A quarter of a century of the European Water Framework Directive—The slow path towards sustainable water management

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The European Water Framework Directive (WFD) is one of the most analyzed environmental legislations in the scientific literature, influencing the water management in some non-European countries. The WFD has the strong ambition of achieving a good ecological status of water bodies across all river basins in Europe. However, the advances towards sustainable management are falling far behind the planned schedule. The emphasis of the Directive is focused on water quality rather than on water quantity. The advances during the last quarter of century since its inception have been strong on urban and industrial point pollution, but not on agricultural nonpoint pollution that remains high and even increases in major basins. Water quantity aspects have been mostly left aside in the Directive, despite the fact that water scarcity is a serious problem in Southern European countries, and will become more critical with climate change in most basins across Europe. Some policy measures of the WFD need to be reformed, in particular measures for abating agricultural pollution, and new measures for addressing water scarcity. The narrow focus of the WFD on water pricing to solve at the same time issues of financing, water allocation and efficiency, environment, opportunity costs and pollution abatement, should be broadened. The challenge is giving more emphasis to command & control and collective action instruments, and designing combinations of instruments adapted to sectoral and spatial locations in basins. This overhaul of the water policy instruments by the European Commission will be needed to advance in the sustainable management of river basins in Europe.

Keywords: Water Framework Directive, sustainable water management, policy instruments, pollution abatement, water scarcity.

1. Introduction

Ongoing water management and policies across the world deal with water resources by reallocating water to the most financially profitable activities or to priority uses (e.g., drinking water), with little or no consideration of the effects of reallocations on the deterioration of water resources and the ensuing damages on aquatic ecosystems (Vörörsmarty et al. 2010 and 2018). This inadequate recognition of the environmental services and related benefits in water allocation decisions has resulted in the degradation of many valuable ecosystems globally. In fact, biodiversity in inland aquatic ecosystems is the most threatened of all ecosystems (MEA 2005; Arthington 2012).

There are three main issues for the sustainable management of water resources: water quantity, water quality, and the services provided by water dependent ecosystems. Water policies in both the European Union and the United States show that the main issue that has been addressed is water quality, while water scarcity and ecosystems services are mostly disregarded. Both the European Water Framework Directive (WFD) and the Clean Water Act (CWA) in the US seek to improve the health of water bodies by reducing the pollution loads. The WFD is quite ambitious pursuing the good ecological status of all surface and groundwater bodies, while the Clean Water Act only considers the water quality of surface water by setting point source pollution standards.

Craig (2018) indicates that the EU WFD has not achieved is ambitious objective of good ecological status for all water bodies, claiming that the US CWA has been successful in achieving its more modest objective of point pollution control. However, the abatement of point pollution is more advanced in Europe, since the share of tertiary treatment plants in most EU countries are well above 60% while the share in US is below 50% (OECD 2023a).

The problem in the US is that water regulation does not address many areas of water management. The management of river basins by basin authorities has not been developed in the United States. The only institutional arrangements have been some interagency committees and river basin commissions without authority for regulations, and the federal and interstate water compacts. Studies on the river basin plans were undertaken in the 1930s but the only outcome was the Tennessee Valley Authority, given that there is no federal authority on interstate basins and states have the control of water in their territory. Another attempt to elaborate basin plans was made by the Water Resources Council, which was created in 1965 and eliminated in 1982.

The sustainable management of water resources needs scientific knowledge and appropriate governance at basin level for enhancing the balance between human water withdrawals and environmental flows in basins, and for curbing pollution loads. Understanding the interactions between humans and rivers is essential for the assessment and implementation of adequate river management that could protect environmental flows (Baccour et al. 2023 and 2021, Anderson et al. 2019).

The water policy interventions in Europe in recent decades have clearly lessened the pollution of rivers, by reducing the loads of organic matter, nutrients, and dangerous substances such as heavy metals and chemical compounds. The main drivers have been the installation and upgrading of wastewater treatment facilities in urban centers and industries, and the use of phosphate-free detergents. Despite regulations and large investments in urban and industrial water treatment plants, water quality remains low in many river basins because nonpoint pollution loads from agriculture are not decreasing or even increasing in some basins. Also, water scarcity issues have been barely addressed in European water policies.

The paper is organized by describing the historical background of the WFD in Section 2, followed by Section 3 which presents the objectives, program of measures and monitoring mechanisms. Section 4 analyzes the implementation problems of the Directive in irrigation and nonpoint pollution, and Section 5 deals with the water scarcity issue in the case of Spain. The conclusions and policy implications are presented in Section 6.

2. Historical background of the Water Framework Directive

The initial water legislation in Europe was passed to deal with the quality of water resources, by enacting the Dangerous Substances Directive (1967) and the Quality of

Surface Water Directive (1975). Major water reforms were undertaken in more recent decades, and the main water regulations include the Urban Waste Water Treatment Directive and the Nitrates Directive, both of 1991, the Drinking Water Directive of 1998 (revised in 2020), and the Water Framework Directive of 2000. The emphasis of all these European regulations has been on water quality issues rather than on water quantity. Early legislation followed emission standards or water quality approaches for pollution abatement. But in the 1980s, European governments recognized the need to address industrial, urban and agricultural pollution together. The consequence was the adoption of the Urban Waste Water Treatment, Nitrates and Drinking Water Directives, and the preparation of a framework instrument establishing the principles of sustainable water policy leading to the Water Framework Directive.

The Urban Waste Water Treatment Directive required building depuration plants with secondary or tertiary treatment facilities. The investments in urban treatment plants have been large, with recent annual sanitation expenditures at €33 billion in EU-27 (OECD 2020). This has achieved a significant reduction of organic matter and of nitrogen and phosphorus emission loads into water media, and has resulted in less environmental damage to aquatic ecosystems. The Central and Northern European countries have depuration plants with tertiary treatment in place, and tertiary treatment is also prevailing in Southern and Eastern countries. In Southern Europe, treated urban wastewater is reused in areas with strong water scarcity, and the potential is significant. The main reuse areas are located in Spain (10% reclaimed or 500 Mm^3), Italy and Greece (5%), and Cyprus (89%) and Malta (60%).

The Nitrates Directive aims to protect water quality by preventing nitrates from agricultural sources to pollute ground and surface waters. The main policy measures are the identification of vulnerable zones to nitrate pollution, good farming practices, and the setting of fertilization limits. The purpose is the abatement of nitrate pollution in water bodies and the mitigation of greenhouse gas emissions that are generated by excessive nitrogen fertilization and manure surpluses. However, the achievements of the Nitrates Directive during the last three decades are questionable. One problem with the Directive is the weak enforcement mechanism, and another is the setting of homogeneous measures across the different European regions, which is questionable since the magnitude of the nitrogen pollution loads in soils varies widely by region.

The WFD largely addresses water quality for achieving the good ecological status of water bodies. This is clearly stated in the Directive which declares “This Directive aims at maintaining and improving the aquatic environment in the Community. This purpose is primarily concerned with the quality of the waters concerned. Control of quantity is an ancillary element in securing good water quality and therefore measures on quantity, serving the objective of ensuring good quality, should also be established.” (EC 2000).

All these major water policy initiatives between 1991 and 2000 were taken in order to deal with the widespread water quality degradation from non-point and point pollution all over European basins. However, water scarcity which is the main issue in Southern European basins was barely addressed. The forty-one definitions of terms used in the WFD (Article 2) do not include key concepts for sustainable management such as environmental flows or water scarcity. It took up to 2015 for the acknowledgement by the European Commission of the importance of environmental flows by issuing a guidance document on the subject (EC 2015a), in order to implement environmental flows in the second management cycle of the WFD (2016-2021).

3. The Water Framework Directive

The WFD intends to achieve good ecological status for all water bodies through water management at basin level, the combination of emission limits and water quality standards, water pricing policies that follow the cost recovery and polluter pays principles, and the participative management of basins. The first phase of the Directive up to 2009 covered the definition of river basin districts and basin authorities by 2003, the characterization of pressures,[1] impacts and economic analysis of basins by 2004,

[1] The Water Information System for Europe (WISE 2024) indicates that “the WFD requires the identification of significant pressures from point sources of pollution, diffuse sources of pollution, modifications of flow regimes through abstractions or regulation and morphological alterations, as well as any other pressures. ‘Significant’ means that the pressure contributes to an impact that may result in failing to meet the WFD objectives of not having at least good status.”

and the elaboration of the basin management plans and the programs of measures by 2009. The second phase involved their implementation in the first management cycle (2009-2015), by introducing the water pricing policies in 2010 and by making the programs of measures operational in 2012, which were supposed to reach the good ecological status of water bodies by the end of the first cycle in 2015. We are now in the third cycle 2022 to 2027, and European countries are still far from achieving good ecological status for all water bodies.

This failure of governance results to achieve good status has not been the main focus of the scientific literature. The primary issue in WFD studies is water quality in relation to the management and control of pollutants in rivers and groundwater. The second issue deals with the ecological status of water bodies, based on biological, trophic and hydromorphological aspects. The third issue in importance is related to chemicals or other priority substances and sediments. The WFD is one of the most studied environmental legislations with 250 papers per year since 2010 (Copetti and Erba 2023). This literature concentrates on science-related issues with five times more studies than on governance, although governance failures are the main reasons for the meager advances in the sustainable management of European basins.

At the launch of the WFD, the only European countries with well-developed basin authorities were Spain and France, since their basin authorities were established in the 1920s and 1960s, respectively. Basin authorities in other European countries have mostly been established in the years before or after the approval of the WFD in 2000. The water management approach in Spain is institutional and based on stakeholders' cooperation in river basin authorities, where stakeholders are involved in all their governing bodies and run the local watershed boards. An important outcome is that stakeholders reduce water withdrawals during periods of water scarcity. In France, basin authorities include representatives of water users and of local, regional and national authorities. Their main tasks are setting the water taxes and deciding the investments, where they follow the "water pays for water" rule which means that financing comes from the water users in each basin.

The WFD was designed following the French approach to basin management where "water pays for water" in basins, rather than the Spanish approach of institutional cooperation based in the collective action of stakeholders. This “water pays for water” approach underlies the emphasis of the Directive on water pricing, cost recovery of water services, and the polluter pays principle. Other key policy instruments such as command and control, water markets, or stakeholders’ collective action are barely or not mentioned. The policy shortcomings of the Directive derive from ignoring the need to combine different policy instruments to deal with the public good, common pool resource, and private good characteristics of water, with specific instrument combinations across locations and sectors.

3.1 The program of measures

The program of measures is the tool for achieving the good ecological status objective in each basin plan, and water pricing is regarded as an essential component of the program. The Directive introduces the principle of water prices close to full recovery cost, considering also that water pricing will improve water use efficiency. The full cost must include abstraction, distribution and treatment costs, as well as environmental costs and resource value.

The use of water pricing as a single environmental policy instrument for recovering the supply, treatment, environmental and resource components of full costs is questionable. The problem is the following: a unique policy instrument, water pricing, cannot be used to achieve different objectives such as financing water infrastructures, control allocations, protect the environment, cover the opportunity costs of water, promote the efficiency in water uses, and abate water pollution. The Tinbergen Rule (Tinbergen 1952) states that to successfully achieve n independent policy targets, at least the same number of independent policy instruments are required.

Some authors question the idea of “getting the price right” for achieving different policy targets such as environmental (ecosystem protection, water conservation and efficient use) and cost recovery targets, which is a conceptual mistake that confounds the two issues (Massarutto 2020). Other authors advocate for a policy mix that includes water pricing, non-pricing measures, and governance initiatives at different scales (Berbel and Expósito 2020).

The principle of pricing and cost recovery as key elements in the policy analysis advocated by the directive has been reiterated in the successive documents of the European Commission and by experts and think tanks (EC 2012; European Parliament 2012; Treyer and Convery 2012; EC 2019a; Pellegrini et al. 2023; OECD 2023b). Cost recovery is clearly indispensable for maintaining and upgrading water infrastructures. Increasing water prices up to recovery cost is an interesting measure in urban and industrial networks; in that context, water has private good characteristics and water demand responds to water prices, thus leading to higher water use efficiency. Massarutto (2020), however, indicates that in urban networks cost recovery and ecological and social sustainability are separate issues that require additional economic instruments beyond “getting the price right”. Water pricing is paramount in Central and Northern Europe where water demand is largely urban and industrial, while water pricing may not be the best reallocation instrument in Southern Europe because irrigation has mostly common pool characteristics precluding the use of water pricing for reallocation. Also, environmental flows are public goods external to markets (Albiac et al. 2020).

The policy measures of the Water Framework Directive (WFD) are divided between basic and supplementary measures. Mandatory basic measures include water pricing, point and non-point pollution abatement, and any measure required under previous legislation, such as the Nitrates or the Urban Wastewater Treatment Directives. Optional supplementary measures include legislative, administrative and economic instruments, emissions and abstraction controls, environmental agreements, codes of good practice, wetland restoration, and demand management and water efficiency enhancements.

The European countries have considerable flexibility in selecting the adequate combination of measures in each river basin management plan. However, the combination of measures selected by countries in river basins failed to achieve the 2015 deadline for good status of water bodies. The progress toward sustainable management is very slow because of the drawbacks in the design, implementation and enforcement of measures.

3.2 The ecological monitoring of water bodies

The WFD has brought about a great effort across member countries to monitor the ecological status of water bodies. This ecological status is measured through biological, hydromorphological and physicochemical quality indicators. This work is supported through "intercalibration", which involves extensive cross-comparisons of the status of European water bodies across European basins. The assignment of the ecological status or class depends on the worst quality element in each indicator of the water body affected by human activities; this is what is known as the "one out, all out" principle. Despite this significant monitoring effort, the effects of human pressures on ecosystems are poorly known (Carvalho et al. 2019). This linkage between pressures and impacts is critical for developing sound measures that improve the ecological status in basins, with the understanding that they would be politically feasible.

The biological, hydromorphological and physicochemical indicators are the basis for the WFD system. The conceptual foundation relies on the Pressure-State-Response model developed by the OECD, which was adapted by the European Environment Agency by adding the driver and impact components. The indicators show the gap between the current and "pristine" ecological status of water bodies, and the WFD policy measures are supposed to offset any human disturbances. The programs of measures are embedded in the basin plans, and should be built on previous assessments of pressures and impacts that follow a systemic approach to capture all relevant interactions. However, Linton and Krueger (2020) claim that the conceptual separation between people and nature in the WFD precludes both the political legitimacy and the scientific credibility of the Directive.

The European Commission issued the Actions toward good status of water (EC 2015a) and the Fitness Check of the WFD (EC 2019b), where it states that the European water legislation is adequate. These assessments indicate that there is progress towards addressing the challenges faced by water resources, although recognizing that there is room for improvement. However, there is a long way to go before the quality of most EU water bodies reach good ecological status. Significant water policy shortcomings exist, and the Water Information System for Europe indicates that 60% of EU surface waters had not yet reached good ecological status by 2018 (EEA 2018).

In the second management cycle 2016-2021 the estimation of the ecological status has been expanded to almost all water bodies, although there are significant gaps in the accuracy of biological and hydromorphological indicators. Also, the chemical status of many water bodies is unknown due to deficient monitoring. These problems of inaccuracy or lack of information prevent the design and implementation of reasonable measures to achieve good ecological status or even to make improvements in these water bodies.

The overall ecological status has not improved across basins since the first management cycle. The exemptions to achieve good status are used extensively with around half of water bodies under exemptions, justified by technical feasibility, natural conditions or disproportionate costs. Also, the Fitness Check (EC 2019b) claims that the meager progress in ecological status responds to insufficient changes in water pricing policies.

4. Implementation issues

Some important implementation issues for the WFD are the suitability of water pricing for water reallocation in irrigation, the claim of using the polluter pays principle for the abatement of nonpoint pollution, and the wicked challenge of nutrient pollution for economic instruments.

4.1 The difficulties of using water pricing in irrigation for water reallocation

Water pricing gained recognition during the 1990s in the Dublin Conference on Water and the Rio Declaration, and it has received support from the World Bank and the OECD. The result has been that the price instrument was included in water legislation in Brazil (1997), South Africa (1998), the European Union (2000), Bangladesh (2013), and China (2016).

Perry et al. (1997) discuss if considering water as an economic good is a solution or a problem. They indicate that water pricing choices are exceptionally difficult because of the role of water as basic need, merit good, and social, economic, financial and environmental resource. Further difficulties arise from the complexity of water flows in basins that lead to externalities, market failure, and substantial transaction costs. These difficulties imply that market tools can have unpredictable and negative effects in the absence of strong institutional preconditions.

Grafton et al. (2020) use case studies to solve the decision makers "paradox of water pricing", where water never equals its value or covers its costs. They indicate that solving the paradox requires addressing the tradeoffs between efficiency and equity, clarifying the objectives of water pricing, and the adequate design of water tariffs. For irrigation, they highlight the case of Vietnam, where irrigation charges were discontinued leading to the degradation of water infrastructures.

There is a debate on the water pricing instrument in irrigation. Bosworth et al. (2002) and Cornish and Perry (2003) describe the difficulties of water pricing in irrigation reviewing both the literature and the experiences on the field. They find that the response to volumetric pricing is minimal, and the withdrawal restrictions in areas under water scarcity are set up through water allocation or rationing rather than pricing. They also claim that water markets are more effective than water pricing for achieving allocation efficiency. In the same vein, Schierling and Treguer (2016) point out that irrigation demand is price inelastic, with small reductions requiring high price increases and large income losses to farmers.

Hellegers and Davidson (2023) explain the difficulties of irrigation water pricing using the concepts of private and full water supply costs, and private and full values of water demand. The full (private and external) benefits and costs are mostly disregarded in pricing reforms, and markets ignore these full benefits and costs. Water pricing for irrigation is an unsuitable instrument to reduce demand because of the shape of supply and demand, the existing equilibrium position, and the size of the charge for getting to the social optimum. Farmers cannot be asked to pay for the substantial price hikes that include environmental damages, and therefore water rationing is a much more effective instrument for reducing demand.

Water pricing in irrigation has been compared by Kahil et al. (2016) with water markets and the current institutional cooperation, as alternative instruments to deal with water scarcity in the Jucar Basin (Spain). The results show that water pricing is very detrimental to farmers by tripling their benefit losses (-75% of baseline without drought) with respect to the losses under establishing water markets or the current institutional cooperation (-25%). This finding shows that water markets or institutional cooperation are much more economically efficient and equitable, and selecting the water pricing instrument generates disproportionate costs to farmers which would surely lead to policy failure.

Because of the pressures of the European Commission, water pricing in irrigation is being considered in Southern Mediterranean countries but not in Central and Northern European countries, although the information available is quite scarce. Berbel et al. (2019) indicate that there are no water taxes for irrigation in Germany, the Netherlands and Denmark. In Germany, there was a water tax only in the state of Baden-Württemberg that was eliminated in 2011, and in the Netherlands the water tax implemented for large irrigation farms was eliminated in 2008.

There are irrigation water taxes in Spain, Italy, France and Portugal that cover the costs of storage and delivery facilities, or taxes on withdrawals. Taxes are around 0.005 €/m^3 in Spain, 0.002 €/m^3 in Italy, 0.007 €/m^3 in France and 0.003 €/m^3 in Portugal. Average water prices that include the management costs of water user associations are 0.07 €/m^3 in Spain, 0.05 €/m^3 in Italy, 0.07 €/m^3 in France, and 0.03 €/m^3 in Portugal and Greece (Berbel et al. 2019 and 2007; Montginoul et al. 2015; Massarutto 2015; Latinopoulos 2005).

The range of water taxes in these countries is between 0.002 and 0.007 €/m^3 and the prices of irrigation range from 0.03 to 0.07 €/m^3, and these water taxes and water prices are very low to alter water demand because the shadow prices of water are much higher. The shadow prices of irrigation water depend on the crop, and in the case of Spain shadow prices are around 0.90 €/m^3 for fruit trees, 1.10 €/m^3 for vegetables, and 0.15 €/m^3 for field crops (Baccour et al. 2023; Esteban and Albiac 2012), although shadow prices in greenhouse production areas are above 5 €/m^3. Therefore, water taxes have to be increased by two orders of magnitude to start lifting water prices towards the shadow prices of crops.

Water pricing could be used in agriculture in the long run to recover costs and to indicate water scarcity in basins. However, water pricing is not feasible in the short run to reallocate water during droughts because the price hike to balance supply and demand would be politically unfeasible. There would be also very challenging technical and information obstacles in undertaking the tatonnement process by sector, location and season, in order to find equilibrium prices and quantities for withdrawals and environmental flows.

The narrow focus of the European Commission documents on water pricing precludes the need for considering the combination of instruments to address the control of both quantity withdrawals and pollution loads.

4.2 The polluter pays principle and the nonpoint pollution wicked problem

The Water Framework Directive includes the OECD's "polluter pays" principle as the suitable rule for pollution. The principle is applied with success to urban and industrial point pollution following the economic analysis of point sources using typical control instruments such as taxes, emission standards or emission permits (Baumol and Oates 1988). The very large investments to comply with the Urban Waste Water Treatment Directive in recent decades have reduced substantially organic matter and nutrients, decreasing the environmental damages.

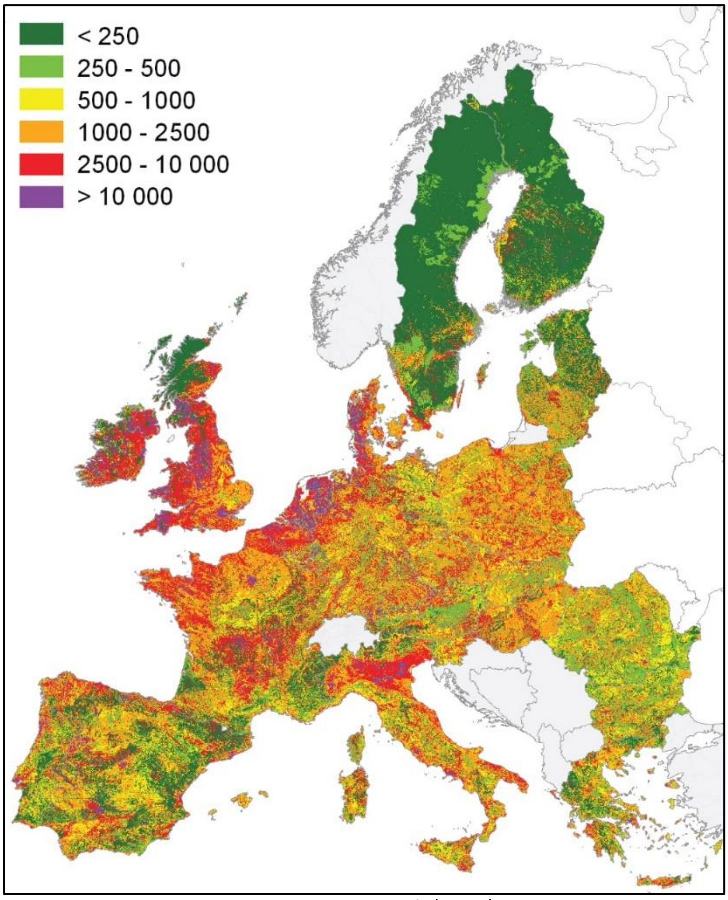
Agricultural nonpoint pollution is a quite different problem generating nutrient emissions into water media, and emissions of greenhouse gases into the atmosphere. Both water pollution by nutrients and GHG loads are complex problems arising from excessive use of fertilizers and intensive livestock farming. The "polluter pays" principle cannot be applied to pollution from agriculture, since pollution loads from agriculture are nonpoint emissions, and the tools used in point source pollution are not suitable for non-point pollution.

The control of non-point pollution is more difficult because the regulator lacks information about the location of the source of pollution, the volume of emission loads, and the transport and fate processes between the source and the receiving body. This situation favors the strategic behavior of agents, since the information is asymmetric, and the polluting agent has more information than the regulatory entity.

Shortle and Horan (2017) indicate that the complexity derives from the existence of multiple pollutants from multiple sources, which follow transport and fate processes along several paths, and with the ensuing ambient pollution loads damaging ecosystems and affecting humans' health. Pollution monitoring or even prediction modeling are unfeasible because source loads and pollution pathways to receptors are highly stochastic and cannot be observed. The use of economic instruments remains theoretical, and they have not achieved any demonstrable results. These authors point out that the complexity of the biophysical environment implies that a single pollution price implicit in taxes or permit markets does not exist, and they conclude that this lack of a pollution price converts nonpoint pollution abatement with economic instruments into a "wicked challenge". The biophysical complexity along the transport and fate of pollutants, the asymmetric information, and the transaction costs of the abatement policies, imply that pragmatic regulation cannot be based on economic instruments. Therefore, nonpoint pollution policy instruments cannot adhere to the "polluter pays" principle and practical solutions should be based on command and control and collective action instruments, or combination of instruments.

Several policy initiatives have been taken in some countries to address the abatement of agricultural nonpoint pollution, such as the Nitrates Directive in Europe or the conservation programs in the USA. The Nitrates Directive seeks to limit nitrogen emissions from farming systems caused by excessive nitrogen fertilization and manure surplus. However, the achievements of the Nitrates Directive during the last three decades are questionable because the entry of nitrogen in soils has not been curtailed.

The main problems with the Directive are the focus on isolated vulnerable zones instead of full basins, the absence of enforcement mechanisms over crops not receiving substantial subsidy payments, the lack of customized measures for each spatial location targeting pollution hotspots, and weak enforcement mechanisms based on penalizing agricultural subsidies of farmers drawn at random (Albiac 2009; Albiac et al. 2020). The information on nitrogen pollution in European rivers confirms the disappointing results. The existing data from OECD (2008) show no abatement at the mouth of rivers or even pollution increases, compared to 1991. Billlen et al. (2011) estimate the loads at the mouth of European river at 4 million tN (Figure 1), and the



Source: Sutton et al. (2011).

Figure 1. Density of N emission loads to aquatic systems (kgN/km^2 per year).

available basin studies for the Seine (Romero et al. 2016), Po (Musacchio et al. 2020) and Thames (Howden et al. 2011) rivers indicate pollution increases since 1991, even doubling the nitrogen load at the river mouth in the case of the Seine.

The results of conservation programs in the United States are another case that shows the failure of economic instruments in reducing agricultural nonpoint pollution. Despite spending 5 billion US dollars per year in conservation programs over the last two decades, there is no clear general improvement of water quality in basins (Ribaudo 2015).

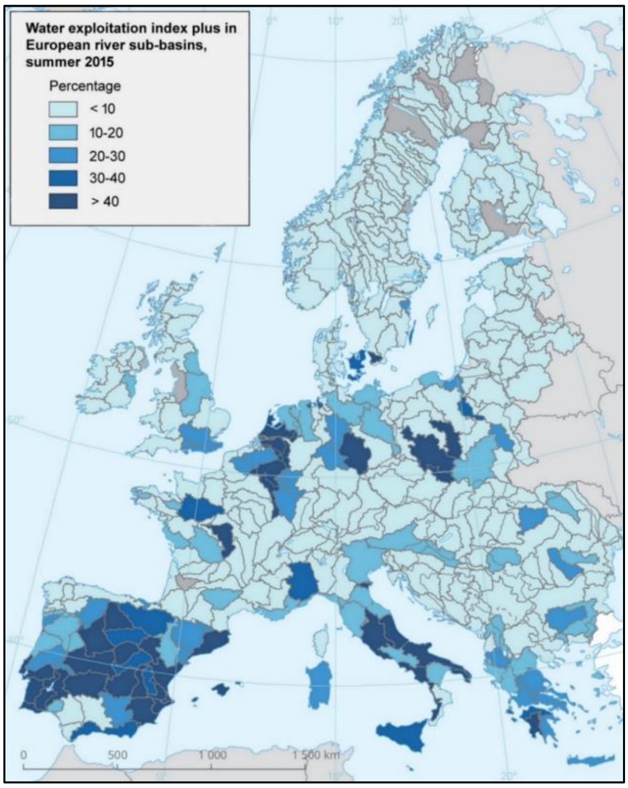
The management of nutrient pollution needs the support of the collective action of farmers, where economic instruments could only be an ancillary tool in the combination of command and control, stakeholders' cooperation and economic instruments. This is the case in Denmark, where substantial nitrate abatement has been achieved with the successive Action Plans started in the 1980s, by combining a mix of command and control (fines) and collective action instruments for the profitable substitution of synthetic fertilizers by manure (Dalgaard et al. 2014).

The new European initiatives for addressing water, soil and air pollution are the Green Deal and the Farm to Fork strategies (EC 2019c and 2020), which rely also on payments. Agriculture is identified as an important source of emissions, contributing to biodiversity losses, depletion of natural resources and climate change. The goals of the Farm to Fork and the Green Deal are expected to be achieved by the Common Agricultural Policy, through the eco-schemes and agri-environment-climate measures. Both measures offer payments for adopting environmentally friendly practices. Also, there would be additional obligations to receive direct payments from the Common Agricultural Policy, related to complying with practices for the abatement of nutrients and pesticides.

Bieroza et al. (2021) indicate that the Farm to Fork Strategy goals for 2030 are overly ambitious and seem unachievable: the abatement of nutrient and pesticide pollution by half, and the reduction of 20% in fertilizer use. It is quite unlikely that these large reductions could be achieved based on incentive payments for using environmentally friendly practices or on penalizing the direct payments to farmers. This payment-based mechanism is similar to the payments reductions of the Nitrates Directive, which has been unable to reduce nitrogen pollution in more than three decades across basins in Europe.

5. Water scarcity in the European water regulation and the case of Spain

Water scarcity is an important concern in the European Mediterranean countries, which will be aggravated by the impacts of climate change (IPCC 2022). The costs of drought damages have been estimated at €9 billion per year in the European Union, and the countries with large drought damages are Spain (1.5 billion/year), Italy (1.4) and France (1.2) where the drought planning efforts and climate adaptation actions should concentrate (Cammalleri et al. 2020). Most of the damages affect the agriculture (50%) and energy sectors (35%), followed by the urban water supply sector (13%). Future damages would depend on the increase in the global warming temperature, with damages increasing up to five times for a +3°C scenario (Feyen et al.



Source: EEA (2022). The accuracy of the map is not perfect, and the EEA recognizes that data availability of water abstractions is limited. An example is the Guadalquivir Basin in the south of Spain, where the yearly WEI+ is 60% (3600/6000 in Mm^3), while the map shows a WEI+ between <10 and <30%.

Figure 2. Water scarcity in European basins measured by the WEI+ index.

2020). The countries which have developed the more comprehensive drought management plans in basins are those with the higher drought damages: Spain, Italy and France. Other countries have drought management plans dealing mostly with urban water supply, such as in the Czech Republic, the Netherlands and Cyprus.

As indicated above, the text of the Water Framework Directive is focused on water quality, and do not address water scarcity or environmental flows. In 2007 the Commission issued a Communication addressing the challenge of water scarcity and droughts (EC 2007), which was not a directive but rather a mere declaration without any obligation or enforcement mechanism. Later in 2015 the Commission issued a Guidance on ecological flows (EC 2015a), and water scarcity and droughts have been recognized as one priority in the European Green Deal.

The problem of water scarcity is becoming quite critical in Southern European basins, with falling stream flows in river basins that would be aggravated by the impacts of climate change. Figure 2 shows the basins with water scarcity problems, as

Figure 3. River basin authorities in Spain

measured by the Water Exploitation Index Plus (EEA 2022), which is the proportion of water consumption (withdrawals minus return flows) over renewable resources. We illustrate the water scarcity challenge by the situation of river basins in Spain, where scarcity is severe and basin authorities provide ample information on quantities of water flows across water systems.

Water scarcity in Spain is mainly linked to the enormous development of irrigation, while quality degradation is linked to pollution from urban, industrial, and agricultural sources. Water withdrawals for consumptive uses were 15,500 Mm^3 per year in 1960, at the beginning of a strong economic growth period. Six decades later, water withdrawals have doubled to 31,600 Mm^3 over the 110,000 Mm^3 of renewable resources. The surge has been mainly driven by the expansion of irrigation acreage from 1.8 to 3.7 million hectares, and the growth in urban and industrial withdrawals which have tripled their water demand.

The pressure on water resources is much higher in the southern basins of Spain (Segura, Júcar, Guadalquivir and Guadiana) than in the northern basins (Duero and Ebro) (Figure 3). The basins of the southern half of Spain are almost hydrologically closed basins, with very small stream flows at their mouth, because of the enormous overdraft of surface and subsurface waters. The worst situation occurs in the Segura basin where withdrawals double renewable resources, and the gap is covered with the

Tajo-Segura interbasin transfer (300 Mm^3), seawater desalination (230 Mm^3), and groundwater overdraft.

Overexploitation of groundwater is a serious problem in southern basins, and despite the declaration of groundwater as public domain in the Spanish Water Law of 1985, aquifer depletion in southern basins is around 1000 Mm^3 per year. The overexploitation and water quality degradation in aquifers is severely damaging aquatic ecosystems, including the main ecosystem assets in Spain (Doñana and Tablas de Daimiel).

The water policies in recent decades have attempted to respond to the water scarcity problems in southern basins. One strategy has been the building of dams in southern basins to cover the growing water demand, resulting in a high proportion of dam storage over renewable resources in these basins (between 130% and 220% of renewable resources). The National Water Plans of 1993 and 2001 projected massive investments to interconnect the basins with expenditures at 5% and 1% of GDP, respectively. The huge size of investments and water transfers in both plans triggered strong controversies and distrust among territories, political parties and the entire society, leading to the collapse of both plans.

The National Irrigation Plan of 2002-2008 achieved the modernization of 1.5 million hectares, with the declared objective of reducing irrigation withdrawals. This plan increased the competitiveness of the sector and reduced nonpoint pollution, but did not reduce water scarcity. The "paradox of irrigation efficiency" (Grafton et al. 2018) shows that the efficiency gains at plot level increase water consumption by crops, and reduce return flows to basins aggravating water scarcity (Ward and Pulido 2008). Other water augmentation policies have been the Desalination Plan of 2005, doubling the desalination capacity up to 1000 Mm^3 per year, and the recent policy of reusing treated urban wastewater which employs 10% of treated wastewater.

The management of water in Spain is based on the institutional cooperation of stakeholders in river basin authorities, where users cooperate in reducing surface withdrawals during periods of scarcity. However, subsurface withdrawals are maintained or increased during droughts because of lack of control. Despite this institutional cooperation, water withdrawals in basins have continued to increase, and the national and state policies have been unable to stop or dampen down the progressing water scarcity.

The water scarcity problem will be aggravated by climate change with falling inflows in basins. As river basins become closed, both water resources degradation and damages on ecosystems escalate considerably, and the current and future development of economic activities is threatened. The reform of water policies should be guided by multisector plans based on scientific knowledge that accounts also for environmental flows that support ecosystem services. However, the key for the success of sustainable water planning depends on the priorities of the society in choosing the management alternatives. The experience in Spain shows that policy makers use water to gain electoral advantages in the short term, which worsen the sustainability of resources in the middle and long terms.

But there are also successful experiences in sustainable management. One example is the Mancha Oriental aquifer system, the largest in Spain, where extractions have been reduced down to recharge levels. Other efforts to deal with scarcity are the expansion of seawater desalination and the reuse of urban wastewater. Spain is an interesting test bench for management strategies and water technologies, supported by water expertise, strong companies in the water sector working in international markets, and experienced river basin authorities based on stakeholders' cooperation. The gathered expertise could be employed to achieve a more sustainable use and a better environmental protection of water resources in the coming decades. These experiences in Spain could be useful for other river basins in Southern Europe confronting severe water scarcity.

6. Conclusion and policy implications

The Water Framework Directive is an important policy initiative that seeks the protection and sustainable management of water resources, although the advances in the quarter of century since its onset have been quite slow. Good ecological status was planned to be achieved at the end of the first management cycle in 2015, but the deadline is being postponed and will not be achieved at the end of the current third management cycle in 2027.

Since the beginning, the main thrust of the WFD has been on water quality. There has been substantial progress in the abatement of urban and industrial pollution involving very large investments in wastewater treatment, with tertiary treatment becoming generalized and with new initiatives to address pharmaceutical and cosmetic micropollutants and pollution from storm water overflows. However, the WFD has been unable to deal with agricultural nonpoint pollution because of the inappropriate design of the abatement instruments.

Water quantity aspects are mostly disregarded in the WFD, despite the fact that water scarcity challenges are important in Southern European basins. Water scarcity and droughts have been addressed only with a Communication (EC 2007) lacking obligations or enforcement, while floods are addressed with a full European Directive.

The inadequate governance results, which have not achieved the planned good ecological status deadline, has not been the main focus of the scientific literature. The literature concentrates on the discipline of water science rather than on water governance. The governance problem of the WFD derives from the deficient design of the policy instruments, where water pricing is the essential component of the program of measures. Water pricing cannot be used as the unique instrument to address very different and conflicting objectives such as financing infrastructures, water allocations, environmental protection, opportunity costs of water, water use efficiency, and pollution abatement.

Despite the fact that the ecological status has not improved since the first management cycle, the European Commission reiterates in the recent Fitness Check of the WFD that water pricing is the main policy instrument to advance the ecological status. Water pricing in irrigation has been abandoned in the few Central and Northern European countries that were applying it, and irrigation taxes are only used in Southern countries. However, these taxes would have to be increased by two orders of magnitude for reducing demand, which is politically unfeasible.

Also, the polluter pays principle cannot be used in agricultural nonpoint pollution because of the complexity of the biophysical environment, where a single pollution price does not exist and the use of economic instruments is a “wicked problem”, remains theoretical, and have not achieved any demonstrable results (Shortle and Horan 2017). Any practical abatement solution should include combinations of instruments adapted to sectoral and spatial locations. However, the new European Green Deal and Farm to Fork strategies to address nonpoint pollution still rely on payments to farmers, and seem overly ambitious.

Finally, water scarcity in basins has not been given a high relevance in the WFD, even though the pressure on Southern Mediterranean basins has been worsening in recent decades, and the impacts of climate change will reduce basin inflows in the south but also will expand scarcity problems towards northern basins. The case of Spain shows the challenges created by excessive withdrawals and the range of intervention policies that have been deployed in the country. These experiences in Spain on management strategies and water technologies is an interesting test bench for other European basins confronting the problems of water scarcity.

The progress of the European WFD in achieving sustainable water management has been slow in the last quarter of century, which seems to indicate the need for reform. The design of the water policy instruments should be guided by multisector plans based on scientific knowledge that protect both economic and environmental benefits in basins, and have to be supported by the collective action of local water stakeholders. The reliance of the WFD on economic instruments should be broadened by giving much more prominence to command & control and collective action instruments.

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