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METHODOLOGY FOR ANALYSIS OF SGDS COMPLIANCE IN URBAN WATER SYSTEMS. IMPLEMENTATION IN CASE STUDIES IN THE VALENCIAN COMMUNITY

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Abstract

The current economic, social, and technological development demands high quantities of good quality water, putting in more stress water resources. However, if water resources could be managed in a sustainable way, it will be possible to satisfy the present needs without compromising its long-term capacity. Given the situation, it has become a challenge to manage water systems sustainably, achieving all the goals set by the SDGs. In this sense, the sustainability of hydraulic systems must be considered globally to integrate all the aspects that intervenes in the concept, such as the economic, social, technical, and environmental fields. Key performance indicators (KPIs) can help managers to audit and evaluate hydraulic systems over time and from a sustainable point of view. This contribution presents a methodology for the implementation of sustainability indicators that will allow to assess the compliance of all the SDGs goals that intervenes in urban water systems. The defined indicators are linked to the management of hydraulic systems, and it was developed a classification of use based on their usefulness, complexity and cost when measuring them in the systems. This study also proposes a classification by levels of sustainability of the water systems, such as the energy efficiency classification of electrical appliances. The methodology is applicable for all types of hydraulic systems (supply, sanitation, treatment) and for each of its processes (operation, maintenance, administration, infrastructure). For the implementation of the KPIs, the level of development of the country or region where the study is carried out is considered. Therefore, for each case different indicators are defined from those already established to consider the characteristics of the systems and for the calculation of each KPI. A description of the system must be carried out, to have a memory of the evolution of the complete system and to define the indicators that are relevant. Therefore, through the results of the analysis it is possible to establish 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. By improving the performance and sustainability of the systems, it is not only possible to achieve the objectives of goal 6, but also other associated goals will benefit, which highlights the relevance of sustainability indicators in hydraulic systems.

Keywords
SDGs, sustainability indicators, performance indicators, urban water systems, sanitation, water networks.

1 INTRODUCTION

Nowadays the concept of sustainability is quite well known, and it can be defined as a process that seeks to meet the present needs without compromising the capacity of the resources in the long or short term [1]. It was implemented by the UN to establish goals that will help to reach a sustainable development specially in developing countries. The UN established the concept followed by a plan of action known as the Agenda 2030, in which it is included 17 global goals (Sustainable Development Goals, SDGs) and targets to reach those goals [1]. Those goals are based on the pillars of a sustainable development: social, economic, and environmental.

The social component aims to improve the quality's life of the society by eradicating poverty, achieving equity and access to basic services such as education, water supply, sanitation, among others. The economic perspective looks to produce goods and services with a tariff policy characterized by a reasonable price. This implies that the demand is satisfied at a price that will allow to recover the costs and stimulates the investment. The environmental component seeks to preserve the ecosystems through the reduction of emissions, managing waste and improving the energy efficiency.

One of the SDGs is dedicated to water resources and systems, covering: supply, sanitation, management, and water quality. The SGDs present some interrelation between them, some of these relations are more explicit than others. For example, 3.3 (end with water-borne and communicable diseases), 3.9 (reduce number of deaths and diseases from water contamination) and 12.4 (management of chemical and waste reducing their release to water) are related to SDG6 (clean water and sanitation). There are others SDG that have a connection with SDG6 like, SG7 (water-energy nexus), SDG11 and SDG13 [1].

Considering the importance that concept of sustainability has taken in recent time, the need and desire for measuring the different aspects that a sustainable development carry has increase, including urban hydraulics systems. Water is a renewable resource, crucial for human and social development. According to the guideline of a sustainable development, such resources can't be used at a rate greater than its natura generation. Water has the potential of run out due to the current social, economic, and technological development that demands higher quantity and quality of the resource.

The actual water demand punt in stress water resources, as well as supply managers by trying to satisfy the demand. Actions are taken to meet the requirements but without considering sustainable aspects or looking out for the future state of the resources. The importance of the resource in daily activities and the increasing demand highlight the need to incorporate sustainable solutions in water systems.

According to the last report of the UN, there is still a deficit more than 60% in the achievement of the SDG6. In developed countries, water networks are not managed from a sustainable point of view and in developing countries the problem settles in the fact that not even the basics sustainable requirement are fulfilled, like the lack of water supplies and sanitation. Besides, 80% of the wastewater are discharge in water bodies with an accurate treatment.

Given the current situation and pressure imposed on the resources, the administration of hydraulics systems becomes a challenge. It's important that all the stakeholders that intervene in those systems have reliable information of the state and management of the networks. To assess it, Key Performance Indicators (KPIs) that evaluates the different aspects of sustainability in the systems are needed. Such indicators have been evaluated and proposed in different research.

KPIs are used to monitor and evaluate hydraulic systems. There are many types of indicators such as volumetric, percentual, among others. However, it must be established a system of indicators that help to audit from a sustainable point of view. This contribution presents a methodology for

the implementation of sustainability indicators (SIs) that will assess the compliance of all the SDGs goals that intervenes in urban water systems, such as supply, treatment, and sanitation.

2 METHODOLOGY

2.1 Establishment of indicators

Through KPIs it is possible to evaluate a level of performance in a period of time for a system. According to the IWA [3], indicators for water system should have the following characteristics be quantifiable, objectives, with concise meaning, reasonably calculable, auditable, measurable, and easy to understand. The IWA's indicators are currently well known and used because of its easy and universal implementation. Also, because they have proved the efficiency in the measurements. Therefore, the properties of indicators defined by them was important to follow in the establishment of the proposed indicators so that these can be implemented as well.

In Figure 1 it is plotted the methodology that was implemented for the establishment of the indicators. The first step was a review of different case studies in which Sis were implemented. Also, other important sources were analysed such as UN reports and others made by governments and organizations, indicators guidelines like IWA's. Indicators that were often used in different research and had great value, were also review, such as those related to energy and environmental aspects.

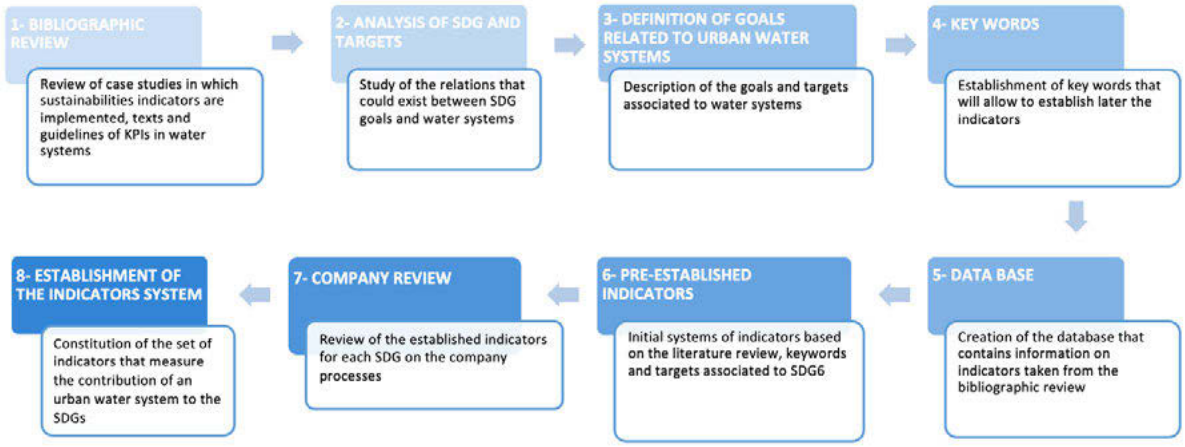

Figure 1. Methodology followed for the establishment of indicators

The second step was to analyse in detail the goals based on the reviewed information. Important data about the concepts, definition of the key words and variables of each target was studied. Based on that, was described a relation between every SDG and the water urban systems. This step was important because to establish sustainable indicators that can capture all the variable and desire measures in water systems, the relationship must be described. Also, this will allow to consider all the interrelation between all the SDG and hydraulics systems or SDG6.

The third step was simultaneous with step 2 and consisted of defining and describing the related targets in which hydraulics systems can contribute in achievement of the sustainable development. As an example, one of the targets of SDG5 in which water systems can contribute defined was 5.1, about ending of discrimination against women. Water services providers can guarantee equal working conditions as well as increasing the number of female workers, if necessary. Also, by improving the coverage of the network, hygiene and sanitary facilities for women can be ensured.

The fourth step was the establishment of key words that will allow to define the indicators. According to the concepts and interrelations found for every SDGs, some key words were defined. These key words allow to cover entirely the concept and measurements that each goal requires.

The fifth step was the creation of a database about the information collected from the bibliographic sources consulted, such as the indicators implemented. Since some were frequently used, reference values were stored to subsequently calculate levels of sustainability. Also, indicators that had not been implemented were included, because of their relevance in the measurements, such as those related to personnel, equality policies, among others.

The sixth step was the establishment of the initial system of indicators for each SDGs, based on the information previews reviewed and the key words. These indicators were intended to really focus on sustainable aspects rather than a more technical side of urban water systems. Continuously, in the next step a detailed reviewed process for each indicator was carry on. In this step the possible implementation and measurement of an indicator was studied in the different process that a company carries. This was done to be able to determine which indicators were able to be implemented but also to define its measurements and the contribution in the sustainable development of the company. During the review of the different processes carried out in the company, new indicators were established since they resulted relevant for the measurement of sustainability in water systems.

With the review of all the indicators and their implementation in different company's processes, it was possible to highlight the contribution of a hydraulic system for each SGDs. The last step was to define the indicators that could be used to measure the sustainability in water resources. The KPIs established, comply with characteristics mentioned before and are applicable to all types of hydraulic system (supply, sanitation, treatment) and for each of its processes (operation, maintenance, management, etc.).

2.2 Implementation of the system

The established KPIs system allows measuring the sustainability of urban water system (such as distribution, treatment plants, collection, and regeneration). When the methodology is carried out, the results obtained will allow to take measures that can improve a sustainable management of the system or at least comply with the basics sustainability principles that the UN exposes. For the implementation of the established system of indicators, it is proposed to follow the process presented in Figure 2.

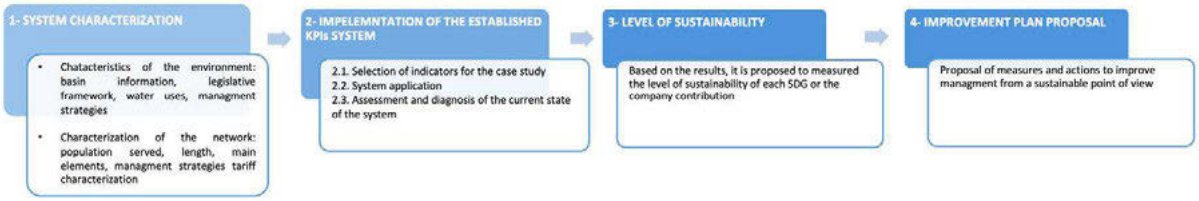

Figure 2. Implementation process proposal for the KPIs system

To implement the methodology, the first step proposed is to identify the state of the environment where the system and the network are developed, so an evolutionary memory can be obtained and will allow to see the impact of the system in the sustainable development. Therefore, changes can be identified, and solutions can be defined. The characterization of the environment implies collecting information of the basin (e.g., area, characteristics of the water bodies and the land, uses of the water, legislative information, among others). On the other hand, for the characterization of the network it is important to obtain data on the population served, location of the treatment plant, outlet flow, length of the network, control elements and operational strategies.

The second step is the implementation of the established SIs system. For these, first should be selected the indicators defined by the type of systems. This means, that if the methodology will be applied to a treatment plant, only those indicators defined for this type of system would be selected from the list. The next step (2.2 in Figure) is to apply to the system the indicators by recollecting all the information and data relevant according to the variables needed. In this step, in addition, a list of the reasons was established for those cases in which the data for an indicator was not possible to measure. In Table 1are some of the arguments that were defined were that the measurement was the cost for assessing the information was high, not profitable or that it did not apply to the case since it referred to a different water cycle. Also, the level of difficulty in data collection was classified.

Table 1. Arguments implemented for those indicators without data

Difficulty level		Arguments	Description of the arguments
1	Very low difficulty	A	Cost of information: it's not profitable to carry out the measurement
2	Low difficulty	B	Data protection
3	Medium difficulty	C	Measurement takes too long
4	High difficulty	D	Time scale of the data is not useful
5	Very high difficulty: it's not possible to have access to the information	E	Third party data
		F	Doesn't apply for the case
		G	Type of measured not performed
		H	Others

The step 2.3 is to process and calculate all the indicators to evaluate the status of the system from a sustainable point of view. Also, this will lead to a diagnosis from which it will be possible to take solutions or strategies that aim to improve a sustainable management of the water system and therefore raising the achievement of the SDGs. The solutions to be implement can be aimed at improving one or more SDGs, depending on which targets the company wants to improve first.

As a third step, it is proposed to calculate a level of sustainability. Initially, it is proposed that these levels have mobile ends since there is not much data yet. In this way, the same system (for example, a supply) will be able to feed its level database with more and more information and, said, the extreme values would be recalculated based on the amount of data.

The last step is to propose a plan based on the results obtained, in which a series of actions or measures can be defined to improve management from on a sustainable point of view. As mentioned before, the actions taken can be focused on improving the level of a single SDG or many

of them. In the case of less developed countries, management can focus on fulfilling at least basic sustainability requirements.

3 RESULTS

3.1 Establishment of indicators

As described in the methodology, the second and third step for the establishment of the KPIs was the study and the goals and targets to be able to obtain an interrelation between the SDGs and urban water systems. Table 2 shows the result of the relations obtained. As mentioned before the defined targets established are those in which the urban hydraulic systems can contribute in certain way. The Table 3 shows an example of the described interrelation between SDG5 and SDG6, as well as the key words.

Table 2. Targets related to water systems for each SDGs

SDGs	Target related to urban water systems (SDG6)
SDG 1-No poverty	1.1; .1.4; 1.5; 1.a
SDG 2-Zero hunger	2.1; 2.2; 2.3; 2.4; 2.a
SDG3- Good health and well-being	3.1; 3.2; 3.3; 3.8; 3.9
SDG4- Quality education	4.4; 4.5; 4.7; 4.a; 4.b
SDG5- Gender equality	5.1; 5.4; 5.5
SDG7- Affordable and clean energy	7.1; 7.2; 7.3; 7.a; 7.b
SDG8- Decent work and economic growth	8.1; 8.2; 8.3; 8.4; 8.5; 8.6; 8.8
SDG9- Industry, innovation, and infrastructure	9.1; 9.2; 9.4; 9.5;9.a
SDG10- Reduced inequalities	10.1; 10.2; 10.3; 10.4; 10.5; 10.b
SDG11- Sustainable cities and communities	11.; 11.3; 11.4; 11.5; 11.6; 11.b
SDG12- Responsible consumption and production	12.2; 12.4; 12.5; 12.6; 12.8; 12.a
SDG13- Climate action	13.1; 13.2; 13.3
SDG14- Life on below water	14.1; 14.2; 14.3
SDG15- Life on land	15.1; 15.4; 15.5
SDG16- Peace, justice and strong institutions	16.1; 16.6; 16.7; 16.10
SDG17- Partnerships for the goals	17.3; 17.5; 17.7; 17.16

Table 3. Related targets of SDG5 and description of the relationship with SDG6

SDG	Target	Decription of the interrelation with SDG6	Keywords
SDG5 – Gender equality and women's empowerment	5.1	Asegurar instalaciones sanitarias y de higiene para mujeres y niñas en todos los lugares. Asegurar la igualdad de condiciones y cantidad de mujeres trabajando en los sistemas hidráulicos.	Género, desigualdad, discriminación, mujer, niña
	5.4	Fuentes de agua e instalaciones más cerca al hogar o zonas urbanas, para evitar el acoso en mujeres que transportan el agua (países en desarrollo)	Género, trabajo doméstico, servicios públicos, infraestructura, protección social, hogar, familia
	5.5	Asegurar la igualdad de condiciones y cantidad de mujeres trabajando en los sistemas hidráulicos.	Género, participación, mujer, igualdad, política, económica, pública

The system of KPIs was established to assess the achievement of all the SDGs related to water resources. For each SDG, was defined direct and indirect indicators. For the first, the relation between the SDG and the indicator is almost evident and the measurement is direct. Meanwhile, for the indirect indicators the relation even though the measurement does not contribute much to the tracking of the SDGs, there is still some link.

Also, for each indicator, the following information was defined and classified:

- ID
- SDGs's targets related to water
- Sustainable aspect: technical, economic, environmental, or social management (it could be related to more than one option)

- Water cycle: stage of the cycle for which the indicator is implemented (collection, treatment, distribution, collection, purification, and regeneration)
- Type of indicator: performance, financial, productive, energy and environmental efficiency

The KPIs system is conformed by 135 indicators. The Figure 3 shows that 110 can be implemented in supply systems (caption and distribution), 100 are for sanitation systems (collection and disposal) and finally 87 can be used for water treatment systems. Also, in Figure 4 is presented the number of indicators established for each SDG, according to the type of urban system. As an example, for SDG1, 10 indicators were defined for supply systems as well as for sanitation and 7 for treatment systems.

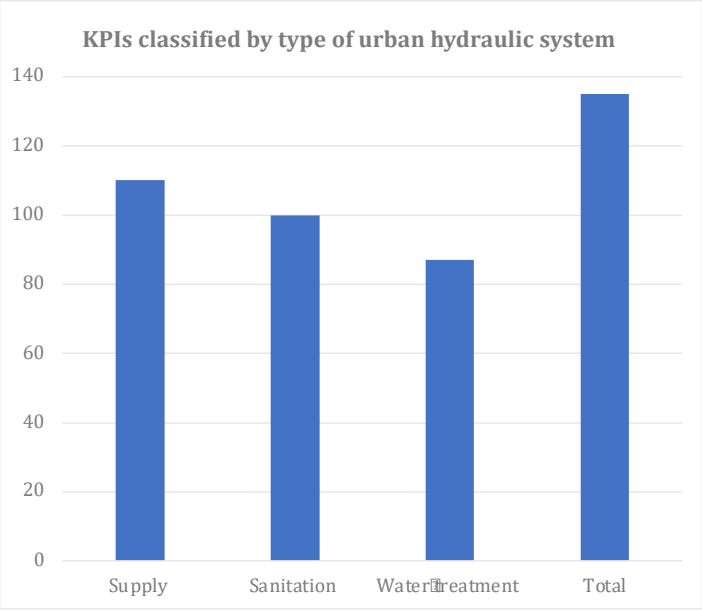

Figure 3. Distribution of the indicators classified by type of urban hydraulic system

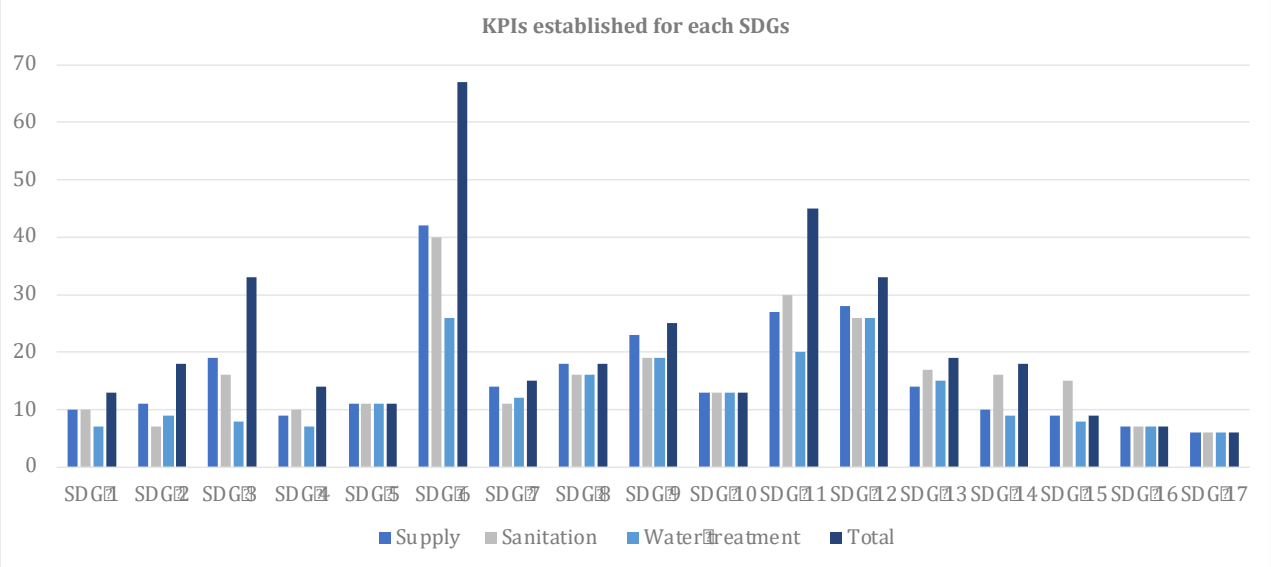

Figure 4. KPIs established for each SDGs, classified by type of urban water system

3.2 Implementation of the system – case study

After having established the system of indicators, the implementation of it in a case study was next. The case study refers to the distribution network of the city of Valencia. As described in the methodology, once the characterization of the environment and the network was carried out, the indicators were selected to evaluate the system. Considering that the service to be evaluated was supply, there were 110 indicators for this type of system and only 97 could be applied. Figure 5 shows the distribution of the KPIs implemented in each SGDs for the case study respect to the total number of indicators of each SDGs established.

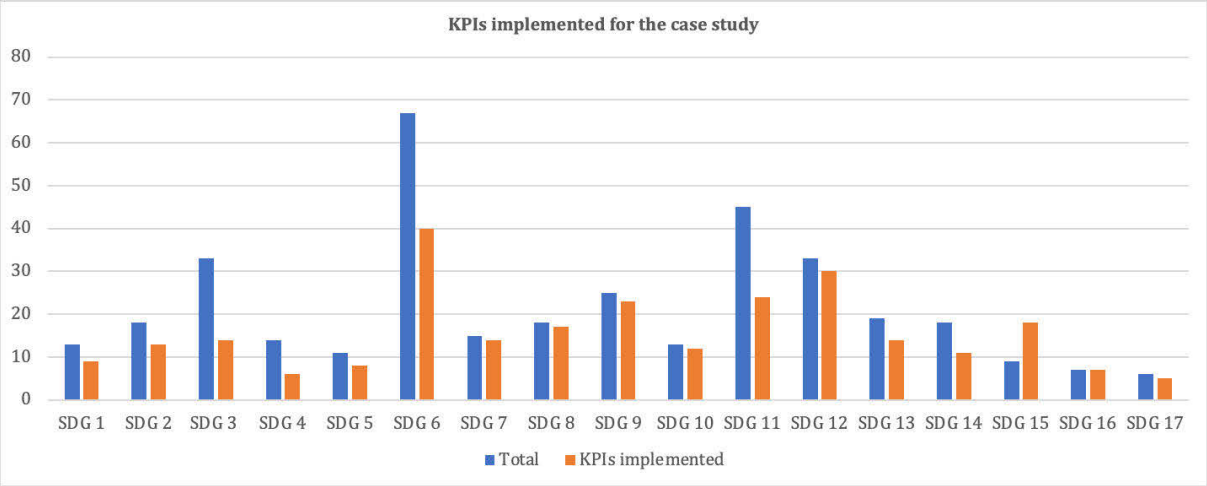

Figure 5. KPIs for each SDGs implemented for the case study

Figure 6. Resume SDG6 results about indicators applied

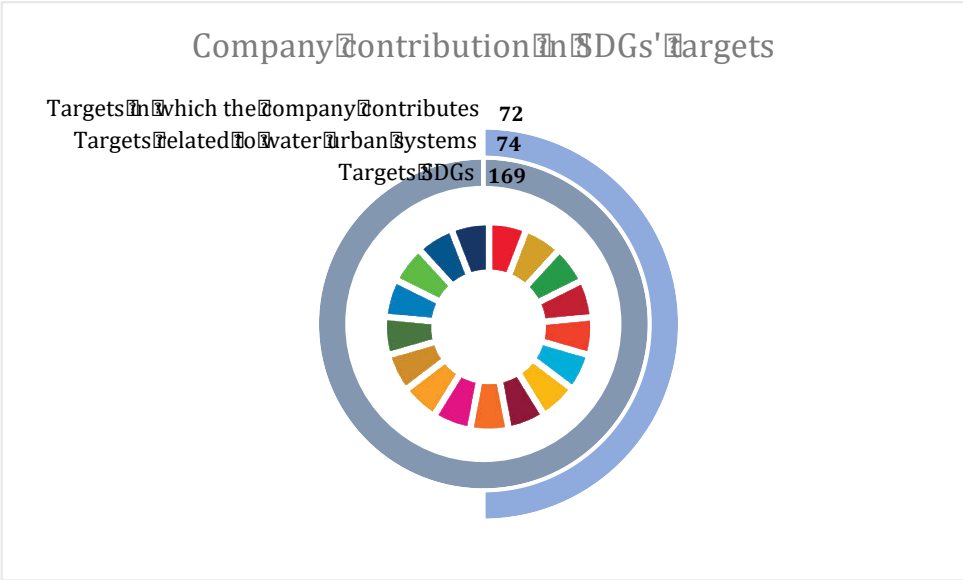

Figure 7. Company's contribution in SDGs' targets

In Figure 7 is represented the company's contribution in the SDG's targets. The UN established 169 indicators in total. It was found that from those, 74 targets have a interrelation with the SDG6 or urban water systems. Once the methodology was implemented and evaluated in the case study of Valencia, it was found that the water company contributes in 72 of those targets. Only in SDG 10 and SDG14, there are some indicators that were not implemented and therefore the contribution is not 100%. Nevertheless, the company's contribution is quite good.

Figure 8. Company contribution in SDG's 6 targets

Figure 6 presents as an example the results of the indicators implemented specifically for the SDG6. It could be observed that of the 42 indicators established for supply systems, only 40 were applied. Alternatively, Figure 8 shows the contribution of the company specifically to the targets of SDG6. Of the 8 goals established by the UN for this SDG, 7 were related to the defined KPIs system and the company contributes in 7 of them. This mean that, the service provider has a considerable influence on this goal since it manages to contribute to almost all targets. If a sustainable management were followed by the company, all these targets could improve.

In general, there were 135 indicators, of which 32 were not applied. For supply systems, as mentioned before, 13 indicators couldn't be applied. The level of difficulty in data collection was classified, being 1 very low difficulty a very easy access to the information and 5 high difficulty indicates that there is no access to the data. In addition, certain arguments were defined to describe the reasons for the measurements that couldn't be performed. This was all represented in Table 1.

Of the 32 indicators for which information could not be obtained, the level of difficulty in collecting it mostly was 1, which represents a low rate. Only a few (less than 5) were classified as level 4 which indicates higher difficulty. However, even though the data was easy to obtain, the main reason for the lack of information was because it didn't apply or matches to the case of study. Besides that, for certain indicators the measurement of the variables was not made and in other cases it was not relevant to measure for the company. This can be seen in Figure 9 and Figure 10.

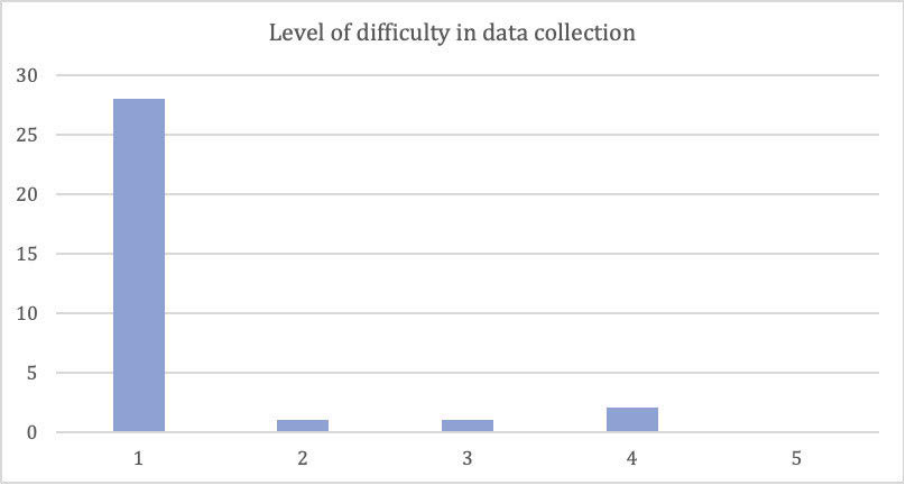

Figure 9. Level of difficulty in data collection

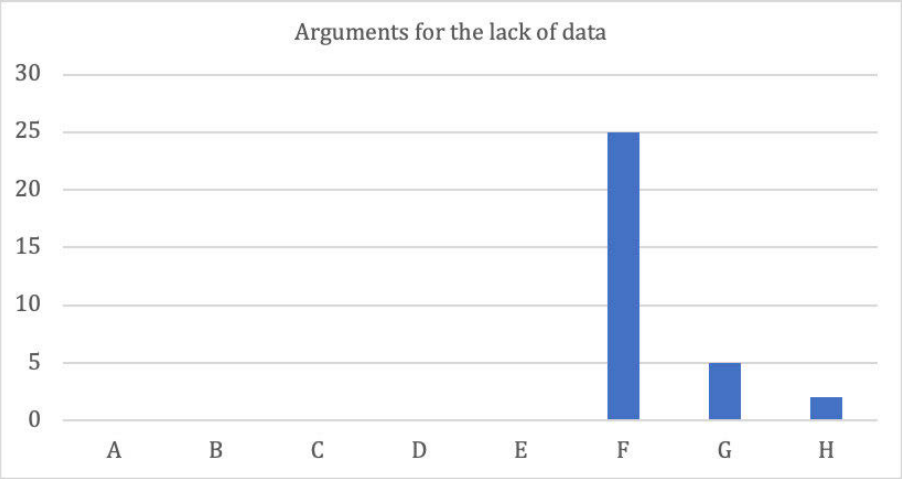

Figure 10. Arguments for the lack of data

4 CONCLUSIONS

The current social and technological development are putting under pressure water resourced due to the high demand (in quantity and quality). Therefore, the state of the resources is in risk for future generations. Also, such demand puts service managers under stress, making them to take decisions in which the sustainability or future status of the resources is not a priority. Besides that, the climate change also put pressure in the condition of water systems. Hence, its quite a challenge to manage urban water systems in a sustainable way that can contribute to the achievements of the SDGs.

With the implementation of a sustainable management, the present demand can be satisfied without compromising the capacity of the resources in the future and could lead to an optimal operation. In this research a methodology and a system of indicators was proposed that will allow to assess different hydraulics systems from a sustainable point of view. It will evaluate the contribution of the company for all the SDGs that the UN has defined to achieve a sustainable development.

As a first step of the methodology a bibliographic review was made, in which case study and guidelines were analysed. Then a detailed evaluation of the interrelation between the SDGs, targets and water systems was made. All the SDGs have a connection with urban water systems,

some of these relations are more explicit than others. Based on the interrelations and some key words defined for each target, it was possible to establish a system of indicators.

The system is conformed by 135 indicators that will allow to evaluate water urban systems from a sustainable view. Of those, 110 can be implemented in supply systems, 100 are for sanitation and 87 can be used for water treatment systems. All of them comply with indicators' characteristics (IWA, 2000) such as being quantifiable, auditable, concise in meaning and universal. Also, each indicator was classified by its targets and SDGs, sustainable aspects, stage in water cycle and type of indicator.

An outline of the implementation process of the indicators was also proposed. It consisted of a series of steps such as: system characterization (information of the network and environment), assessment and diagnosis based on the sustainable indicators. Finally, an action plan can be made according to the results.

For the implementation of the methodology, two factors play a crucial role in the selection of the indicators from those already established. It will depend on factors such as the type of urban water system and its location. For networks in developing countries, the information may be a bit more complicated to obtain. In addition, some basic services indicators should be considered since they are not usually fulfilled, such as the service coverage. In developed countries this indicator could be not applied since the coverage of the services its already satisfied by a 100%. Therefore, the KPIs systems proposes implemented in a developed country could align the company's objective to the improvement of the SDGs instead of complying with the basics requirements.

The methodology was implemented in the supply system of Valencia, Spain. According to the type of system in which was used the KPIs system, only 110 indicators could be applied and only 97 could be measured. In general, 32 indicators were not applied. Of the 169 targets established by the UN, 74 are related to urban water systems. The company's contribution in the case study is from 72 targets, which is quite good.

The level of difficulty in the data collection was mostly low, meaning that was easy to access to the information. Only a few measures were classified as high difficulty. The main reason for the lack of data was because in most cases it didn't match the case of study and because for some indicators the measures were not made by the company or not relevant.

Based on the results, actions can be taken to improve the operation of the network for a more sustainable plan. Such actions can be focused on improving all the SDGs or only some of them, for example a company can choose if the target is to improve only SDG7 and create an energetic plan linked to sustainability or if should be align all the strategics plans of the company to sustainability. The proposed methodology will allow to evaluate the contribution of water services to the SDGs' targets. Therefore, it can be said that the systems can be global drivers for change in water systems. With more data, it will be possible to establish a degree of achievement the SDG to obtain sustainability levels and classified the system in a particular range. This could be a target for further studies.

5 ACKNOWLEDGMENTS

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