

Public policies as strategic asset management enablers: the case of Portugal

H. Alegre^{IWA}^{a,*}, R. Amaral^{a,b}, R. S. Brito^a and J. M. Baptista^{a,b}

^a Laboratório Nacional de Engenharia Civil (LNEC), Av. Brasil, 101, 1700-066 Lisboa, Portugal

^b LIS-WATER, Av. Brasil, 101, 1700-066 Lisboa, Portugal

*Corresponding author. E-mail: halegre@lnec.pt

Abstract

Urban water supply, wastewater and storm water services (globally, water services) are essential to society. The lack of permanent, safe, and respondent services has inevitable consequences on public health and the well-being of communities, on the economy, and on the environment. Goal 6 of the Sustainable Development Goals (SDGs) recognizes this; failing to meet it necessarily affects the accomplishment of many of the other SDGs. Water services' provision depends on expensive and long-lasting physical assets. Managing them strategically (e.g., according to the international standards on asset management, series ISO 55x and to the IWA recommendations on infrastructure asset management) is, therefore, fundamental for sustainable societies. Countries need to have sound public policies that enable asset management of water infrastructure. Portugal is a paradigmatic case. This paper elaborates on key government goals, on why asset management is important to meet them, and on key building blocks that a coherent public policy should consider in order to enable asset management of water infrastructure. It also presents how Portugal has been implementing this process, addressing the challenges that need to be overcome.

Key words: asset management, policy-maker, Portugal, public policy, utility, water service

Highlights

- Demonstration of why asset management matters to achieve SDGs and Governments goals.
- Explanation of key building blocks that a coherent public policy should consider to enable asset management of water infrastructure.
- Illustration of a implementation process followed by a south European country.

GLOBAL CHALLENGES AND GOALS

The 17 Sustainable Development Goals (SDGs) of the United Nations are nowadays 'THE' reference framework for any country to foster development and sustainability. They are a great synthesis of the most relevant aspects any country or any region needs to consider in its public policies, including those related to urban water services, specifically addressed in Goal 6 – Clean water and sanitation. However, water services influence and are influenced by almost all the other goals. In particular, access to safe and reliable water services is key to overcome poverty (SDG1), hunger (SDG2) and

This is an Open Access article distributed under the terms of the Creative Commons Attribution Licence (CC BY 4.0), which permits copying, adaptation and redistribution, provided the original work is properly cited (<http://creativecommons.org/licenses/by/4.0/>).

inequalities (SDG5 and 10), for economic growth (SDG8), public health (SDG3) and education (SDG 4), for the sustainability of cities and communities (SDG11), and for peace and justice (SDG16). The quality of water services also influences life on land (SDG15), life below water (SDG14), and clean energy production (SDG7). On the other hand, innovation and infrastructures (SDG9), climate action (SDG12), responsible consumption and production (SDG13), and adequate partnerships (SDG17) are critical to meet SDG6. This framework is valid for developing regions, where major shortcomings in terms of access to safe water still exist. It is also fully valid for developed regions, where challenges due to climate change, public health (e.g., emerging contaminants), migration, safety and security, social inequities, and sustainability are drivers for change.

It is therefore based on this framework that many governments and organizations set their own goals and implement actions to achieve them. Urban water systems need to contribute to a more circular economy, be able to cope with emergent pollutants, become more flexible and resilient to face future uncertainties and extreme weather conditions. We need water-smart cities that integrate surface water in urban planning, increasingly adopt nature-based solutions, explore alternative water sources, new materials, massive sensing, digital intelligence, or advanced treatment technologies.

However, water smart cities and urban water systems of the future do not start from scratch. They are built upon existing assets. Governments and utilities need to cope with the slow pace of evolution driven by expensive and long-life water assets and often also with an increasing accumulated deficit in water system rehabilitation. There is the need for roadmaps from the current state of urban water systems to an envisaged state that allows meeting the intended government global goals, taking benefit from available or emerging technology, governance models, management systems, and business opportunities. To cope with these challenges, sound public policies are desperately needed. Governments at all levels have a very important role to play. They need to understand that at the end of the line the water utilities, who own and manage the water systems, need to act in alignment with them. For this, public policies need to provide them an appropriate environment that accelerates change, fosters the long-term value of the assets, and effectively contributes to achieving the global government goals.

LINKING GOVERNMENT GOALS, PUBLIC POLICY, AND ASSET MANAGEMENT TO BETTER SERVE SOCIETY

‘Asset management is the coordinated activity of an organisation to realize value from assets.’ Conversely, ‘An asset is an item, thing or entity that has potential or actual value to an organisation’ (ISO 55000 2014). Asset management is ruled by four main principles:

1. Assets exist to provide value to the organization and its stakeholders.
2. Asset management transforms strategic intent into technical and financial decisions, plans, and activities.
3. Leadership and workplace culture are determinants of value realization.
4. Asset management provides assurance that the assets fulfill their required function.

Applied to the case of urban water services, and particularly to the urban water infrastructure, implementing asset management has a major impact on societies, immediately and in the medium and long terms.

Figure 1 illustrates the link between government goals, public policies, and asset management. Governments act for the well-being of societies. As previously stated, the UN SDGs synthesize the common sustainability goals of humankind, safe and reliable water services being at the core of them. Although with this reference, each government needs to take into account its own role and context and define its specific goals. In order to achieve them, governments need to establish and implement a public policy that drives an effective management of assets and resources, maximizing

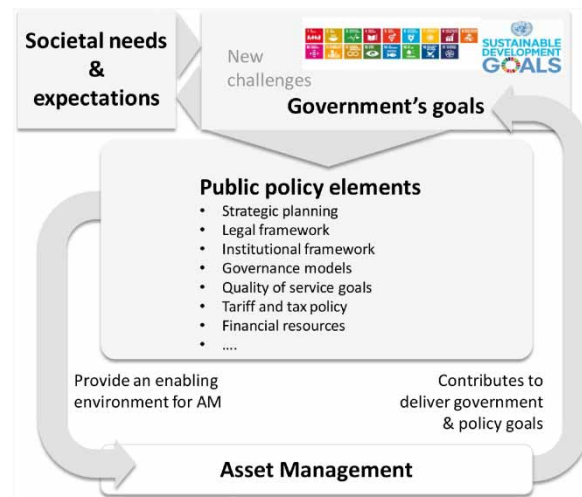


Figure 1 | Water services: public policy and asset management.

their value for society and for the environment, in a long-term perspective. In practice, public policies creating an enabling environment for asset management will achieve their goals more efficiently and effectively.

Benefits from having a favorable environment for water utilities to adopt asset management include, among others:

- improved use of financial resources;
- demonstrated compliance with the governments' goals and related utilities' objectives;
- well-grounded priority setting and solutions' selection and implementation;
- transparency and accountability of the decisions;
- alignment between government's strategic goals and intents with all the value chain until daily water systems' operations;
- opening room for research and innovation;
- managed risk, particularly with regard to critical infrastructure;
- incorporation of a long-term perspective.

Overall, a broad implementation of asset management by water utilities is in the critical path for all governments committed to complying with the UN SDGs.

PUBLIC POLICY ENABLING STRATEGIC ASSET MANAGEMENT

In general terms, any public policy regarding access to safe and reliable water services should adopt a holistic approach addressing key building blocks such as those listed in Table 1. The successful implementation of public policies for water services depends on the ability to manage the implementation of all these elements concurrently, ensuring an effective global and integrated approach (Baptista 2014). Additionally, the introduction of asset management enablers in the public policy for water promotes the long-term value of the water assets. A holistic approach of asset management in all these building blocks of a water public policy is essential for the long-term sustainability of the infrastructure. Table 1 contains recommendations on how to achieve this. It builds on the listing of building blocks recommended by Baptista (2014), slightly adjusted, and elaborates on how each of them can provide a supportive environment for effective asset management.

Table 1 | Building blocks of a public policy enabling asset management

Public policy building block	This public policy building block can provide a supportive environment for effective asset management implementation by...
Strategic planning	... including strategic directions and setting up priorities for asset management, as a relevant component of the public policy, taking into consideration a long-term vision for the existing assets and maximizing their value, to support the policy objectives
Legal framework	... including the requirements, enforcement mechanisms and penalty tools in the legislation conducive to better asset management practice ... regulating this subject, avoiding legal gaps and overlaps, and overcoming existing barriers
Institutional framework	... including clear mandates and adequate skills (in the institutional framework in general and in the laws of the regulatory authorities), to promote the enforcement of asset management in the sector as a common practice of the service and program providers
Governance models and contracts	... including clear obligations and incentives to promote the adoption of asset management, such as, for instance, good leadership, accountability mechanisms, AM implementation goals and specification of the end of contract target value of the asset portfolio and service levels in the contracts. One of the aspects to foster is that public procurement addresses life cycle costs, performance and risk, instead of allowing selection based only on the lowest bid or lowest investment cost
Quality of service goals	... including in the quality of service assessment system a set of performance indicators able to assess the asset management practice and setting up realistic quality of service targets
Tariff and tax policy	... including the medium- and long-term cost coverage of the needed investment to assure the adequate quality of service, accounting for long-term sustainability of the assets
Financial resources	... being mobilized in a way that allows implementing the strategic plan, aligning the mechanisms for allocation of funds with the defined priorities, and introducing incentives and requirements in this allocation that lead to effective asset management by the service and program provider
Infrastructure construction and rehabilitation	... adopting the adequate and emerging methodologies, technologies, and practices to optimize the value of existing assets and to promote the transition between the current state of the assets and the long-term envisaged state through a balanced share between new assets (expansion) and maintenance and rehabilitation of existing assets
Operational efficiency	... enabling and encouraging a long-term view of operational efficiency gains, by making use of economies of scale (assuring the alignment with asset management strategic goals, scope, and process) and by monitoring and promoting better operational processes and practices by the service and program providers
Training and capacity building	... identifying and addressing needs in terms of education, training of the staff, and capacity building of the service and program providers that are felt necessary to achieve the long-term vision regarding the asset management good practices
Research and innovation	... identifying the existing gaps and enabling and promoting problem-driven research and innovation on asset management, fostering co-production and knowledge transfer and promoting a strong link between the knowledge and practice
Business development	... enabling and promoting creative, healthy and sustainable enterprises, which help implementing new services and products to better support good practices of the service and program providers on asset management
Data, information, and knowledge	... recognizing that sound data, information, and knowledge on assets, on their condition and on asset systems' performance is critical for decision making by the service and program providers on asset management decisions; by independently verifying that information is accurate and trustworthy
Community engagement and users protection	... reaching out and engaging the community; by enabling the creation of awareness of the assets value, including an intergenerational responsibility perspective; by ensuring that users have the possibility to complain about poor service quality due to failures on asset management practices

THE CASE OF PORTUGAL

Brief historical background

Portugal is a republic, located in south-western Europe and on archipelagos in the North Atlantic, with an area of 92,212 km². Portugal belongs to the European Community and is a developed country. In Portugal, the fundamental law is the Constitution, dated from 1976. There are four sovereign pillars: the President of the Republic, the Assembly of the Republic, the Government, and the Courts. The main administrative divisions in Portugal are the 18 districts (on the continent) and two autonomous regions (Azores and Madeira), which are subdivided into 308 municipalities. Although the districts remain the most relevant subdivision in the country, serving as the basis for a series of administrative functions, the municipalities are responsible for several public policies. By the end of the 20th century, the country had joined the European Union (EU) in 1986 and followed a path for modernization. Successive governments made several reforms, and today, with all the development registered, with large investments in infrastructure, the economy is based on services and industry.

When Portugal joined the EU, the water services' coverage was quite low and the quality of the service provided was very poor in most of the country. Even in the bigger cities, water interruptions were frequent, tap water was not safe to drink, and most of the wastewater was disposed in non-controlled septic tanks or drained directly to the receiving bodies, without any treatment. By joining the EU, Portugal started to access cohesion funds aiming at leveraging the country's development. The effectiveness of these funds was not the same for all essential services. For instance, the mobility sector evolved significantly in this period, but with weaknesses about the railway transport mobility. The case of water services has globally been a rather successful story, 'The Portuguese miracle', as Paul Reiter, former Executive Director of IWA, used to call it. Why? Because in 1993 a coherent public policy started to be established and implemented. A major reform in the legal and institutional frameworks and sound strategic planning were key cornerstones for this process. As regards the physical assets supporting the services, the main government objectives in the first years were to build new infrastructures to increase the service coverage and improve the quality of service. In recent years, the major challenge has been to ensure service sustainability by maximizing the value of the existing infrastructures, in a long-term perspective.

With a consistent public policy (1993–2019), Portugal mobilized for a wise allocation of large public investments in the water sector (c. 13 billion Euros in a country of ten million inhabitants), and the coverage and quality of the service provided by public infrastructure improved considerably at national level. [Figure 2](#) illustrates the national evolution between 1993 and 2017, in terms of access to drinking water supply and wastewater management services, drinking water quality, coastal bathing water quality, and inland bathing water quality. The high investment effort, predominantly applied to bulk services, resulted in significant progress in the physical access to services, in drinking water quality, and in bathing water quality ([Figure 2](#)).

Portugal has currently a very valuable water asset portfolio, mostly recent but some being too old, complex, and demanding in terms of management. Effective asset management is nowadays a priority to ensure that the value of these assets is duly managed, ensuring sustainable water services' provision.

Public policy enabling strategic asset management in Portugal

[Table 2](#) provides some examples of what Portugal did about each building block of the public policy listed in [Table 1](#). This table also refers to some difficulties, less successful issues, challenges, and recommendations to overcome them. The national regulatory authority for the water services, ERSAR,

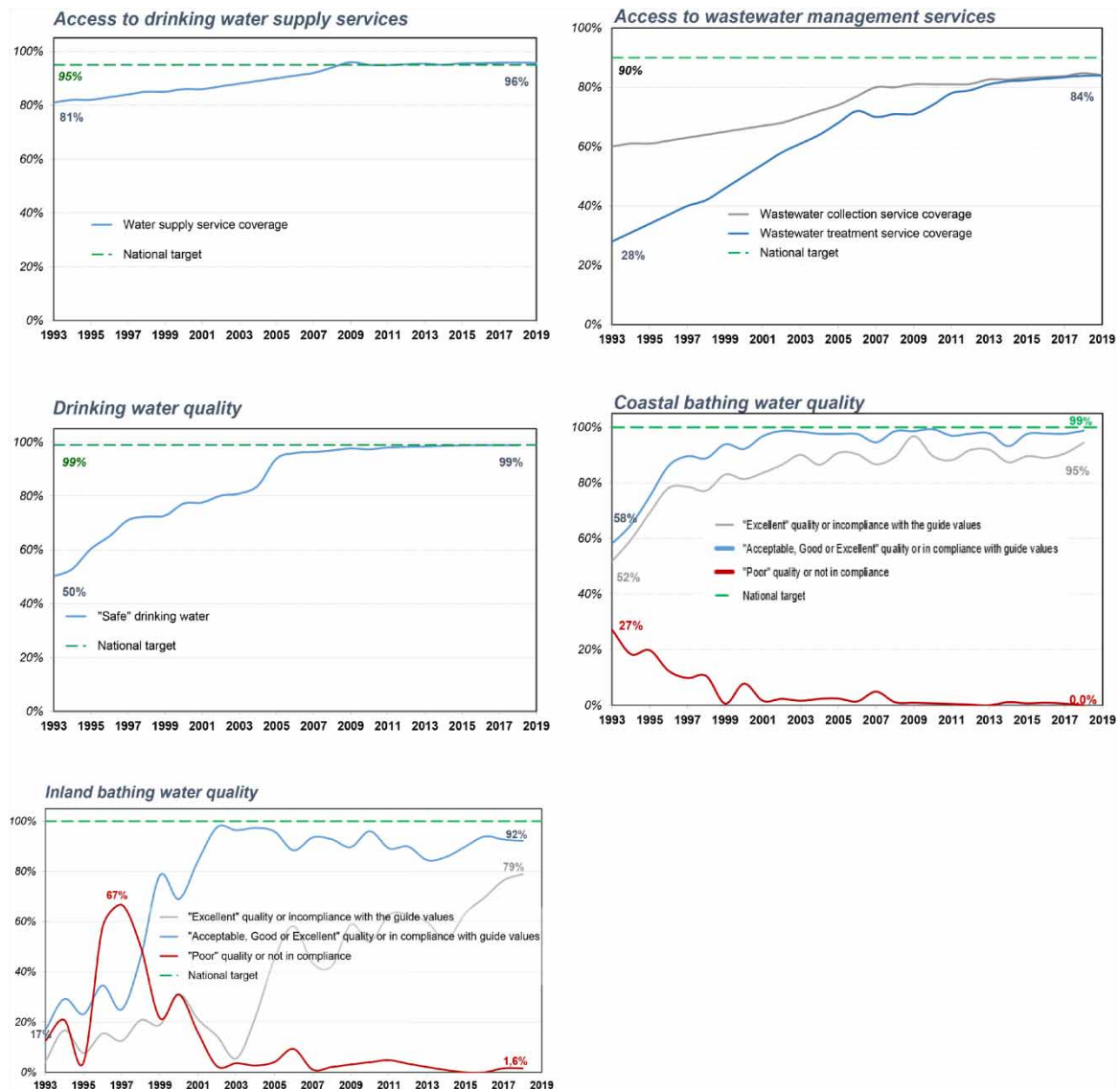


Figure 2 | Evolution on water services and water resources in Portugal between 1993 and 2019 (sources: data from RASARPs, annual reports from ERSAR, and REAs, annual reports by APA; analysis by the Portuguese Water Partnership).

has had a pivotal role in this process. In countries or regions of different sizes and characteristics, the same principles may apply. Naturally, specific implementation needs to take into account the local context. Even though the examples provided in Table 2 may not be directly applicable in every other case, these provided examples may be motivational.

CONCLUSION

In conclusion, the sustainability of water systems does not solely depend on the will of individual utilities to implement asset management. It is crucial to pave the way to service effectiveness and sustainability by including the asset management concern in the public policies for water, with the right tools and incentives.

The recent experience achieved in Portugal, in view of the world's drivers and challenges, demonstrates that the establishment of a sound public policy enabling asset management for the water sector is a key success factor for the water services' sustainability.

Table 2 | Building blocks of a public policy enabling asset management of the urban water systems – the case of Portugal

Public policy building block	In the case of Portugal...
Strategic planning	... since 2000, the national strategy for the water sector is defined in strategic plans for a period of 7 years. These plans include an assessment of the situation, the establishment of national objectives, the definition of priorities, an estimation of investment needs, and the definition of the funding strategy. These plans are assessed and reviewed periodically. The current national Strategic Plan (2014–2020) (MAOTE 2015) has introduced a paradigm shift for the sector, defining that the strategy should be less concentrated on the construction of new infrastructures and more focused on asset management
Legal framework	... and with regard to municipal systems, some IAM practices are recognized in the legislation as duties of water utilities. In particular, the water utilities serving more than 30,000 inhabitants are required to have an infrastructure asset management (IAM) system. This requirement has helped to attract the attention of the water utilities to asset management. However, since legislation does not refer to specific requirements that are associated with an IAM system and there is no verification of compliance with these duties and penalty tools, in practice, this is not yet adopted in many water utilities. As regards multi-municipal systems, a technical report about the performance and condition of the infrastructures and the future rehabilitation and renewal requirements shall be delivered every 5 years. These reports are subject to external certification The regulatory authority has recently made efforts in order to make the legal requirements more specific (and thus increase legal effectiveness by allowing easier identification of any breaches of duty, etc.), namely, through the development of new asset knowledge and management indices. These indices are audited annually as part of the quality of service assessment process (ERSAR 2018)
Institutional framework	... ERSAR has mandate and skills to promote the enforcement of asset management, included in its regulatory model. The enlargement of the scope to regulatory intervention (applicable since 2011) to all water utilities has promoted the improvement in utilities' information management and accounting systems, which are fundamental bases of IAM. The dissemination of service quality information and the annual awarding of utilities of excellence have also contributed to fostering competitiveness in the sector. Additionally, ERSAR has had an important role in the circulation of technical guides and in the promotion of and support to IAM projects. The major challenges are related to the financial sustainability of the services due to the limited power of the regulator to set the tariffs (only recommendations could be issued). The recent strengthening of ERSAR's powers will allow this authority to define the sector's tariffs and apply fines and the enforcement of debts. This is a challenge to overcome in order to further improve service quality and ensure full cost recovery
Governance models and contracts	... strong incentives for the aggregation of the small and medium size water utilities into larger ones, getting economies of scale, are paving the way to sound asset management practices ... ERSAR is responsible for the legal and contractual regulation of the water services, and includes the asset management in this activity. In particular, by requiring some IAM practices as part of the contracts and defining minimum targets in terms of quality of service indicators
Quality of service goals	... ERSAR is responsible for the quality of service regulation and includes asset management concerns in this activity. Within the scope of quality of service regulation, a fully audited annual assessment and comparison process for all water utilities operating in mainland Portugal is in place since 2011. The quality of service assessment is currently based on 16 performance indicators for each service: drinking water supply, wastewater management, and municipal waste management. The results of this assessment process are publicly available in the Annual Reports on Water and Waste Services in Portugal (RASARPs) with the aim to incentivize utilities to increase efficiency and to consolidate a culture of concise, reliable, and easily interpretable information for all (e.g., ERSAR 2018). Since 2014, this information is also available through a freely downloadable mobile ERSAR app. Since 2016, several new asset management indices are included (ERSAR 2017a, 2017b)

(Continued.)

Table 2 | Continued

Public policy building block	In the case of Portugal...
Tariff and tax policy	<p>... ERSAR has set out a tariff policy for public water services with the goal of promoting a gradual trend towards cost recovery, consistent with the economic capacity of the population. Asset management is also addressed in this activity, for long-term sustainability of the assets, particularly by accommodating the need of expansion and rehabilitation costs in the tariffs according to sound priorities</p> <p>... an effort has been made to introduce tax instruments, which encourage desirable behavior, for example, the efficient use of water as a primary resource or as final destination, through a water resources usage tax. These taxes feed the Environmental Fund, which partially returns to the water utilities, namely, to support activities related to asset management, such as back off activities (e.g., improving the asset registries), expansion, and rehabilitation of water systems</p>
Financial resources	<p>... the funding program for the water services includes measures to support good practices on asset management, in accordance with the priorities defined in the national strategic plan. Additionally, some incentive mechanisms that have started to be used are to require minimum values of the asset knowledge and management indices to assign certain kinds of EU funds. Even so, some studies have revealed that there is a rehabilitation funding gap and this tendency will increase in the near future if the current investment trend is kept (e.g., Amaral 2017). This, combined with the reduction of subsidies from the EU, is a major challenge to the sector in the medium term</p>
Infrastructure construction and rehabilitation	<p>... technical regulation, manuals of best practice, good consulting services, and decision support software exist on asset management (e.g., ERSAR 2010a, 2010b, 2017a, 2017b; ERSARA 2017a, 2017b, 2017c, 2017d). Despite this, improvements in many water utilities, the application in smaller utilities, with limited technical and financial resources, is still a big challenge. One of the aspects to improve is that public procurement is still very much driven by investment costs' criteria, instead of by life cycle costs, performance, and risk criteria</p>
Operational efficiency	<p>... ERSAR is responsible for enabling and encouraging a long-term view of operational efficiency gains. The quality of service assessment system has contributed to push the level of operational efficiency in water utilities; however, there is plenty of room for improvements</p>
Training and capacity building	<p>... continuous training of staff and capacity building initiatives for utilities have been implemented with success regarding asset management practices (e.g., iGPI initiatives, ProAguas program). The National Civil Engineering Laboratory (LNEC) has taken a leading role in this regard (Cardoso et al. 2016)</p>
Research and innovation	<p>... research and innovation projects are continuously produced to support leading-edge asset management practices. The activity in IAM research began under the research program 'Water Infrastructure Asset Management' (Alegre 2008). Since then, several relevant research and collaborative projects have followed, at national, European, and international level (e.g., AWARE-P project, EU TRUST project, the iGPI initiatives, igpi.aware-p.org). An integrated IAM methodology was developed and materialized in the publication of two technical guides (ERSAR 2010a, 2010b). An innovative IAM decision support software was also developed and tested in several utilities (Coelho et al. 2013). Master dissertations (e.g., Serra 2016) and PhD theses have brought relevant scientific contributions (e.g., Feliciano 2016; Amaral 2017, Gonçalves 2019). Many national and international conferences, workshops, courses, and meetings have been organized in Portugal (e.g., IWA LESAM 2007; IAM workshop in IWA World Water Congress 2014)</p>
Business development	<p>... more private companies offer services to support rehabilitation, for instance, to update the network records and new software tools</p>
Data, information, and knowledge	<p>... ERSAR collects, validates, processes, and disseminates data and information on the existing assets and their performance and sustainability</p>
Community engagement and users' protection	<p>... ERSAR is responsible for enabling community outreach and engagement in establishing the assets long-term vision. Many utilities try to engage their community; however, there is still significant room for improvement</p> <p>... ERSAR recognises that users should be protected by giving them the possibility to complain about poor quality of service, inclusively due to incorrect asset management practices; in this regard, ERSAR manages users' complaints</p>

The asset management ISO standard regarding guidance for public policy-makers, currently under preparation (ISO/TC251/WG7), will be a valuable resource to guiding governments in this process, complementing the existing ISO standards on asset management (ISO 55000 2014; ISO 55001 2014; ISO 55002 2018).

DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

REFERENCES

- Alegre, H. 2008 Water infrastructure asset management, Research Program, Series Thesis and Research Programmes, LNEC, Lisbon, ISBN 9789724921341 (in Portuguese).
- Amaral, R. 2017 *Investment Strategic Planning of Water Services Investments in Portugal*. PhD Thesis, Instituto Superior Técnico, Universidade de Lisboa, Portugal (in Portuguese).
- Baptista, J. M. 2014 *The Regulation of Water and Waste Services: An Integrated Approach*, Vol. 13. IWA Publishing, London, UK.
- Cardoso, M. A., Silva, M. S., Poças, A., Ribeiro, R., Almeida, M. C., Coelho, S. T. & Alegre, H. 2016 *Innovation results of IAM planning in urban water service*. *Water Science & Technology* **74** (7), 1518–1526. doi: 10.2166/wst.2016.291.
- Coelho, S. T., Vitorino, D. & Alegre, H. 2013 AWARE-P: a system-based software for urban water IAM planning. In *LESAM 2013 – Leading Edge on Strategic Asset Management*, 10–12 September 2013. International Water Association, IWA & AWA, SAM SG, Sydney, Austrália.
- ERSAR 2010a *Infrastructure Asset Management for Wastewater and Storm Water Supply Services. A Rehabilitation-Centred Approach*. Technical Guide 15. ERSAR, LNEC, IST, Lisboa, Portugal. Available from: <http://www.ersar.pt> (in Portuguese).
- ERSAR 2010b *Infrastructure Asset Management for Water Supply Services. A rehabilitation-centred approach*. Technical Guide 16. ERSAR, LNEC, IST, Lisboa, Portugal (in Portuguese).
- ERSAR 2017a *Guideline for the Assessment of the Quality of Water and Urban Waste Services to Users*. 3rd generation of ERSAR assessment system. Technical Guide 22. ERSAR and LNEC, Lisboa, Portugal. Available from: <http://www.ersar.pt> (in Portuguese).
- ERSAR 2017b *Development and Implementation of an Infrastructure Asset Management Process: Technical Guide 21*. ERSAR and LNEC, Lisboa, Portugal. Available from: <http://www.ersar.pt> (in Portuguese).
- ERSAR 2018 *RASARP: Annual Report of the Water and Waste Services in Portugal 2018*. Vol. 1 – Characterisation of the water and urban waste sectors and Vol 2 – Drinking water quality control. ERSAR, Portugal. Available from: <http://www.ersar.pt> (in Portuguese).
- ERSARA 2017a *Guidelines on Introduction to Infrastructure Asset Management of Urban Water Systems*. Guias Técnico 2. Entidade Reguladora dos Serviços de Águas and Resíduos dos Açores (ERSARA), p. 34 (in Portuguese).
- ERSARA 2017b *Guidelines on Performance Assessment System to Support Infrastructure Asset Management – Why, What for and How*. Guias Técnico 3. ERSARA, p. 25 (in Portuguese).
- ERSARA 2017c *Guidelines on Registering Water Supply, Wastewater and Storm Water Infrastructures – Why, What for and How*. Guias Técnico 4. ERSARA, p. 32 (in Portuguese).
- ERSARA 2017d *Guidelines on Work Orders – Why, What for and How*. Guias Técnico 5. ERSARA (in Portuguese).
- Feliciano, J. 2016 *Infrastructure Asset Management in Urban Water Utilities. Knowledge Creation Through the Implementation of Combined Methodologies*. PhD Thesis, Instituto Superior Técnico, Portugal.
- Gonçalves, J. 2019 *Operational Management of Hydraulic Infrastructures*. PhD Thesis, Faculdade de Engenharia, Universidade do Porto, Portugal (in Portuguese).
- ISO 55000 2014 *Asset Management – Overview, Principles and Terminology, Terms and Definitions*.
- ISO 55001 2014 *Asset Management – Management Systems – Requirements*.
- ISO 55002 2018 *Asset Management – Management Systems – Guidelines for the Application of ISO 55001*.
- MAOTE 2015 *PENSAAR 2016–2020: Strategic Plan for the Water and Sanitation Sector in Portugal*. MAOTE – Ministério do Ambiente, Ordenamento do Território and Energia. Approved by Despacho n. 4385/2015, Diário da República, 2.ª série – N.º 84–30 April 2015 (in Portuguese).
- Serra, A. 2016 *Financing Models of the Water Services Fostering Good Practices of Infrastructure Asset Management*. Master Dissertation, Instituto Superior Técnico, Lisboa, Portugal (in Portuguese).

First received 21 August 2020; accepted in revised form 23 September 2020. Available online 22 October 2020