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Chapter

Management of River Basin Physical Assets

Mario Andrés Urrea-Mallebrera, Luis Altarejos-García and Juan Tomás García-Bermejo

Abstract

River basin management involves, among other activities, the operation, maintenance and renewal of existing water and wastewater physical infrastructure assets, as well as the planning, designing, procurement and construction of new water infrastructure assets, in order to provide and secure present and future water demand, and other services, such as flood control and mitigation. Focus is set on increasing demand issues and uncertainty in available resources due to climate change. But there is a challenge also in the management of an aging portfolio of critical infrastructures, including storage, diversion and flood protection facilities, water wells, water conveyance facilities and wastewater treatment plants. Though physical asset management methodologies are well developed and established, such as ISO 55001, their application to infrastructures managed by river basin authorities is not widespread. This chapter presents key components for effective management covering the following aspects: asset monetary valuation; asset condition assessment; estimation of risks linked with asset condition; planning and prioritization of capital and maintenance expenditures; and expected impacts on water tariffs. A raw water distribution system in the Segura River Basin in Spain has been used as case study.

Keywords: water infrastructure, asset management, risk, tariffs

1. Introduction

Since the publication of various international standards for physical asset management, significant and growing research has been carried out in different asset-intensive sectors: industry, water supply and sanitation, water purification, road transport, rail transport and port facilities [1, 2]. Investigations have been aimed at ascertaining the advantages of implementing methodologies in asset management from the point of view of ensuring asset performance, minimizing the risks of potential failures and the consequent effects on users and/or the environment. In particular, asset management has been used by companies in the water sector at different levels of the water supply process, with focus on minimizing failures and reducing potential effects on users, both from a social and economic point of view [3].

The importance of physical assets managed by administrations at different levels has been highlighted [4]. It has been also pointed out the importance of achieving a full understanding of these assets, which requires effective and efficient inventories, not only from a financial and/or accounting point of view, but also considering asset condition and performance. These inventories provide the data needed to carry out risk management of assets in the physical dimension, focused on asset performance and, also in the financial dimension, focused on asset sustainability [5]. It is this importance from an accounting and performance perspective that has led international organizations to focus their analyses on public sector balance sheets, and specifically on some of the lesser known elements, such as non-financial physical assets.

River basin authorities are accountable, among other responsibilities, for providing raw water for irrigation and urban use in a reliable manner, usually managing a complex infrastructure system. This system should be able to deliver access to water with enough quantity and quality levels, under variable hydrologic conditions, while accounting for regulatory and institutional context and operation and maintenance requirements. The system shall also meet current and future, long-term, demand forecasts.

A study of different river basins authorities in Spain covering the 2009–2014 period [6] showed that their degree of financial self-sufficiency was 53% on average value, with values ranging between 24% and 76%. Their economic viability depends on transfers from the government. For instance, in year 2016 a total amount of 225 million euros for capital and 26 million euros for current expenses were transferred. It was found that sources of cash flow imbalances are not only the delays in payments by users of the fees charged by river basin authorities, but also and more important the gap between the needed amount to effectively maintain and renew the asset portfolio and the amount retrieved via tariffs and taxes. There is not an asset management methodology set in place at the river basin authority level and raw water distribution lacks a regulatory framework as far as the management of the physical assets is concerned.

Planning that is currently carried out addresses two aspects:

a. achievement of the objectives of the EU Water Framework Directive, in particular reaching good status of the different water masses in the basin;

b. adequate satisfaction of the demands of the users served.

The diagnosis leads to the conclusion that, since a common methodology for the management of assets does not exist inside river basin authorities, different degrees of deterioration of the hydraulic infrastructure can be found, as a consequence of different efforts in maintenance, conservation and replacement of assets, together with different tax load burdened by the users, which leads to high inequalities in the system.

Therefore, it is needed to improve the management of physical assets operated by river basin authorities, developing methodologies for analyzing the current situation and providing new approaches that allow this very important sector to redirect and redefine the variables used in decision-making by the responsible managers. Portrayal of current situation shows that:

a. infrastructure maintenance and conservation policies have been developed mainly from a corrective point of view, i.e., once the asset have failed, which may not be the optimal strategy, either in terms of asset performance or in terms of the budgetary funds needed to correct it;

b. there are no adequate databases, including sound failure records, to allow performing asset management in accordance with international standards, thus failing to take advantage of the enormous engineering knowledge body that the experts responsible for these organizations have been building up over generations;

c. there is no analysis of the engineering or financial effectiveness of the system so far, particularly when these databases, when they exist, are not properly structured in a homogeneous way.

The investigation carried out in [6] has shown that preventive-predictive maintenance is not widespread across river basin authorities in Spain, there are no protocols for analyzing the current condition of assets and consequently there is no systematic risk analysis of performance associated with the assets. River basin authorities would be, in the best case, at initial stages of implementation of some processes equivalent to good practices, always on an individual basis, not coordinated, and far from requirements of international standards. River basin authorities lack a standardized and homogeneous methodology, which allows for a clear differentiation of budget items in such a way that partial budgets of income and expenses corresponding to the management of hydraulic infrastructures can be differentiated. Consequently, there are no strategic plans for the management of physical assets that involve planning of what needs to be done in the short and medium terms. There is no systematic analysis of actions to be undertaken, how they should be financed, and what impacts may be expected on water tariffs under current legislation.

Therefore, it is considered appropriate, and to a certain extent necessary, to define a common approach for management of assets that may allow at least a future no-deterioration of the hydraulic infrastructure heritage value, redefining budget needs.

2. Management of river basin physical assets

2.1 Overview of water management in Spain at river basin scale

Water management of the 25 Spanish River Basin Districts, which include both inland waters and transitional and coastal waters, is articulated through a continuous adaptive process that is specified through the monitoring of the current hydrological plan of each district, and its revision and updating every six years. This six-year cycle is regulated at different levels by national and Community regulations that make up a basic procedure, significantly common to all the Member States of the European Union, based mainly on the Water Framework Directive. Spanish hydrological planning must make the achievement of environmental objectives for water bodies and associated ecosystems compatible with socio-economic objectives by meeting the demands for different water uses.

The 25 Spanish river basin districts have approved their hydrological or water management plans for the second planning cycle (2015–2021) established by the Water Framework Directive. These are those corresponding to the 11 inter-community districts, whose competence falls to the Central Administration; the Eastern Cantabrian river basin district, with competences shared between the Central Administration and the Autonomous Community of the Basque Country; and 13 intra-community districts: the three with competences in their preparation by the Autonomous Community of Andalusia, the Balearic Islands, Galicia Costa, the River Basin District of Catalonia and the 7 districts of the Canary Islands, whose plans are approved by the Government of the Canary Islands. The 15 river basin districts located in the Iberian Peninsula are shown in **Figure 1**.

Figure 1.
River basins in Spain (only 15 river basins located in the Iberian Peninsula are shown).

The hydrological plans currently in force, 2015–2021, will have to be revised before the end of 2021, giving rise to new plans for the period 2021–2027, which will incorporate, with respect to the current ones, the adjustments that are necessary for their application until their next revision.

The resolution of the discrepancies between the different river basins' plans corresponds to the National Hydrological Plan, which, from a global perspective, must contemplate a harmonious and coordinated use of water resources capable of satisfying the planning objectives in a balanced manner. For this reason, the preparation of the National Hydrological Plan must involve not only the different public administrations, but also the civil society through a broad process of social participation that begins with the development and approval of the River Basin Management Plans. Eventual unbalances between demand and available resources are addressed at the National Hydrological Plan, mainly through inter-basin water transfers.

The first river basin authorities were created in 1926 by Royal Decree Law, being defined in the Water Law as entities of public law with their own legal personality and different from the State, attached for administrative purposes to the Ministry of Agriculture and Fisheries, Food and Environment, through the Directorate General of Water, as an autonomous body with full functional autonomy.

River basin authorities have been operating uninterruptedly since their birth, playing an important role in hydrological planning, resource management and exploitation, protection of the public water domain, concessions of rights of private use of water, water quality control, design and execution of new hydraulic infrastructures, dam safety programs and management of data.

The river basin authorities are public law entities with their own legal personality and have the autonomy to govern and administer by themselves the interests entrusted to them. They can acquire and dispose goods and rights that may constitute their own patrimony. They can contract and bind themselves to exercise, before the Courts, all kinds of actions without any other limitations than those imposed by the law. Their acts and resolutions put an end to the administrative process.

Therefore, river basin authorities have the competence in the management of assets, basically hydraulic infrastructures, which, whether owned by the State or by themselves, constitute an extensive portfolio, with a very important asset valuation, estimated in 5773 millions of euros by year 2015 [6]. It is clear that, proper maintenance of these physical assets is a major challenge for river basin authorities, in order to carry out the functions entrusted by the legislation and including raw water supply network in the territories where they are located.

The main source of funding is through fees, charges, and tariffs. The following items summarize sources of funding:

a. concession canon (for industrial and pasture activities),

b. water regulation canon,

c. wastewater discharge canon,

d. other equity income, through water use and electricity sales fees,

e. funds from the former Ministry of Agriculture, Fisheries, Food and Environment, now MITECO,

f. European Regional Development Fund subsidies,

g. other transfers from the European Union (Life Funds, Feder Funds, etc.).

2.2 Asset management systems

2.2.1 Asset management according to ISO 55000:2014

The ISO 55000:2014 standard provides an overview of asset management, its principles and terminology, and the expected benefits from adopting asset management; defines the factors that influence good asset management, including the nature and purpose of the organization, its financial limitations and regulatory requirements, and the needs and expectations of the organization and its shareholders and highlights the benefits of proper asset management, including improved financial results, information about asset investment decisions, risk management, and improved services and products. Other benefits include the improvement of corporate social responsibility and organization's sustainability, efficiency, and effectiveness.

The standard specifies the foundations on which asset management is based, which includes monetary valuation of assets, planning to achieve the proposed objectives, and leadership and commitment. It is considered essential to achieve the objectives set, for which is necessary to clearly define roles in terms of responsibilities and hierarchies, and to ensure competence, involvement, and training of the staff. Another key aspect is the relationship between individualized assets and their aggregation into systems. Basically, an asset management system is used to direct, coordinate and control asset management activities.

An Asset Management System can be described as a set of interacting and interrelated elements in an organization, whose function is to establish the asset management policy and the asset management objectives, and the processes required to achieve those objectives.

The advantages observed following the implementation of asset management methodologies in organizations include:

a. reduction of operating costs of assets;

b. reduction of capital costs of the investments made;

c. improved performance;

d. reduction of negative impacts on society, mainly associated with health;

e. reduction of operational risk of the assets;

f. minimization of environmental impacts;

g. enhancement of the organization's reputation within society;

h. better organization's performance;

i. reduction of legal and regulatory risks associated with the operation.

2.2.2 Key activities of asset management

Key activities of asset management that in some way should be adapted to the context of river basin authorities are:

a. developing policies, setting the link between the river basin authority strategic plan and the operation and maintenance plans;

b. developing strategies to achieve the objectives set at the organizational level;

c. creating an asset management plan aimed to define over time, what to do and by whom;

d. monitoring the plan, and if necessary, modify strategies in order to achieve the objectives;

e. training of the staff, to always have the best professionals over time in order to achieve the goals set with the least cost;

f. perform risk management, which represents a critical area in the organization;

g. information management, to document and record asset management processes.

2.3 Features of raw water infrastructure assets

It is obvious that both large hydraulic infrastructures of regulation and storage, as well as the distribution networks for water supply and sanitation networks, together with the different facilities of water treatment, such as drinking water treatment plants, purification plants and desalination plants, constitute a wide set of physical assets that can be cataloged as critical [7]. Raw water infrastructures as physical assets present a series of common characteristics:

a. can be subject to monetary valuation, and consequently be represented in the balance sheets;

b. can be inventoried and managed with the corresponding additions, removals and changes;

c. their monetary value depreciates over time;

d. level of performance decreases over time;

e. play a key role with high responsibility in the provision of a critical public service.

It is essential for the implementation of an effective asset management strategy, to understand that these assets do not represent a set of elements that are immovable in time, but are elements that respond to the surrounding conditions in which they perform. Recognizing that assets have a useful life, their proper management results from the combination of financial and engineering strategies, together with a good understanding and management of the risks associated with their performance. Moreover, the evolution of their condition over time is highly correlated with past efforts in operation and maintenance as reflected by budgets. Therefore, asset management aims to meet the challenge of how to do the best in terms of performance, with the lower possible budget, while minimizing the risk.

2.4 Key components of asset management for river basin authorities

2.4.1 Degree of maturity

The first component focuses on the general question of assessing the degree of maturity of the river basin authority organization in their current implementation asset management practices. The concept of maturity for a given organization is understood as the degree of implementation of the methodologies set out in international standards such as PAS 55, ISO 55000:2014, ISO 55001:2014 and ISO 55002:2018. This initial qualification allows the design and application of the proposed management model to be put into context. The management model should ultimately enable the definition of a Strategic Asset Management Plan from the point of view of defining and optimizing the conservation and maintenance budgets and replacement investments to be made, based on a series of objective indicators.

2.4.2 Inventory of assets

The second component would be the inventory of hydraulic infrastructures. The structuring of the inventory should allow, starting from individualized assets, their aggregation into subsystems and subsequent aggregation into a single operating system [5]. Then, a compilation of the available information should be carried out, including new implementation, maintenance, conservation, and replacement actions performed over time, with an indication of the budgets allocated for this purpose.

2.4.3 Asset condition

It is necessary to assess the evolution over time of the monetary value of assets, based on their depreciation over time considering replacement investments and conservation and maintenance actions. It is needed to define indicators of budgetary efficiency and operational sustainability that will make it possible to relate the condition and value of the assets to the conservation, maintenance and replacement actions undertaken in the past. These indicators, in turn, should make it possible to estimate the condition and future value of the assets associated with a given action plan for them [8]. The objective is to describe what has been done in the past in terms of upgrading and maintenance of physical assets, as well as to assess their value and remaining useful life, from a budget point of view.

2.4.4 Risk assessment

A key part of the framework would be to establish a methodology for estimating the risk associated with the different elements that make up an asset, to help prioritize the formulation of action plans for the assets [9]. Prediction of future risk levels after risk mitigation actions have been adopted helps to identify the most efficient measures.

2.4.5 Planning of investments on assets

Based on the above information, different options for investment plans on assets can be made, with the objective of minimizing both risk and asset de-capitalization. For each investment option, an estimate of the evolution of the future monetary asset valuation would be simulated, together with a prediction of the level of future risk associated with the assets, sub-systems and systems according to the possible actions proposed. The potential impact on tariffs and fees associated with each investment intensity would be also simulated.

As a culmination of the above, plans would be defined, including investments and associated budgets for future actions in the short to medium term, typically 6 years, that will make it possible to contribute to the non-deterioration of assets and to the recovery of initial levels of performance, considering both their technical and financial viability, including the estimation of the impact on tariffs over users.

2.4.6 Strategic asset management plan

The next step would be the drafting of a proposal for a Strategic Asset Management Plan, using the above information as background information. A Strategic Asset Management Plan is a document that specifies how the organizational objectives are to be converted into asset management objectives. In addition, it describes the approach the organization takes to comply with these asset management objectives. Aspects covered are scope, definition of stakeholders, setting, asset management policy, asset management objectives, asset status, change management, asset management strategy, performance management, description of asset management system and how the plan would be evaluated.

2.5 Application to a case study

2.5.1 Case study

Part of the assets operated by the Segura River Basin Authority in south-east part of Spain has been used as a case study. The Segura River basin, shown in **Figure 2**, has and extension of 20,200 km^2. It is the driest area of Spain, with average annual rainfall lower than 400 mm, very unevenly distributed both in space and time. Potential evapotranspiration is approximately 990 mm per year. Average runoff is estimated as 43 mm/year, which is the lowest value in Spain. Main river in the basin is the Segura river, with a length of 260 km and annual mean discharge volume of 700 Mm^3. The Segura River Basin has a population of approximately 2,200,000 people. Water resources available are 1566 Mm^3 per year, including

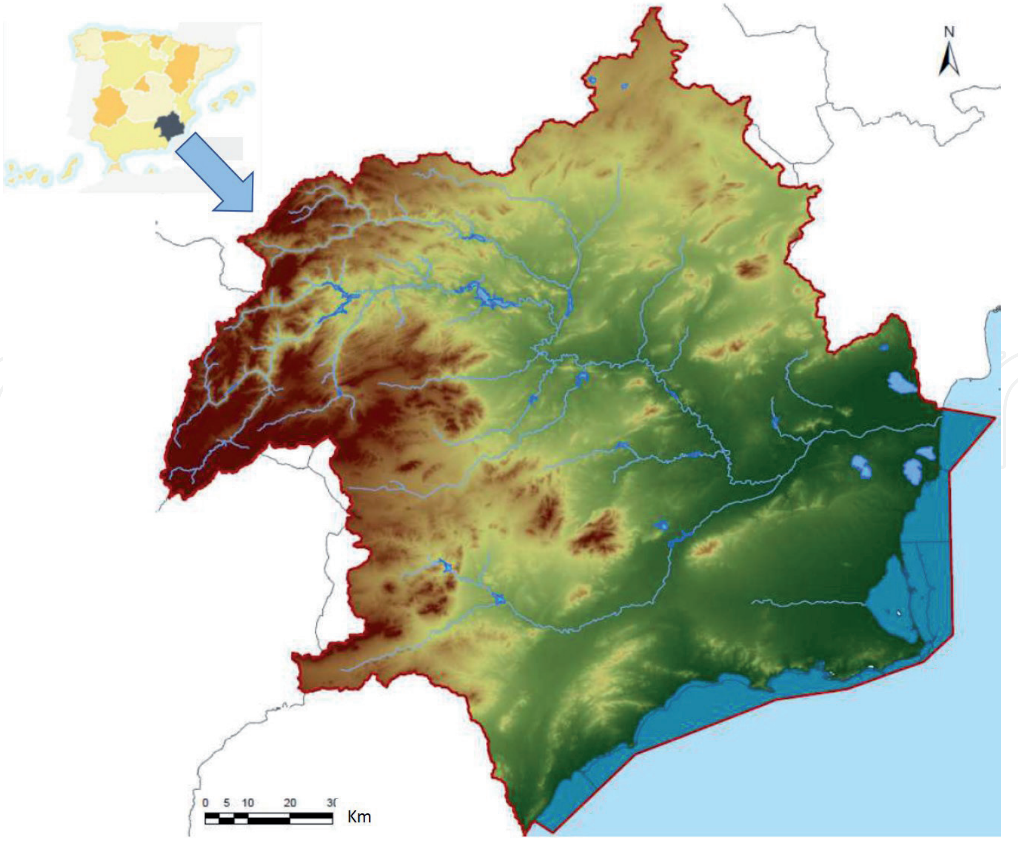

Figure 2.
Segura River basin (source: Segura River basin authority and [10]).

ground water, desalination, reuse, and water transfers from other river basins. On the other hand, water demand is 1843 Mm^3 per year, which results in an average deficit of 277 Mm^3 per year.

The operation of the raw water system in the basin is organized as one single operational system, which is divided into different sub-systems. Each sub-system includes a variety of infrastructure assets: dams, water pumping wells, water mains, pressure pipes, pump stations and wastewater treatment plants. The Segura River Basin system is divided into 5 different sub-systems.

Sub-system 5, for irrigation and domestic water supply, has been used as case study. Sub-system 5 includes 8 assets, as shown in **Figure 3**. Asset n°1 is a reservoir for regulation with capacity of 2.8 Mm^3, with a concrete gravity dam 20 m high. Asset n°2 is a water main with capacity for 10 m^3/s and 128 km long, starting at Asset n°1 and connected with Assets n°3 and n°4. Asset n°3 is a reservoir for regulation with capacity of 1.5 Mm^3, with an embankment dam 32 m high. Asset n°4 is a reservoir for regulation with capacity of 50 Mm^3, with and embankment dam 80 m high. Asset n°5 is a water main with capacity for 30 m^3/s, with a first Section 30 km long before it bifurcates into two branches: one with capacity of 16 m^3/s and 30 km long connected to Asset n°6, and another with capacity of 30 m^3/s and 24 km long connected to Asset n°7. Asset n°6 is a reservoir for regulation with capacity of 15 Mm^3, with an embankment dam 55 m high. Asset n°7 is a reservoir for regulation with a capacity of 220 Mm^3, with an embankment dam 65 m high. Asset n°8 is a water main with maximum capacity of 25 m^3/s and 64 km long.

2.5.2 Inventory of assets

Databases containing information on budgetary investments made since the commission of assets constituting Sub-system 5 have been compiled. Data includes

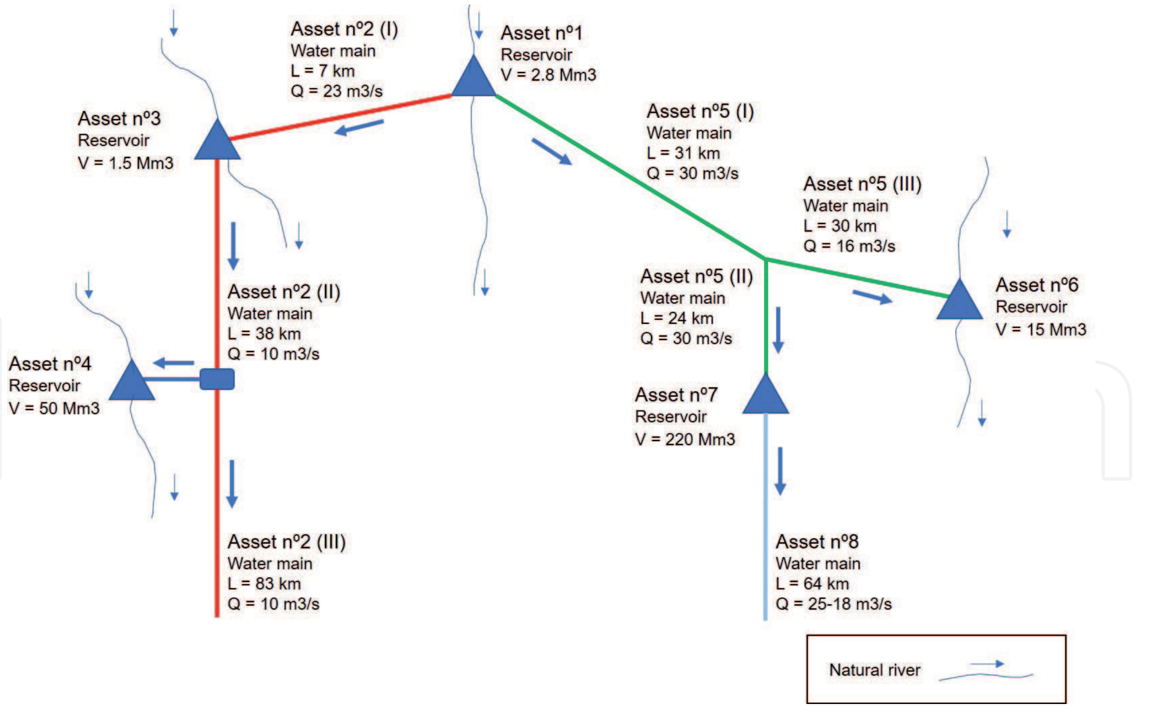

Figure 3.
Schematic of sub-system 5.

actions financed with funds from the Spanish Directorate General for Water, and investments undertaken using the Segura River Basin Authority own funds. This database includes new capital and replacement investments as well as specific maintenance expenditures. Asset valuation sheets include the variables required to undertake monetary valuation over time based upon investments made for new and replacement purposes and those specific to maintenance and preservation. In this case linear depreciation is assumed. Salvage value of assets is expressed as a % of their monetary value at time of commissioning. These percentages vary typically between 80% for civil works and 10% for electrical equipment. Another variable in the database is the useful life of the asset in question. Service life assumed is 50 years for civil works, 25 years for electromechanical equipment and 15 years for electrical equipment.

Monetary valuation of the whole Subsystem 5 at year 2015 is 493.6 M EUR. Value of each asset is shown in **Table 1**.

2.5.3 Asset condition indicators

The index used to evaluate asset condition is the Asset Sustainability Index, ASI(t), which is defined as the ratio between the Cumulative Amount Budgeted for infrastructure maintenance and preservation over the whole life-cycle of the infrastructure, evaluated at time t, CAB(t), and the total Amount Needed to achieve a specific infrastructure condition over the whole life-cycle of the infrastructure, AN, as shown in Eq.(1). The amounts shall include all maintenance actions that contribute to retain the asset in, or to restore the asset to, a certain state, which is the target [10].

$$ASI(t) = \frac{CAB(t)}{AN} \tag{1}$$

A key aspect for successful use of the index is the accurate assessment of the amount needed, that should consider past experiences of the organization

	Assets in subsystem 5							
	N°1	N°2	N°3	N°4	N°5	N°6	N°7	N°8
Monetary value at year 2015 (M EUR)	33.5	128.7	3.7	56.9	40.5	121.4	49.1	59.8

Table 1.
Monetary value of assets of subsystem 5, year 2015 (millions of euros).

together with industry best practices. The amount needed per year is estimated as a fraction of the initial value of the asset. Typical values range from 1% for civil works, 4% for electromechanical equipment, and 8% for access and service roads [10]. Maintenance budget estimated according to these percentages should be understood as an estimate of the minimum maintenance budget which should be provided every year in relation to current replacement costs of the infrastructure, in order to provide a basis for ongoing service delivery. The condition of the infrastructure inferred from the ASI indicator can classified as 'good' (1.0–0.8), 'medium' (0.8–0.6), 'poor' (0.6–0.4) and 'very poor' (0.4–0.2). Values below 0.2 may indicate risk of failure. **Table 2** shows ASI values estimated at year 2015 for the 8 assets included in Sub-system 5.

Analysis of past investments in the full Sub-system 5 for both routine maintenance and replacement actions has been carried out for the period 2008–2015. Average annual value of conservation and maintenance investments is 0.83 M EUR, which is approximately the 0.17% of the assets monetary value. Average annual value of replacement actions is 2.13 M EUR, which represents 0.4% of the monetary value. Altogether, the average annual joint budgetary effort is 2.96 M EUR, which is 0.6% of the monetary value of the full Sub-system 5.

2.5.4 Risk

A risk assessment has been performed, based on the surveys conducted among the management staff and technical staff in charge of assets. A qualitative risk index for the different assets has been determined, on a 0–10 numerical scale. Risk evaluation is done according to the following classification: 'very high' (10–8), 'high' (8–6), 'moderate' (6–4), 'low' (4–2) and 'very low' (2–0). Risk is assessed considering the classical approach of multiplying a qualitative probability of failure index times a qualitative consequence index. Both indexes for probability of failure and consequences are assessed by the river basin authority staff using verbal descriptors of probabilities and verbal descriptor of expected range of consequences. **Table 3** shows Risk Index estimated for year 2015, corresponding to the 8 assets of Subsystem 5.

2.5.5 Planning of investments

Different investment plan alternatives can be prepared based on the results obtained from the operational sustainability indicator, ASI, and the risk level index for 2015, as well as from the analysis of the amounts allocated to replacement investments and to preservation and maintenance. Plans are set for a 6-year time span, corresponding to the period 2016–2021. The 6-year period is distributed in 3 tariff blocks, of 2 years duration each: block n°1 (2016–2017), block n°2 (2018–2019) and block n°3 (2020–2021). Plans include investment efforts of two types: (a) annual investments in asset replacement, and (b) annual budgets for preservation and maintenance.

	Assets in sub-system 5							
	N°1	**N°2**	**N°3**	**N°4**	**N°5**	**N°6**	**N°7**	**N°8**
ASI (2015)	1.00	0.56	1.00	0.07	1.00	0.29	0.44	0.37
	Good	Poor	Good	—	Good	Very poor	Poor	Very poor

Table 2.
ASI of assets of sub-system 5, year 2015.

	Assets in subsystem 5							
	N°1	**N°2**	**N°3**	**N°4**	**N°5**	**N°6**	**N°7**	**N°8**
Risk index (2015)	8.05	7.13	6.33	7.06	7.37	6.38	6.33	8.05
	Very high	High	High	High	High	High	High	Very high

Table 3.
Risk index of assets of subsystem 5, year 2015.

	Simulated water tariffs for different user types (EUR/m^3)			
	Past	**Investment plan 2016–2021**		
	2014–2015	**2016–2017**	**2018–2019**	**2020–2021**
User type 1	0.1219	0.1235	0.1242	0.1249
User type 2	0.1640	0.1652	0.1665	0.1676
User type 3	0.0382	0.0394	0.0396	0.0398
User type 4	0.0579	0.0592	0.0597	0.0601

Table 4.
Simulated water tariffs (in euros per cubic meter).

Considering the monetary valuation obtained for Sub-system 5 at year 2015, the average amounts to be applied on an annual basis of result in 6. 93 M EUR per year, which represents 1.4% of Sub-system 5 monetary value. This amount is divided into asset replacement and renewal, 4.66 M EUR per year, and preservation and maintenance, 2.27 M EUR per year. Given the aging of the various elements, excluding civil works, it would be advisable to carry out a major replacement work over the next six years, 2016–2021, and the following six-year period, 2022–2027.

Assuming that the weight of the investment effort would be fully carried by users, current tariffs should be modified accordingly. Once the structure and the corresponding formulation of the tariff to be applied is known, the simulation of tariff changes is carried out in such a way that only the variables that are affected either by preservation and maintenance actions or by replacement investment actions are modified, keeping constant all the other variables, such as water demand. **Table 4** shows the expected impact on tariffs corresponding to the 4 different kind of users, according to legal framework in the basin, allowing comparison with past tariffs for the period 2014–2015.

With this information, the Strategic Plan for Asset Management should specify the actions to be undertaken during its period of validity, which is intended to be 6 + 6 years. In the first phase, only the actions to be carried out will be detailed, by identifying the asset, type and consequently the sub-system and systems on which the action is to be taken. This is the case of the model tested in Sub-system 5, for that first initial period of 6 years. After the analysis of the tariff impacts, the ASI index and the risk index must be re-evaluated according to the investments made and the new perceptions that the managers responsible for the operation have, in the event that the actions planned for the different scenarios proposed are carried out.

3. Conclusions

The work presented tries to contribute to the improvement of current asset management practices followed by river basin authorities in relation to physical assets of raw water systems. Typical questions that concern decision-makers are:

a. What assets need investment?

b. How much budget should be allocated?

c. When the maintenance or replacement actions should be taken?

d. What is the degree of improvement/minimization of the risk?

e. How does the action program impact on tariffs?

Some gaps and weaknesses have been identified in current practice, including:

a. insufficient disaggregation of budgetary information related to assets;

b. inadequacy of the patrimonial accounting valuation, which makes difficult to support a suitable management of assets;

c. need to improve budget management based on properly constituted cost centers;

d. need for multi-year planning, resulting from a common practice for the different basin organizations across the country.

Decisions on conservation and maintenance of physical assets, as well as decisions on investments for replacement, to be adopted by river basin authorities can be supported by the application of the methodologies and practices described in the present work, which can be considered as a first step in the implementation of the good practices in asset management.

The use of indicators to assess budgetary sustainability based upon historical data of the asset databases managed, as well as the semi-quantitative and qualitative assessment of risk, allows to identify how much budget should be planned and where it should be allocated. Once the critical assets have been identified, different scenarios for replacement investments and maintenance and conservation actions can be proposed, and the impact over future water tariffs can be simulated. The analysis of the impacts on tariffs and the comparison with the existing helps to understand and evaluate the viability and acceptance of these tariffs by the users. The simulation of different scenarios, thanks to the automation of the process of determining the ASI and tariffs, favors the analysis of multiple alternatives that can be adapted to the foreseen financial capacities, or even define the budgetary needs of the period, determined in its case additional financing mechanisms and thus avoiding the progressive decapitalization that has been suffered in the hydraulic asset portfolio.

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