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Performance measurement and indicators for water supply management: Review and international cases

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ABSTRACT

This article presents a literature review on performance measurement and indicators, addressing the general aspects of this area of knowledge and contextualizing it for the water supply sector, including international applied cases. Performance measurement systems and indicators allows managers to quantify the efficiency of resources/inputs use and the effectiveness of the services provided, and must be developed according to systems' characteristics, based on performance goals in a collaborative process involving stakeholders and technical actors. Many factors (such as data availability and amount of resources needed for deployment) are required for the effectiveness of PMSs in water supply systems. The sustainability and environmental performance measurement is a trend in this area of knowledge, with the development of specific methodologies in addition to the traditional performance measurement.

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1. Introduction

Water supply is associated with the economic, environmental and social spheres of sustainable development, and the promotion of performance improvements in these systems is essential to ensuring the reliable availability of water at affordable costs. The need to implement performance measurement systems for the water supply sector, although technically indisputable, encounters barriers in developing countries, of predominantly political nature. According to The United Nations Educational, Scientific and Cultural Organization [1], public utilities are subject to low performance caused by low motivation, poor management, low cost recovery and inappropriate political interference in many of these countries.

The most relevant example of the inefficiency of water supply systems (WSSs) is the average water losses rate, which exceeds 36% in Brazil [2]. Araujo et al. [3] indicated that the water losses rate in WSSs ranges from 30% to 40% worldwide, while Colombo and Karney [4], quoting other authors, quantified the volume of unaccounted water in Europe in the range of 9% to 30%. This scenario implies in low efficiency, poor service quality and reliability, reduction of raw water availability for other uses, waste of energy during the water supply processes, unnecessary emissions of greenhouse gases, among other inconveniences.

WSSs presents one of the most emblematic cases of the so called “water-energy nexus”, a concept that reflects the various water uses for energy production and energy uses for water production. According to Stambouli [5], water and energy are intricately connected and increasingly scarce; in this sense, energy policies can result in water savings, as the development and deployment of water resources technologies can result in energy savings and reductions of greenhouse gases emissions, as demonstrated by Liang and Zhang [6]. In reference to the mentioned waste of energy, the main energy use for water production is for pumping [7]. It is estimated that between 2% and 3% of the worldwide electricity is consumed for pumping in WSSs [8], been 80% to 90% of this consumption absorbed by motor-pump sets [9,10]. The fact that many WSSs use motor-pump sets in the production and distribution processes implies that water losses results, at least, in proportional energy losses, reducing WSSs energy efficiency. In this sense, Vilanova [11] developed a set of indicators aimed to quantify the absolute hydraulic and energetic efficiency of WSSs, in relation to its optimal operational and physical conditions. A thorough analysis of the energy requirements for water production and supply is presented by Plappally and Lienhard [12].

As mentioned above, the water supply involves the economic, environmental and social spheres of sustainability. Therefore, the promotion of efficiency and improvement of performance of WSSs plays a strategic role in the pursuit of sustainable development and also in meeting the goal of halving the proportion of people without sustainable access to safe water and sanitation by the year 2015, according to The Millennium Development Goals [13].

Considering these facts, this paper presents a literature review on performance measurement systems (PMSs) and performance indicators applied to water supply systems. It aims to provide an overview and the advances in measurement and monitoring tools that may contribute to the efficiency, effectiveness and sustainability of water supply utilities through analytical techniques. Besides providing important contributions to researchers, the work has an applied nature, since it clarifies relevant concepts and tools useful to WSSs managers.

2. Methods

For the literature review, relevant works in the area of knowledge, published in journals of recognized scientific quality, were

prioritized, considering publications that specifically discussed performance measurement and indicators in the water supply context. Then, the concepts and theoretical bases of measurement and performance indicators in a general context are discussed. This discussion includes a theoretical analysis of the historical evolution of performance measurement, from a purely economic approach until its association with service quality measures. In addition, this analysis includes an exposition of some classical methods of performance measurement, such as benchmarking.

Assuming that the content of this work is relevant not only in academic terms but also for the dissemination of knowledge for WSSs managers and decision makers, we present the characteristics and conditions required for the effectiveness of performance measurement systems (PMSs). After discussing the theoretical framework of performance measurement and indicators, we present this framework in the context of its application to water supply systems through the analysis of cases reported in the literature.

Important questions were investigated, such as the conditions for effective PMSs development and implementation. After presenting the theory and concepts concerning performance measurement and indicators, we reviewed international cases of performance indicators in WSSs. We then analyzed how PMSs and performance indicators are related to sustainable development based on sustainability indicators, environmental performance and methodologies according to the concept of footprint, which is a current trend in this field of knowledge. During the review, we tried whenever possible to associate the theories and concepts presented with their applications and with cases found in the literature to add empirical knowledge to the research.

3. Performance measurement

In an extensive literature review directed toward the identification of the state of the art of performance measurement, Nudurupati et al. [14], based on work by Neely et al. [15], defined performance measurement as the “[...] process of quantifying the effectiveness and efficiency of actions.” A performance measurement system is defined by the same authors as the set of measures used to quantify the effectiveness and efficiency of these actions. In a corporative perspective, effectiveness is understood as the level of service achieved in relation to consumer needs, while efficiency refers to the economic use of company resources to provide a certain level of satisfaction with this customer [16].

Performance measurement has several main objectives [17]: to support decision making; to change behavior and increase motivation; to monitor performance trends; to state priority and actions; to verify the effectiveness of optimization measures already implemented; to aid dissemination of organizational results via marketing; and to aid benchmarking processes.

For Neely [18] and Nudurupati et al. [14], the period between 1994 and 1996 was revolutionary in terms of the scientific literature on performance measurement. During this period, more than 3600 publications on the subject were published, and the financial approach to performance measures based on the past performance of the organization was surpassed by the aggregation of strategic planning elements, such as customer satisfaction, internal processes, learning and growth. This transition occurred in the early 1980s, during which time many executives found a deterioration of the financial records of their companies due to a decline in quality and consumer satisfaction or the growth of global competitors [19].

One of the events most representative of this paradigm shift was the publication of “The Performance Measurement Manifesto” by Harvard Business School professor Robert Eccles [20]. For Eccles [20], this revolution changed the perception that financial measures are

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