39th IAHR WORLD CONGRESS GRANADA, SPAIN 2022 From Snow to Sea 19-24 June 2022

Proceedings of the 39th IAHR World Congress
19–24 June 2022, Granada, Spain
doi://10.3850/IAHR-39WC2521716X2022975

Assessing water distribution systems across indicators based on Sustainable Development Goals

Camila Garcia[(1)], P. Amparo López-Jiménez[(1)] , Modesto Pérez-Sánchez[(1)]

[(1)]Hydraulic and Environmental Engineering Department, Universitat Politècnica de València, Valencia, Spain
cgarcia1@posgrado.upv.es, palopez@upv.es, mopesan1@upv.es

Abstract

Given the conditions of the current society, it's a challenge to manage water resources sustainably, that can achieve all the goals set by the SGDs. The sustainability of hydraulic systems must be considered globally to integrate all the aspects that affect the whole concept, such as the economic, social, technical and environmental fields. To do this, the characterization and proposal of key performance indicators (KPIs), which allow water managers to audit and assess their hydraulic systems over time is crucial. These indicators will be able to evaluate the different processes of hydraulics systems as the infrastructure, operation, maintenance and administrative part. This contribution presents and analyzes in-depth the scientific-technical interest of knowledge of the proposed sustainability indicators, which allow quantitatively evaluating those SDGs in which water engineering intervenes. For the implementation of the KPIs, first, a characterization must be carried out of the hydraulic system and the water bodies involved, to have a memory of the evolution of the complete system. When these indicators are proposed and their implementation is carried out together with the analysis of the database, the possibility of establishing a benchmarking on the sustainable aspects of the water distribution system would represent a design, diagnosis and management tool, which will improve sustainability in hydraulic systems. Improving the performance of the systems, not only the targets of goal 6 are achieved, but also helps to achieve other associated goals which highlight the relevance of the sustainability in hydraulics systems.

Keywords: SDGs; Sustainability indicators; Urban water systems; Sustainability; sanitation; supply; hygiene; water networks.

1. INTRODUCTION

Water is a natural resource that plays a big role in human and social development. Nevertheless, society's growth is nowadays limited by the access and availability of water resources. Even though water is a renewable resource it has the potential to run out. According to the guidelines of sustainable development, no renewable source may be used at a rate greater than that of its natural generation.

Due to the economic, social and technological development currently, the water demand (both in quantity as well as quality) is highly increasing. This puts pressure on the water resources and supply managers that seek to satisfy the demand leading to the development of action plans where sustainability is not the main factor in most cases. In addition, climate change has affected the water resources and therefore the availability has decreased.

Sustainable development seeks to meet the present needs without compromising the capacity of resources in the long or short term. The term implemented by the UN establish global goals that will reach such development. The pillars of sustainable development are three: social, economic, and environmental. Social development aims to improve the quality's life of society. This component looks to eradicate poverty, achieve equity and access to basic services such as education, sanitation, transportation, among others. On the other hand, economic development implies producing goods and services with a tariff policy that allows satisfying the demand at a reasonable price but also recover the cost and stimulates the investment. Environmental development seeks to preserve ecosystems through management of waste, reduction of emissions, energy efficiency.

Within the 17 SDGs, there is one Global Goal dedicated to water which covers 4 components: supply, sanitation, management of water resources and water quality. In addition, there are other goals in which water is related such ad 3.3 (end with water-borne and communicable diseases), 3.9 (reduce the number of deaths and diseases from water contamination) and 12.4 (management of chemical and waste-reducing their release to water). Besides, due to the water nexus with other aspects such as food and energy, by working to improve thSDG6 other goals are also achieved.

According to the last report of the UN (2021) some countries showed a deficit of 61% in the achievement of SDG6. About 71% of the population lack water supplies managed efficiently and sustainably, which is

equivalent to 3/10 people who do not have access to a safe service. Besides, more than 80% of the wastewater are poured into water bodies without any treatment, leading to the contamination of the sources.

There is also a current concern about water stress since too much water is extracted compared to the freshwater available, which limits the development of the society due to the lack of resources. Africa and Central Asia are the ones with the highest levels of water stress with 102.9% and 87.9% respectively. Increasing the efficiency in water use is a key factor to improve the percentage of water stress.

Given the conditions that society currently imposes, it is a challenge to manage water resources sustainably. Assessing the state of a network based on sustainability indicators is necessary to implement solutions that lead toward optimal operation. Depending on the information provided by the indicators, it is possible to design and operate the different processes of the system with solutions that allow achieving the SDGs. Therefore, the indicators should not focus on just one part of the scheme, but rather evaluate the entire system.

Currently, several indicators allow evaluating the management and efficiency of networks such as volumetric indicators, percentual and others. However, those must be associated with the goals set for the SDGs to assess the sustainability of the hydraulics systems. A supply can be managed properly but it may be not optimal from a sustainable point of view. A detailed system of indicators will allow the study of the network but also compare the results with others. In this way, the more sustainable networks can serve as an example for those who are still in progress.

2. SUSTAINABILITY IN THE WATER SECTOR

2.1. Sustainability in water systems

Given the importance of the hydraulics systems in the development of the community, the sustainability of the service in all aspects (economic, environmental, social, and technical) should be guaranteed. Through this type of management, the current demand can be assured without affecting the future demands in terms of quality and quantity. The current conditions of the resources highlight the need to improve the management of water systems.

One of the main causes of the problem is the lack of policies and values for the different uses of water. From a point of view more focused on the hydraulics networks, the problem lies in the state and operation of the infrastructure. Integral management in the supply systems allows acting towards sustainable development considering the economic, social, technical, and environmental perspectives.

Besides the increased demand, the need for others water sources and high energy consumption, currently the infrastructure of the networks exceeds the useful life, especially in developing countries. Another problem is the operation of the system far from an optimal point. From the different perspectives that sustainability covers, the problems in water networks can be identified as shown in Table 1. The low efficiency in water networks due to the previous conditions leads to water losses and other consequences that affect the resources, which is not sustainable.

Table 1. Current problems of water networks from different sustainability perspectives.

PERSPECTIVE OF SUSTAINABILITY	DIFFICULTIES
SOCIAL	- Low efficiency in the operation of the system, therefore the quantity and quality of the service is bad - Lack of staff training - Lack of community education to teach strategies for saving water (lower demand) - Value in different water uses - Network coverage - Poor water quality due to fatigues infrastructure
ECONOMIC	- Insufficient rate policy - High energy requirements, therefore higher operation cost
TECHNICAL	- Lack of maintenance and renovation of infrastructure - Lack of measurement and control instruments - Low energy efficiency (no implementation of renewable energy source or saving plans)

ENVIRONMENTAL	- High level of extraction - Affectation on the basins due to the high demands - No consideration of ecological flow conservation - Pollution due to the system operation (gas emissions)

3. METHODOLOGY

For the process of implementing the indicators, the evaluation is not the objective, but rather it is part of the procedure for the improvement of the performance (IWA, 2000). It is necessary to set the objective of the process, in this case, it will be the measurement of the level of sustainability of water systems based on the SDGs. Therefore, it was important to find a relation between the SDGs and the water system by analyzing the targets of each goal.

A detailed analysis of each goal was carried out, studying its definition, global indicators, measurement variables and methodology. The information was taken from summaries presented by the UN for each SDG, as well as other methodological guides for measuring. For each SDG several aspects were determined: a description of the relation with hydraulics systems, associated targets and keywords to later establish indicators based on the above.

3.1. Establishment of indicators

Through indicators, it is possible to express the level of performance of certain areas in a time frame. Considering the above about the objective of the evaluation, the systems of indicators must be related to each SDG to be able of measuring the sustainability in water systems. According to the IWA Guideline, the indicators in water systems must comply with certain properties such as: be quantifiable, clearly defined (concise in meaning), calculable, auditable, avoid any assessment subjective or personal, universal in its use, simple and easy to understand.

Before the definition and creation of the indicators, a search was carried out in various articles and books to determine indicators that were essential for the evaluation. In other words, those indicators that were universal, quantifiable, most used, and more objective with the measurement of the goals were important when picking up the standards. An example of those most useful indicators was the one implemented in the IWA Guideline that has been reviewed numerous times to ensure its efficiency in performance measurement.

Once the indicators were selected from different sources, a list was drawn up with all the data found and with new indicators not implemented in previous studies but was considered important to measure the different goals of the SDGs. The indicators that were often implemented offer some references values from the water systems that are very useful in defining levels of sustainability.

Considering the previously established targets of the SDGs related to water systems and their key aspects, the indicators that allowed the evaluation of the target were defined for each of them. The indicators proposed by the UN for monitoring the goals were studied in detail, even though these were global. In this study, an indicator could be related to more than one goal.

For each indicator the following information was established:

- ID
- SDG goals and targets with which it related
- Sustainable aspect (technical, economic, environmental, or social management). An indicator could be related to more than one area
- Water cycle: it indicates the stage within the water cycle where the indicator participates (catchment, treatment, distribution, harvest, depuration and regeneration)
- Type of indicator: performance, financial, production efficiency, energy and environmental

3. IMPLEMENTATION OF INDICATORS

As mentioned, this system of KPIs aims to measure the level of sustainability of water systems (eg, distribution networks, treatment plants, collection, and purification). Based on the results, measures can be taken to improve networks management. For the implementation of the sustainable indicators, a process shown in Figure 1 is proposed. Identifying the state of the environment and the network before the evaluation is important. In that way, an evolutionary memory can be kept in which the changes can be observed and define possible solutions easier.

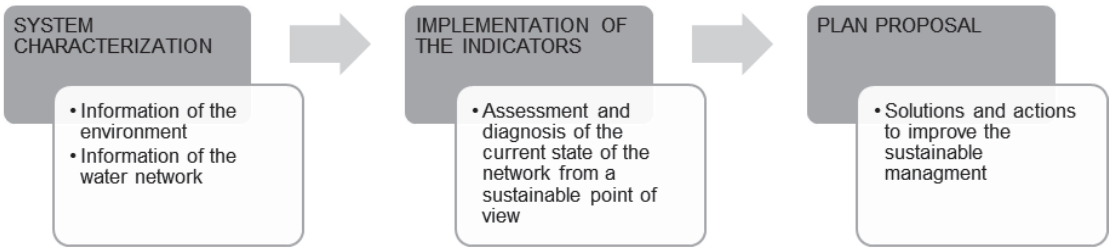


Figure 1. Implementation process scheme

The characterization of the environment in which the water system is placed involves collecting information of the basin (e.g. length, area, characteristics of the water bodies and terrain, use of water). Also, data of legislative framework and management strategies is useful to get to know the system. Besides, for identifying the network it is important to collect information about the treatment plant's location, population served, outlet flow, length, control elements and operation strategies.

Once the required data and information are collected, each indicator from the KPIs is calculated. In this process, the measurement, and the state of the water system from a sustainable perspective will be carried out. Considering the results of the system of indicators, then solutions will be taken to improve the sustainability of the water system and help to achieve the SDGs.

4. RESULTS

4.1 Relation between SDG and water sector

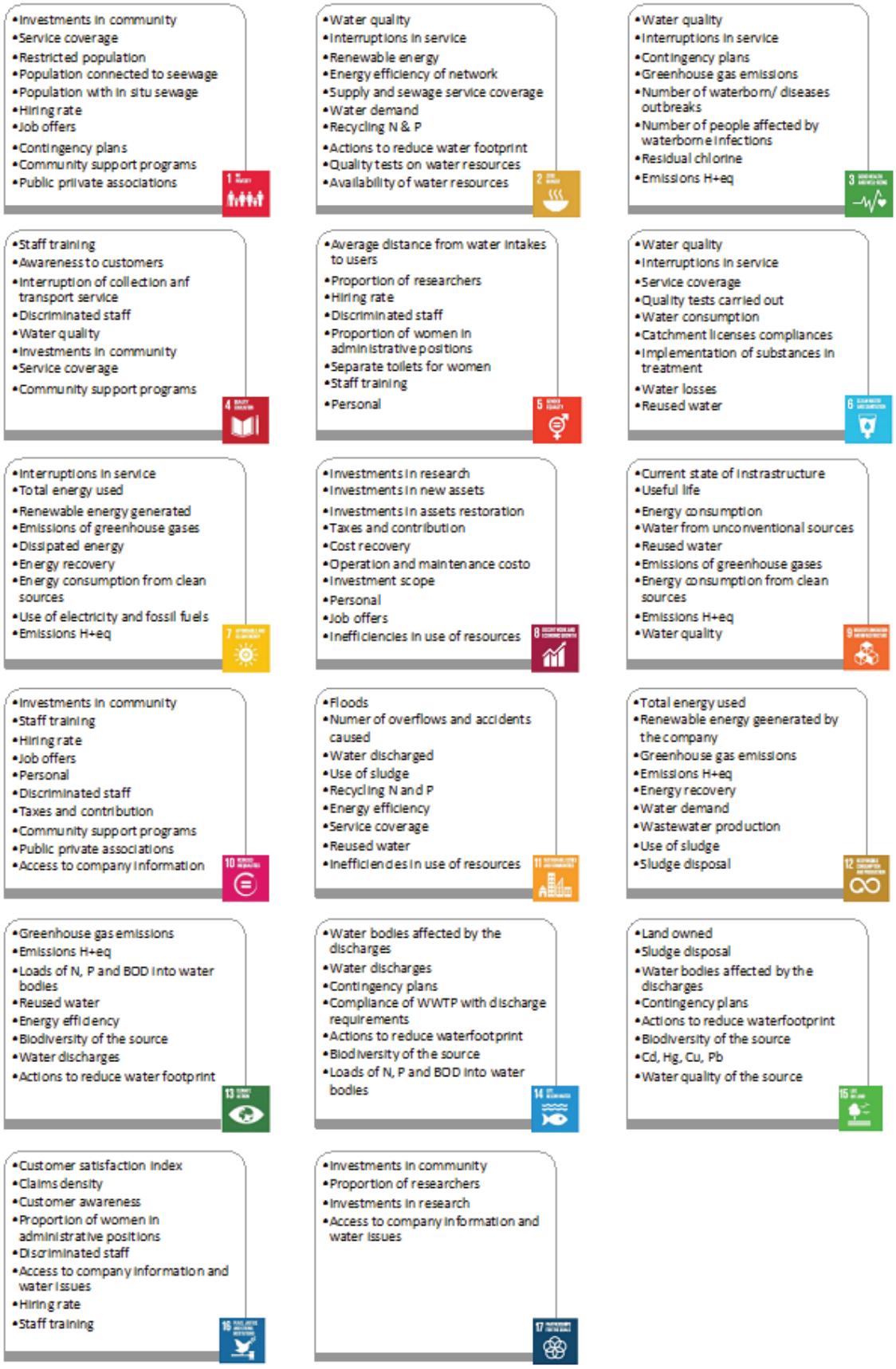
All the SDGs have a relationship with water systems. It was found that there were objectives that had targets where water is mentioned. However, there were other goals for which the relationship with water was not so explicit. Figure 2 presents the targets related to the SDG6 and hydraulics systems.

5.1. Establishment of indicators

98 indicators were established, each associated with the targets of the SGDs that had been previously defined. Figure 3 presents some of the indicators that were defined for each goal. Indicators can be associated with more than one goal.

Figure 2. Targets related to water resources and SDG6

Figure 3. Indicators established for all the SDGs



5. CONCLUSION

Due to the great current social and technological development, water systems are under pressure due to the high demands. Therefore, the quantity and quality of the resources are affected and at risk for future generations. This and other problems, such as the hydraulic infrastructure and climate change, it's a challenge to manage water resources in a sustainable way that contributes to the achievement of the SDGs.

Through sustainable management of water systems the present demands should be provided without compromising its capacity in the future, and leading towards an optimal operation. In this study a system of indicators was proposed, that will allow the evaluation, from a sustainable view, of the different processes of hydraulics systems such as infrastructure, operation, and maintenance.

Before the establishment of the KPIs, a detailed analysis of the relationship between SDGs and water systems was made. All the SGDs proposed by the UN have a connection with water resources, some of them are more explicit than others. Through that, it was possible to associate targets and keywords with which the indicators were later defined. There were 98 indicators established, some presented in Figure 3. All comply with properties such as being quantifiable, auditable, concise in meaning and universal in its use.

For each indicator was defined information such as an ID, targets and goals related, its sustainable aspects, stage in the water cycle, variables of measurement and type of indicator. It was also suggested an outline of the process that should be followed to implement the KPIs. Such procedure consists of a system characterization (information of the environment and the network), assessment and diagnosis with the sustainable indicators and finally, a proposed plan should be made.

Based on the results of the reports, solutions and actions can be taken to improve network management. With this is possible to keep an evolutionary memory of the state of the network and follow the improvement of the networks. In addition, the KPIs and the reports allow the comparison with other networks. In this way, more sustainable networks can serve as an example for those that are still in process.

With these KPIs, not only an evaluation of the sustainability of the water system can be carried out, but also it will be possible to measure the degree of achievement of the SDGs. For that, a correlation between quantifiable variables in hydraulics systems and the KPIs should be made, which will allow classifying the system within a particular range of sustainability. This is a target for further studies.

6. ACKNOWLEDGEMENTS

Authors greatly acknowledge financial support from the "Catedra Aguas de Valencia" in the grant "Assessing water distribution systems across indicators based on Sustainable Development Goals" for the first author of this contribution.

Grant PID2020-114781RA-I00 funded by MCIN/AEI/ 10.13039/501100011033

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