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Water Pricing in Agriculture following the Water Framework Directive: A Systematic Review of the Literature

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ABSTRACT

In October 2000, the Water Framework Directive (WFD) established a common framework for water management in Europe, thereby substantially reforming European water legislation. The Directive encourages the use of economic instruments, including water pricing, to ensure water resource management and conservation. The aim of this systematic review was to establish the state of academic research on water pricing in connection with the WFD within the agriculture sector. It emerges that the issue of water pricing is very broad, site-specific and mostly, it faces multidisciplinary issues. Researchers should cross their conventional boundaries of investigation, trying to cut edges. While the Directive advocate for a larger implementation of economic instruments such as pricing, it seems that the large contribution from the economists is yet to come.

***Keywords**: water pricing; agriculture; irrigation; Water Framework Directive; systematic literature review*

1 Introduction

Water is a limiting resource in agriculture worldwide and is critical for socio-economic development, healthy ecosystems and for human survival itself (García-Tejero at al., 2014). The increasing population and the economic development, lead to a growing demand for water-intensive goods and services, more specifically agro-food products. According to Berbel et al. (2009), agriculture is a major sector in terms of total water usage in Europe and its growth can put the management of water resources under pressure. Moreover, water resource status is getting worse because of climate change. IPCC projections for several countries show both a reduction in precipitation and water availability and the augmentation in irrigation water needs, resulting in higher demand for irrigation water (IPCC, 2014). In such circumstances, a sustainable and appropriate approach to water resource management is essential.In this context, particular importance is assumed by demand-side instruments such as water pricing, water trade (water markets and water banks) or enhancing water-saving technologies (Gómez-Limón et al., 2020).

The introduction of the EU Water Framework Directive 2000/60/EC (WFD) heralded a new era for European water management, focusing on understanding and integrating all aspects of the water environment in order for water use to be efficient and sustainable (Berbel et al., 2020). The Directive introduced new criteria for water management, regulation and pricing, including the principle of full cost recovery and the polluter pays principle. In particular, it emphasizes the role of water pricing as a convenient economic instrument to ensure efficient water resources management and conservation (Gomez-Limòn and Riesgo, 2004). Water pricing is widespread recognized as an efficient instrument to contribute to multiple policy goals (equity, efficiency, environmental sustainability) (Sjödin, J. et al., 2016, Lika et al., 2017, and Cortignani et al., 2018). It is also considered an essential policy instrument for improving the efficiency for water use for irrigation. However, twenty years after its enactment, the WFD is struggling to achieve its full implementation and the effectiveness of water pricing has proved to be questionable. In spite of the evident importance of the issue both from an economic and environmental perspective, water pricing received little attention from economists: a general search of scientific publications based on the keywords “water pricing” and “agriculture” and “water framework directive” generated few articles. The topic resulted to be broad, complex and fragmented. Therefore, the main aim of this study was to build a comprehensive up-to-date framework of water pricing in agriculture related to the WFD. For this purpose, a systematic literature review was carried on. This methodology is characterized by a rigorous and objective selection procedure allowing the increase of the output reliability.

The paper has the following structure. In section 2 the methodology adopted is described, followed, in section 3, by the illustration of the results categorised in six different thematic cluster. The discussion of findings and their implications are reported in section 4. Limitations, possible gaps to fill and conclusions are provided in section 5 and 6, respectively.

2 Methodology

The present work adhered as closely as possible to the PRISMA statement, which consists of a 27-item checklist and a four-phase flow diagram. The aim of the PRISMA statement is to help authors to improve the reporting of systematic review and meta-analysis (Moher et al., 2009).

Authors decided to follow the protocol proposed by Jesson et al. (2011) for reporting a systematic literature review, adapted to the PRISMA statement. It consists of seven key phases as shown in Table 1. The first phase consists of preparing the review plan. During this phase, the objectives of the research and the key data sources have been identified.

The study was conducted in order to answer the following research question:

RQ: To what extent has the water pricing issue been addressed following the Water Framework Directive (WFD) within the agriculture sector?

Having identified the research goals, follows the keywords detection and the eligibility criteria setting. The keywords chosen were “water pricing” and “agriculture” and “water framework directive”. These keywords allowed a broad investigation and, at the same time, were relevant to the research question.Then, the sources were limited to peer-reviewed journals as they can ensure that only high-quality research is published, especially in reputable journals, by determining the validity, significance and originality of the study. The main advantage of a peer review process is that peer-reviewed articles provide a trusted form of scientific communication. Therefore, Scopus and Web of Science were used as electronic databases. The former is considered the largest database of peer-reviewed literature. According to Bramer et al. (2016) “investigators and information specialists searching for relevant references for a systematic review (SR) are generally advised to search multiple

databases and to use additional methods to be able to adequately identify all literature related to the topic of interest". Furthermore, a single database is not considered enough to retrieve all references for systematic reviews (Bramer et al., 2017). Hence, including Web of Science as a second database was considered appropriate.

Table 1.
Systematic Review Protocol

1.Mapping the field through a scoping review
Objective
Examine and consolidate the current status of water pricing in connection with the Water Framework Directive
Research Question To what extent has the water pricing topic in connection to the Water Framework Directive (WFD) been addressed?
2. Methodology
Search Terms: "water pricing" AND "agriculture" AND "water framework directive"
Included Databases: Scopus, Web of Science (WoS)
Study Criteria:
Inclusion Criteria IC1: Articles published in Academic Journal IC2: Peer-reviewed journals IC3: Publication on the topic of water pricing in connection to the WFD IC4: Publication years between 2000 and 2019 IC5: English as publication language
Exclusion criteria EC1: Conference papers or book chapters EC2: Non peer-reviewed Journals and grey literature EC3: Publication years before 2000 EC4: Publications not in English
3. Quality Assessment
Assess the relevance of the studies concerned to answering the research question
4. Results
Report data obtained in the previous stage
5. Discussion
Summarize the main findings including the strength of evidence for each main outcome
6. Limitations
Highlight the limitations and any possible gaps to overcome
7. Conclusions
Provide a general interpretation of the results in the context of other evidence, and implications for future research

Additionally, the search period was limited to the range 2000-2019 range of years. The choice of this range is related to the date of issue of the Directive in question. In specular fashion, the following exclusion criteria were defined: i) articles not published in English language, ii) published before the year 2000 iii) belonging to the grey literature. The term grey literature refers to research that is either unpublished or has been published in non-commercial form. Many libraries and major databases do not collect or organize such literature, as they do with peer-reviewed literature. Furthermore, for the same reason (difficulty in "data" availability) we decided to exclude book chapters and conference papers.

Moreover, the PRISMA statement, as shown in the flow diagram structure, provides the possibility to add records from sources other than the databases detected. Hence, we added three extra articles considered important in addressing the research question. In all, 62 articles were generated from the search of both databases and additional sources.

Search string inserted in both databases:

("water pricing") AND

("agriculture") AND

("Water Framework Directive**")**

The keywords defining the search query were purposely made broad enough to consider as many results as possible related to the research question posed in this systematic review. Eliminating duplicates, the number of articles was pruned to 42. We then screened the articles, relying on their titles and abstracts, and excluded eight records, reducing the main body of articles to 34.

Then, after a thorough reading of each article the eligibility criteria were applied. As a result, all the articles were included except for four, three of which were considered not relevant while the other was a conference paper missed during the previous screening stage. Thus, in all, 30 articles were included in the review and constituted the basis for all future analysis. At this stage, as suggested by PRISMA guidelines, the description of the process for selecting studies was reported.

2.1 Quality Assessment

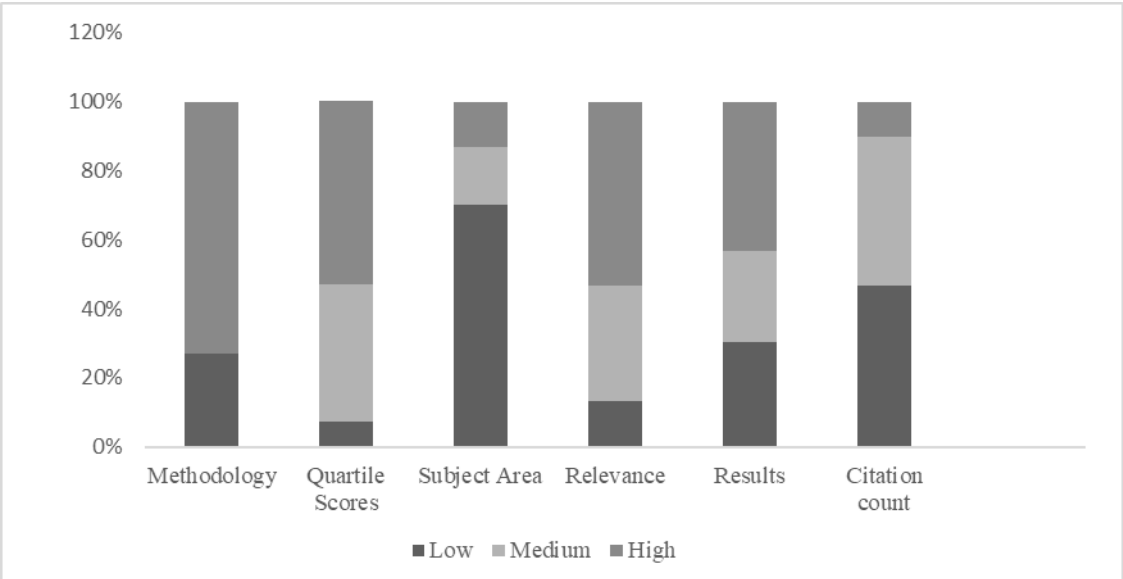

Figure 2. Percentage of articles rated low, medium, or high according to quality assessment.

The first criterion concerned the qualitative or quantitative nature of the paper. The next two were related to the features of the journal: each article had a different score based on the quartile score and the journal subject area. The fourth criterion concerned the pertinence of each study. Lastly, the remaining criteria referred respectively to the adequacy of the results and the number of citations per paper. For more details see table A.1 in the Appendix.

The studies identified were rated as low, medium, or high quality, based upon a combination of the scores assigned to each of the six assessment criteria; there is no difference in weighting for each criterion. A study was considered "high quality" if it rated "high" for three or more criteria; "medium quality," if it received two "high" scores or one "high" and two "medium"; the remaining studies were classified as "low quality". For a complete list of the papers' scores in all the criteria and their overall quality rating, see table A.2 in the Appendix.

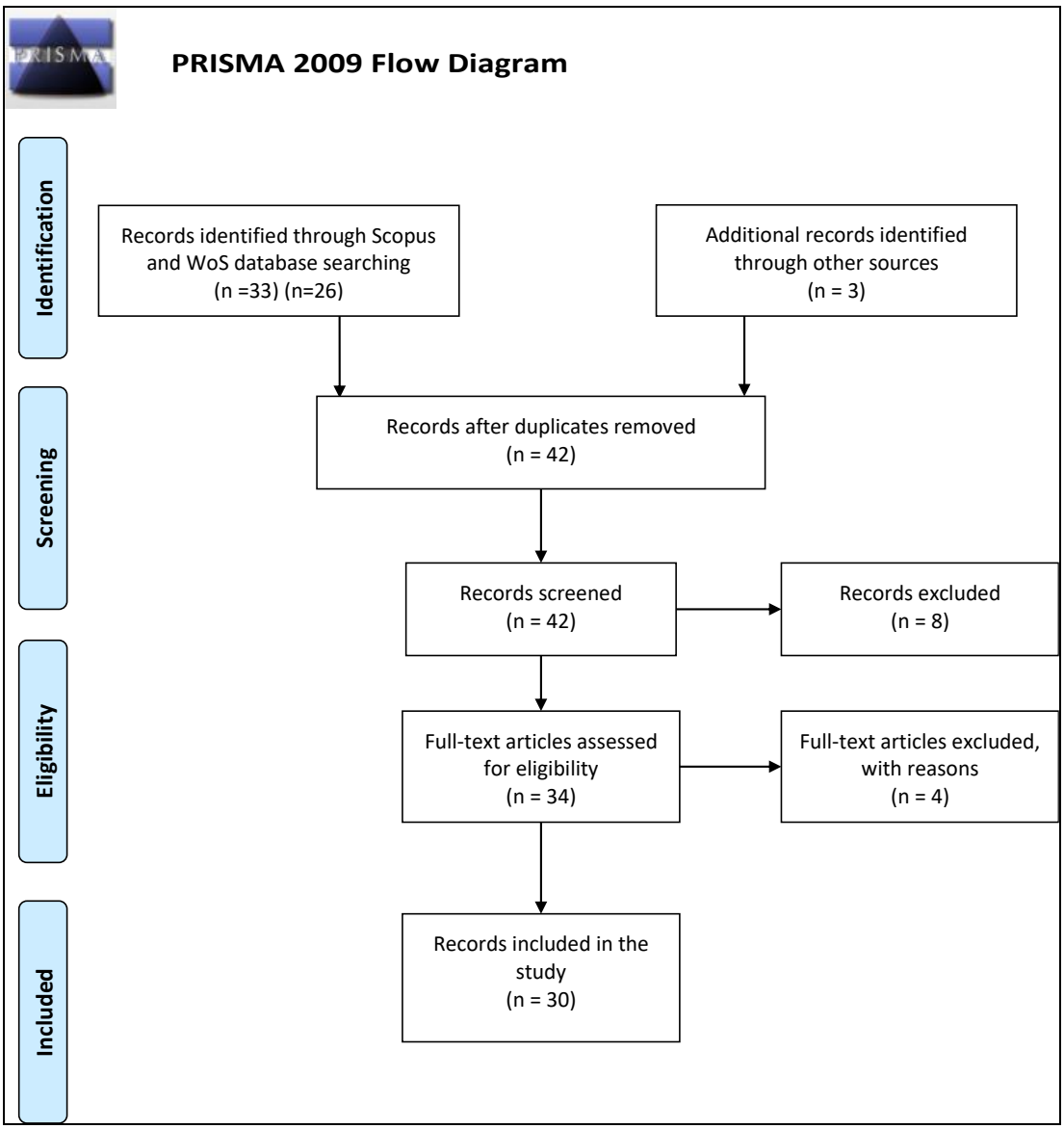

Figure 1. Articles selection process.

3 Results

Once we identified the final body of articles to be included in the review, we extracted two types of results: the descriptive analysis and the cluster of articles. Indeed, an in-depth study enabled us to identify six categories of articles sharing the same research objectives.

As shown in table 2, the six categories detected are:

1. Relationship between the WFD and CAP
2. Water pricing related to the nitrate pollution
3. WFD negative effects on farmers' revenue
4. Analysis of different water pricing schemes
5. General difficulties in the WFD implementation
6. Water metering and WFD

Table 2.
Grouping Publications

Cluster 1	Relationship between WFD and CAP
Kampas et al., 2012	Price induced irrigation water saving: Unravelling conflicts and synergies between European agricultural and water policies for a Greek Water District
Gallego et al., 2008	Effects of the application of the new CAP and the Water Framework Directive in irrigated agriculture. The case of Arévalo-Madrigal
Bazzani et al. 2004	Irrigated agriculture in Italy and water regulation under the European Union Water Framework Directive.
Mejías et al., 2004	Integrating agricultural policies and water policies under water supply and climate uncertainty.
Mohaupt et al., 2007	WFD and agriculture activity of the EU: First linkages between the CAP and the WFD at EU Level.
Cluster 2	Water pricing related to nitrate pollution
Martinez et al., 2007	A dynamic analysis of nonpoint pollution control instruments in agriculture.
Albiac et al., 2007	Instruments for water quantity and quality management in the agriculture of Aragon.
Gallego et al., 2011	Irrigation water pricing instruments: A sustainability assessment.
Martinez et al., 2004	Agricultural pollution control under Spanish and European environmental policies.
Blöch, 2001	EU policy on nutrients emissions: legislation and implementation.
Cluster 3	WFD negative effects on farmer's revenue
García-Tejero et al., 2014	Towards sustainable irrigated Mediterranean agriculture: implications for water conservation in semi-arid environments
Giannoccaro et al., 2010	Assessing the impact of alternative water pricing schemes on income distribution.
Latinopoulos, 2008	Estimating the potential impacts of irrigation water pricing using multicriteria decision making modelling.
Philip J.M. et al., 2014	Technological change in irrigated agriculture in a semiarid region of Spain
Zamudio et al., 2006	Sustainable management for woody crops in Mediterranean dry-lands
Berbel et al., 2009	Estimating demand for irrigation water in European Mediterranean countries through MCDM models
Cluster 4	Analysis of different water pricing scheme
Cortignani et al., 2018	Recovering the costs of irrigation water with different pricing methods: Insights from a Mediterranean case study.
Davy et al., 2009	Pricing water and sustainable management of water resources
Gallego-Ayala,2012	Selecting irrigation water pricing alternatives using a multi-methodological approach
Ward et al., 2009	Incentive pricing and cost recovery at the basin scale
Heumesser et al., 2012	Investment in irrigation systems under precipitation uncertainty
Berbel et al., 2011	Value of irrigation water in Guadalquivir Basin (Spain) by residual value method
Cluster 5	General difficulties in WFD implementation
Socratous, 2011	Water Pricing Policy in Cyprus: The Implications of the Water Framework Directive
Heinz et al., 2007	Hydro-economic modeling in river basin management: implications and applications for the European water framework directive
Voulvoulis et al., 2017	The EU Water Framework Directive: From great expectations to problems with implementation
Giannakis et al., 2016	Water pricing and irrigation across Europe: Opportunities and constraints for adopting irrigation scheduling decision support systems
Cluster 6	Water metering and WFD
Lika et al., 2017	Water authorities' pricing strategies to recover supply costs in the absence of water metering for irrigated agriculture
Giraldo et al., 2014	Simulating volumetric pricing for irrigation water operational cost recovery under complete and perfect information
Viaggi et al., 2010	Designing contracts for irrigation water under asymmetric information: Are simple pricing mechanisms enough?
Galioto et al., 2013	Pricing Policies in Managing Water Resources in Agriculture: An Application of Contract Theory to Unmetered Water

3.1 Descriptive Analysis

In this section we provide a descriptive analysis of our initial sample. The analysis of the contents of the identified clusters will be faced in phase of discussion.

First, we carried out an analysis to observe the trend of articles publication in peer-reviewed journals. The two decades between 2000 and 2019 were considered for the analysis. It may be noted that the trend is extremely variable. Thus, even if the WFD represents an important milestone from a normative and environmental viewpoint it seems that the scientific community did not react enough to this input. This further reinforces the need to tackle this topic.

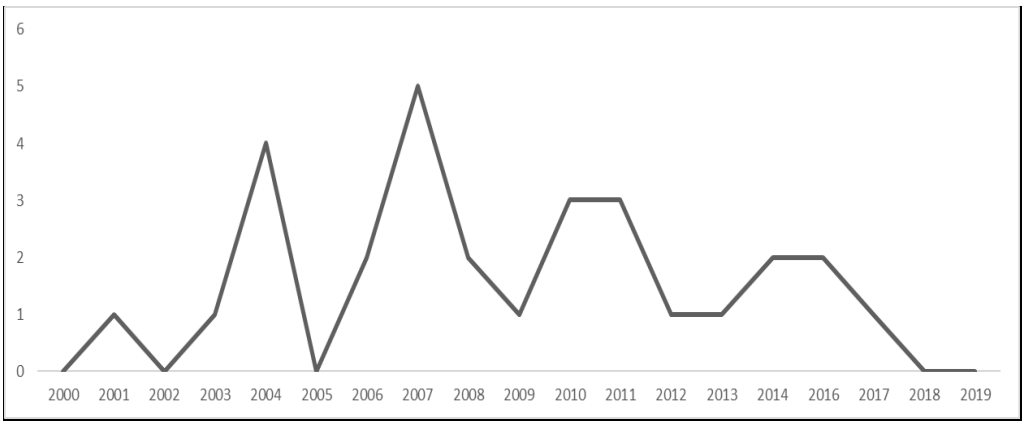

Figure 3. Growth of articles on water pricing in connection with the WFD from 2000 to 2019.

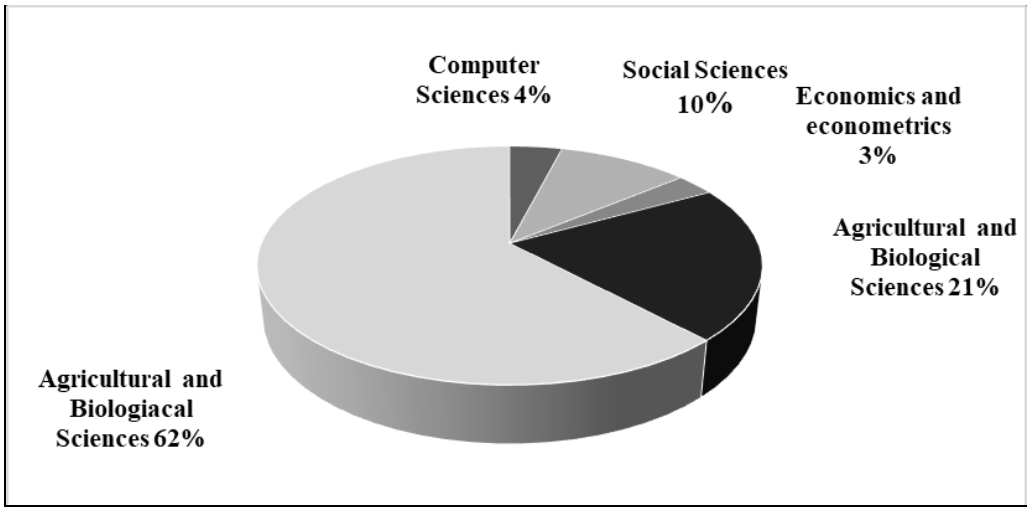

Figure 4. Percentage of documents by subject area.

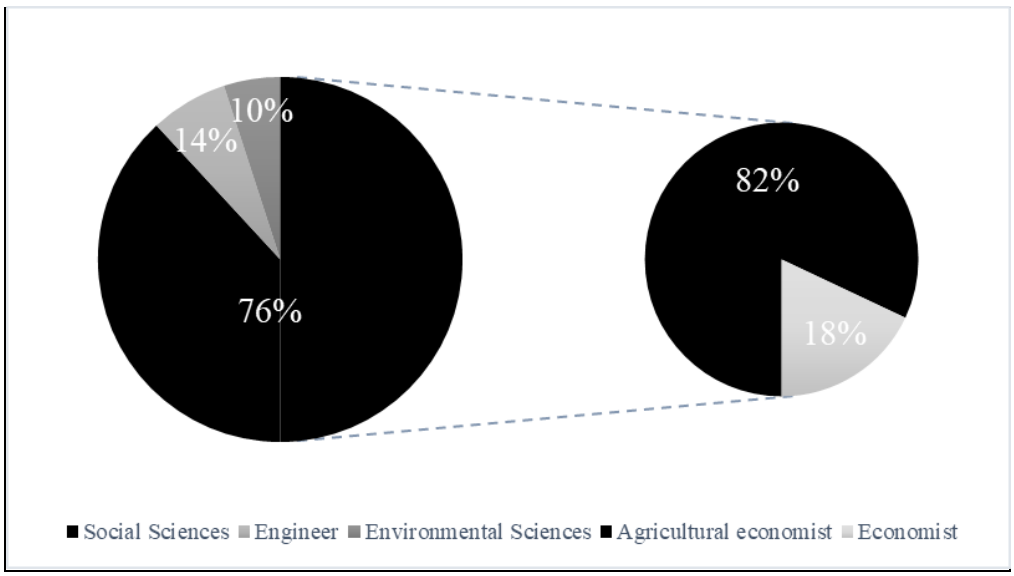

Figure 5. Percentage of author's by background.

Subsequently, we analysed the subject area to which the documents belong. As shown in figure 4 the 3% of the documents are published in Economics and econometrics, followed by 4% of documents published in journals covering Computer Sciences. The percentage rises referring to Social Sciences and Agricultural and Biological Sciences with, respectively, 10% and 21%. Finally, the most relevant percentage is reached by Environmental Sciences with 62 percentage points. On balance, it results that the issue of water pricing is poorly treated by economics, econometrics and social sciences journals. This result is reinforced by the figure 5 representing the percentage of author's background. Indeed, the majority of author's are Agricultural economist (82%) against the pure economist, poorly represented (18%).

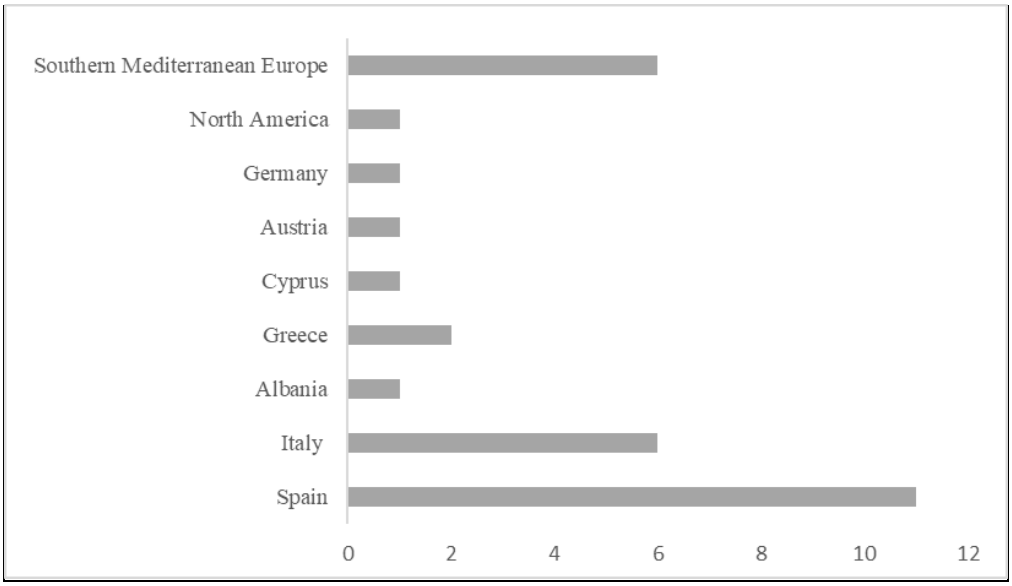

Figure 6. Number of articles by study area.

Proceeding in our descriptive analysis, we observed, as expected, that the study areas are most frequently located in southern Europe. This area is the most responsive to concerns related to water pricing in agriculture. Indeed, the agriculture demand for water in these areas reaches 70-80% of total water withdrawal (Massarutto,2003).

4 Discussion

Expected future population growth and climate change are increasing the pressure on available water resources at global level. The objective of the WFD was to create a legislative framework for water regulation in Europe identifying different economic tools, as water pricing, to guarantee efficient water resources management and conservation (Giannoccaro et al., 2010). In this regard, this review aims at establishing the state of academic research on water pricing in agriculture in connection with the Water Framework Directive based on a systematic literature review.

With regard to the descriptive analysis of the research output, the most interesting data that emerged concern the distribution of articles over the years 2000-2019 and the type of subject area in which the articles are published. Overall, the research output includes 30 articles over 20 years, a very small number. Surprisingly, the data suggest little interest of the scientific community towards the topic.

However, upon examining the articles in detail, the extensive variability and difficulty in finding data relating to the irrigated agricultural sector justify this trend. These characteristics may in some cases discourage researchers, resulting in a low publication frequency.

An additional factor explaining the smallness of the output identified is related to the weakly implementation of the WFD all over the Europe. In mainstream economic theory, prices are determined by the interaction of supply and demand assuming a perfectly competitive market for private goods, where the price equals its marginal cost and ensuring an optimal allocation of the resource. In the case of water, the reality is usually much more complex.

Therefore, the majority of member states adopt fees, charges, tariffs, eco-taxes (see Berbel et al., 2019) but water pricing, as identified by economic theory, is rather rare (Sjödin et al., 2016).

Other food for thought is concerns the type of subject area in which the articles fall. Indeed, although the Directive strongly emphasizes the use of economic instruments, including water pricing, the percentage of economic and social sciences journals addressing the topic seems to be quite limited. This result is reinforced observing the author's background: only the 18% are pure economists. Therefore, it would be desirable to promote an integrated approach, based on a multiple combination of skills in which the contribution of the economists is more represented.

In addition, we discuss the results for each thematic cluster of articles identified.

The first category includes articles that investigate the relationship between the WFD and CAP (Common Agricultural Policy) policies. A synergistic approach between water policies and agricultural ones is crucial for achieving an efficient management of water resources. However, in some circumstances the WFD and CAP objectives are conflicting. According to Meijas et al., (2004) water pricing policies produce certain negative effects on farmers' income and water will not be notably reduced. Moreover, Kampas et al., (2003) argue that CAP reform promotes at lower prices the adoption of intensive water demanding crop-pattern. That said, as the articles belonging to this category are rather dated, the results need contextualization. Indeed, the last CAP programming (2014-2020) introduces the ex-ante cross-compliance that enables Member States to condition CAP subsidies to meet certain environmental and water requirements. The ex-ante cross-compliance is a great opportunity of integration and synergy between WFD objectives and agricultural policies.

The second category concerns articles that analyse the role of water pricing in managing nitrate pollution. Martinez and Albiac (2004, 2007) and Calatrava et al. (2010) highlight the inefficiency of water pricing as an emission control instrument. Furthermore, in some cases water pricing induce farmers to withdraw from private wells, enhancing groundwater deterioration. By contrast they identified taxes on pollution emissions as a good policy measure, both in terms of cost and environmental effectiveness, to ensure good emissions management. Moreover, it is widely argued that the purpose of a pollution tax is to internalise externalities associated with anthropogenic climate change (G.E. Metcalf, 2013).

The third and fourth category consists of the articles that analyse different water pricing schemes and the impact that their implementation could have on the farmers revenue. The results show that volumetric pricing generates savings of consortia water but increases the use of chemicals and fails to reduce, or even increases, groundwater use. Therefore, although the Directive also suggests volume pricing, it turns out to be a good instrument only considering the long run and the surface water.

Additionally, implementation of volumetric water pricing entails numerous difficulties due to the negative and diversified impacts it can have on farm incomes (Berbel et al., 2009, Giannoccaro et al., 2010). Indeed, application of this kind of water tariff often means costs for farmers, which threaten to narrow their profit margins (e.g. Latinopoulos (2008) observe 35% of income losses at 0.10 €/m3) that may generate, in the medium and long term, serious economic implications to he agricultural sector. Consequently, the increase in the price of water often results in land abandonment. In this context, de Sousa Fragoso and Marques (2015) suggest alternative water pricing scheme as the block pricing one. However, Hagel et al. (2014) argue that mild water pricing can increase the awareness of water scarcity and lead to implementation of water saving production methods. Therefore, the authors believe, according to El Chami et al. (2011), that the line of research aimed at identifying, if any, a trade-off between better management and allocation of water resources and the loss in profitability and land abandonment could be interesting and useful to steer water policies.

Finally, the last two categories contain articles that deal with two closely related themes: "General difficulties in implementing the Water Framework Directive" and "the Lack of metering". Implementation and the effects of the economic tools proposed by the Directive depend on several factors (excessive bureaucracy, unclear definition of " good ecological status", difficulty in obtaining data and obsolete irrigation infrastructures) which often reduce their efficacy. The main constraint is the lack of metering. This problem mainly concerns surface irrigation which often uses non-pressurized water delivery pipes on which meters cannot be installed (Lika, 2018). This condition makes it impossible to monitor the volumes used and to encourage volumetric pricing system ensuring efficient water use (Viaggi et al., 2010). In 2015, the Italian Ministry of Agricultural, Food and Agro-forestry Policies issued guidelines for defining the criteria for monitoring volumes and a method for estimating environmental and resource costs to be considered in designing water tariffs (Zucaro et al., 2015). However, the guidelines have not yet been implemented in many regions. In conclusion, what emerges from the interpretation of the results is that the issues related to water pricing in agriculture in the aftermath of the WFD are rather complex and delicate, the factors involved being numerous. The vital nature of water resources does not allow any factors to left out, at the risk of making rough evaluations.

In this context, the goal of this work was to help consolidate and shed light on the topic. The authors are confident that a systematic literature review thereof may be useful for policy makers and for any scholar who decides to address the issue.

5 Limitations

The study is not exempt from limitations. First, retrieving the articles was far from straightforward and most of them were far from up-to-date. Second, the quality of the studies included was variable. We used an *ad hoc* protocol due to the lack of standardised quality assessment tools for studies concerning the social sciences. We are aware that such limitations could affect the replicability and make it difficult to update the study.

6 Conclusions

This work set out to focus on studies dealing with water pricing in relation to the Water Framework Directive 60/2000/EC. The research used the e-libraries Scopus and Web of Science, implementing PRISMA methodology and adapting the protocol suggested by Jesson et al. (2011) in order to produce a systematic review. The results show that there are several problems related to this issue making the directive difficult to implement and water pricing of doubtful utility in achieving the desired objectives. In particular, it would seem that water pricing on its own cannot achieve satisfactory objectives regarding the conservation and allocation of resources. Its effectiveness, considering the pollution abatement and the water quality preservation, is also questionable. Therefore, the high number of categories identified, and the evidence debated allow us to conclude that the issue of water pricing is very broad, site-specific and mostly, it faces multidisciplinary issues.

A further point of interest relies on the lack of economic journal and economist authors who have dealt with this issue. Although the central role of economics aspects characterizing the directive and the nature of the instruments it focus on, they seem to be poor represented. More precisely, just 3% of the articles collected are published in economics journal and 10% in a social sciences one. Additionally, among the author's article background only the 18% consists of pure economics.

In conclusion, given the economic nature of the topic in hand, a major contribution by economists is strongly requested. Therefore, in order to improve the progress of this field, they should broaden their research interests and put their skills on the line.

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Appendix

A.1

Table A1.
Criteria Description

STUDY ATTRIBUTE	CRITERIA ASSESSED	QUALITY RATING		
METHODOLOGY	Research paper or review?	**Low** Qual	**Medium** n/a	**High** Quant
QUARTILE SCORE	Journal Quartile Index	Q4	Q2-Q3	Q1
CITATION COUNT	Citation Count	< 13	14-50	>50
RELEVANCE	WFD directly tackled or just mentioned?	No	Slightly	Yes
RESULTS	Are the impacts on income, employment and crop patterns considered?	No	Slightly	Yes
SUBJECT AREA	Economic Subject Area	No	Social	Yes

A.2

Table A2.
Assessment for each article

Author, date	What is the research methodology used in this study?	Journal Quartile Scores	Journal Subject Area (economic or not?)	Is the Directive directly tackled?	Impact evaluation on income, employment, and crop pattern	Citation Count
Cortignani et al., 2017	High	High	Low	High	High	Low
Lika et al., 2017	High	Medium	High	High	Medium	Low
Voulvoulis et al., 2017	Low	High	Low	High	Low	High
Giannakis et al., 2016	Low	Medium	Low	Medium	Low	Medium
Giraldo et al., 2014	High	Medium	Low	High	Medium	Low
Garcia Tejero et al., 2014	Low	Medium	Low	High	High	Medium
Galioto et al., 2013	High	Medium	Low	High	Medium	Low
Kampas et al., 2012	High	High	Low	High	High	Medium
Heumesser et al., 2011	High	High	Low	Low	High	Medium
Jordi Gallego-Ayala, 2011	High	Medium	Low	Medium	Low	Low
Gallego-Ayala et al., 2012	High	Medium	Low	Low	High	Low
Julio Berbel M et al., 2011	High	High	Low	Low	Medium	High
Giannoccaro et al., 2010	High	High	High	High	Medium	Medium
Viaggi et al., 2010	High	High	Low	High	Medium	Medium
Berbel et al., 2009	High	Medium	Medium	Medium	High	Medium
Gallego et al., 2008	High	Low	High	High	High	Low
Latinopoulos, 2008	High	High	Low	Medium	High	Medium
Ward, 2007	High	High	Medium	High	High	Medium
Mohaupt et al, 2007	Low	Medium	Low	High	Medium	Low
Martinez at al., 2007	High	Low	Medium	Medium	Low	Low
Heinz et al., 2007	High	High	Low	Medium	Low	High
Albiac et al., 2007	Low	Medium	Medium	Low	Medium	Low
Martinez et al., 2004	Low	High	Low	High	High	High
Fernández-Zamudio et al., 2006	High	Medium	Low	Medium	Medium	Low

Philip J.M. et al., 2014	High	High	Low	Medium	Low	Medium
Bazzani et al., 2004	High	High	Low	High	High	Medium
Mejias et al., 2004	High	High	Low	Medium	High	Medium
Socratous, 2011	High	High	Low	Medium	High	Medium
Davy et al., 2003	Low	High	Medium	High	Low	Low
Blöch, H., 2001	Low	Medium	Low	High	Low	Low