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Abstract:

This document describes the work carried out in the scope of Task 6.1 Methodological framework and definition of social, economic and environmental indicators. Being more specifically, this deliverable provides a framework to analyse the management ang governance of water resources regarding socioeconomics and environmental aspects and stablishing a series of indicators to monitor them in an adaptive way through the platform and provide services to different users for Watermed 4.0. For this purpose, we have considered different types of variables to be measured that will allow us to obtain results and data to be used in long term management strategies of conventional and non-conventional water resources in pilot areas.

Keywords:

Integrated Water Resources Management, Socio-Economic Data, Environmental Governance, Indicators

Revision History

The following table describes the main changes done in the document since created.

Revision	Date	Description	Author (Organization)
v1.0	11/06/2020	First version of the document	Jesús Argente (UMU)
v1.1	23/06/2020	Review of water management and governance indicators and management issues at different levels in the pilot areas	Vicente Richart (CBU)
v1.2	25/06/2020	Final revision of the document	Vicente Richard (CBU) & Jesús Argente (UMU)
v1.3	22/07/2020	Final version	Vicente Richard (CBU) & Jesús Argente (UMU

Executive Summary

This document describes the definition of the framework for analysing socioeconomic and environmental aspects, through indicators to be integrated in the platform, that can influence good or bad management of water resources in agriculture and to be taken into account when making decisions related to the management of these resources. In this sense, it will allow to have information related to cost benefit practices that will serve to carry out an Integrated Water Resources Management (IWRM) and improve water governance in the pilot areas, considering the socioeconomic and environmental factors which can influence in the living conditions of their population.

Therefore, the methodological framework will serve to identify the inefficiencies and existing opportunities to promote an adaptive, fair and efficient management of water resources related to agriculture and to facilitate decision-taking process using and testing the platform developed by the project. This will allow us to test and validate socio-economic and water governance and management information in all partners countries and to determine the long-term effects of water management through the WATERMED4.0 platform, on local populations, economic growth, new jobs, talent, new professional specialization, new businesses and income.

Disclaimer

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1. INTRODUCTION

Accessible, high quality freshwater is a limited and highly variable resource. Organisation for Economic Co-operation and Development (OECD) projections indicate that 40% of the world's population lives in watersheds under water stress and that water demand will increase by 55% by 2050 (OECD, 2012a). Overexploitation and pollution of aquifers worldwide will pose major challenges to food security, ecosystem health and drinking water supply, and will increase the risk of subsidence, among other impacts.

Water infrastructures are antiquated, technology is obsolete, and governance and management systems are often not well equipped to meet the growing demand for water in agriculture, environmental challenges and climate change.

Also, water policies are complex and closely linked to the domains that are fundamental to development, including health, the environment, agriculture, energy, spatial planning, regional development and poverty alleviation. Thus, the study of the system of governance of water resources in agriculture is of great relevance, not only because of its direct relationship with ecological subsystems (basin, river, aquifers), but also because of its link with the prosperity of the area through the involvement of different individuals (governments, users, farmers, women as end users) through their actions.

The results of the study will promote innovation in public policies for better regulation and governance and management of water systems and will serve as a basis for practical recommendations on the most profitable and socially sustainable alternatives for improving the management of water resources (conventional and non-conventional) related in the study areas, including the corresponding necessary changes in the regulations in force. New perspectives will also be offered for future trends and business in agriculture with a strong digital technology component.

2. GOVERNANCE AND MANAGEMENT OF WATER RESOURCES: THE NEED TO ASSES THEM TO PROMOTE SUSTAINABLE AGRICULTURE

2.1 Environmental governance and management of water resources and relationship

Governance of water resources can be defined as the set of processes, laws, norms, incentives, values and structures (and networks) through which the rules that shape the behavior of the actors, in relation to the use and management of water resources, are established and revised.
It is important to highlight the differences between governance and management and their relationship. Management would be the elements of governance that are easily seen (e.g. management plans, management groups) and governance would be the least visible part (people to people negotiations, agreements, rules, market influences). Management (whether it is effective or not) would always be influenced by governance.

In recent years many scientific studies have focused on how to improve governance and management of natural resources such as water. These studies have shown the need to evaluate the efficiency of the governance system in order to determine, with the results obtained, which management measures to carry out. In this line, a basic framework has been developed by several authors who have been specifying the variables needed to be evaluated (Ostrom 2009, OECD).

Therefore, the study of governance through the systematization of various case studies is justified by the need to accumulate information, related to the socio-economic and environmental aspects, to diagnose problems and opportunities in the use and management of water resources related to agriculture. The accumulation of knowledge will reveal which variables affect to carry out a good or bad management and establish strategies for action and improvement.

In this sense, WATERMED4.0 project proposes the use and analysis of governance indicators as the first step to determine and analyze other more specific (such as economics, or social and environmental) management indicators in each pilot area in order to improve the use and management of water resources (conventional and non-conventional), in a cost effective way, used in agriculture in semi-arid areas of the Mediterranean.

2.2 Definition of social, economic and environmental variables and indicators to analyse governance and management in pilot areas

The governance and management indicators (sections 3.2 and 3.3) have been defined taken into account socio-economic and environmental variables based on OECD principles and recent scientific studies related to socio-ecological systems (Fig. 1 y Fig. 2) and on the premise that there is no general solution to the challenges of water use and management related to agriculture, but that governance and water management policies must be adapted to different water resources and to each territory and, in turn, must adapt to changing circumstances.
The assessment of governance and management through the analytical framework proposed (section 3) aims to improve the management of water resources in a sustainable and integrated manner in order to promote a sustainable agriculture. Considering that governance and management is good if it helps to solve the key challenges of agriculture-related water uses in pilot areas (and others where they apply) using a combination of bottom-up and top-down processes, while at the same time fostering constructive relations between the State and society. Governance is bad if it generates excessive transaction costs and does not respond to local needs.

To emphasize that for a good management and environmental governance of water resources, three basic criteria must be met: efficiency, effectiveness and trust and engagement among users.
This will define the variables and indicators to be analyzed in pilot areas, and in this sense, the following (as can be seen in figure 1) basic principles have been selected and will be taken into account in the definition of final indicators: (1) Roles and responsibilities; (2) Appropriate scales within basin systems; (3) Policy coherence; (4) Capacity; (5) Data & Information; (6) Financing; (7) Regulatory frameworks; (8) Innovative governance; (9) Integrity and transparency; (10) Stakeholder engagement; (11) Trade-offs among users, rural and urban areas; (12) Monitoring and evaluation.

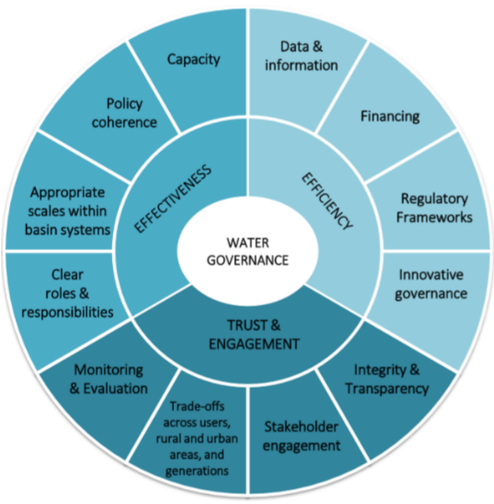

Fig. 1. OECD Principles on Water Governance (2015, p.4)

3. ANALYTICAL FRAMEWORK FOR SOCIAL, ECONOMIC AND ENVIRONMENTAL ASPECTS

Conventional and non-conventional water resources used by man are part of socio-ecological systems (SES). These systems are composed of several subsystems and internal variables within these at linked levels (Ostrom, 2009). SES are made up of 4 main subsystems, linked together: (1) the resource system (e.g. river basin); (2) the resource units (e.g. river, aquifer, regenerate water); (3) the governance system (e.g. government and organizations that manage the resources, agreements); and (3) the users (e.g. farmers, women as end users and other users), which depend on the political, economic and social conditions of each area (Fig. 1). In this sense, a novel analytical framework for the socio-economic assessment and to evaluate the efficiency of governance and management system of water resources in agriculture in the 3 pilot areas of the project through indicators has been developed to be integrated in the WATERMED4.0 platform.
Under these premises, WATERMED 4.0 will work by combining bottom-up and top-down processes, measuring and analyzing, with a greater frequency than the traditional monitoring methods used in Hydrological Planning, the effects generated by the different water resource management strategies on socioeconomic and socio-ecological aspects, as a basic and fundamental element for a correct governance that will in turn allow the generation of new strategies with enough time to guarantee the sustainability of the resource and avoid its deterioration as, unfortunately, has occurred to a greater or lesser degree in the pilot areas.

The objectives are (1) to identify the inefficiencies and existing opportunities to promote an adaptive, participative and efficient management of water resources related to agriculture; and (2) to improve and facilitate decision-taking process using and testing the WATERMED4.0 platform developed by the project.

This will allow the monitoring and evaluation of the information obtained from the analysis of social, economic and environmental indicators related to the management and use of water resources in the pilot areas and their countries. In this sense, the results will be used to establish management strategies in the short, medium and long term, using the WATERMED4.0 platform, with the aim of benefiting the economic and social development of local populations and their future generations through the sustainability of their water management practices.

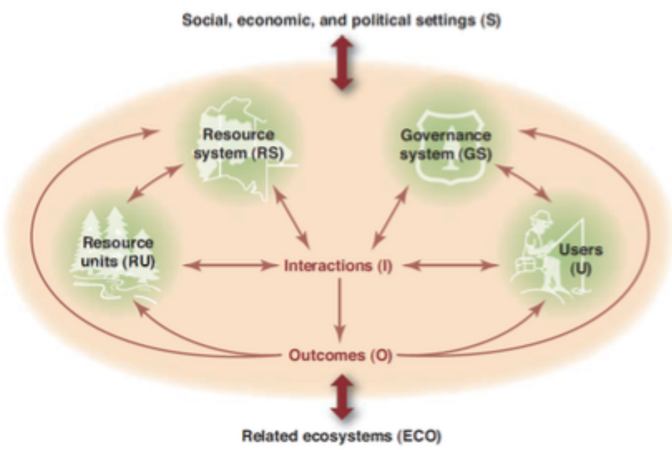

Figure 2. Main subsystems in an SES, and global and local drivers (Ostrom, 2009)

The analytical framework has 3 main sections (detailed in 3.1, 3.2 and 3.3) that will allow us to identify and evaluate the social, economic and governance factors that influence the efficiency of water management. On the one hand, it seeks to identify the socio-economic and governance barriers that hamper the implementation of technologies for non-conventional water uses, and, on the other hand, it seeks to understand the social and environmental benefits of the use of these technologies and also the implementation of digitization in water management resources for agriculture, with special attention to gender influences on behaviors and perceptions, and to involve society and policy makers to ensure a sustainable use of the proposed tools and technology once the project is completed. The analytical framework can be applied and replicated in other regions and it is recommended an annual monitoring in each pilot area in order to get an evaluation of indicators and establish an adaptive strategy in the pilot areas.

The analysis and collection of information will be carried out by users of the platform and, when necessary, with the support of consultation of key stakeholders through:
(1) online questionnaire addressed to managers and users with the information established in the analytical framework.
(2) online questionnaire addressed to scientists (specialized on agriculture or new technologies) who carry out their work in the river basin of each pilot zone
(3) questionnaire addressed to farmers, end users and key actors, considering the gender aspects (and the role of women in digitalization of water management) of the pilot areas.

The three levels of access and management of information and water management will allow a perspective or analysis from the plot to the exploitation system, adding the information that can be obtained from the different sources. This is a key aspect of WATERMED 4.0 because it ultimately allows the focus to be placed on a higher or lower level, giving governance a specific, multiple and differentiating character from the traditional vision. It is expected that this will be achieved thanks to the management of the different levels of management and the different indicators and impacts produced at each level analyzed.

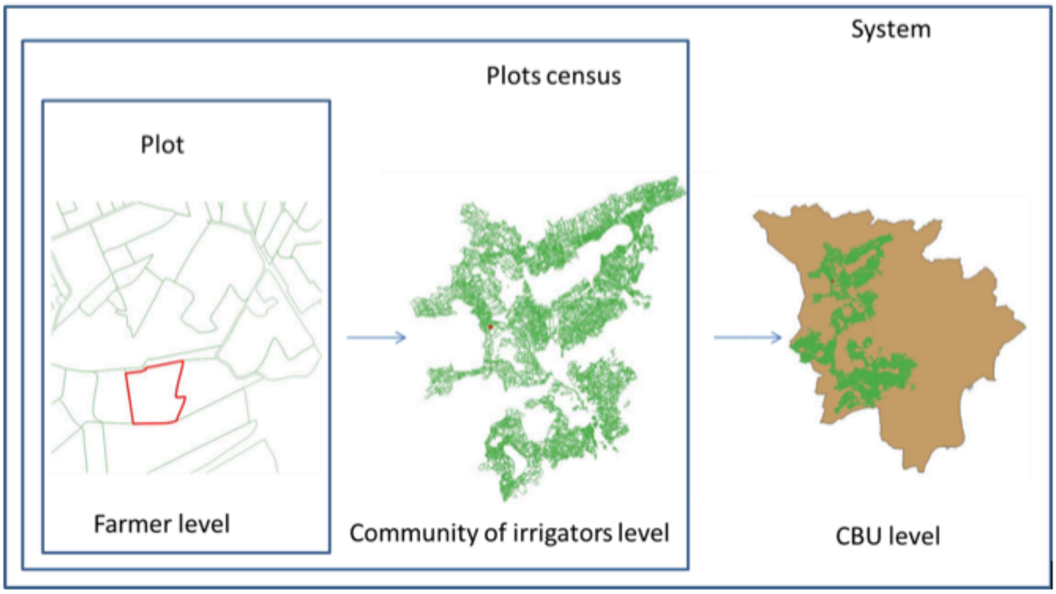

Figure 3. Access levels to platform and managements units. Example for Vinalopó (CBU, 2019)

3.1 General context of pilot area

In this section, the socio-economic context and the general situation of each pilot area will be analyzed in relation to the management of water resources used in agriculture. It will provide a general overview as a basis for determining which specific management indicators are analyzed in each pilot area (section 3.3).

In this regard, in 3.1, the following information will be collected and analyzed: (1) the socio-economic context of the pilot areas; (2) the types of crops and water resources used in their cultivation and the type of technology used; (3) the drivers and conflicts in the management of water resources and use of new technologies; and (4) the type of governance and management that is being carried out.

The parts and information that will be collected in each point of this section are shown in detail below:

1. Context:
Date
Name of pilot area, river basin and country
Per capita Gross Domestic Product (GDP)
GDP Growth rate
Main economic sectors (relative employment and GDP contributions)

2. Crop types, type of water resources and technologies used for irrigation in plot and obtaining the resource in high waters:
Crop
Area by crop, average size of cultivation areas
Provisions for cultivation, production, costs, sale prices for crops
Origin of water (groundwater, superficial water, Water reuse, desalation, water transfer)
Water costs by origin
Irrigation type

3. Drivers and conflicts:

- what factors are driving incompatible uses and management of water resources related to agriculture and how do the impacts related to these uses undermine the effective use and management of water resources.
- what factors or barriers hamper the implementation of technologies for non-conventional water uses
- what are the benefits of the use of technologies and digitization in agricultural water management?

4. Water Governance and Management Framework:

- Type A. Government Governance
- Type B. Shared governance (government and other actors such as farmers)
- Type C. Governance by private individuals and organizations (private governance)
- Type D. Governance by local farmers

3.2 Analysis of water governance through indicators

In this section it will be possible to evaluate the efficiency of governance system through the analysis of 12 category of indicators based on OECD framework of water governance and on recent scientific SES studies. For this purpose, attributes have been established for each indicator that determine its degree of implementation and existence. This will make it possible to know whether management is efficient or not and, with this, to act on the improvement of the indicators with low scores to improve general efficiency; and 2) to facilitate the analysis and establishment of the management indicators in each pilot area (section 3.3) that make it possible to know how water management affects social, economic, environmental and financial issues and to use them to improve the sustainable socio-economic development of these areas.

The analysis of governance will allow us to know the role and influence that governance has in water resources management and how to improve it.
The different levels of access (farmers, irrigation community and central user board) will have the possibility to evaluate the different indicators. In this way, a multilevel vision of governance is generated and, therefore, the general and particular efforts to be made.
The following is a brief explanation of how to conduct the information analysis and evaluation of the governance system and the variables and indicators to be analyzed:
1.Through the platform users must choose one option for each variable. Each option has been assigned an attribute that can range from 0 to 1 (0: minimum efficiency level; 0.5: medium efficiency level for and 1: maximum efficiency level). In the end, a result will be obtained from the sum total of the analysis of all the indicators providing a percentage of efficiency.
2. In order to facilitate and visualize the result there will be a general graph where the efficiency of each variable is indicated. Also, different colors to each category will be added depending of the degree of efficiency (red: 0-low, orange: 0,5-mid, green: 1-high).

Category	Indicator	Classification and attribute	Efficient management
1. Roles and responsibilities	1a. Existence and level of implementation of a water law	There is not (0) In process (0.5) There is and/or implemented (1)	1
	1b. Existence and functioning of ministry, line ministry, central agency with the core water-related responsibilities for policy making		
	1c. Existence and implementation mechanisms to review roles and responsibilities, to diagnose gaps and adjust when need to be		
2. Appropriate scale	2a. Existence and level of implementation of integrated water resources management policies and strategies	There is no and/or not implemented (0) In process (0.5) There is and/or implemented (1)	1
	2b. Existence and functioning of institutions managing water at the hydrographic scale		
	2c. Existence and level of implementation of cooperation mechanisms for the management of water resources across water-related users and levels of government from local to basin, regional, national and upper scales		
3. Policy coherence	3a. Existence and level of implementation of cross-sectorial policies and strategies promoting policy coherence between water and key related areas, in particular environment, health, energy, agriculture, land use and spatial planning	There is no and/or not implemented (0) In progress (0.5) There is and/or implemented (1)	1
	3b. Existence and functioning of an inter-ministerial body institution for horizontal coordination across water related policies		
	3c. Existence and level of implementation of mechanisms to review barriers to policy coherence and/or areas where water related practices, policies or regulations are misaligned		
4. Capacity	4a. Existence and level of hiring policies based on a merit-based and transparent professional and recruitment process of water professionals independent from political cycles	There is no and/or not implemented (0) In progress (0.5) There is and/or implemented (1)	1
	4b. Existence and functioning of mechanisms to identify and address capacity gaps in water institutions		
	4c. Existence and level of implementation of educational and training programmers for water professionals		

5. Data and information	5a. Existence and functioning of updated, timely shared, consistent and comparable water information systems	There is no and/or not implemented (0) In progress (0.5) There is and/or implemented (1)	1
	5b. Existence and functioning of public institutions, organisations and agencies in charge of producing coordinating and disclosing standardised, harmonised and official water-related statistics		
	5c. Existence and level of implementation of mechanisms to identify and review data gaps, overlaps and unnecessary overload		
6. Financing	6a. Existence and level of implementation of governance arrangements that help water institutions collets necessary revenues to meet their mandates and drive water-sustainable and efficient behaviors	There is no and/or not implemented (0) In progress (0.5) There is and/or implemented (1)	1
	6b. Existence and functioning of dedicated institutions in charge of collecting water revenues and allocating them at the appropriate scale		
	6c. Existence and level of implementation of mechanisms to asses short, medium- and long-term investment and operational needs and ensure the availability and sustainability of such finance		
7. Regulatory frameworks	7a. Existence and level of implementation of policy frameworks and incentives fostering innovation in water management practices and processes	There is no and/or not implemented (0) In progress (0.5) There is and/or implemented (1)	1
	7b. Existence and functioning of dedicated public institutions responsible for ensuring key regulatory functions for water services and resources management		
	7c. Existence and level of implementation of regulatory tools to foster the quality of regulatory processes for water management at all levels		
8. Innovative governance practices	8a. Existence and level of implementation of policy frameworks and incentives fostering innovation in water management practices and processes	There is no and/or not implemented (0) In progress (0.5) There is and/or implemented (1)	1
	8b. Existence and functioning of institutions encouraging bottom-up initiatives, dialogue and social learning as well as experimentation in water management at different levels		

	8c. Existence and level of implementation of knowledge and experience-sharing mechanisms to bridge the divide between science, policy and practice		
9. Integrity and transparency	9a. Existence and level of implementation of legal and institutional frameworks (not necessarily water-specific) on integrity and transparency which also apply at water management at large 9b. Existence and functioning of independent courts (not necessarily water-specific) and supreme audit institutions that can investigate water-related infringements and safeguards the public interest 9c. Existence and level of implementation of mechanisms (not necessarily water-specific) to identify potential drivers of corruption and risk in all water-related institutions at different levels, as well as other water integrity and transparency gaps	There is no and/or not implemented (0) In progress (0.5) There is and/or implemented (1)	1
10. Stakeholder engagement	10a. Existence and level of implementation of legal frameworks to engage stakeholders in design and implementation of water related decisions, policies and projects 10b. Existence and functioning of organizational structures and responsible authorities to engage stakeholders in water-related policy decisions 10c. Existence and level of implementation of mechanisms to diagnose and review stakeholder engagement challenges, processes and outcomes	There is no and/or not implemented (0) In progress (0.5) There is and/or implemented (1)	1
11. Trade-offs across water users, rural and urban areas, and generations	11a. Existence and level of implementation of formal provisions or legal frameworks fostering equity across water users, rural and urban areas, and generations 11b. Existence and functioning of and Ombudsman or institution(s) to protect water users, including vulnerable groups. 11c. Existence and level of implementation of mechanisms or platforms to manage trade-offs across users, territories and/or over time in a no discriminatory, transparent and evidence-based manner	There is no and/or not implemented (0) In progress (0.5) There is and/or implemented (1)	1

12. Monitoring and evaluation	12a. Existence and level of implementation of policy frameworks promoting regular monitoring and evaluation of water policy governance	There is no and/or not implemented (0) In progress (0.5) There is and/or implemented (1)	1
	12b. Existence and functioning of institutions in charge of monitoring and evaluation of water policies and practices and help adjust where need be		
	12c. Existence and level of implementation of monitoring and evaluation mechanisms to measure to what extent water policy fulfils the intended outcomes and water governance frameworks are fir-for-purpose		

Table 1. Governance variables and indicators, attributes and level of efficiency

3.3 Analysis of water management through indicators

The objective of this section is to define the methodology for the integration of management indicators such as agricultural economic data related to crop yields, prices, costs, input use, etc. as well as social parameters related to the population involved in the pilot regions.

This information will be uploaded in the Decision Support System (DSS) in order to be used in management activities and will allow analyse the direct economic impact on farms related to water management options. In this sense, section 3.3 will define two main issues to be adapted and applied to each pilot area: (1) the definition of the data collection process; and (2) the definition of the economic indicators assigned to each area that will be integrated, calculated and used by the DSS. The two points are explained below:

1. Data collection process in each pilot area:

There will be three alternatives, depending of the characteristics of each area, for the integration of economic data:

1) Farmers enter the economic data at plot level
2) Use of secondary information (public statistics at provincial level)
3) Mixed alternative

The following are the relevant issues to be considered when choosing the alternative:

- Selection of the crop alternatives to be considered in the DSS. Farmers will declare the crops grown in each plot. This is not a problem if farmers enter all the data that is needed. On the contrary, if public statistics are used, there might be a problem of lack of data for marginal crops. We would then need to restrict the system to the main crops in the area and allow for the classification of the remaining crops within some of the major crop types.
- Delays in public statistics. Public statistics on crop yields and production costs usually take two years to be published. Weekly/monthly data of crop prices is available with relatively little delay.

- Adequacy of public statistical databases, which may not provide data on crop yields and prices for some crop and/or crop varieties.
- Time steps of data management (e.g. crop area is declared at the beginning of the agricultural year, but yield, prices and costs would be declared at the end). Consequently, calculations should be done at the end of the agricultural year.

The above issues suggest the DSS should mostly rely on the data provided by farmers themselves at the plot level (alternative 1). However, if the DSS has to provide indicators on farm profitability, some assessment of crop production costs is needed. Obtaining detailed crop production costs from farmers can be difficult. There are three alternatives to account for crop production costs:

1) Ask farmers to fill an exhaustive questionnaire on crop production costs, what would require doing personal interviews to farmers or a full software development in itself. Both alternatives are very expensive and time consuming and would require a lot of collaboration from farmers.
2) Calculate production costs using a common crop production cost structure taken from previous studies or from interviews to a sample of farmers.
3) Ask farmers to provide an estimate of the unitary production cost (per kg or per unit), as the selling price above which they do not lose any money.

Alternative 2) is the simplest one. It would only require differentiating between production costs that are defined on a per-hectare basis and those that are proportional to the crop yield. Cost data could be updated using public input price indexes or new studies on the issue. However, this alternative would require accounting for all possible crop alternatives, which can be difficult. This potential problem could be solved by combining alternatives 2) and 3). This way, user would only have to introduce three economic data for each plot in the system: the crop planted, the average crop selling price and the average unitary crop production cost.

Aggregated information, not only agronomic, will allow decision-making and implementation of governance strategies both at the farmer level and at the management level of integrated water resources systems.

2) Definition of economic indicators

The DSS will compute different economic indicators that will serve to assess the direct social and economic impacts of farming activities in the area. The DSS will provide these indicators aggregated/averaged at different spatial levels (plot, farm, irrigation districts, hydrogeological areas, etc.). The DSS will first compute indicators at plot level and then will aggregate them at greater spatial levels. We propose using the sets of indicators shown in Tables 2 and 3 respectively.

ITEM	INDICATOR	UNITS	SOURCE/CALCULATION
Land and water use per plot	Plot area	ha	Included in the system
	Irrigated area	ha	Supplied by users
	Water use	m^3	Supplied by the system
	Unitary water use	m^3/ha	water use divided by irrigated area
Basic economic data per plot	Crop yield	kg/ha, units/ha	Supplied by users
	Crop selling price	€/kg, €/unit	Supplied by users
	Unitary crop production costs	€/kg, €/unit	From economic studies / supplied by users
	Crop production costs	€	From economic studies
	Labour use	days	From economic studies
Productivity measures per plot	Value of agricultural production	€	crop yield multiplied by its selling price
	Plot land productivity	€/ha	value of agricultural production divided by irrigated area
	Plot water productivity	€/m3	value of agricultural production divided by irrigated area
	Plot labour productivity	€/day	value of agricultural production divided by labour use
Profitability measures per plot	Farm net margin	€	value of agricultural production minus crop production costs
	Farm net margin per hectare	€/ha	Farm net margin divided by irrigated area
	Average value of water	€/m^3	Farm net margin divided by water use

Table 2. Indicators used at plot level

ITEM	INDICATOR	UNITS	SOURCE/CALCULATION
Aggregated land and water use	Total area	ha	Included in the system: summation of plots' areas
	Total irrigated area	ha	Supplied by users: summation of plots' areas
	Total irrigated area by crop	ha	Supplied by users: summation of plots' areas with the same crop
	Total water use	m^3 (hm^3)	Supplied by users: summation of plot's water use
	Total water use by crop	m^3 (hm^3)	Supplied by users: summation of plot's water use for the same crop
	Unitary water use	m^3/ha (hm^3/ha)	Total water use divided by total irrigated area
	Unitary water use per crop	m^3/ha/year	Total water use by crop divided by total irrigated area by crop
Aggregated economic data	Average crop yield	kg/ha, units/ha	Average of plots' crop yields
	Average crop selling price	€/kg, €/unit	Average of plots' crop selling price
	Total direct employment	jobs	Summation of plots' labour use divided by 240 days/job
Aggregated productivity measures	Total value of agricultural production	€	Summation of plots' value of agricultural production
	Aggregated land productivity	€/ha	Total value of agricultural production divided by total irrigated area
	Aggregated water productivity	€/m^3	Total value of agricultural production divided by total water use
	Aggregated labour productivity	€/job	Total value of agricultural production divided by total direct employment
	Employment per hectare	jobs/ha	Total direct employment divided by total irrigated area
	Employment per water use	jobs/hm^3	Total direct employment divided by total water use in hm^3
Aggregated profitability measures	Total farm net margin	€	Summation of plots' farm net margin
	Average net margin per hectare	€/ha	Total farm net margin divided by total irrigated area
	Aggregated average value of water	€/m^3	Total farm net margin divided by total water use
Groundwater body measures	Average piezometric descent	m/year	Average piezometric descent per groundwater body by year
	Total Water extractions	Hm3/year	Total Water extractions by year
	Exploitation rate	N/A	Extractions/natural recharge
	Natural recharge by	Hm3/year	Natural recharge by year
	Demands	Hm3/year	Total demands by year
	Irrigation demands	Hm3/year	Total irrigation demands by year
	Supply demand	Hm3/year	Total supply demands by year
	Surplus/Deficit	Hm3/year	Natural recharge – extractions
System exploitation measures	Total Water extractions by exploitation system	Hm3/year	Total Water extractions by all river basin o zone
	Total Water extractions	Hm3/year	Total Water extractions by year

ITEM	INDICATOR	UNITS	SOURCE/CALCULATION
	Exploitation rate	N/A	Extractions/natural recharge
	Natural recharge by	Hm3/year	Natural recharge by year
	Demands	Hm3/year	Total demands by year
	Irrigation demands	Hm3/year	Total irrigation demands by year
	Supply demand	Hm3/year	Total supply demands by year
Energy measures	Energy consumed by water bodies	kWh/year	Energy consumed for the large distribution for all uses in water bodies
	Energy consumed by system exploitation	kWh/year	Total energy consumed for the large distribution for all uses in system exploitation in water bodies
	Energy consumed by m3 in water bodies	kWh/m3	Average energy consummation by m3 in water bodies
	energy consumed by m3 in system exploitation	**kWh/m3**	**energy consummation by m3 in system exploitation in water bodies**
	Energy consumed by desalation	kWh/year	Energy consumed for the large distribution for all uses in desalation
	Energy consumed by system exploitation	kWh/year	Total energy consumed for the large distribution for all uses in system exploitation in desalation
	Energy consumed by m3 in wastewater	kWh/m3	Average energy consummation by m3 in wastewater
	Energy consumed by m3 in system exploitation	kWh/m3	energy consummation by m3 in system exploitation in wastewater
	Cost of energy	€/kWh	Unit price of electricity
Specific economic Water measures	m3 cost WB	€/m3	Average cost m3 of water by water bodies
	m3 cost WB SE	€/m3	Average cost m3 of water by system exploitation in water bodies
	m3 cost DT	€/m3	Average cost m3 of water by desalation
	m3 cost DT SE	€/m3	Average cost m3 of water by system exploitation in desalation
	m3 cost WW	€/m3	Average cost m3 of water by wastewater
	m3 cost WW SE	€/m3	Average cost m3 of water by system exploitation in wastewater
	m3 cost WT	€/m3	Average cost m3 of water by water transfer
	m3 cost WT SE	€/m3	Average cost m3 of water by system exploitation in water transfer
Non-conventional water measures	Hm3 WW	Hm3	Annual total wastewater amount produced in the sub-basin
	Hm3 DT	Hm3	Annual total desalation amount produced in the sub-basin
	Hm3 WT	Hm3	Annual total water transfer in the sub-basin

Table 3. Indicators aggregated at higher spatial levels

There are two major issues to be considered for the calculation of the above indicators. The first one refers to the point of measurement of water volumes. Water volumes can be measured at plot level (net water before water application to crops) and then transformed to gross volumes using efficiency ratios (application, distribution, transportation, storage) before doing the calculations at aggregated spatial levels, or the opposite way. The second issue refers to the time unit considered, regardless of whether it is the normal or hydrological/agricultural year. Data provided by users for each plot refers to a yearly value, but that poses a problem with farms with more than one productive cycle with different crops, so the system should allow to account for this.

The sequence of data gathering, and calculation of indicators would be:

1. Introduction of plot data by users (crop yield, selling price and average production cost);
2. Check/validation of the data entered. Algorithms must control/restrict the data introduction process by setting limit intervals to the values to avoid typo errors and/or inconsistent values. These intervals can be based on data from public statistics and/or data provided by the user in previous years or by other users in the previous or the same year.
3. Calculation of economic indicators as previously defined.

Development of the economic module of the DSS

The steps to be followed in the development of the economic module of the DSS are:

i. Programming the economic data module (variables and equations);
ii. Select a group of farmers to collaborate in the pilot;
iii. Collaborating farmers introduce the data in the pilot;
iv. Checking the correct functioning of the module and getting feedback from collaborating farmers;
v. Compare the results with secondary sources of data;
vi. Revise and improve the functioning of the module.

As the work progresses, additional indicators considered of interest could be incorporated, especially those referring to the macroeconomic analysis of the region that require revision to choose those that are really useful.

4. WATERMED4.0 PLATFORM TO GATHERING, USE AND VISUALIZE SOCIAL, ECONOMIC AN ENVIRONMENTAL DATA OF THE ANALYSIS

4.1 Sources and collection of information and integration of data

Using the platform, the information of the analytical framework will be integrated through different interfaces and modules. In this sense, on the one hand, there will be one module for the analysis of the environmental context and the governance indicators (socioeconomic and environmental) and will be carried out as indicated in sections 3.1 and 3.2; and on the other hand, another specific module for the management indicators (economic and social) will be established and will be carried out as indicated in section 3.3. This will make it possible to obtain information and correlate data for being used in an annual monitoring that will make it possible to carry out an adaptive management of water resources with the maximum benefits for the stakeholders, from the plot to the river basin.

4.2 Services and visualization

On the one hand, through the WATERMED4.0 platform, different services will be provided to users at different levels: (1) for management at plot level and for the benefit of farmers and end users; (2) for decision-making in watershed management useful for managers and irrigation communities; and (3) for the establishment of integrated water resources management (IWRM) strategies carried out at the political level in the pilot areas and regions and, on the other hand, it will be possible to visualize the information and results obtained, in an easy and intuitive way, in order to facilitate the understanding of the analysis. For that purpose, different modules will be provided to show aspects such as temporal data analysis and comparing or ranking study areas. Also, it will be possible to generate pdf documents to be used such as reports.

Below are figures of the pilot modules integrated into the platform ready to be tested and visualizing a proof conducted analysis:

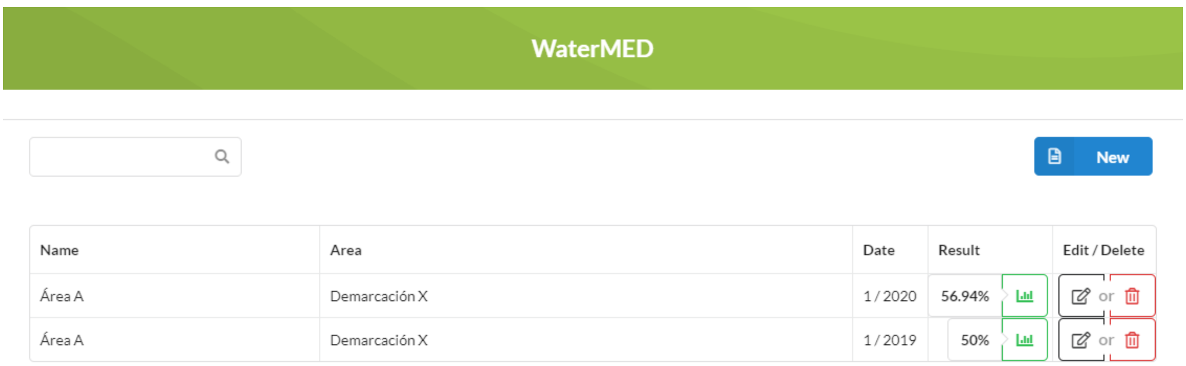

Figure 4. Temporal series of data analysis per pilot area

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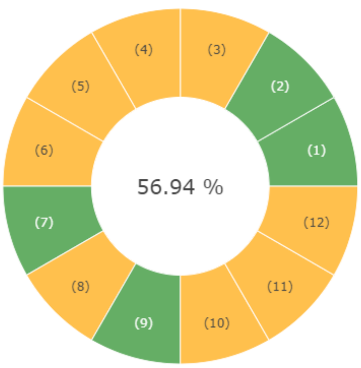
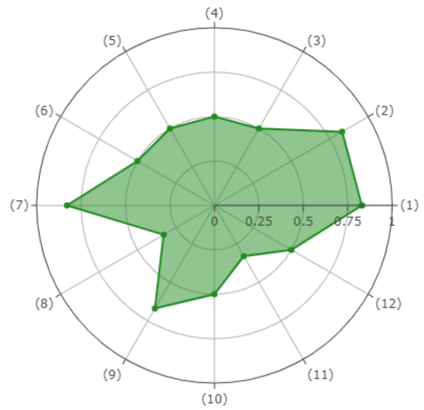
Indicadores

(1)	Principle 1: Roles and responsibilities	0.83
(2)	Principle 2: Appropiate scale(s)	0.83
(3)	Principle 3: Policy coherence	0.5
(4)	Principle 4: Capacity	0.5
(5)	Principle 5: Data and information	0.5
(6)	Principle 6: Finance	0.5
(7)	Principle 7: Regulatory frameworks	0.83
(8)	Principle 8: Innovative water governance practices	0.33
(9)	Principle 9: Integrity and transparency	0.67
(10)	Principle 10: Stakeholder engagement	0.5
(11)	Principle 11: Trade-offs across water users, rural and urban areas, and generations	0.33
(12)	Principle 12: Monitoring and evaluation	0.5
	Total	56.94 %





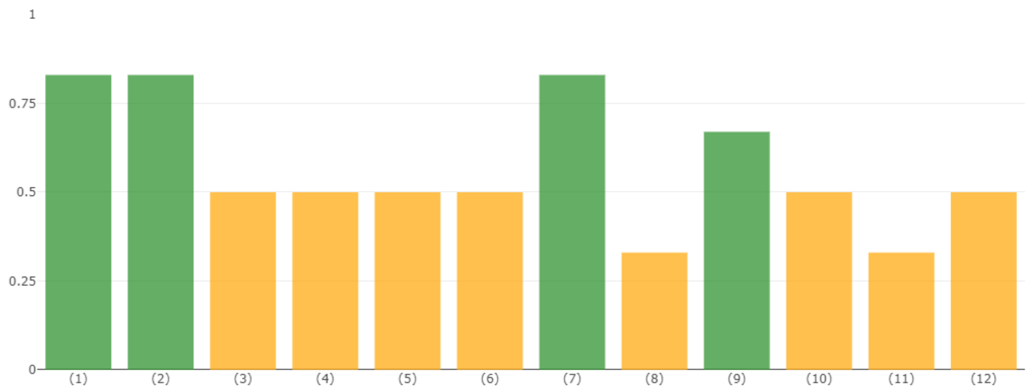


Figure 5. Annual governance indicators analysis per pilot area

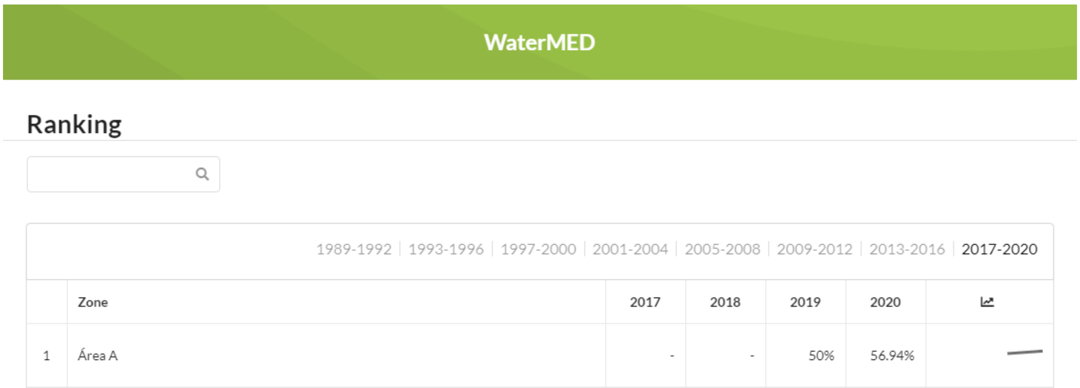


Figure 6. Evolution and annual trend of the analysis

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Compare

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Área A

		2019	2020
(1)	Principle 1: Roles and responsibilities	0.67	0.83
(2)	Principle 2: Appropiate scale(s)	0.5	0.83
(3)	Principle 3: Policy coherence	0	0.5
(4)	Principle 4: Capacity	1	0.5
(5)	Principle 5: Data and information	0.83	0.5
(6)	Principle 6: Finance	0.33	0.5
(7)	Principle 7: Regulatory frameworks	0.5	0.83
(8)	Principle 8: Innovative water governance practices	1	0.33
(9)	Principle 9: Integrity and transparency	0.33	0.67
(10)	Principle 10: Stakeholder engagement	0.33	0.5
(11)	Principle 11: Trade-offs across water users, rural and urban areas, and generations	0.17	0.33
(12)	Principle 12: Monitoring and evaluation	0.33	0.5
	Total	50 %	56.94 %

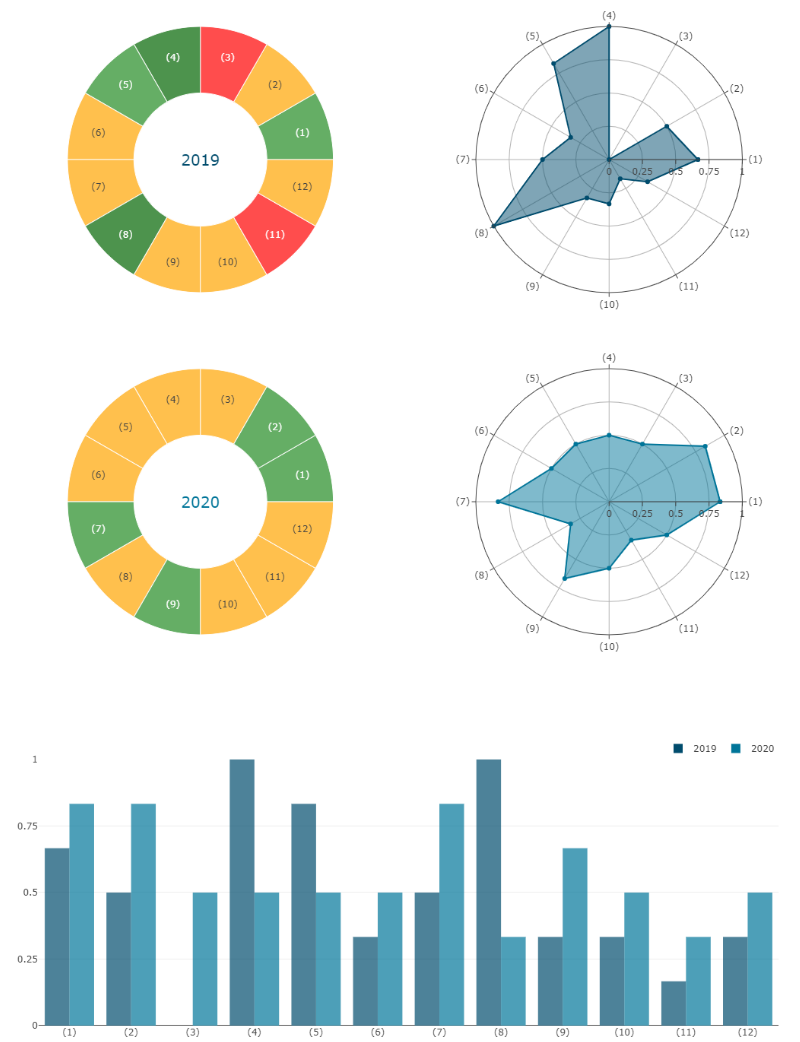

Figure 7. Comparison by year

4.3 Statistics

The statistics of access and use of the platform will themselves be a diagnostic and governance tool. Multi-level access, as described, will allow verifying the usefulness of the information for different users and, in turn, where appropriate, to establish strategies that promote and redound to its use.

4.4 To whom services could be useful

As explained in section 4.1, services will be provided at different levels from plot to the river basin, and regarding different users. In this sense, at the plot level and focused on end users there will be able information and data useful for infrastructure monitoring and maintenance, such as, inspections, equipment list, maintenance list, real-time water pump list, flow rate, etc…and it will also allow a better management of the basin's water resources, from citizens and farmers themselves to senior managers and administrations interested in the information and results obtained.

5. CONCLUSIONS

The proposed methodological framework and the use of the Decision Support System (DSS) platform developed through the project will make possible to analyze the existing conditions regarding the governance and management of conventional and non-conventional water resources in the pilot areas. This will provide social and economic data of the regions to be used in decision making process related to water management and in promoting, through a cost-benefit analysis, the implementation of an integrated water resources management (IWRM) perspective.

The definition and analysis through the developed social, economic and environmental management indicators will allow to carry out a continuous monitoring and with the results to be able to establish short, medium and long term strategies to carry out an adaptive and efficient management of water resources related to agriculture in the pilot zones and, at the same time, to be able to replicate them in other semi-arid zones of the Mediterranean.

The application of the new technologies developed in WATERMED4.0 are very useful tools to facilitate access to information for users and key actors, and thus improve water resources management processes and their governance. In this sense, its use will serve to optimize management processes which will translate directly into economic savings in agricultural practices and socio-environmental sustainability of the regions where they are applied, improving the quality of life of farmers and the generation of jobs and new businesses opportunities.

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