How Big Data can enhance multi-utilities' management?

J. Feliciano*, R. Almeida, A. Santos**, A. Ganhão**, J. Coelho**, D. Covas***, H. Alegre******

* AGS – Administração e Gestão de Sistemas de Salubridade, S.A., Sintra Cascais Escritórios, Rua da Tapada da Quinta de Cima, 2714-555 Sintra, Portugal, jfeliciano@ags.pt
** AGS – Administração e Gestão de Sistemas de Salubridade, S.A., Sintra Cascais Escritórios, Rua da Tapada da Quinta de Cima, 2714-555 Sintra, Portugal, ralmeida@ags.pt, asantos@ags.pt, aganhao@ags.pt, jcoelho@ags.pt
*** Instituto Superior Técnico, Universidade de Lisboa, Av. Rovisco Pais, 1049-001 Lisbon, Portugal, didia.covas@tecnico.ulisboa.pt
**** Urban Water Division, Hydraulics and Environment Department, LNEC - National Civil Engineering Laboratory, Av. Brasil, 101, 1700-066 Lisbon, Portugal, halegre@lnec.pt

Abstract: Water utilities sustainable management is nowadays a leading challenge in which data management and information analysis play a key role. Data generated is too many, moves too fast and is too diverse. As other cases of big-data, innovative information processing forms are needed to enhance organization's management. AGS (Administração e Gestão de Sistemas de Salubridade, SA) is a multi-utility operator that manages 13 water utilities with long-term concession agreements. For water utilities, efficiency and effectiveness of systems' management and its inherent quality of service require complex information that has been increasingly reinforced with legal obligations in developing infrastructure asset management (IAM) plans. These requirements added with reporting commitments with different entities led AGS to a step forward in data management. To support data supervision and advanced analytics AGS developed a technological tool – AGS platform. Based on big-data concepts and benchmarking principles this platform enables a complete vision of utilities and promotes different perspectives in systems' performance and management. The present paper describes AGS approach to information analysis and the platform's development process. Following IAM concerns and having the platform as support to evaluate Portuguese utilities' data, a case study regarding the relation between rehabilitation investments and systems' performance, in terms of non-revenue water, was analysed.

Keywords: dynamic platform, performance assessment, asset management

Introduction

Data management and information analysis is one of the major challenges in any organization. Producing data has become the easy step in the path to achieve real-time relevant information analysis. Nowadays, the amount of available data inside and outside organizations has been increasing and analysing large data sets, called big-data, became a key basis for innovation, decision-making processes and performance improvement. Decision-makers in water sector will have to deal with big-data implications leaving behind traditional data-oriented analyses.

Managing several utilities with long-term concession agreements, geographically disperse, regarding different management models and contexts promoted AGS growing process to a new wave of information analysis. AGS utilities have reporting obligations to shareholders, banks, national regulator (ERSAR – National Water and Solid Waste Services Regulator), among other stakeholders. Information is reported regarding different purposes but is always based on standardized indicators (Alegre *et al.*, 2006; Matos *et al.*, 2003).

Adding reporting requirements with legal obligations in developing IAM plans and the decision to implement an asset management policy inside the Group promoted AGS awareness on the need to enlarge information boundaries. Decisions and strategic plans can only be properly developed if supported by quality information and sophisticated analytics in order to obtain a deep knowledge of the systems. The ability of globally assess performance in different ways by crossing data from organizations with data from external sources will enlighten new knowledge dimension. This is essential to support IAM plans development and to improve a sustainable management.

Asset management policy in a multi-utility group

In Portugal, IAM concepts and methodologies as mandatory processes are relatively new, being an important driver towards "new way" of managing water services. The IAM integrated methodology, supported by ERSAR's technical guides (Alegre and Covas, 2010; Almeida and Cardoso, 2010) and recently complemented with ISO 55000, ISO 55001 and ISO 55002, requires a more advanced systems' assessment, challenging water utilities to change its information management approach.

According to this methodology, proper long-term planning should be achieved through the balance between cost, performance and risk at strategic, tactical and operational levels. Three key competences are called: engineering, information and management (Alegre, 2008).

This methodology requires the alignment between the planning levels in order to set up a clear course of action from organization's strategic objectives to operational activities. For a multi-utility operator, this request can only be achieved through the alignment between the holding company and its subsidiary organizations in which utilities' strategic decisions are linked with holding's tactical goals (Figure 1).

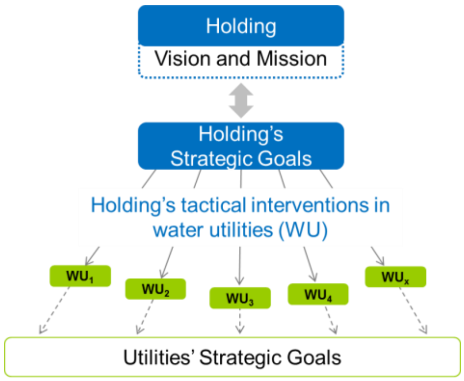


Figure 1. Strategic and tactical levels' alignment in a multi-utility company.

Having this principle as a baseline, AGS developed a tool that could monitor and control the holding and its utilities' performance based on audited data and standardized indicators. From the holding's perspective, the tool provides utilities' assessment, its performance evolution and ranking, benchmarking and the identification of intervention priorities with proper solutions, supporting AGS tactical decision level. In the utilities' perspective the tool supports strategic planning through system's global assessment and performance indicators (PI) monitoring.

Information management process - AGS platform development

The development of the platform was one of the results of the awareness regarding data and information management. This growing process enabled AGS to improve information systems and also methodologies increasing the utilities' performance and service.

AGS information management process can be divided in three main stages: i) data collection, processing and data quality assessment; ii) information systems integration; and iii) large scale information use (Figure 2). The first stage was characterized mainly by the implementation of different information systems such as supervisory control and data acquisition (SCADA), geographical information systems (GIS), work orders' applications, among others. The main goal of the second stage was to promote information systems' integration and the implementation of standardized procedures to support reporting systems and benchmarking processes. The third stage aimed to achieve a new level of information analysis by creating a platform for increasing utilities control and to support requests such as: a) data analysis; b) reporting; c) ERSAR's data and PI analysis; d) benchmarking; e) trend analysis and prediction models; f) medium and long-term planning; and g) support IAM methodologies.

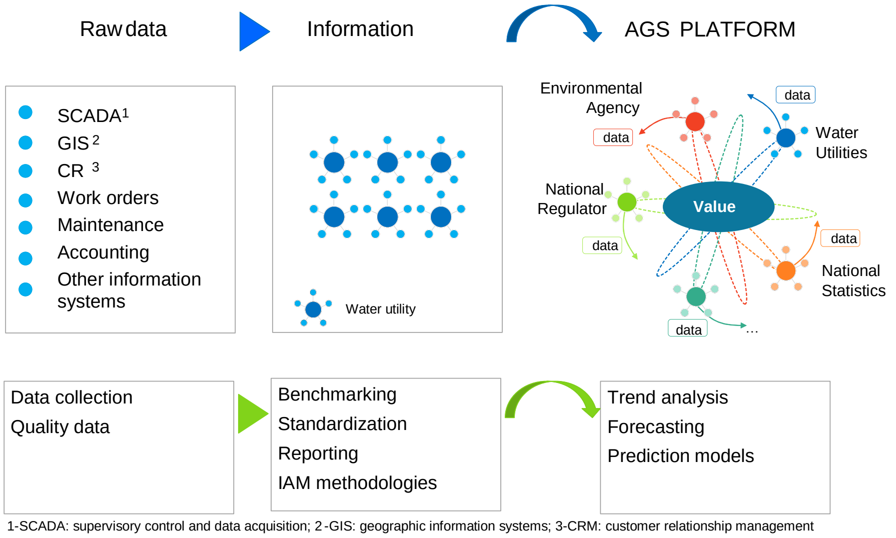


Figure 2. AGS information management process.

The tool's flexible structure provides a dynamic analysis, being possible to quickly change selections and globally assess performance grouped in several ways, as an example: management model; hydrographical basins; territory's administrative area, etc. Adding this flexibility with input data from external sources, such as data regarding general statistics, meteorology, and environment or water quality, provided a new analysis' dimension making information transparent and usable with higher frequency. These features allow new relations to be analysed, improving utilities' management.

Based on this concept a platform module was developed focusing on water utilities regulation and ERSAR's service quality assessment system. This module is presented herein to demonstrate the value of the information made available by the platform.

In 2004, ERSAR published the first Service Quality Assessment Guide for Water and Urban Solid Waste Utilities (Alegre *et al.*, 2004) defining a set of PI that could describe water and waste services, its performance assessment and also promote utilities' metrics benchmarking.

Despite legal obligations, ERSAR's service quality assessment system had a high leverage effect on AGS control of its utilities performance, fulfilling the goal of seeking excellence and contributing to the evolving information management process.

Usually, water utilities use ERSAR's PI to monitor and control their own performance. Adding to this, the tool presented in this paper has promoted a global holding's evaluation, a benchmarking easier process and allowed an easier performance evolution analysis of each utility. This became even more important after 2012 due to the universal regulation of all Portuguese water utilities. Until 2012, only the private sector was regulated.

The developed platform module enables different analyses and statistics, divided in seven dashboards:

- ***Executive summary***: water utilities overview regarding management model, type of service (*e.g.* water, wastewater or solid waste) and type of system (*e.g.* water treatment, distribution systems, etc).
- ***Geographical analysis***: water utilities' quality of service assessment (global, by strategic objective or by PI) according with its geographical dispersion or combined in different geographical clusters, such as national territorial unit districts (Figure 3 a)).
- ***Performance indicator***: water utilities ranking by PI, enabling PI analysis by service level or strategic objective (Figure 3 b)).
- ***Water utility detail***: provides all publicly available information of each water utility, including quality of service historical data and PI evolution.
- ***Correlation function***: computes correlation functions based on historical data allowing analysis between PI and data supporting trends and prediction models (Figure 3 c)).
- ***Research***: allows a detailed search of any data and user-tailored data export.
- ***Reporting***: customized report system providing, for any combination of data items, management information or PI, the comparison of any water utilities or sets of water utilities (Figure 3 d)).

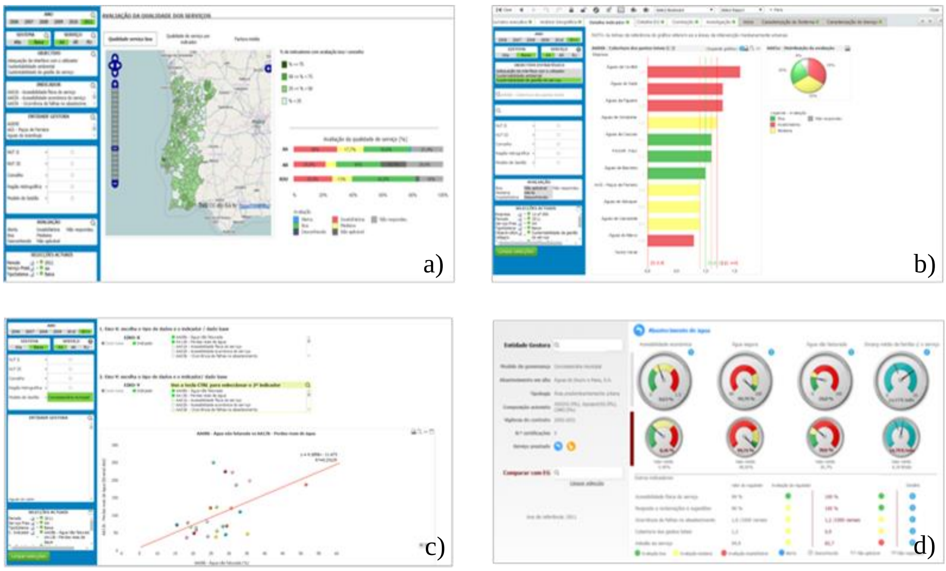


Figure 3. Dashboards of the platform module: (a) Geographical analysis. Quality of service global evaluation. (b) Utilities' ranking and PI assessment. (c) Correlation function. Example: Analysis between non-revenue water and real losses. (d) Reporting's dashboard. Comparison between two water utilities regarding economic accessibility, water quality, non-revenue water and average families' economical accessibility with water service.

Case study description

The presented case study followed IAM concerns and the main goal was to analyse rehabilitation investment impact on system performance, namely regarding the Non-Revenue Water (NRW) levels. Data from all Portuguese Water Services (audited and publicly available data) were computed in the platform enabling a global performance analysis. Considering ERSAR's economic and infrastructure assessment criteria two audited PI were analysed: NRW (AA08) and mains rehabilitation (AA10) (cf. Table 1).

Table 1. Performance indicators definition.

Performance Indicator	Definition
AA08 – NRW (%/year)[(1)]	$\frac{System\ input\ volume - Billed\ authorised\ consumption}{System\ input\ volume} \times 100$
AA10 – Mains rehabilitation (%/year)	$\frac{Lenght\ of\ mains\ with\ more\ than\ 10\ years\ old\ that\ have\ been\ rehabilitated\ on\ the\ past\ 5\ years}{\frac{1}{5}\sum_{i=1}^{5} lenght\ of\ mains\ with\ more\ than\ 10\ years\ old\ at\ year\ i} \times \frac{100}{5}$

[(1)] Fi46 from International Water Association PI system.

For each PI, reference values established by ERSAR were considered to grade the level of service as good, fair or poor (cf. Table 2).

Table 2. ERSAR reference values.

Reference values	Good	Fair	Poor
AA08 - Non-revenue water (%/year)	[0.0; 20.0]	]20.0; 30.0]	]30.0; 100]
AA10 - Mains rehabilitation (%/year)	[1.0; 4.0]	[0.8; 1.0[or]4.0; 100]	[0.0; 0.8]

Figure 4 presents the "retail services" Portuguese water utilities overview for AA08 and AA10 on AGS platform, representing a sample of 285 utilities for the ERSAR publicly available data.

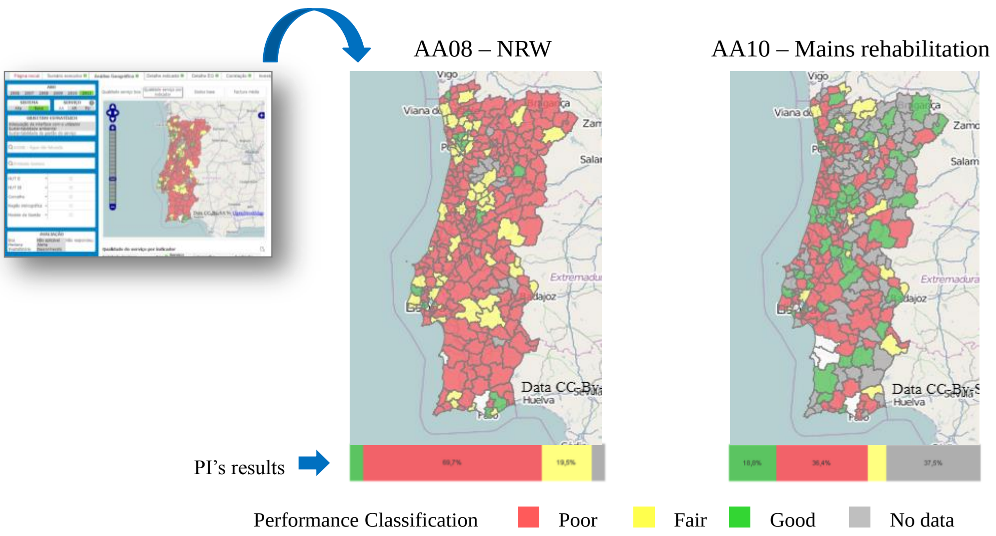


Figure 4. Portuguese "retail services" water utilities overview for AA08 and AA10 (2011).

From the available information, approximately 70% of the Portuguese water utilities have NRW levels below 30% and 35% have poor level (less than 0.8) in mains rehabilitation PI (AA10). 37.5 % of the utilities failed to report to ERSAR due to lack of data.

Based on these figures, two water utility clusters have been identified:

- AGS utilities supplying inhabitants between 40,000 and 200,000 that developed IAM plans;
- Other water utilities (including AGS') supplying more than 140,000 inhabitants, corresponding to utilities with a number of inhabitants above percentile 70. There is no obligation to develop IAM plans for municipalities serving less than 30,000 inhabitants, representing around 70% of the Portuguese municipalities, so data is insufficient in these municipalities. In the municipalities with more than 30,000 inhabitants and less than 140,000 there are around 20% of the municipalities where data regarding all the ERSAR PI aren't yet reliable enough, so it was considered the remaining 10% of the municipalities to be studied.

In order to analyse the relation between mains rehabilitation and NRW, the correlation function in the platform was used.

Results and discussion

Results from the relation between AA08 and AA10 in 2011 are presented in Figure 5. It is possible to identify two different clusters in this analysis, A and B, with a clear correlation. Cluster A is composed of utilities that serve more than 140,000 inhabitants while Cluster B is a mixed group including all AGS utilities combined with other water utilities.

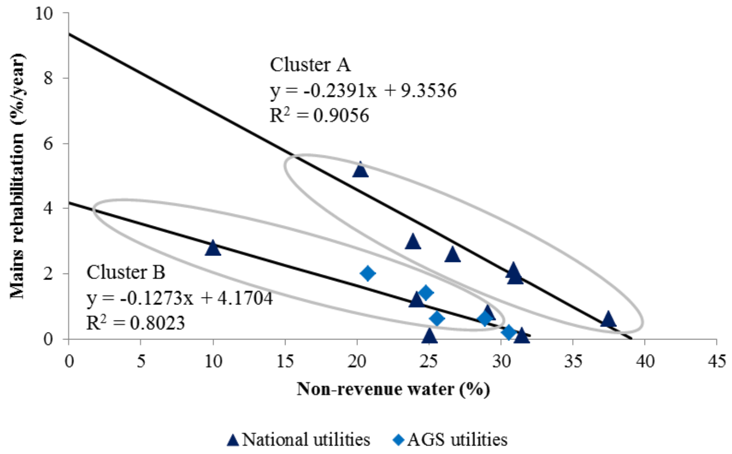


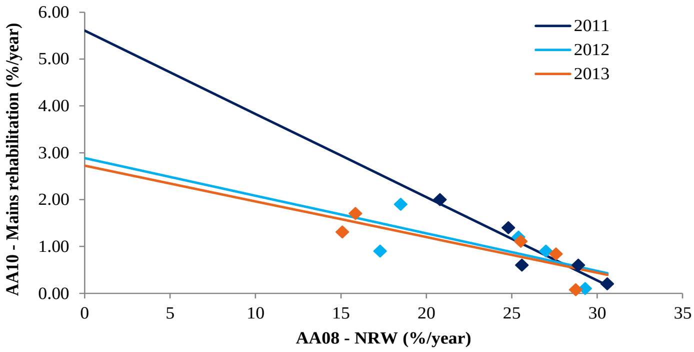
Figure 5. NRW and mains rehabilitation analyses for 2011.

Results have shown that both clusters have linear regressions with high values of coefficients of determination (R^2), meaning that is possible to establish a relation between NRW and mains rehabilitation rate.

For the same NRW level, a higher effort on rehabilitation investments is required by Cluster A than Cluster B. At the same time, for equal rehabilitation rates, Cluster B presents better NRW levels than Cluster A and, therefore, rehabilitation investments are more effective on reducing NRW in Cluster B.

The difference of rehabilitation effectiveness between Clusters A and B can result from efficiencies gained through good operating practices due to utilities concerns on NRW (*e.g.* implementation of operating practices to control water losses and leakage).

Based on this latter hypothesis, the second goal was to analyse the evolution from 2011 to 2013 in AGS utilities where rehabilitation rates have been steady. In all of them, a strong effort has being made to improve operating practices to control water losses and to reduce NRW. Figure 6 presents the linear regressions between AA08 and AA10, computed for 2011, 2012 and 2013 in AGS utilities.



Correlation functions:

2011
y= - 0.1778x+5.6076
R^2 = 0.8698

2012
y= - 0.0803x+2.8872
R^2 = 0.4336

2013
y= - 0.0762x+2.7246
R^2 = 0.6804

Figure 6. Linear regression between NRW and mains rehabilitation for 2011, 2012 and 2013 in AGS utilities.

The linear regressions between 2011 and 2012 are very different. In 2012 rehabilitation rates are far more effective on reducing NRW than in 2011. This difference is explained by operating practices' efficiency gained in 2012. However, due to the diversity of operating changes in each utility, results are less consistent and R^2 decreases from 0.8698 in 2011 to 0.4336 in 2012.

Comparing 2012 with 2013, the difference between linear regressions is not so noticeable. In 2013, efforts made in operating practices' efficiency are closer to "maximum" or "optimal" results and therefore the slope of linear regression is similar to 2012. Additionally, in 2013 operating changes are stabilized and that could be represented by an increase of R^2 value from 0.4336 in 2012 to 0.6804 in 2013, reflecting a more consistent result and a higher alignment in the water utilities policies.

In conclusion, results show that improving efficiency with operating practices, the relation between NRW levels and rehabilitation rates tends to normalize, and it is possible to establish a reliable relation between these two dimensions.

Conclusions

Sustainable management must be supported by reliable information and sophisticated analytics that should be an important requirement for water utilities' decision makers. Therefore, analysing large amount of data is nowadays a reality and a key-step to support management decisions.

The development of the AGS platform enabled the analysis of all national utilities' PI evolution, its performance ranking and the production of standardized reports. This process brought significant benefits such as: ability to analyse data from several different sources at the same time in a single central tool; dynamic analysis in real time; selection of key PI to analyse current and past performance; utilities' performance assessment and trend analysis.

With the development of this tool, it is possible, for the first time, to have a complete vision of each system and to answer to stakeholders on a real-time basis with higher accountability. The comparison with peers is obviously important and nowadays possible and easy, representing an important step forward in terms of the water sector's transparency.

Better IAM was a key driver for developing this platform. A use case regarding rehabilitation investments is analysed. Results have shown that after achieving optimal operating practices efficiency it is possible to establish a normalized relation between rehabilitation investments and NRW levels. These results are extremely important from a multi-utility's point of view and to support policies at national level. The ability to compute "universal" and consistent relations based on reliable data are essential for decision-making processes when considering holding's tactical decisions and interventions in each water utility.

References

Alegre H., Baptista J.M., Cabrera E. Jr., Cubillo F., Duarte P., Hirner W., Merkel W., Parena, R. (2006). *Performance indicators for water supply services*. IWA Publishing, London, United Kingdom, ISBN: 1 900222 27 2.

Alegre H. and Covas D. (2010). *Gestão Patrimonial de infra-estruturas de abastecimento de água (Infrastructure Asset Management of Water Services).* Technical Guide n.16. ERSAR, LNEC, IST, Lisbon, Portugal, ISBN: 978-989-8360-04-5.

Alegre, H., Hirner, W., Baptista, J. M., Parena, R. (2004). *Indicadores de desempenho para serviços de abastecimento de água (Performance indicators for water supply services)*. Instituto Regulador de Águas e Resíduos e Laboratório Nacional de Engenharia Civil (*Solid waste and water Regulator Institute*). [translation] Patricia Duarte, Helena Alegre e Jaime Melo Baptista. Lisbon: ISBN: 972-99354-2-4.

Alegre H. (2008). *Gestão patrimonial de infra-estruturas de abastecimento de água e de drenagem e tratamento de águas residuais (Drinking water and wastewater infrastructure asset management)*. Series Teses e Programas de Investigação LNEC, Lisbon, Portugal, ISBN: 9789724921341.

ISO 55000:2014. *Asset Management – Overview, principles and terminology*. Geneve, Switzerland.

ISO 55001: 2014. *Asset Management – Management systems – Requirements*. Geneve, Switzerland.

ISO 55002: 2014. *Asset Management – Management systems – Guidelines for the application of ISO 55001.* Geneve, Switzerland.

Matos R., Cardoso A., Ashley R., Duarte P., Molinari A., Schulz A. (2003). *Performance indicators for wastewater services*. IWA Publishing, London, United Kingdom, ISBN: 1 900222 90 7.