’s contributions to people” are in decline (UN Water, 2021[7]). Of the 14, three are water-related – including regulation of freshwater quantity, coastal and freshwater quality, and protection from hazards and extreme events – and their decline will in turn contribute to the decline of the other ecosystem services categories (UN Water, 2021, p. 16[7]).

Worldwide, growing understanding and recognition of the interlinked nature of these challenges to ecosystems as a whole has contributed to greater interest and investment in nature-based solutions (NbS) for restoring and building ecosystem resilience and meeting multiple policy objectives (e.g. biodiversity conservation, resilience against water-risks, recreational purposes). The next section further explores existing EU requirements and guidance on NbS, as well as their considerable potential to support the implementation of the WFD.

## 2.4. The economic cost of water scarcity

The economic cost of water scarcity is not known with accuracy. Partial studies suggest it is significant. In Europe, most of the losses caused by drought (~EUR 9 billion/year) affect agriculture, the energy sector and the public water supply. Extreme droughts in western and central Europe in 2018, 2019 and 2020 caused considerable damage. In 2018 alone, agricultural damages amounted to some EUR 2 billion in

France, EUR 1.4 billion in the Netherlands, and EUR 770 million in Germany. With global warming at 3°C, droughts would happen twice as often and the absolute annual drought losses in Europe would increase to EUR 40 billion/year, with the most severe impacts in the Mediterranean and Atlantic Regions.

In 2021, IEEP reviewed the existing literature and was able to identify seven academic attempts to estimate the economic costs of water scarcity, mainly in Australia and Spain. Estimates focus on the foregone ecosystem services, which water would have provided, had it been available (IEEP, 2021, p. 40[21]). In addition to supporting agriculture, industry and households, these services include recreational, flood management, nutrient cycling, and on-use values (e.g. habitat for species). Based on a literature review, IEEP cites EUR 0.30 / $m^3$ as the value of the environmental externality per unit of water abstracted from a water body; this is considered a conservative estimate. Obviously, the specific value would vary across basins or catchments.

While the robustness of the cost estimate is debatable, it provides a useful reference to gauge how much abstraction charges reflect the estimated cost of scarcity. IEEP reviewed five case studies in Europe. The case studies indicate that, when they are in place, abstraction charges only internalise 2-3% of the estimated cost of water scarcity (IEEP, 2021, p. 52[21]).

# 3 Policy options and considerations for addressing water scarcity and meeting the goals of the WFD

In view of the water scarcity challenges Europe faces (see above) and the European Commission's recommendations for improved economic analysis and pricing, this section examines a variety of economic instruments and related policy options for addressing water scarcity in the implementation of the WFD to support the achievement of its ecological objectives. It incorporates illustrative practical lessons from both EU and non-EU countries. The aim is to support member states to weigh these potential solutions according to their specific contexts and experiences of water scarcity, and potentially to take inspiration from other countries' approaches and experiences.

The OECD Council Recommendation on Water (2016[22]) – to which all OECD member countries are Adherents – encourages countries to manage water quantity using a combination of water demand management policies, promotion of water use efficiency, water allocation regimes, collective management approaches where appropriate, and improved knowledge and monitoring of water resources, use and sustainability limits. These are fundamental components of strong water management plans and provide an overall organising framework for the different complementary instruments and options explored here. The following sections examine how some of these measures may be pertinent to EU member states in managing water scarcity and implementing programmes of measures under the WFD.

## 3.1. Balancing demand management and supply augmentation

### *3.1.1. Prioritisation of demand management measures*

Water demand management measures – defined as measures to limit demand of freshwater from water users - are typically considered a low-regrets "first best option" for managing water scarcity (see also the discussion of the hierarchy of water use, below), given that demand levels can be influenced via various instruments and measures that support efficient and effective water management. This is also due to the observation that over-reliance on supply augmentation faces limitations, particularly in the face of uncertainty regarding future water demand and availability (see the discussion of supply augmentation below) (OECD, 2018[23]). As an illustration, storage only operates as a buffer when reservoirs are full, a condition that is increasingly challenged by uncertainties about future water availability and demand.

Sound water demand management can be instrumental in reducing future investment needs for water infrastructure and supporting the allocation of water to where it creates the greatest value for society. Water demand management policies should reflect short- and long-term projections, account for uncertainty regarding current and future levels of water availability and demand, and be grounded in water management plans that reflect the ecologically sustainable limits of water systems (OECD, 2016[22]; OECD, 2018[23]). Demand management is generally best delivered through a combination of pricing instruments (e.g. tariffs) and non-pricing measures (e.g. water efficient technologies, awareness campaigns) (EEA, 2017[10]).

Korea is one example of a country that, in considering demand management measures, faced a common underlying issue: insufficient valuation of water as a scarce, precious resource (OECD, 2018[23]). The low value of water by different users is driven by factors such as: excess rates of water loss and leakage; low water pricing that fails to recover costs or incentivise user efficiency; poor design and enforcement of abstraction rules and permits; and lack of user recognition of water's environmental value (ecological flows) (OECD, 2018[23]). Such policy settings not only limit the efficiency of water use, but can also contribute to lack of trust in water management systems and water service provision (which can affect willingness to pay for water services). They underscore the potential of well-designed and integrated economic instruments such as robust pricing and abstraction charges to help manage demand and ensure that water is allocated to society's highest value uses.

Taking the example of Korea, at the culmination of a collaborative national policy dialogue in 2018, the OECD recommended that Korea improve its water demand management through a range of economic instruments and other policy measures (OECD, 2018, p. 39[23]). These included: more proactive groundwater management and abstraction controls; the introduction of abstraction permitting for all surface water abstractions; ensuring compliance with ecological flows; proactive monitoring and enforcement of abstraction permit compliance; efforts to reduce leakage; introduction of water charges for abstraction and water pollution at basin scale (reflecting opportunity costs); and development of a water use efficiency strategy for agriculture. These recommendations not only highlight the potential role of robust water pricing, but also reflect a purposeful situation of efforts to manage water demand within the broader context of a water resources management plan, including an improved water resources allocation regime.

Demand management requires decision makers to grapple with significant uncertainty. Scenario planning – a tool recognised for helping to manage uncertainty – can be a useful method for predicting demand and informing the design of demand management measures and broader water resources management plans (OECD, 2018, p. 109[23]). Box 3.1 provides some considerations for forecasting water demand amid uncertainty.

### Box 3.1. Forecasting water demand amid uncertainty

Understanding the drivers of demand for water, and then translating these into the basis of forecasts, is one of the most challenging elements of any water resource plan.

Forecasts for future water demand from households, energy, agriculture, industry and the environment should be included. Changes in energy policy, for example progressively abandoning coal-fired generation in favour of wind and solar sources, will affect water availability by reducing water demand for cooling. As noted in Section 2.2, industrial and agricultural water demand can be very difficult to forecast, so a scenario approach will help to expose potential risks. Changes in land use, such as afforestation or deforestation, will not only affect overall demand for water in a basin in a way that is difficult to control, but also the runoff characteristics and potentially also water quality.

A further, important consideration is to ensure that there is sufficient water for the environment in the future. This is complicated by the potential temperature increases and flow changes that will result from climate change. Such changes are likely to modify ecosystems. This uncertainty needs to be factored into water resources planning and appropriate allocation of water for environmental flows[10].

All these variables in the forecasts will have a different influence on the location, magnitude and timing of total demand for water. The impact of policy and regulation is critical, particularly for the promotion of measures and behaviours to support water conservation.

Source: OECD, 2018. *Managing the Water-Energy-Land-Food Nexus in Korea: Policies and Governance Options*. (OECD, 2018, pp. 99-100[23])

### *3.1.2. Considering the price elasticity of water demand*

Studies to date on the price elasticity of water demand suggest that elasticity varies according to sector and use, as well as other factors. On the basis of a case-study assessment, an EEA-commissioned study (EEA, 2017[10]) concludes that water demand management strategies need to find the right mix of pricing and non-pricing instruments, because, rather than in isolation, it is in combination with other instruments that pricing can effectively and efficiently contribute to reducing household water consumption. The study argues that this insight is widely recognised but that policy makers in the member states struggle to find the right mix for their circumstances while implementing water policy. In some cases, the provision of water hardly resembles a market in the sense that one can relate individual consumption volume with the amount paid, a precondition to derive a price elasticity.

The (EEA, 2017[10]) study also provides an overview of econometric estimates of price elasticity across the EU, concluding that the (domestic) demand for water tends to be usually inelastic to price, i.e. the consumption volume has a weak reaction to price. Its relies on two meta-review studies (Dalhuisen et al., 2003[24]; Montginoul, 2013[25]), which despite a considerable variation in methods, data quality and aggregation level find that nearly all estimates of (short-run) price elasticities fall in the range of -1.0 to -0.1. A cross-country econometric study commissioned by the JRC of the European Commission has confirmed these findings (Reynaud, 2015[26]). A number of cases in which water demand may be price elastic (see Box 3.2) may merit consideration in assessing options for managing water scarcity (Leflaive and Hjort, 2020[27]). Analysis of **household** water use in Brazil observed that price elasticity varies depending on the characteristics of the household, timing, and type of use (OECD, 2017, p. 116[28]).

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[10] The *Background note: Water investment planning and financing* for the first thematic workshop synthesises information on how climate change is integrated in European RBMPs in practice.

Elasticity diverges with household size and, in developed countries, studies have shown that lower income groups are more price-responsive than higher income groups. Studies have also suggested higher price elasticity in absolute values during summer periods, and while household water use for human consumption or cooking purposes tends to be highly price inelastic, leisure-related uses for activities such as gardening or swimming pools are generally more elastic (OECD, 2017, p. 116[28]); a point corroborated by EEA (2017, p. 59[10]).

It follows that water demand management for domestic uses needs to combine water pricing with non-price mechanisms, such as awareness raising campaigns, education, or regulation on water uses in times of scarcity. The promotion of water efficient appliances and network efficiency also contribute to decreasing domestic demand for freshwater.

For **agriculture**, elasticity estimates are sensitive to the elasticity calculation methods used, though it is generally found that agricultural water demand is more elastic than residential water demand, given the possibility to adjust extensive margins (e.g. by shifting to comparatively less water-intensive crops) and intensive margins (e.g. by decreasing the irrigation rate of individual crops) (OECD, 2017, p. 124[28]) in the long term. At the same time, quantitative studies of water pricing in irrigation have highlighted the inelasticity of water demand especially under scarce conditions ( (Kefayati, 2018[29]); (Scheierling, Loomis and Young, 2006[30])). This means that introducing small price signals is unlikely to have a significant impact on water withdrawals, and even less on water consumption: a careful calibration of price signals is required, that factors in low elasticity of water use and a range of consequences (e.g. on crop patterns, farmers' revenue and financial incentives to augment supply). Note that water use efficiency in agriculture only alleviates scarcity if saved water is properly monitored and allocated; otherwise, there is a risk that saved water will be used to increase irrigated land or grow water-intensive crops (the so-called rebound effect).

In general, **industrial** water demand tends to have higher price elasticity compared with demand from households and agriculture (OECD, 2017[28]). A range of studies on industry demand has generated contrasting results: while most studies find that industrial water demands are inelastic, a few indicate that industrial water demand can exhibit significant elasticity (OECD, 2017, p. 119[28]). In fact, price elasticities can differ widely between industrial sectors, and different firms may therefore react in different ways to water price increases or the introduction of charges. Firms have been found to have different price elasticities for water supplied through municipal networks in comparison with self-supplied water. Overall, commercial and industrial users' relatively higher price elasticity can be traced to the potential for in-plant recirculation of water; recirculation is usually found to be a substitution for use of freshwater. Industrial water users' responses to price changes therefore depend on the nature of the industry, the source used, and the time taken to consider, adapt or shift to alternative water uses or sources (OECD, 2017[28]). Note that pollution charges, when they spur technology or process changes, can contribute to addressing pollution and water quantity at the same time.

### Box 3.2. Household use: Price elasticity of demand in the water supply and sanitation sector

In the water supply and sanitation (WSS) sector, a common objection against the use of tariffs for WSS services is that domestic water demand is price inelastic, so raising WSS tariffs will not result in substantial reductions in consumption. Reynaud et al. (2016[31]) state that while domestic users are commonly found to be sensitive to prices, the elasticity of water use to price changes is, in most cases, found to be relatively small. Thus, tariff increases need to be substantial to induce a change in water users' behaviour. Such increases may have direct social consequences for some consumers.

Claims that domestic water demand is unresponsive to price are undermined by a number of studies showing that: i) informing consumers about the volumetric price they pay on their water bill increases price elasticity; ii) consumers are more responsive to price changes the longer they have to adapt, meaning that the long-term price elasticity of water demand is greater than short-term price elasticity; iii) price elasticity increases with higher prices, because at higher prices, water charges account for a larger share of household expenditures; and (iv) price elasticity of water demand depends on the local context and a number of variables, implying that water pricing and conservation policies must be differentiated by specific groups of users (Reynaud, 2015[26])..

OECD studies confirm that price-based approaches can control long-run urban water demand. In New Zealand, in places where volumetric pricing has been introduced, this has been followed by significant decreases in the amount of water used, including for the residential sector. Having to pay for their actual water use, consumers have adopted water-saving habits (Watercare, n.d.[32]). In Denmark, water prices were raised by 54% over two decades, leading to a 20% decline in water consumption.

**Leveraging price elasticity to help manage water scarcity**

Although its potential is relatively small, price elasticity of water demand can be used as a means to manage short episodes of scarcity and drought. Research has explored how dynamic pricing can signal scarcity and manage short-term demand. Dynamic pricing at the utility level models the potential impact of high tariff increases to cover short episodes of drought. In a particular context where elasticity of demand to price equals -0.4, a 50% increase of the tariffs could trigger a 20% decrease in water demand, which may help address a drought in the short term (for a few days or weeks). Dynamic pricing is not appropriate to address frequent or lasting droughts, as changing prices may have social consequences, but can potentially help address short episodes of scarcity.

Studies emphasise that a combination of price- and non-price strategies is needed to achieve significant water use reduction. Regulation, education, information campaigns and stimulation and uptake of innovation in water efficient technologies play important roles in water conservation policies (Reynaud, 2015[26]).

Source: Leflaive and Hjort, 2020. *Addressing the social consequences of tariffs for water supply and sanitation*. OECD Environment Working Papers No. 166. (Leflaive and Hjort, 2020, pp. 18-19[27])

### *3.1.3. Options for supply augmentation that offer multiple benefits*

Experiences in countries including Korea, Brazil (e.g. in Sao Paulo) and South Africa (e.g. in Cape Town) underline that a prioritisation of water supply augmentation over demand management - rather than accompanied by demand management - can have the effect of postponing action to pre-empt future water scarcity, for a number of reasons. The additional supply may then be used to accommodate new water-intensive activities (supply creating its own demand) rather than be set aside as a buffer for times of drought and higher water stress. Note that in the past natural water bodies (groundwater in particular) have served as a stock buffering the effects of variable precipitation and related external inflow. Reliance on infrastructures such as reservoir storage can risk the failure of supplies during severe drought (OECD, 2018[23]), if storage capacity is not properly managed. Given the uncertainty regarding the precise nature of future water scarcity and climate change impacts at local and regional levels, traditional approaches that first prioritise investment in major augmentations of water supply may face significant limitations (OECD, 2018[23]; OECD, 2015[33]).

The 2007 European Commission communication on water scarcity and droughts emphasised the need for member states to follow the "water hierarchy" for water use (explored further below) and prioritise alternative supply augmentation options (European Commission, 2007, p. 10[34]): This can take the form of additional storage, transfers, or alternative sources. In the EU, new water supply dams and water transfers are subject to EU legislation, such as the key WFD requirements, i.e. to maintain good quantitative status and an ecological flow. Tapping into alternative water sources – such as rain and storm water, used water, and desalinated sea or brackish water – can help alleviate water scarcity, but one should ensure they are not used up in times of relatively plenty supply. Where they are economically viable (such as through setting a scarcity premium on water abstraction), non-conventional water sources such as treated wastewater and desalinated water may be considered as an alternative to conventional freshwater supplies during drought periods or, sparingly / partly as a complement to conventional supplies during normal periods. Nature-based solutions (NbS) also have significant potential to augment water supply and storage.

### *Water reuse for supply augmentation*

Reused water, supplied from either centralised or decentralised distributed systems, has been increasingly recognised over recent decades as a sustainable source for certain water uses, such as for irrigation, groundwater recharge, and possibly for non-potable domestic uses (OECD, 2021, p. 35[35]). Water reuse can effectively increase available water resources while minimising outflows of wastewater (EEA, 2018[36]). By warranting a reliable supply, reused water can be particularly beneficial for agricultural activities that need predictable continued water supplies during irrigation periods, helping to reduce the risks of crop failure and income loss (European Commission, 2021[37]). In some cases, certain crops can also benefit from the nutrients contained in wastewater, resulting in reduced need for fertilisers (European Commission, 2018[38]). Another recognised potential economic benefit of water reuse is its potential to contribute to agricultural job security and job creation (European Commission, 2021[37]).

Water reuse can also offer important environmental benefits, reducing pressure on water resources by substituting abstraction, while also relieving the pressures of wastewater discharges to sensitive areas. It generally requires lower investment costs and energy compared with other alternative sources (e.g. desalination, water transfer), and can support greenhouse gas emissions reductions (European Commission, 2021[37]).

Beyond a relatively well-known group of non-EU countries including Israel (see Box 3.3), the United States, Singapore and Australia, water reuse has been established in several EU member states, including Spain, Italy, Greece, Malta, Cyprus, Belgium and Germany, which have various initiatives in place for water reuse for irrigation, industrial uses and aquifer recharge (European Commission, 2021[37]). Cyprus and Malta reuse more than 90% and 60% of their wastewater respectively, while Greece, Italy and Spain reuse between 5 and 12% of their effluents, which highlights the considerable potential for further application of water reuse (European Commission, 2021[37]). Despite these examples, as of 2015, the total volume of reused treated wastewater in the EU was still estimated to account for only 2.4% of the total volume of treated effluents produced, or just 0.4% of annual EU freshwater withdrawals (European Commission, 2018[38]).

### Box 3.3. Encouraging water reuse in Israel

For Israel, overcoming the challenges of an arid climate and scarce natural water reserves has always been a vital necessity for the growth of the population and economy and food security. Since the 1990s, Israel has become a world leader in water reuse. A number of important advances in policy were required for sustainable wastewater reuse to become a reality while safeguarding groundwater from diffuse pollution:

1. In 1992, the Ministry of Health (which controls potable water quality and manages the effluent irrigation permitting system) released new regulations that set secondary wastewater treatment plant (WWTP) quality standards for biochemical oxygen demand and total suspended solids. As a result, municipalities built intensive WWTPs with national loans of USD1.5 billion and restricted wastewater reuse was permitted for agricultural irrigation.
2. In 2001, the Water and Sewerage Corporations Law was passed. The Law transferred the management and ownership of water and sewerage infrastructure and services from public municipalities to corporate entities. The process was initially a voluntary one, but since 2008, state loans in the water sector are given only to private water and sewerage corporations.
3. In 2006, Parliament approved the establishment of a National Water Authority (under the Ministry of National Infrastructures, Energy and Water Resources) with overall responsibility for water, sewage and water resources management policy. One of the main principles introduced was that water tariffs should enable full cost recovery in the water sector, including costs of water conveyance, piping systems and wastewater treatment. This principle, together with construction of desalination plants along the Mediterranean coast, dramatically increased water prices in Israel for all sectors. Today, the domestic sector is paying about USD 2.6 per cubic meter of potable water. Therefore, the incentive for wastewater reuse was further enhanced.
4. In 2010, tertiary WWTP water quality standards came into force to enable unlimited irrigation of crops while ensuring diffuse pollution is limited and water and soil quality are protected.

Investments in wastewater treatment plants (WWTPs) and the volume of treated wastewater increased over 5-fold and 3-fold respectively between 1992 and 2008. The reuse of wastewater treated at the secondary level for use as irrigation (under restrictions) was originally encouraged through zero fees from the WWTP. Farmers and water associations had the responsibility to construct the piping and distribution systems, and the reservoirs to collect the water for irrigation. Since wastewater quality was upgraded to tertiary level, farmers pay USD 0.3¢ /m3; the additional cost to attain the improved water quality standard (from secondary to tertiary level treatment) is approximately USD 0.1¢/m3 (capital + O&M). The benefits of tertiary treatment and unlimited effluent irrigation are much greater than the costs. In addition, freshwater ecosystems are flourishing due to a permanent and steady environmental flow of treated wastewater that can be used for various purposes downstream of WWTPs. This has triggered further investment in advanced treatment technologies at WWTPs, carrying out nitrogen and phosphorus reduction, filtration and disinfection.

By 2017, treated wastewater constituted about 21% of total water consumption in Israel and approximately 45% of agricultural consumption. Out of about 510 million cubic metres of wastewater produced in Israel annually, 97% of the wastewater is collected and about 85% of it is reused. 52% is treated to tertiary level and 41% is treated to secondary level. The ultimate objective is to treat 100% of Israel's wastewater to a level enabling unrestricted irrigation in accordance with soil sensitivity and without risk of pollution to soil and water sources.

Source: OECD, 2017. *Diffuse Pollution, Degraded Waters: Emerging Policy Solutions*. (OECD, 2017, pp. 73-74[39])

In 2012, the European Commission's Blueprint to Safeguard Europe's Water Resources noted the limited extent of water reuse in the EU to date. The limited uptake has been attributed to limited knowledge of the potential benefits and a lack of a clear facilitating framework for water reuse in the EU. As part of this, it identified concerns regarding the lack of standards/guidance and potential negative impacts on water quality and health risk from water reuse (European Commission, 2012, p. 14[40]). Other countries' experiences and approaches have confirmed that health-related risks (e.g. possible water contamination during domestic use, or salinisation of irrigated soils) need to be taken into consideration in the development of alternative sources of water, including from an economic sustainability perspective. Australia's National Water Quality Management Strategy in the early 2000s addressed such risks by including quality guidelines and monitoring for the safe use of recycled water. These were also economically important as the standards for reused water can influence the payback period of the additional investment costs required (e.g. equipment or in-house dual plumbing) (OECD, 2009 in (OECD, 2021, p. 35[35]).

In 2020, in the context of its Circular Economy Action Plan, the European Commission released its new regulation on minimum requirements for water reuse for agricultural irrigation that will apply from mid-2023 (European Commission, 2020[41]). The regulation's central aim is to support the voluntary uptake of water reuse wherever it is appropriate and cost-efficient for member states (European Commission, 2020[41]). The regulation outlines harmonised minimum water quality requirements for safe reuse of treated urban wastewaters in agricultural irrigation; minimum monitoring requirements (notably on frequency and validation); risk management provisions to assess and address potential additional health risks and possible environmental risks; permitting requirements; and transparency provisions (European Commission, 2021[37]).

The EU water reuse regulation recognises that the relatively low uptake to date has also been driven by the level of investment needed to upgrade and/or operate and maintain wastewater treatment plants for reuse, and the lack of financial incentives for practising water reuse in agriculture (European Commission, 2020[41]). It proposes to address these problems through economic incentives for member states to properly account for both the costs and the socioeconomic and environmental benefits of water reuse, and by actively promoting innovation. The example of Israel suggests that water allocation regimes that guarantee a stable volume of reclaimed water, admittedly against significantly higher prices as before – while the volume of available freshwater remains uncertain – can stimulate demand for treated wastewater, in particular from farmers who grow perennial crops.

A 2016 analysis of the costs, pricing and financing of water reuse highlights that water reuse requires a comprehensive recalibration of the water tariff system; prices for other supply sources, including abstraction, need to adapt to overall change in demand when the additional supply becomes available (De Paoli and Mattheiss, 2016[42]). While prioritising the cost recovery objective, pricing strategies for water reuse need to be designed and delivered within broader pricing strategies, considering the components of the system, the costs included in the system, and the benefits (including environmental). The analysis finds that appropriate pricing strategies for water reuse depend on site characteristics, cost-profile, and who will recover the costs of water reuse (including which costs are recovered, objectives of the reuse scheme, the beneficiaries of the reuse, and the objective of pricing) (De Paoli and Mattheiss, 2016[42]).

### *NbS to address water scarcity*

As noted above, nature-based solutions (NbS) are gaining traction globally for their shared economic, environmental and social benefits, and have been encouraged in the context of WFD implementation for a number of years. The Blueprint to Safeguard Europe's Water Resources (European Commission, 2012[40]) emphasised the great potential of green infrastructure (another term for NbS), especially those focused on natural water retention, such as the restoration of floodplains and wetlands to hold water in periods of abundant and excessive precipitation and provide supply in periods of scarcity. More recently, the review of RBMPs called for more widespread use of green infrastructure and natural water retention measures in view of the multiple overlapping benefits they provide compared with grey infrastructure (European Commission, 2019, p. 245[12]). This is likely to require a refinement of analytical methods to adequately reflect the costs and effectiveness of non-structural measures: "The completeness of cost-benefit analysis differs across countries that apply this method. Environmental benefits are rarely considered, even though these can be especially important for the evaluation of non-structural measures and natural flood management options. In these cases, the combination of cost-benefit analysis with multi-criteria analysis seems to be promising as it allows to capture environmental benefits that can be decisive" (European Commission, DG Environment, 2021, p. 77[3]). The comparative advantages of NbS come out more clearly when the environmental costs of grey alternatives are thoroughly reflected. On-going work by the Green Climate Fund to calculate and factor in the carbon footprint of (steel and cement) materials used in grey infrastructures is a promising step in that direction.

Water-related NbS can have a range of direct and indirect benefits for water resources – in addition to recharging groundwater supplies and helping sustain surface flows, their storage characteristics can also improve the retention of moisture in soils (UN Water, 2021, p. 41[7]). They may be implemented in combination with grey infrastructure, and can in fact increase the effectiveness and operable life of grey infrastructure. For example, integrating NbS into grey flood control measures can increase water absorption capacity, reduce velocity, and regulate peak flows (Browder et al., 2019 in (OECD, 2020, p. 10[43]). In the Odra basin in Poland, natural flood retention areas (dry polders) have been combined with traditional flood embankments to protect against the recurrence of a very severe (1,000-year) flood (Browder et al., 2019 in (OECD, 2020, p. 10[43]).

The benefits of NbS have been found to outweigh the costs of implementation and maintenance in a range of contexts (OECD, 2022[44]; OECD, 2021[45]). Research has shown that in some cases, NbS can be more cost-effective than grey alternatives, and in particular for less extreme hazards. However, studies that compare the value of NbS to alternative approaches are rare, and economic appraisals often do not properly capture or value the full suite of co-benefits of NbS.

In addition to reducing losses and damages from water-related disasters and climate change impacts, the multiple co-benefits of NbS can have significant economic value. In Europe, it was found that restored rivers, in addition to increasing flood protection, enhanced agricultural production, carbon sequestration and recreation, yielding an estimated net societal economic benefit over unrestored rivers of an estimated EUR 1,400 per hectare per year (Vermaat et al., 2015 in (OECD, 2020, p. 9[43]).

## 3.2. Managing water scarcity through robust allocation regimes

### *3.2.1. Key principles and characteristics of effective regimes*

The OECD defines water allocation regimes as combinations of policies, laws and mechanisms to manage the risk of shortage and to help allocate water resources among competing uses. Robust water allocation regimes have a fundamental role in ensuring that approaches to water allocation do not exacerbate water scarcity but instead account for and address it. Well designed and implemented allocation regimes have two broad characteristics: they perform well under both average and extreme conditions, and are able to be adapted and adjusted to changing conditions at the least cost over time (OECD, 2015[46]).

In managing the risk of water shortage, water allocation regimes should aim to maximise the value that individuals and society obtain from water resources in terms of economic, environmental and social outcomes (OECD, 2015[46]). To achieve this, three generic principles can be used as a guide: economic efficiency, environmental sustainability, and social equity – described in Table 3.1. Well-designed allocation regimes should manage the risk of shortage without compromising the effectiveness of arrangements needed to ensure full control of flood, water quality and other water management tasks.

From an economic efficiency perspective, member states may wish to consider two central issues. The first relates to determining an efficient level of water supply that balances the “marginal costs” of increasing supply or improving its reliability (e.g. through new supply sources, storage or distribution) with the marginal benefits of doing so. This “supply side” approach has often been a response to increasing pressure on water resources, although as noted above, it is not always appropriate when greater net benefits can be reaped from improving demand side management. The second issue relates to how existing water resources are allocated among various purposes, accounting for allocative and technical efficiency[11], and incorporating appropriate abstraction charges.

## Table 3.1. General policy objectives of water allocation regimes

| Economic efficiency | Environmental sustainability | Social equity |
|---|---|---|
| • Allocative efficiency (allocating water to higher value uses).<br>• Efficiency in water use.<br>• Efficient allocation of risk of shortage.<br>• Efficient level of investment in augmenting water supplies and water dependent activities.<br>• Incentives for innovation and investment.<br>• Administrative efficiency. | • Hydrological integrity of the system.<br>• Adequate ecological (environmental) flows to support ecosystem services.<br>• Adequate ecological (environmental) flows to support key freshwater species. | • Equity among water users (or groups of users) and between existing users and new entrants.<br>• Equity in the process of allocation and re-allocation.<br>• Fair distribution of costs and benefits of the allocation regime.<br>• Equitable sharing of risk of shortage.<br>• Equity between generations (ensuring sustainable use of the resource) or community groups, including Indigenous people.<br>• Perceived fairness of the allocation regime. |

Note: These various (sometimes conflicting or competing) objectives need to be balanced, which requires addressing trade-offs between them. How this is done in a specific context will be strongly influenced by historic circumstances that have shaped existing allocation arrangements, the relative weight given to certain policy objectives over others, and the prevailing political orientation. Pricing instruments can help, although in practice, their level and structure will reflect similar relative weigh and trade-offs. In practice, water allocation arrangements are often put in place to serve other policy objectives outside of the water domain per se, such as food or energy security.
Source: OECD, 2015. *Water Resources Allocation: Sharing Risks and Opportunities*. (OECD, 2015, p. 38[46])

Historically, most countries’ allocation regimes were established in a piecemeal fashion over multiple decades, making many regimes poorly equipped to adjust to changing conditions and deal efficiently with current and future pressures (OECD, 2015, p. 30[46]). Allocation arrangements can be difficult and costly to adjust: they often have a high degree of path dependency that manifests itself in both institutional arrangements (law, property rights and policies) and long-lived water infrastructures, such as dams, canals and pipelines. As a result, many allocation regimes are usually not well-equipped to deal with mounting pressure on the resource, the emergence of new scientific understanding (of the resource or of related ecological needs), or adapt to shifts in societal preferences, such as increasing value placed on water-related ecological services. Such allocation challenges are aggravated by the entrenchment of weak water policies (under-pricing water or lack of regulating use), which contributes to structural water scarcity (OECD, 2015, p. 20[46]).

The OECD “health check” for water resources allocation (OECD, 2015[46]) can act as a guide to the fundamental principles and features of robust allocation regimes, posing a series of questions about their design and operation (see Box 2.1 and Box 3.4). Importantly, it underscores how different economic instruments and policy tools operate in combination with one another, not in a vacuum (OECD, 2017[28]). While an in-depth discussion of each component of this framework is beyond the scope of this note, the

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[11] Allocative efficiency focuses on allocating water to its highest value uses. Technical efficiency focuses on encouraging efficiency in water use (OECD, 2015, p. 36[46]).

outline provided in Box 3.4 reflects some critical policy, institutional and governance features that are needed to support sound allocation regimes. These include, for example, clearly defined government authorities and institutions with the right structures, mechanisms and resources in place to deliver their functions accountably and transparently, as well as the establishment of clear legal status and agreements for managing water resources within a jurisdiction. Another vital element is information (science, data, knowledge) which underpins knowledge of water resources availability and scarcity as well as monitoring and evaluation.

OECD work suggests that water allocation regimes are in a state of flux. Prevailing regimes are not fit for current and future challenges (they are typically maladapted to uncertainties about water availability and demand, driven by climate change). Moreover, reforms take time and are politically challenging.

Water allocation reform is essentially a socio-economic and political process involving significant iteration and negotiation, and adopting an overly technical approach can result in delays to the water reform programme (OECD, 2015[46]). It also benefits those actors that have the greatest capacity for engaging with strongly technical and legal processes, who tend to be the already privileged. The reform process allows for many opportunities for participation and negotiation, which can make it difficult to maintain control over a tight implementation plan and schedule. However, the negotiations can be an effective means to devise compromises and appropriate compensation measures to mitigate the potential negative impacts of the reform. This must be recognised from the outset, and as such extensive stakeholder engagement is necessary. Considering the sequencing of reform elements from a holistic perspective has proven equally critical (OECD, 2015, p. 114[46]).

Two directions for reform deserve particular attention in relation to the implementation of the Water Framework Directive and the risk of water scarcity. One relates to the definition of return flows and ecological flows: ecological flows define how much water remains in the water body to sustain ecological services. Return flows are an integral element of ecological flows as it defines how much abstracted water returns to the water body: net abstraction, or water consumption, is more accurate than mere water abstraction to address ecological needs; see some illustrations below. The other direction relates to building the capacity to adapt to shifting conditions in the very definition of water entitlements. Collective entitlements fit into this perspective, although pioneer attempts in France are facing institutional challenges (see Box 1.8 below).

### Box 3.4. The OECD "health check" for water resources allocation

Check 1. Are there **accountability mechanisms** in place for the management of water allocation that are effective at a catchment or basin scale?

Check 2. Is there a **clear legal status** for all water resources (surface and ground water and alternative sources of supply)?

Check 3. Is the **availability of water** resources (surface water, groundwater and alternative sources of supply) and **possible scarcity** well understood?

Check 4. Is there an **abstraction limit** ("cap") that reflects in situ requirements and sustainable use (cf. warranting the minimally required ecological flow?

Check 5. Is there an effective approach to enable efficient and fair management of the **risk of shortage** that ensures **water for essential uses**?

Check 6. Are adequate arrangements in place for dealing with **exceptional circumstances** (such as drought or severe pollution events)?

Check 7. Is there a process for dealing with **new** water users and for **increasing or varying existing entitlements**?

Check 8. Are there effective mechanisms for **monitoring and enforcement**, with clear and legally robust sanctions?

Check 9. Are **water infrastructures** in place to store, treat and deliver water in order for the allocation regime to function effectively?[12]

Check 10. Is there **policy coherence** across sectors that affect water resources allocation (e.g. agriculture, energy or urban development)?

Check 11. Is there a **clear legal definition** of water entitlements?

Check 12. Are **appropriate abstraction charges** in place for all users that reflect the impact of the abstraction on resource availability for other users and the environment?

Check 13. Are **obligations related to return flows and discharges** properly specified and enforced?

Check 14. Does the system allow water users to **reallocate water among themselves** to improve the allocative efficiency of the regime[13]?

The health check is generic but could be used with an environmental perspective to assess how an allocation regime supports the objectives of the WFD.

Source: OECD, 2015. *Water Resources Allocation: Sharing Risks and Opportunities*. (OECD, 2015, p. 120[46])

### *3.2.2. Ensuring adequate return flows and ecological flows*

Addressing return flows under allocation regimes can be particularly challenging (OECD, 2015[46]). When water becomes scarce, entitlement holders have an incentive to reduce return flows and save the water for themselves. This can undermine the integrity of the allocation regime if the change in the effective rate

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[12] This question has a "dynamic" counterpart: is there a clear investment path towards an efficient water supply mix? (personal communication by Paulus Arnoldus, DG Environment)

of consumption is not accounted for. There are generally two approaches to address this issue: i) reducing the abstraction limit as the technical efficiency of water use increases, with the reduction averaged across all entitlement holders equally; or ii) specifying return flow obligations in water entitlements (OECD, 2015, p. 49[46]).

Choosing between these options depends on an assessment of administrative costs and preference for stimulating innovation (OECD, 2015, p. 49[46]). The first approach rewards first movers in the pursuit of technically more efficient uses of water. The rate of adoption of more efficient irrigation technology should be faster. Those that move first benefit from access to water that was previously being used by others. The latter approach is more equitable, as changes in the choice of technology made by one person, which increase the technical efficiency of water use, have no impact on the amount of water allocated to all other users, as would be the case in the first approach. However, the latter approach is much more expensive to administer as the type of technology used by each person needs to be tracked and accounted for. In some cases, including several parts of the United States, a hybrid approach is taken. No attempt is made to account for changes within a farm, but when an entitlement is transferred to another person the entitlement is adjusted for expected changes in the return flow. As noted above, most EU member states need to better connect abstraction levels and ecological flows.

In designing an allocation regime and setting a long-term abstraction limit, it is important to decide whether to include some or all entitlements in this limit. The most common approach is to set aside the amount needed for environmental needs, non-consumptive uses, and transfers to other systems (including downstream obligations) as a prior right and then to allocate the remainder to take water for consumptive purposes (OECD, 2015, p. 48[46]).

An alternative approach, as seen in Australia, is to assign some water to the environment as an entitlement to a share of all inflows and define this entitlement separately from the arrangements used to ensure that base flows, for example, are maintained (OECD, 2015, p. 48[46]). For managing water allocation in the Murray-Darling Basin, Australia established a Commonwealth Environmental Water Holder to hold a given share of the basin’s water entitlements. Under this new arrangement, it is not possible for the government to allocate water to consumptive users without making a pro rata allocation to the Commonwealth Environmental Water Holder. Australia moved to this approach to put ecological flows on the same footing as all other water users, with allocations to be made in proportion to the number of entitlements held in the interests of the environment, no matter how dry or wet it is.

Other countries take various approaches to allocating water for ecological purposes. In certain areas of Israel, a minimum quota of water has been set aside and must be allocated to ecosystems. In Slovenia, the ecologically acceptable flow is set depending on the type of water use and type of ecological needs. In England and Wales, environmental flow indicators are used to determine the flows required by the environment by particular ecosystems. In Portugal, minimum environmental flows are determined on a case-by-case basis. (OECD, 2015, p. 70[46])

## 3.3. Designing abstraction charges

Appropriate abstraction charges are a central instrument in effective allocation regimes. At a minimum, they should reflect the full costs of providing access to water and act as an incentive to eliminate the most inefficient water uses (i.e. reflecting the opportunity cost of using water). In practice, though, many charges tend to function as administrative fees rather than being predicated on the economic value of water abstracted (Hanemann, 2006 in (OECD, 2015[46]). The figure below provides some illustrations.

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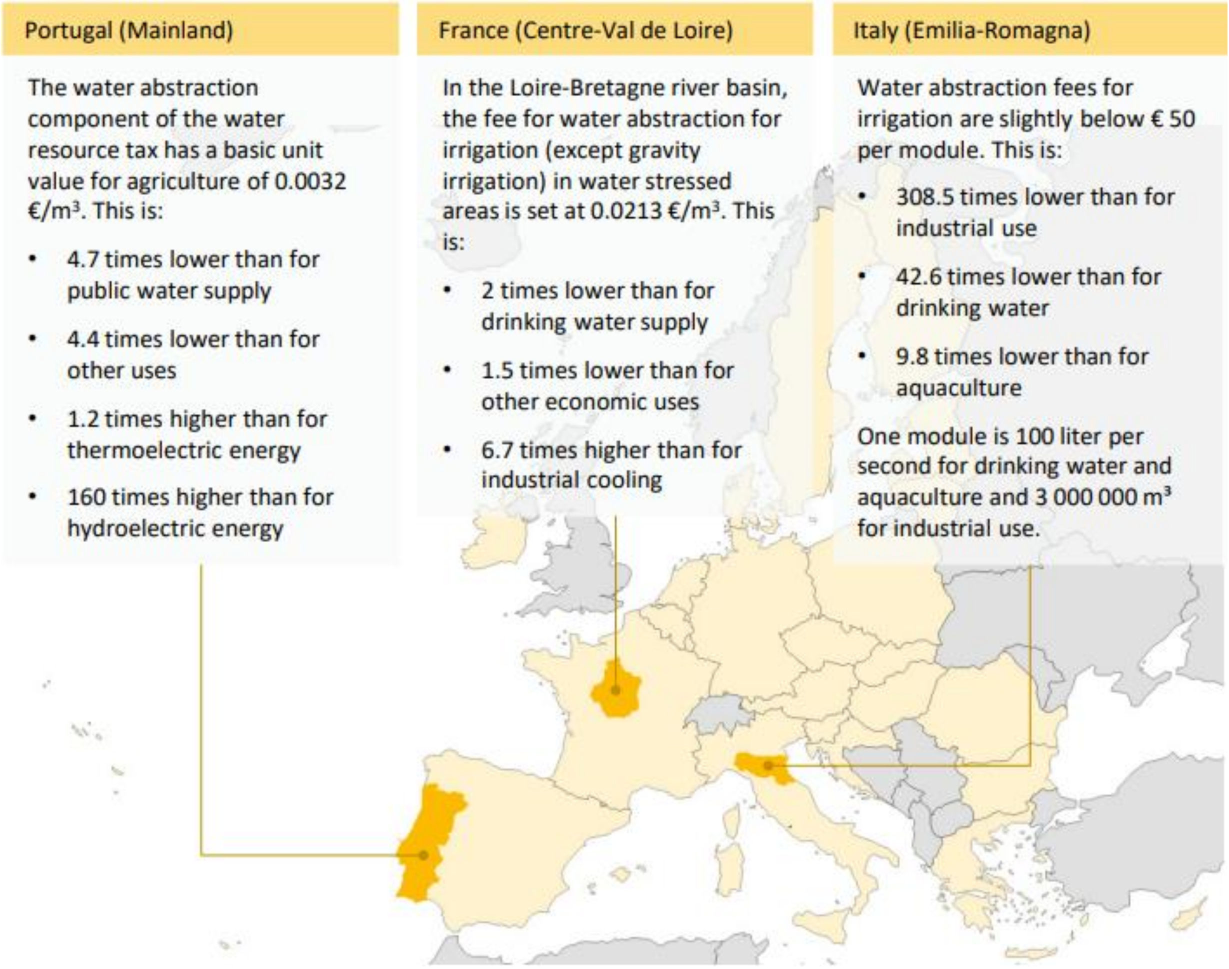
[13] In practice, various arrangements can be considered, such (more or less formal) trading, saving entitlements over time, setting up a water bank with buy-back and stabilisation function.

Figure 3.1. Comparison of water abstraction fees by sector



**Portugal (Mainland)**

The water abstraction component of the water resource tax has a basic unit value for agriculture of 0.0032 €/m³. This is:

- 4.7 times lower than for public water supply
- 4.4 times lower than for other uses
- 1.2 times higher than for thermoelectric energy
- 160 times higher than for hydroelectric energy

**France (Centre-Val de Loire)**

In the Loire-Bretagne river basin, the fee for water abstraction for irrigation (except gravity irrigation) in water stressed areas is set at 0.0213 €/m³. This is:

- 2 times lower than for drinking water supply
- 1.5 times lower than for other economic uses
- 6.7 times higher than for industrial cooling

**Italy (Emilia-Romagna)**

Water abstraction fees for irrigation are slightly below € 50 per module. This is:

- 308.5 times lower than for industrial use
- 42.6 times lower than for drinking water
- 9.8 times lower than for aquaculture

One module is 100 liter per second for drinking water and aquaculture and 3 000 000 m³ for industrial use.

Source: (European Court of Auditors, 2021, p. 25[47])

According to a recent study (European Commission, DG Environment, 2021[3]), abstraction and pollution charges are in place in several Member States and generate significant revenues leading to high “financial cost recovery”. However, revenues from such charges are not always earmarked to water management and are sometimes directed to the Central Government budget or are allocated to regional, local or municipal budgets. This may reflect potential tensions between the need to secure funding for water-related investments and the optimal allocation of public budgets across policy areas.

Many countries differentiate the rate of abstraction charges by the type of users (e.g. agriculture, domestic, industrial, energy production). This may (imperfectly) reflect net abstraction rates. For instance, water used to cool thermal plants is usually returned to the river body (albeit at a higher temperature). The agricultural sector commonly benefits from lower rates or from exemptions, as does the use of potable water, such as in Flanders (Belgium) (OECD, 2017[48]). Box 3.5 describes some examples of water charges and collective management in agriculture.

### Box 3.5. Water charges and collective management approaches in the agriculture sector

**Water charges for agriculture***

In England and Wales, the same level of charges applies to agriculture as to other sectors. The only special feature is to acknowledge that for irrigation the demand will fluctuate from year to year depending on rainfall. Consequently, irrigators are subject to a two-part tariff, where there us a standing charge of 50% of the full amount, and the remainder is variable according to actual usage. In order to be eligible for this, they must have a well-maintained, calibrated meter on the pump, and submit data on usage to the Environment Agency. They are also subject to more rigorous inspection, particularly in dry years.

France offers an example of a combined approach using abstraction charges and collective management. Farmers pay an abstraction charge, based on the volume of water taken from a water body. The charge varies by basins. In the Seine River Basin, there are set abstraction charges for irrigation for surface water and groundwater. The charge goes up in parts of the basin where water is chronically scarce. When farmers agree to collectively manage an entitlement in a water scarce area, they benefit from a reduced rate, which aims to serve as an incentive for farmers to create users associations (*Organismes uniques de gestion collective, OUGC*).

**Use of collective management in France****

The intermittent nature of demand for agricultural water is conducive to collective sharing of right of access (as opposed to individual ownership of a property right), as irrigators may, depending on the crops cultivated, draw water from a common resource at different times.

In France, the government created OUGCs to function as “single collective management bodies” to allow water users to take on the task of allocating a fixed abstraction limit among themselves. This aimed to address perceived failures of collective action in France, as problems had emerged in situations where irrigation expansion followed individual plans and decisions, as individual entrepreneurs failed to factor in the consequences of their decisions on the local community.

However, implementation has faced numerous challenges. The OUGCs have sparked strong controversy due to the conflictual relations between those exercising the tasks of the OUGCs and those that are meant to benefit from them (irrigators), as well as decision-making procedures which seem to limit the influence of some stakeholders. Furthermore, farmers have notably reacted to the fact that a collective quota has replaced their individual, permanent water entitlements. Also, a lack of clarity regarding key aspects in the legislation, including with regards to sanctioning and the judicial relation between the OUGCs and the farmers, has led to further lack of support of the collective management model.

Sources:
*On agricultural water charges: Adapted from input from Ian Barker, Peer-Reviewer for the OECD Brazil National Policy Dialogue, Water Policy International Ltd (England and Wales) in (OECD, 2017, p. 127[28]).
**On collective management in France:
OECD, 2015. *Water Resources Allocation: Sharing Risks and Opportunities*. (OECD, 2015, p. 102[46])
OECD, 2017. *Groundwater Allocation: Managing Growing Pressures on Quantity and Quality*. (OECD, 2017, p. 50[9])

In 2019, the OECD surveyed country adherents to the OECD Council Recommendation on Water (2016[22]) (comprising both EU and non-EU member states), and found that 74% of respondents had abstraction charges in place for surface water and groundwater[14] (OECD, 2021, p. 119[35]). For surface water, abstraction charges were most frequently applied to energy producers (i.e. in 63% of respondents), while for groundwater, abstraction charges were most often applied to industrial users (in 59% of respondents) and domestic users (in 44% of respondents). Less than half of the Council Recommendation's adherents (17 of 38 surveyed) reported that they used pricing as an instrument to manage water demand in agriculture (OECD, 2021[35]). The OECD concluded that further detailed reviews were needed to identify whether countries were designing their abstraction charges to signal the opportunity costs of water abstraction (i.e. primarily as water policy instruments) or to generate revenue (i.e. primarily as financing/administrative instruments).

Most abstraction charges are based on the price per volume of water abstracted, with the user paying a unitary rate per cubic meter abstracted or using a two tier tariff system (fixed charge and volumetric above some level) (OECD, 2021[35]). Some charges are also fixed per hectare for agricultural abstraction, a price per megawatt-hour for energy production, or nominal license fees linked to an abstraction permit regime like in the United Kingdom (OECD, 2021, p. 121[35]).

The level of the water charge is usually different based on whether it is sourced from groundwater or surface water. Some Adherents, federal states or water basins apply unique water charge to all types of sources such as in Germany (13 of 16 federal states) (Gruère, Shigemitsu and Crawford, 2020[49]). Special zones, aquifer, or rivers are subject to specific rates (e.g. "water distribution areas" in France or specific aquifers in the Flemish region in Belgium and in Estonia). Higher charges are often imposed on groundwater than on surface water (one exception is the Czech Republic) (OECD, 2017[48]).

The OECD (2021[35]) analysis indicated that many countries manage water abstraction charges at the sub-national level. For instance, charges are set at the regional level in Belgium, provincial level in Canada, and at state level in Germany, at the hydrographic basin level in France (with a legislated national price ceiling), and by four devolved administrations in the United Kingdom (OECD, 2017[28]).

Around the world, many countries' water abstraction charges still do not account for varying levels of water availability. The 2015 OECD Survey of Water Resources Allocation found that abstraction charges generally do not reflect water scarcity or the opportunity cost of using water (OECD, 2015[46]); this corroborates the observation by IEEP (2021[21]) in Europe referred to above. In those cases, the costs of depleting water levels are borne by the community at large, rather than by targeting those that use more water during scarce times or in scarce regions. In periods of severe scarcity, pricing instruments are usually supplemented by regulatory instruments restricting certain usages, such as in France or Japan where restrictions on low-value water uses are implemented during periods of scarcity (e.g. bans on washing cars, gardening or filling private swimming pools).

To reflect geographical and temporal variations in water scarcity levels, water abstraction charges can be flexibly adapted (a "scarcity premium"). In France, the threshold under which water users are exempt from paying abstraction charges depends on the water agency, the type of resource and the scarcity of water (OECD, 2017[28]). In Portugal, a legislated scarcity coefficient for different river basins has been used to reflect different levels of water scarcity geographically and temporarily throughout the year (OECD, 2015[46]). Spatial and seasonal variation can be particularly important in agriculture. For instance, in Greece, water pricing is differentiated by region, while in Hungary, pressure multipliers are applied to raise prices in groundwater bodies facing water risks (OECD, 2021[35]).

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[14] Abstraction charges for both surface water and groundwater were absent in only three responding adherents to the OECD Council Recommendation on Water (2016[22]): Austria, Chile and Sweden. Notably, Austria and Sweden are water-abundant adherents, while Chile extensively relies on market instruments to allocate water where it is most needed (OECD, 2021, p. 120[35]).

Box 3.6 describes some of the main challenges and options for addressing both the environmental costs and overall opportunity costs of water.

### Box 3.6. Reflecting the environmental and opportunity costs of water use

Assessing the distinct values, costs and benefits associated with water (both quantity and quality) can assist policy makers in prioritising investments and determining policy options that provide the greatest welfare. However, choosing the level of an abstraction or charge to cover precise environmental and opportunity costs is highly complex and challenging for a few reasons:

- Assessing environmental costs implies valuing the cost of the damage caused by abstraction or pollution of water on the ecosystem (for instance when nutrient run-off from agriculture into surface water leads to extra water treatment costs downstream). Some of these costs may be visible only in the long run (for instance, the impact on the fish population or biodiversity) and are difficult to monetise because several environmental benefits are not currently priced.
- Measuring some costs faces acute methodological issues (e.g. measurement and attribution of diffuse pollution to polluters).
- Measuring the opportunity cost of using water in a scarce environment requires measuring the benefit induced by water for all types of use (agriculture using irrigation water, drinking water supply, hydropower etc.), with benefits that commonly vary from one season to another (opportunity costs are usually higher when rainfall and runoff are low).
- Economics can provide estimates of (use and non-use) values attributed to a water resource. How practical such estimates are remains an empirical question. There are likely to be conflicting values, missing values and double counting identified during a total economic value study. There are also uncertainties about the underlying environmental responses. The monetary estimates will be context dependent, i.e. they will be contingent on where and when, and under what regulatory system they are estimated. Hence, it is likely that values will vary in both time and space.
- In contrast, one can measure the opportunity cost as based on the shadow cost concept through estimating the price where the freshwater uptake would remain within sustainability bounds. This is an attractive concept, as this would also lead to concrete information to base prices on. However, this requires the use of an economic model of the comprehensive system of water supply and water users, and thus respectively data on their costs and demand functions.

Some techniques to assess environmental and opportunity costs include:

- **Bio-economic studies**: These can estimate the full marginal value of the environmental flow in each watercourse. Such studies are difficult to undertake since they require expertise from various sciences. They are resource-intensive and their findings may not be easily transferable since estimates are going to be site-specific.

- **Non-market valuation techniques** (e.g. contingent valuation, travel cost method): These are employed since environmental benefits are typically not priced. They can estimate the economic value of environmental benefits of water flows and water of a certain quality. Non-market valuation techniques can also be used to monetise scarcity but other techniques to value scarcity are either production function approaches or intermediate good (value added) approaches where the production cost and income will be affected by access to water. For instance, if there is a government programme providing water for farmers, income differences between those having access to the programme and those not having access would reflect the benefit of the programme.
- **Markets for trading water abstraction and pollution rights**: These can provide a clear indicator of the value of water, but prices depend on the number of rights initially provided by the regulator. For instance, in a situation with a too-generous regulator, the value of water rights would be lower, which would not be a good signal of the value of water in a water scarce context.
- A water economic model can help to estimate the shadow price of freshwater (see Dinar and Tsur (2021[50]))

Source: OECD, 2017. *Water Charges in Brazil: The Ways Forward.* (OECD, 2017, pp. 90-91[28]) (Dinar and Tsur, 2021[50])

### *3.3.1. Sustainable agro-environmental measures and farming techniques and crop patterns*

Charges for agricultural water management (as discussed above in section 3.2) should be explicitly linked with agricultural policies. This is because the cost for the farmer of paying those charges, or of reducing water abstraction and pollution, is partly determined by restrictions and charges on inputs, subsidies on equipment, or for environmental practices such as voluntary agro-environmental programmes (OECD, 2017, p. 124[28]).

The new Common Agricultural Policy (CAP) is instrumental in strengthening the efforts of European farmers to contribute to the EU's climate objectives and to protect the environment. Eco-schemes are a new instrument in the CAP to support this transition. Eco-schemes are designed to reward farmers that choose to go one-step further in terms of environmental care and climate action. Member States will have to set eco-schemes in their CAP strategic plans. For example, eco-schemes could support "managing crop water demand by switching to less water intensive crops, changing planting dates and optimised irrigation schedules" under the climate change adaptation strategic plan (European Commission, 2021[51])[15].

Agro-environmental programmes aim to reduce the negative impact of agriculture in exchange for a payment. Farmers are paid for adopting greener practices and for providing ecosystem services such as protecting biodiversity, increasing water quality, and providing flood protection. Agro-environmental programmes have become increasingly important components of agricultural policy in both Europe and the United States (e.g. subsidies for converting to organic farming, for crop rotation). Farmers are paid for planting cover crops during the winter, which curb erosion and prevent nitrogen leaching into groundwater. They also receive some compensation for establishing grass buffer strips along rivers and streams, which filter nonpoint source pollution from fertilisers and pesticides. In England, payment for ecosystem services schemes has gained traction with water utilities, with improved outcomes not only for water quality and reduced water treatment costs, but also for biodiversity, flood management and environmental flows. A

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[15] The *Background note: Water investment planning and financing* for the first thematic workshop synthesises information on eco-schemes under the CAP.

scheme implemented in England (OECD, 2017, p. 124[28]) was found to be more environmentally effective and cost-efficient than upgrades in water treatment to remove nutrients and pesticides.

It should be noted that agro-environmental schemes have been criticised for generating windfall profits: subsidies sometimes more than offset the cost of implementing the greener production process (OECD, 2017[28]). Concerns about equity can arise if payment for ecosystem services (PES) are seen to “reward polluters” while neglecting producers already demonstrating best practice. To address these concerns, PES should only be considered when farmers collectively comply with baseline regulation to achieve “additionally” in response to PES incentives (OECD, 2013[52]).

Low-till agriculture is one example of a farming practice with significant potential benefits for soils, water management and broader ecosystems. It entails the combination of crop harvests that leave at least 30% of crop residue on the soil surface during critical soil erosion periods and some surface work (low tilling). This has the benefit of slowing water movement which in turn reduces soil erosion and can support improved infiltration (European NWRM Platform, 2021[53]).

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