Article publicat / Published paper:
Pires Carneiro, A., [et al.] Sustainability Assessment of indicators for integrated water resources management. "*Science of the total environment*", 1 Febrer 2017, vol. 578, p. 139-147. DOI: 10.1016/j.scitotenv.2016.10.217

SUSTAINABILITY ASSESSMENT OF INDICATORS FOR INTEGRATED WATER RESOURCES MANAGEMENT

A. Pires[a*+], J. Morato[a], H. Peixoto[b], V. Botero[c], L. Zuluaga[c], A. Figueroa[d]

[a] *UNESCO Chair on Sustainability, Polytechnic University of Catalonia, Barcelona, Spain*

[b] *Earth Science Institute, Federal University of Bahia, Salvador, Brazil*

[c] *Environmental and Earth Science Institute, National University of Colombia, Medellin, Colombia*

[d] *Environmental Studies Group, Cauca University, Popayan, Colombia*

* Corresponding author: alex.pires@catunesco.edu.br / alexpires.br@gmail.com

[+]Present address: Av. Luis Viana Filho, 6775, Jorge Amado University Center, Salvador, Brazil, 41745-130

ABSTRACT

The scientific community strongly recommends the adoption of indicators for the evaluation and monitoring of progress towards sustainable development. Furthermore, international organizations consider that indicators are powerful decision-making tools. Nevertheless, the quality and reliability of the indicators depends on the application of adequate and appropriate criteria to assess them. The general objective of this study was to evaluate how indicators related to water use and management perform against a set of sustainability criteria. Our research identified 170 indicators related to water use and management. These indicators were assessed by an international panel of experts that evaluated whether they fulfil the four sustainability criteria: social, economic, environmental, and institutional. We employed an evaluation matrix that classified all indicators according to the DPSIR (Driving Forces ,Pressures, States, Impacts and Responses) framework. A pilot study served to test and approve the research methodology before carrying out the full implementation. The findings of the study show that 24 indicators comply with the majority of the sustainability criteria; 59 indicators are bi-dimensional (meaning that they comply with two sustainability criteria); 86 are one-dimensional indicators (fulfilling just one of the four sustainability criteria) and one indicator do not fulfil any of the sustainability criteria.

KEYWORDS: Criteria, Water use, Socio-economic, Decision-making, IWRM, DPSIR

1 INTRODUCTION

Indicators are powerful decision making tools and the adoption of indicators to evaluate and monitor the progress towards sustainable development is strongly recommended by scientists (Bolcárová & Kološta, 2015; Cornescu & Adam, 2014; Moldan et al., 2012), policy developers (UNDESA, 2007), international institutions (OECD, 2014; WWAP, 2003), governments (OSE, 2008), the business sector (WBCSD, 2000) and non-governmental organizations (WWF, 2010).

The application of indicators of water use and management can undoubtedly contribute to a better allocation of this limited resource (Kang & Lee, 2011). Nevertheless, for their formulation, it should not only be considered as a technological issue but also should include the environmental, social, institutional, and economic aspects related to sustainability (Spangenberg, 2004).

Indicators can be applied to natural elements, such as the environment (Zhang, 2015), ecosystems (Fu et al., 2015), forest management (Gossner el al., 2014), water (Lobato et al., 2015; Perez et al. 2015) and land (Zhao et al., 2015; Rosén et al., 2015), as well as to socio-economic-institutional issues related to water resources, i.e. water economic value (Hellegers et al., 2010), urban water systems (Spiller, 2016), governance (Norman et al, 2013; Pires & Fidélis, 2015), political framework (Blanchet & Girois, 2012) and management (Taugourdeau et al., 2014). Several authors (Juwana, et al. 2012; Spangenberg, 2008; McCool & Stankey, 2004) mention that the rise of sustainable development concepts and environmental concerns have led to an extensive and intense application of indicators by a wide range of users in different contexts. In response to the growing search for indicators based on ad hoc approaches, the Bellagio Principles (Hardi and Zdan, 1997) were established to guide the use of indicators to measure progress towards sustainability.

So far, no comprehensive analysis about the precise number of indicators related to sustainable development, environment or water resources has been found, however, authors point to thousands of such metrics (Hak et al., 2012). The United Nations World Water Assessment Programme (WWAP, 2012) remarks that *"a staggeringly extensive array of indicators have been developed, or are proposed, to monitor the state, use and management of water resources, for a wide range of purposes."*

The relevance of indicators for the decision-making process is one of the most important features of the indicators in relation to other forms of information. Indicators can be powerful policy decision tools (Nicholson et al, 2012). Therefore, indicators should present attributes that are considered relevant by the decision makers and not necessarily by a specialized audience (Klug & Kmoch, 2014). Well-developed indicators should condense and unscramble relevant data by measuring, quantifying/qualifying, and transmitting information in a way that is easy to understand (Kurka and Blackwood, 2013).

1.1 IWRM, Sustainable Development and Indicators

Indicators that are selected to address the key concerns of water managers provide critical data for water governance. Water governance is the set of political, social, economic, and administrative systems that make the Integrated Water Resources Management possible (Hooper, 2006). Integrated Water Resources Management (IWRM) takes the view of sustainable development and applies it to the water sector. IWRM became apparent in the late 1980's and is in fact an *"umbrella concept encompassing multiple principles",* which aims at a more coordinated management of water resources (Benson, Gain & Rouillard, 2015).

IWRM adopts a holistic approach: as mentioned by WWAP (2003) the purpose of IWRM *"is maximizing the economic benefits and social welfare of the use of water without jeopardizing the sustainability of the ecosystem".* Hooper (2006) further explains, *"IWRM involves cross-sectoral collaboration and adaptive management rather than single sector, 'line' management and planning of land and water resources".* One of the principles of IWRM is the integration of interconnection between several aspects: e.g. up-stream and down-stream; quality and quantity of water resources; economic and environmental needs; technical and political decisions, etc. (Ludwig, Slobbe & Cofino, 2013).

One of the key issues of IWRM is the need for greater participation from different groups of stakeholders, e.g. policy and decision makers, planners, managers, scientists, and the general public (UN, 1992). To promote adequate participation in the IWRM from such diverse groups, there must be tools for effective communication among them. Indicators can help simplify information on IWRM and establish effective communication among the various groups in the water resources field (WWAP, 2003).

Dahl et al. (2012) urged the scientific community to find better indicators of progress towards sustainability. They demonstrated in their paper *Achievements and gaps in indicators for sustainability* that *"the available indicators mostly succeed at measuring unsustainable trends that can be targeted by management action, but fall short of defining or ensuring sustainability".* This limitation also applies to water resources sustainability (Mays, 2006). Despite several publications and work on this matter, no comprehensive list of the available indicators to assess the sustainable use and management of water can be found. Our research therefore identifies and describes a set of 170 indicators related to the water use and management presented by international institutions and scientific community. So far, no other scientific publication has been found that has compiled and described such an extensive list of water indicators.

It was also noticed that there was no previous study that further investigate if these indicators of water resources fulfil the main components of sustainability. On one hand, some studies have faced similar questions (Juwana et al., 2012; Kang & Lee, 2011; Perez et al., 2014; Spiller, 2016), on the other hand they analysed a limited set of indicators. This paper aims to contribute to fulfil this gap. The general objective of this study was to evaluate how the 170 indicators related to water use and management identified by with study perform against a set of sustainability criteria.

2 METHODOLOGY

The study identified the indicators related to water use and management. In order to do this, an extensive revision of the specialized literature screening the indicators related to water use and management was performed. An assessment matrix with the identification and description of the indicators was constructed classifying them according to the DPSIR framework.

A pilot study served to test and approve the research methodology and data analysis before carrying out the full implementation. This was followed by an international panel of experts, assessing the indicators based on the sustainability criteria. The assessment followed by the classification of the indicators according to the system approach (social, economic, environmental, and institutional components) and the organization of the indicators into four categories: indicators of sustainability, bi-dimensional indicators, one-dimensional indicators and indicators with no relation with sustainability criteria.

The ones that adequately cover the majority of the social, economic, environmental, and institutional criteria were selected as indicators suitable to measure the sustainability of water use and management.

2.1 Identification of the indicators

This research performed an extensive revision of the specialized literature, aiming at identifying the initial set of indicators to take part in this study. This research carried out several electronic searches accessing a number of journal and institutional websites (including relevant grey literature), as well as databases and academic search engines. In total, 54 sources were examined in detail. Among them were publications from internationally institutions renowned for their reliable work on indicators, water resources and/or sustainability, such as FAO (2003), GWP (2006), IISD (1999), OECD (2004), UN (2009), WHO & UNICEF (2010), World Bank (2007), WRI (1998) and WWAP (2009). This study also examined relevant peer reviewed scientific papers related to the subject, including Aldaya & Llamas (2008), Bradfor (2008), Ding, Widhalm & Hayes (2010), Hoekstra (2010), Lawrence et al (2002), Maneta et al (2009), Milman & Short (2008), Scudder (2005), Sullivan & Huntingford (2009), Vörösmarty et al (2005a), Wilhite el al

(2007). Official publications from key governments were also examined including Brazil (MMA, 2006), Spain (OSE, 2008), Catalonia (De Felipe et al., 2008), European Union (Eurostat, 2009), among others.

The indicators of interest to this study are the ones related to water use and management from the perspective of the integrate water cycle including, but not limited to, surface water, groundwater, rainwater and reclaimed water. The river basin is the geographical scale of interest for this study, nevertheless the indicators identified here are not limited to this scope. The indicators identified by this study address one or more of the following aspects:

- Indicators that measure consumptive use of water: indicators associated with extractive uses that alter the amount of water and are mainly linked with three sectors: agriculture, industrial, and domestic uses.
- Indicators of non-consumptive use of water: indicators related to non-extractive practises such as recreation, transportation, power generation, acceptance of waste (pollution), and religious and cultural uses.
- Indicators related to the environmental role of water resources (e.g. conservation of aquatic life, biodiversity, and the preservation of wetlands), water quality, and conservation of natural resources.
- Indicators related to water governance (e.g. legislation, institutional capacity building, user participation, environmental education, knowledge production and management, water economics, water culture, etc.).
- Hydrological indicators (e.g. precipitation, evapotranspiration, stream flow, soil moisture, hydrological status, etc.) that are considered essential to planning, operation and efficiency of water use.

2.2 Construction of the assessment matrix

This study created an assessment matrix aiming to organize the information of the indicators identified and to be used as an evaluation tool to assess their sustainability criteria. Assessment matrixes are useful tools to systematize complex information under evaluation (Sheppard & Meitner, 2005). They have been regularly adopted in several fields including sustainability (Graymore, Sipe & Rickson, 2008), environment (Canter, 1999), among others.

This matrix presented the basic information about each indicator, including name, brief description, position under DPSIR framework (see next section), among others. It is worth mentioning that some original sources analysed presented the indicator's name, but did not provide a definition for it. This was the case with several indicators proposed by the UN World Water Assessment Programme (WWAP, 2003). When needed, we have proposed a summarized description of these indicators based on the consultation of additional sources.

This effort aimed to bring enough elements to the members of the panel of experts in order to allow them to assess the indicators based on an actual description in order to reduce ambiguity and misinterpretation.

2.3 Classification under the DPSIR framework

The next step was to classify the indicators under the DPSIR framework. Several authors argue (Constantino et al., 2004; Mendoza & Prabhu, 2003; Niemeijer & Groot, 2008; Niemi & McDonald, 2004; Wolfslehner & Vacik, 2011) that indicators can be more useful if they are organized in a coherent framework instead of individually as a simple collection of elements. The adoption of a framework is especially important in the case of indicators related to sustainable development, which encompass many subjects and dimensions (IISD, 2008; WWAP, 2006).

The DPSIR approach is the most widely used framework applied for environmental indicators (Spangenberg et al., 2015; WWAP, 2003). DPSIR is based on the pressure-state-response (PSR) conceptual framework firstly introduced by the OECD (1994), and then amply adopted by the EEA (1999) and UN system (WWAP, 2012).

The DPSIR framework organizes the indicators according to the cause–effect schema under the following categories: Drive Forces, Pressure, State, Impact and Response. An indicator, depending on its nature and attributes can be classified under one or more of these components.

The classification of the indicators under this framework was based primarily on the definition by the original source presenting the indicator. When this information was not available, the authors analysed the indicator and proposed a classification. The classification of each indicator under the DPSIR framework was done according to the definitions presented by the EEA (1999) and their adaptation to the water resources sector done by WWAP (2006) based on Costantino et al. (2004) – as described in the Table 1 below.

Table 1 – Definitions of the DSPIR categories to classify indicators.

	Original definition by EEA (1999)	Adaptation of WWAP (2006) to water resources sector
Indicators for driving forces	Describe the social, demographic and economic developments in societies and the corresponding changes in life styles, overall levels of consumption and production patterns. These driving forces exert pressure on the environment.	The basic sectorial trends, the underlying factors and the root causes affecting the development of society, the economy and environmental conditions.
Pressure indicators	Describe developments in release of substances (emissions), physical and biological agents, the use of resources and the use of land. The pressures exerted by society are transported and transformed in a variety of natural processes to manifest themselves in changes in environmental	Human activities directly influencing water resources supply, quantity or quality, or water use; the immediate stress agents or proximate causes.

	conditions.	
State indicators	Give a description of the quantity and quality of physical phenomena (such as temperature), biological phenomena (such as fish stocks) and chemical phenomena (such as atmospheric CO^2 concentrations) in a certain area.	Current conditions and trends; situation or status of the resource or the sector vis-à-vis water at the present time.
Impact indicators	Describe the impacts on the social and economic functions on the environment, such as the provision of adequate conditions for health, resources availability and biodiversity. These impacts are caused by changes on state of the environment.	The effects of changed water-related conditions on human and natural systems; physical and economic losses due to deteriorating water conditions; the effective consequence of the altered state of the resource or its use.
Response indicators	Refer to responses by groups (and individuals) in society, as well as government attempts to prevent, compensate, ameliorate or adapt to the impact of the changes in the state of the environment. Some societal responses may be regarded to reduce or eliminate negative driving forces, other responses may aim at raising the efficiency of products and processes.	The reaction, or efforts of society — at all levels — to change undesirable conditions, to solve the problems that have developed or to counter the stress and impacts imposed on human systems; coping mechanisms as reflected in changes in policies and institutions, production practices or human behaviour.

Sources: EEA, 1999; WWAP, 2006; Costantino et al., 2004

2.4 Sustainability Criteria

At this study, the indicators related to water use and management were evaluated according to the sustainability criteria. As mentioned by, indicators should include the sustainability criteria. Bélanger et al. (2012), IISD (2008), UN (2007), Niemeijer & Groot (2008), BNIA, (2006), SNZ (2002) among other authors identified that sustainability is one of the most relevant criteria for evaluating indicators.

One of the most well-known sustainability principles is the “triple bottom-line approach”, also called the “three pillars of sustainability”, which includes the environmental, economic and social dimensions of sustainability (Elkington, 1997; Juwana et al., 2012; Rosén et al., 2015). However, in 1995 the UN Division for Sustainable Development (UNDPCSD, 1995) formally introduced the institutional dimension as the fourth dimension of sustainable development. According to the International Institute for Sustainable Development (IISD, 2008), the sustainability criterion “*considers the underlying social, economic and environmental system as a whole, including issues related to governance*”. Governance can be understood as the main element of the institutional dimension of sustainability. It should be mentioned that there are also other possible dimensions of sustainability such as the cultural dimension (Hawkes, 2001) or the technological dimension (Spiller, 2016).

Our study adopted the institutional dimension as the fourth pillar of sustainability as presented by Juwana et al. (2012), IISD (2008), UNDPCSD (1995), Spangenberg (2008), WWAP (2003), among others. These four dimensions were then translated to the perspectives of water use and management:

- **Social Sustainability**: to ensure access to water of a quality and amount necessary for human needs;
- **Economic Sustainability**: to ensure the handling and efficient use of water promoting urban and rural development;
- **Environmental Sustainability**: to ensure the appropriate protection of natural resources: soil, biota, and water;
- **Institutional Sustainability**: to ensure an adequate institutional framework to promote the principles of IWRM.

2.5 Evaluation of the Indicators

The indicators were evaluated by an international panel of experts using the assessment matrix and grading each indicator according to their significance in relation to each one of the four sustainability criteria.

Panel of Experts

A panel of experts was assembled to assess whether the indicators fulfil the sustainability criteria. Panels of experts have been used by researchers to provide independent, expert judgement to the assessment of indicators (Singh et al., 2009). Fourteen experts from the scientific community were selected to form the evaluation panel. In order to select them, the following principles, also adopted by Cloquell-Ballester et al (2006), were considered: a) level of knowledge on the subject; b) expected ability to perform the task; c) interest in participating in the process.

These individuals have proven professional experience related to water resources and were selected from international networks related to the topic of the research, mainly the CYTED (Ibero-American Programme for Science, Technology and Development) and the UNESCOSOST Network (UNESCO Chair of Sustainability at UPC - Barcelona). The members of the panel, seven females and seven males, are high-level experts. All of them possesses or pursue a PhD. They are from diverse age ranges with different backgrounds from several Ibero-american countries.

Using the assessment matrix, these experts expressed, based on the evaluation scale (see next section), how they consider each indicator fulfilling each sustainability criterion. They were also invited to provide their comments or observations on the indicators. The experts performed independent evaluations, both remotely and in person. In order to support the work of the panel as well as possible, all materials provided to them (assessment matrix, instructions, e-mails, etc) were designed to be user friendly.

A **pilot study** was carried out in order to test the methodology and statistical techniques employed in this research prior to full-scale implementation. It was performed in order to check if the research design and settings would work as expected. Pilot studies, like the one done here, are of crucial importance in qualitative research due to their ability to reveal any methodological limitations and flaws, and to point for design improvements (van Teijlingen & Hundley, 2001). Pilot studies give researchers the opportunity to make any necessary revisions prior to full implementation, in order to increase the likelihood of success (Turner, 2010).

This pilot study simulated the application of the assessment matrix using the evaluation scale and settings, as presented above, to a group of eight experts from the network of the UNESCO Chair on Sustainability. The test participants were limited in number but diverse in their representation, including professors and PhD/Master students, males and females from diverse age ranges with different backgrounds, from several Ibero-american countries. A sample of 10 indicators related to water use and management was randomly chosen for this pilot study. The results were statistically treated in the same way as the final results would be.

The participants of the pilot study welcomed the design and the material produced. Nevertheless, they provided relevant feedback and suggestions to further improve them, such as, the inclusion of information about the units of measurement for each indicator in the assessment matrix and adjusting the sequence of the indicator in the matrix in order to group indicators according to the topic addressed. The methodology was validated through the pilot study, and the main recommendations from the pilot study were incorporated into the research design.

Evaluation Scale

The evaluation process involved a three-level qualitative scale in which the members of the panel classified each indicator as: not significant, significant, or highly significant, based on its level of compliance with the social, economic, environmental and institutional criteria (Table 2).

Table 2 - Three-level qualitative scale for the classification of sustainability criteria.

Social Sustainability	Economic Sustainability	Environmental Sustainability	Institutional Sustainability

Not Significant			
No significant social component included	No significant economic component included	No significant environmental component included	No significant Institutional component included
Significant			
Includes social components that contribute to improving access to quality water and the amount needed for human needs	Includes economic components that contribute to the efficient use of water by promoting urban and rural development	It includes components of the environment that contribute to the protection of natural resources - soil, biota and water	Includes institutional components that contribute to promoting the principles of IWRM
Highly significant			
Aims to ensure access to quality water and the amount needed for human needs.	Aims to ensure the efficiency of the management and use of water, promoting urban and rural development.	Aims to ensure adequate protection of natural resources - soil, biota and water (especially the springs and groundwater).	Aims to ensure the appropriate institutional framework to promote the principles of IWRM.

These results were scaled numerically as follows: not significant equal to zero; significant equal to seven; and highly significant equal to ten. This zero to ten scale was used because the experts could easily apply it; and because it is a general and largely used scale for rating (Wimmer & Dominick, 2010).

Analyses of the Data

The data obtained from the panel of experts was categorized, processed and analysed applying the fundamentals of descriptive statistics. The summarization of the results was done based on the averages of the ratings assigned by each evaluator to a given criterion. The arithmetic mean was the average measure applied in order to represent the central value on the set of data. The following equation shows how the average scores were calculated for each indicator in relation to each criterion (social, economic, environmental, and institutional).

$$Si_{(c)} = \frac{\sum_{1}^{n} Si_{(c)}}{n}$$

where Si(c) is the score for indicator i and criterion c (social, economic, environmental, and institutional), and n is the number of experts.

The frequency histograms of the data obtained with the evaluation were also used to graphically represent the results.

Selection of the indicators

This study aimed at selecting indicators of water use and management that presented adequate sustainability criteria. In order to select them, the average score of seven was considered as the threshold value to define whether an indicator fulfils the criterion or not. On the evaluation scale adopted by this study, this value corresponds to the classification of “significant”. Thus, every indicator with an average score greater than or equal to seven for any sustainability criterion (social, economic, environmental, or institutional) met the sufficiency cut-off for each specific sustainability criterion.

System Approach

The assessment of the four categories of the sustainability criteria provided the classification of the indicators under the system framework. The systems approach is based on the concept of system dynamics. It contributes to provide a holistic vision of sustainability and it has often been applied to indicators (Gallopin, 2006; Sterman, 2000; Sanò & Medina, 2012; WWAP, 2003). This research adopted a four-components system framework (social, environmental, economic, and institutional), based on the sustainability criteria presented above.

Categories of the Sustainability Assessment

The results were then classified into four categories (sustainability indicators, bi-dimensional indicators, one-dimensional indicators, and the ones with no relation with sustainability criteria) as described in the Table below. The classification into these categories is based on the number of criteria fulfilled by the indicator. The selected indicators are the ones that fulfil the majority of the sustainability criteria (3 or more criteria).

Table 3 – Categories of the Sustainability Assessment.

Category	Meaning	Number of sustainability criteria complied
Sustainability indicators	Fulfil the majority of the sustainability criteria	3 or more criteria
Other multi-criteria indicator (or bi-dimensional)	Fulfil two sustainability criteria	2 criteria

Uno-criterion indicator (or one-dimensional)	Fulfil one sustainability criterion	1 criterion
No relation with sustainability criteria	Do not fulfil any sustainability criteria	-

3 RESULTS

This study identified 170 indicators related to water use and management in the literature. In total, the 14 members of the panel provided 9,520 results; corresponding to the evaluation of the four sustainability criteria for each of the 170 indicators. The frequency distribution of the results was analysed and summarized in the tables and figures below. The evaluation process yielded from this initial list of 24 key indicators that fulfil the majority of the sustainability criteria. The main findings are presented below.

In the first stage, over 240 indicators related to water resources were found in the specialized literature. Out of those, 170 indicators were identified as addressing aspects related to water use and management. These indicators can be found in Annexes 1, 2 and 3.

From this initial list of 170 indicators of water use and management, 24 indicators (14%) comply with the majority of the sustainability criteria (Annex 1). Fifty-nine are bi-dimensional indicators, meaning that they comply with two sustainability criteria (Annex 2) and 86 indicators are one-dimensional indicators, fulfilling one sustainability criterion (Annex 3). This last annex also presents the only one indicator that did not fulfil any of the sustainability criteria.

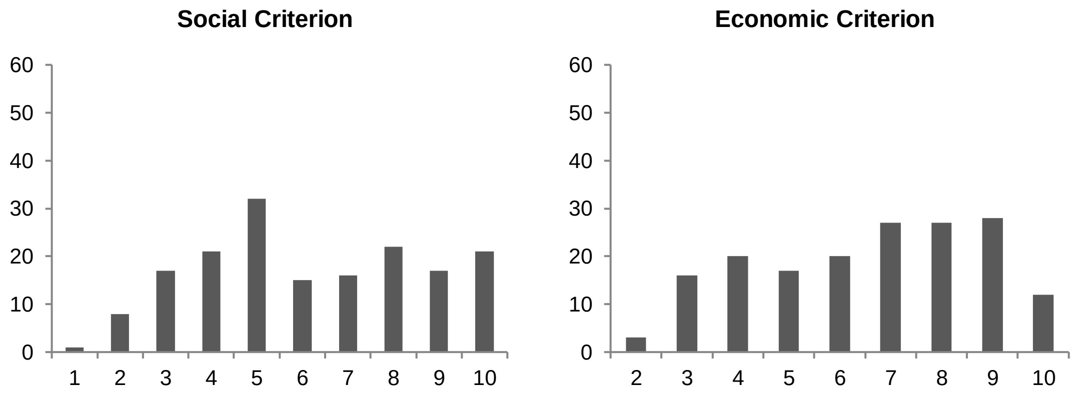
The average result of the set of 170 indicators showed the highest score for the environmental criterion (7.1), followed by the economic (6.1), institutional (5.8), and social (5.7) criteria. Regarding the final list of 24 indicators of sustainability, their average scores range from 8.4 to 7.3. Moreover, in the latter case, the social criterion presents the highest score (8.4), followed by the economic and environmental (7.6 for each case), and institutional (7.3) criteria.

Figure 1 presents the **frequency histograms** for the 170 indicators of water use and management by each of the four sustainability criteria assessed by this research. The main findings are summarized below:

- Forty-five per cent of the scores for the **social** sustainability criterion were greater than or equal to seven. The lowest scores (between one and two) were very unlikely. The most frequent score was five.
- In terms of the **economic** criterion, the scores were between four and ten for 89% of the cases. Fifty-five per cent of the scores were between seven and ten.
- For the **environmental** sustainability criterion, 68% of the indicators had scores between seven and ten. The highest value of the scale (ten) was by far the most frequent grade under this criterion, with 35% of the results.
- The histogram for the **institutional** sustainability criterion showed that four and five were the most common scores, with 17% and 16.5% of the results, respectively. Forty-two per cent of the indicators had average scores greater than or equal to seven.

Table 4 presents the results of the system approach classification of the initial set of 170 indicators and the final set of 24 indicators. It corresponds to the percentage of the indicators that presents each component of the system framework (social, economic, environmental and institutional). Out of the initial set of 170 indicators, 58% (98 indicators) addressed the environmental component, being the highest result among the four components. Nevertheless, the social component was the most frequent one in the final set of 24 indicators: 96% of them (23 indicators).

Table 5 presents the results of the classification for the initial set of 170 indicators and the final set of 24 indicators for the DPSIR framework. On one hand, it is noticeable for both sets that a very limited number of indicators relate to the drive forces (7% of the initial set and none of the final). On the other hand, indicators that describe the state of the environment form the majority of the initial set (53%) and half of the final set of indicators.



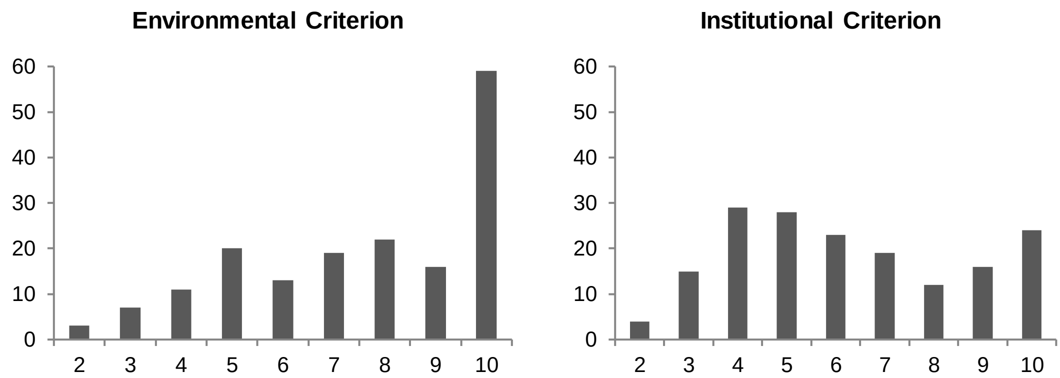


Figure 1 - Frequency histograms for the average scores of the 170 indicators related to water use and management by each of the four sustainability criteria (vertical axis represents the frequency of the answers, and the horizontal represents the scores).

Table 4 – Components of the systems approach of the initial set of 170 indicators and the final set of 24 indicators.

Component	Initial set of 170 indicators	Final set of 24 indicators
Social	36%	96%
Economic	39%	83%
Environmental	58%	71%
Institutional	32%	67%

Table 5 – Components of the DPSIR framework of the initial set of 170 indicators and the final set of 24 indicators.

Component	Initial set of 170 indicators	Final set of 24 indicators
Drive forces	7%	-
Pressure	27%	42%
State	53%	50%
Impact	36%	50%
Response	29%	25%

4 DISCUSSION

Indicators of Sustainable Water Use and Management

The ultimate purpose of this study was to identify the indicators of water use and management that fulfil the sustainability criteria. In order to reach this objective, we analysed specialized literature, constructed an assessment matrix and convened an international panel of experts. Findings of the current study support that 14% (24 indicators) of water use and management fulfil the sustainability criteria.

Eighty-six per cent of the indicators do not fulfil the majority of sustainability criteria, suggesting that most indicators of water use and management reflect the conventional limited view of not considering the multi-dimensionality of sustainability. According to WWAP (2009), the usage of indicators that integrate sustainability criteria is a powerful tool for identifying and monitoring water problems, defining solutions, and evaluating the achievements or failures of policies, plans and programs. However, for their determination, the multi-dimensional perspective of sustainability should be considered. This includes aspects related to the environmental effects (positive and/or negative), the social-economic issues, and the institutional aspects of the indicators.

As noted in the findings of this study, the environmental criterion of the 170 evaluated indicators exhibited a significant number of results between 9 and 10. It shows that generally, the experts coincided in their scores and these values are considered high (68% of the scores are greater than or equal to 7). This prevalence confirmed that, indicators related to water use and management have been usually built for environmental studies.

In general, the 24 indicators that fulfil the sustainability criteria (Annex 1) describe an extensive range of subjects related to water resources. These indicators address issues such as growth in consumption, populations without access to drinking water and/or sanitation, exposure to polluted water sources, and water-related diseases that are associated with imbalances in access to clean and safe water.

The indicator with the highest average score (9.2) is the “water poverty index”, which takes into account the relationships of five components, including the physical extent of water availability, its ease of abstraction, and the level of community welfare (Sullivan and Meigh, 2005). The “Water poverty index” together with the “climate vulnerability index”, “water shortages” and “fraction of the burden of ill-health from nutritional deficiencies” were the only indicators that comply with all four dimensions of sustainability: the average score for each of the four criteria of sustainability was above the threshold.

Among the 24 sustainable indicators, it is noticeable the “water footprint” (WF): a multi-component indicator introduced by Hoekstra and Hung (2002). The WF consists of three components: green, blue and grey water. As mentioned by Hoekstra et al (2011), blue water corresponds to fresh surface or ground water, green water is the precipitation stored in the soil as soil moisture, and grey water is related to water pollution. Pellicer-Martínez & Martínez-Paz (2016) points that water footprint is an indicator that allows a comprehensive view of the sustainability of water use and can be assessed within the framework of IWRM. We recommend further study on this indicator, specially aiming to overcome some limitations regarding the methods for its calculation, as mentioned by Lovarelli et al. (2016).

It should be mentioned, that this study also identified 59 indicators that fulfil two sustainability criteria. Among them are relevant indicators such as "access to safe drinking water": one of the indicators adopted by the United Nations to monitor progress towards the Millennium Development Goals (UN, 2010). These 59 bi-dimensional indicators are distinctive in considering more than just one aspect of sustainability. Therefore, this research recommends the development of further studies about these indicators, especially the ones that presented outstanding grades, i.e. "existence of legislation advocating Dublin principles for water". This indicator received one of the highest scores for the institutional criterion (9.8 as average). It measures the existence of legislation in issues related to water sustainability and management, participatory approach, gender and economic value (ICWE, 1992).

Eighty-six indicators that comply with one of the four sustainability criteria were also identified. They are one-dimensional indicators; which should not be seen as a limitation rather than as a characteristic. They address in an adequate way one of the four components of sustainability, meaning that they are interesting tools that allow seeing, from a specific angle, one of the multiple aspects of water use and management. An interesting example of the former is the "freshwater species population trends index". This indicator, also known as the "freshwater living planet index", tracks changes in freshwater species found in freshwater ecosystems, since the baseline year of 1970, including data on 2,750 populations of 714 species of fish, birds, reptiles, amphibians and mammals (WWF, 2010). It is a very relevant indicator related to the ecological conditions of the watercourses, in fact it received a very high score for the environmental criteria (9.3).

The assessment of the sustainability criteria presented here was the result of the work of an international panel of experts from Ibero-american countries. Therefore future studies could investigate how these indicators perform when assessed by a broader group, including experts from other parts of the world. These further studies could aim to compare results and even identify possible generalizations of the findings. Furthermore, this replication could perhaps point to differences and/or similarities among results and, by doing so, broaden the scope of this study.

DPSIR Framework

The findings of this study showed a noticeable difference in the number of indicators that are classified under the "drive forces" and "state" categories. A much higher amount of indicators (half or more of them) addressed the component "state" and just a few (less then 7%) address the "drive forces". This imbalance emphasizes the need to further develop indicators to assess "drive forces" related to the challenge of sustainable water use and management. These types of indicators are important, as according to WWAP (2006), they assesses the *"underlying factors and the root causes affecting the development of society, the economy and environmental conditions"*. Therefore, this research recommends that indicator developers devote efforts to produce indicators of water use and management focusing on "drive forces".

The assignation of a DSPIR cluster to each of the 170 indicators done by this study was a complex task and confirms Vacik et al. (2006) *"it is always a matter of perspectives"*. The perspective adopted by this study focused on indicators that could measure the sustainable use and management of water. Therefore, other studies could find different framework classifications for these indicators: it is just a matter of perspective.

Several of the indicators assessed in this study are in fact indexes, made up of several sub-components. Considering the multi-dimensional nature of sustainability (social, economic, environmental and institutional issues are interlinked), these indexes were classified in more than one position of the DPSIR framework. For example, the Climate Vulnerability Index (CVI) is an index that considers 6 sub-components (resource, access, uses, capacity, environment and vulnerability). It is classified under four different DPSIR positions, namely Pressure, State, Impact and Response, mainly because its sub-components address very diverse issues, combining them in order to make a holistic assessment of human vulnerability in the context of threats to water resources (Sullivan & Huntingford, 2009).

Usefulness for researchers and policy makers

The list of 170 indicators of water use and management and the set of 24 indicators that fulfil the sustainability criteria are important contributions of our study. They present relevant information in a format that is easy to assess (Annexes 1, 2 and 3). End-users, such as water management institutions, river basin committees, policy and decision makers, can consult these lists in order to identify and select indicators according to their specific needs.

The set of 24 indicators, identified by this study, allows decision makers to measure the sustainability of water use and management. The use of these indicators could contribute to identify and monitor unsustainable water practices, define solutions, and evaluate the achievements or failures of policies, plans, and programs regarding the sustainability of water use and management. Water Management Authorities could use these indicators as relevant elements to set goals and monitor progress at Water Management Plans as well as at Water Management Information Systems. Other possibilities for applying these indicators include supporting the decision-making concerning the concessions of water permits for more sustainable water use.

This study also provides a transparent and reproducible methodological framework that could be applied by the scientific community and indicator developers to identify, select and assess indicators of sustainable water use and management.

5 Conclusions

Indicators are powerful decision making tools and key elements to monitor progress towards sustainable development in the water sector. They should encompass the four dimensions of sustainability: social, economic, environmental, and institutional. Our study aimed to fill these gaps by presenting solid and reliable knowledge on indicators of sustainable water use and management. In order to do this, the research identified the indicators related to IWRM, and evaluated by an international panel of experts to assess whether these indicators fulfil the sustainability criteria.

One hundred and seventy indicators related to water use and management were identified. They were organized in an assessment matrix, described and classified according to the DPSIR framework and the “system approach”. The findings showed that 86% of them do not fulfil the majority of sustainability criteria, suggesting that they do not provide the holistic and multi-dimensional perspectives of sustainability. This should not be seen as a limitation rather than as a characteristic that should be taken into account by decision makers. It is worth mentioning, that 145 indicators addressed in an adequate way one or two of the four components of sustainability, meaning that they are interesting tools that allow us to see some of the multiple aspects of water use and management from specific angles.

This study found that 24 key indicators of water use and management fulfil the majority of the sustainability criteria. The identification of these indicators can be considered a relevant contribution to sustainability research and practice for the water resources sector. These indicators should also provide critical information for water governability.

So far, no other scientific publication that has done a similar assessment has been found. Furthermore, indicator development is a continuous process and therefore this list is not encircled in itself and other indicators may be included by future studies.

Although the identification of these indicators matters, in other to address the key concerns of water managers, the indicators should meet other criteria that go beyond the sustainability criteria. We recommend the development of further studies in order to evaluate the selected indicators based on additional criteria. These criteria should be relevant for the water management community and could include issues such as validity for the proper geographic scale and whether the indicator is based on currently sound and internationally accepted scientific standards.

Despite the widespread recognition of the relevance of indicators to water sustainability worldwide, significant challenges remain. Improved knowledge, research and innovation around this subject are necessary to promote the transition towards sustainable water use and management.

ACKNOWLEDGMENTS

This research has been partially supported by the European Union ALBAN Programme - High Level Scholarships for Latin America. The authors acknowledge the institutional support of the CYTED – Ibero-American Programme for Science, Technology and Development; the ALFA TECSPAR Network; the RESURBE interdisciplinary and multi-sectorial open working platform and RECNET - Recycling the City Network. We are beyond grateful to all of the participants of the panel of experts. The first author gratefully acknowledges Joana Castellar for her academic collaboration. The authors wish to thank Alexandra Muller for proofreading the manuscript. The authors would like to thank the anonymous reviewers.

REFERENCES

Aldaya, M. M., & Llamas, M. R. (2008). Water footprint analysis for the Guadiana river basin Value of Water Research Report Series No. 35. *Value of Water Research Report Series*. Delft, the Netherlands: UNESCO-IHE.

Bélanger, V., Vanasse, A., Parent, D., Allard, G., & Pellerin, D. (2012). Development of agri-environmental indicators to assess dairy farm sustainability in Quebec, Eastern Canada. *Ecological Indicators*, 23, 421–430. doi:10.1016/j.ecolind.2012.04.027

Benson, D., Fritsch, O., Cook, H., & Schmid, M. (2014). Evaluating participation in WFD river basin management in England and Wales: Processes, communities, outputs and outcomes. *Land Use Policy*, *38*, 213–222. doi:10.1016/j.landusepol.2013.11.004

Blanchet, K., & Girois, S. (2012). Selection of sustainability indicators for health services in challenging environments: Balancing scientific approach with political engagement. *Evaluation and Program Planning*, 38, 28–32. http://doi.org/10.1016/j.evalprogplan.2012.11.003

BNIA - Baltimore Neighborhood Indicators Alliance. (2006). *Vital Signs IV: Measuring Baltimore's progress toward strong neighborhoods and a thriving city* (p. 106). Retrieved from http://cdm16352.contentdm.oclc.org/cdm/ref/collection/p15224coll6/id/1744

Bolcárová, P., & Kološta, S. (2015). Assessment of sustainable development in the EU 27 using aggregated SD index. *Ecological Indicators*, 48, 699–705. doi:10.1016/j.ecolind.2014.09.001

Bradfor, A. (2008). An ecological flow assessment framework: building a bridge to implementation in Canada. *Canadian Water Resources Journal*, 33(3), 215-232.

Canter, L. (1999). Environmental impact assessment, 2. Recuperado a partir de ftp://www.energia.bme.hu/pub/hullgazd/Environmental Engineers' Handbook/Ch02.pdf

Cap-Net UNDP. (2008). Integrated Water Resources Management for River Basin Organisations. Pretoria.

Carneiro, A. P., Silva, H., Abraham, E., Subirana, A., & Morató, J.F. (2006). Indicadores de eficiência sócio-econômica-ambiental do uso da água em terras secas da iberoamérica. In*: 5o Congresso Ibérico sobre gestão e planejamento da agua*. Faro: Portugual.

Cloquell-Ballester, V. A., Monterde-Díaz, R., & Santamarina-Siurana, M. C. (2006). Indicators validation for the improvement of environmental and social impact quantitative assessment. *Environmental Impact Assessment Review*, 26(1), 79–105. doi:10.1016/j.eiar.2005.06.002

Constantino, C., Falcitelli, F., Femia, A., & Tudini, A. (2004). Integrated Environmental and Economic Accounting in Italy. *OECD General Economics and Future Studies*, 9, 240–259.

Cornescu, V., & Adam, R. (2014). Considerations Regarding the Role of Indicators Used in the Analysis and Assessment of Sustainable Development in the E.U. *Procedia Economics and Finance*, *8*(14), 10–16. doi:10.1016/S2212-5671(14)00056-2

Dahl, A.L. (2012). Achievements and gaps in indicators for sustainability. *Ecological Indicators*, *17*, 14-19. doi:10.1016/j.ecolind.2011.04.032

De Felipe, J. J.; Sureda, B., & Cruz, I. (2008). Informe de Sostenibilitat a Catalunya. Generalitat de Catalunya, Barcino Solucions Gràfiques.

Ding, Y., Widhalm, M., & Hayes, M. J. (2010). Measuring Economic Impacts of Drought: A Review and Discussion. *Papers in Natural Resources*. Paper 196., 26. Retrieved from http://digitalcommons.unl.edu/natrespapers/196

EEA - European Environment Agency. (1999). *Environmental indicators : Typology and overview*. Copenhagen. Retrieved from http://www.eea.europa.eu/publications/TEC25/at_download/file

Elkington, J. (1997). Cannibals with Forks: The Triple Bottom Line of Twenty-First Century Business. Capstone, Oxford

Eurostat - European Commission. (2009). *2009 monitoring report of the EU sustainable development strategy*. Retrieved from http://ec.europa.eu/eurostat/documents/3217494/5703739/KS-78-09-865-EN.PDF/7ccc9240-03ae-40da-b2d8-2cc8a28df320.

Falkenmark, M., & Lindh, G. (1974). Impact of Water Resources on Population. *Submitted by the Swedish Delegation to the UN World Population Conference*, Bucharest

FAO - Food and Agriculture organization of the United Nations. (2003). Review of world water resources by country. Rome. Retrieved from http://www.fao.org/DOCREP/005/Y4473E/y4473e07.htm

Fu, C., Large, S., Knight, B., Richardson, A. J., Bundy, A., Reygondeau, G., … Shin, Y. (2015). Relationships among fisheries exploitation, environmental conditions, and ecological indicators across a series of marine ecosystems. *Journal of Marine Systems*, 148, 101–111. http://doi.org/10.1016/j.jmarsys.2015.01.004

Gallopin, G. (2006). Los indicadores de desarrollo sostenible: aspectos conceptuales y metodológicos. *In: Seminario de expertos sobre indicadores de sostentabilidad en la formulación y seguimiento de políticas publicas*, 2006, Santiago, Chile.

Gossner, M. M., Fonseca, C. R., Pašalić, E., Türke, M., Lange, M., & Weisser, W. W. (2014). Limitations to the use of arthropods as temperate forests indicators. *Biodiversity and Conservation*, *23*(4), 945–962. http://doi.org/10.1007/s10531-014-0644-3

Graymore, M. L. M., Sipe, N. G., & Rickson, R. E. (2008). Regional sustainability: How useful are current tools of sustainability assessment at the regional scale? *Ecological Economics*, *67*(3), 362-372. doi:10.1016/j.ecolecon.2008.06.002

Grey, D., & Sadoff, C. (2006). *Water for Growth and Development. Thematic Documents of the IV World Water Forum. Comision Nacional del Agua*: Mexico City.

GWP - Global Water Partnership. (2004a). *Current Status of National Efforts to Move Towards Sustainable Water Management Using an IWRM Approach* (p. 29). Stockholm: GWP.

GWP - Global Water Partnership. (2004b). *2005 WSSD Target on National IWRM Planning: Informal Stakeholder Baseline Survey*. Retrieved from http://www.gwp.org/Global/ToolBox/About/IWRM/Progress%20towards%20IWRM%20%28Plans%20and%20Strategies%29/Informal%20Stakeholder%20Baseline%20Survey%20%28GWP,%202004%29.pdf

GWP - Global Water Partnership. (2006). *Setting the stage for change - Second informal survey by the GWP network giving the status of the 2005 WSSD target on national integrated water resources management and water efficiency plans* (p. 84). Retrieved from http://www.gwptoolbox.org/images/stories/Docs/gwp_setting the stage for change 2006.pdf

Hak, T., Kovanda, J., & Weinzettel, J. (2012). A method to assess the relevance of sustainability indicators: Application to the indicator set of the Czech Republic's Sustainable Development Strategy. *Ecological Indicators*, *17*, 46–57. doi:10.1016/j.ecolind.2011.04.034

Hardi, P. & Zdan T. (1997). Assessing sustainable development: Principles in practice. International Institute for Sustainable Development, Winnipeg, Saskatchewan. Retrieved from https://www.iisd.org/pdf/bellagio.pdf

Hawkes, J. (2001). The fourth pillar of sustainability: culture's essential role in public planning. Common Ground Publishing Pty Ltd , Victoria

Hellegers, P. J. G. J., Soppe, R., Perry, C. J., & Bastiaanssen, W. G. M. (2010). Remote Sensing and Economic Indicators for Supporting Water Resources Management Decisions. *Water Resources Management*, 24(11), 2419–2436. http://doi.org/10.1007/s11269-009-9559-2

Hoekstra, A. Y. (2009). Human appropriation of natural capital: A comparison of ecological footprint and water footprint analysis. *Ecological Economics*, 68(7), 1963–1974. doi:10.1016/j.ecolecon.2008.06.021

Hoekstra, A. Y. (2010). The Global Dimension of Water Governance: Why the River Basin Approach Is No Longer Sufficient and Why Cooperative Action at Global Level Is Needed. *Water*, 3, 21-46; doi:10.3390/w3010021

Hoekstra, A. Y., & Hung, P. Q. (2002). *Virtual water trade: A quantification of virtual water flows between nations in relation to international crop trade* (p. 120). Delft, the Netherlands.

Hooper, B. P. (2006). *Key Performance Indicators of River Basin Organizations*. Carbondale: Southern Illinois University. Retrieved from http://www.iwr.usace.army.mil/Portals/70/docs/iwrreports/2006-VSP-01.pdf

ICWE - International Conference on Water and the Environment. (1992). *The Dublin Statement and Report of the Conference*. International Conference on Water and the Environment: Development Issues for 21st century. 26-31 January. Dublin.

IISD - International Institute for Sustainable Developed. (1999). 'Beyond Delusion: A Science and Policy Dialogue on Designing Effective Indicators for Sustainable Development'. *Workshop report*. Retrieved from http://www.iisd.org/publications/beyond-delusion-science-and-policy-dialogue-designing-effective-indicators-sustainable

IISD - International Institute for Sustainable Developed. (2008). Bellagio STAMP: Sustainability Assessment and Measurement Principles. Winnipeg: IISD. Retrieved from http://www.iisd.org/pdf/2009/brochure_bellagiostamp.pdf

Juwana, I., Muttil, N., & Perera, B. J. C. (2012). Indicator-based water sustainability assessment - a review. *The Science of the Total Environment*, 438, 357–71. doi:10.1016/j.scitotenv.2012.08.093

Kang, M.G., & Lee, G.M. (2011). Multicriteria Evaluation of Water Resources Sustainability in the Context of Watershed Management1. *JAWRA Journal of the American Water Resources Association*, 47(4), 813–827. doi:10.1111/j.1752-1688.2011.00559.x

Klug, H., & Kmoch, A. (2014). Operationalizing environmental indicators for real time multi-purpose decision making and action support. *Ecological Modelling*, *295*, 66–74. doi:10.1016/j.ecolmodel.2014.04.009

Kurka, T., & Blackwood, D. (2013). Participatory selection of sustainability criteria and indicators for bioenergy developments. Renewable and Sustainable Energy Reviews, 24, 92–102. doi:10.1016/j.rser.2013.03.062

Kurtz, J.C., Jackson, L.E., & Fisher, W.S. (2001). Strategies for Evaluating Indicators Based on Guidelines from the Environmental Protection Agency's Office of Research and Development. *Ecological Indicators*, 1(1), 49–60.

Lawrence P., Meigh J., & Sullivan C. (2002). The Water Poverty Index: an International Comparison. *Keele Economics Research Papers*. Keele University, 1-17. Doi: 10.1111/1477-8947.00054

Lobato, T. C., Hauser-Davis, R. a., Oliveira, T. F., Silveira, a. M., Silva, H. a. N., Tavares, M. R. M., & Saraiva, a. C. F. (2015). Construction of a novel water quality index and quality indicator for reservoir water quality evaluation: A case study in the Amazon region. Journal of Hydrology, 522, 674–683. http://doi.org/10.1016/j.jhydrol.2015.01.021

Lovarelli, D., Bacenetti, J., & Fiala, M. (2016). Water Footprint of crop productions: A review. *Science of The Total Environment*, *548–549*, 236–251. doi:http://dx.doi.org/10.1016/j.scitotenv.2016.01.022

Ludwig, F., van Slobbe, E., & Cofino, W. (2013). Climate change adaptation and Integrated Water Resource Management in the water sector. Journal of Hydrology, 518, 235–242. doi:10.1016/j.jhydrol.2013.08.010

Maneta M., Singh, P., Torres, M., Wallender, W., Vosti, S., Rodrigues, L., Bassoi, L., & Young, J.(2009). A parsimonious crop-water productivity index: an application to Brazil. *Area*, 41(1), 94-106. Doi: 10.1111/j.1475-4762.2008.00845.x

Mays, L. 2006. *Water Resources Sustainability*. New York, McGraw-Hill.

McCool, S. F., & Stankey, G. H. (2004). Indicators of sustainability: Challenges and opportunities at the interface of science and policy. *Environmental Management*, *33*(3), 294–305. doi:10.1007/s00267-003-0084-4

Mendoza, G.A., & Prabhu, R. (2003). Qualitative multi-criteria approaches to assessing indicators of sustainable forest resource management. *Forest Ecology and Management*, 174(1-3), 329–343. doi:10.1016/S0378-1127(02)00044-0

Milman, A., & Short, A. (2008). Incorporating resilience into sustainability indicators: An example for the urban water sector. *Global environmental change-human and policy dimensions*, 18(4), 758-767. Doi: 10.1016/j.gloenvcha.2008.08.002

MMA - Ministério do Meio Ambiente. (2006). *Plano Nacional de Recursos Hídricos. Ministério do Meio Ambiente*. Secretaria de Recursos Hídricos. Brasília, DF:B.R. Retrivied from http://www.mma.gov.br/estruturas/161/_publicacao/161_publicacao03032011025152.pdf

Moldan, B., Janoušková, S., & Hák, T. (2012). How to understand and measure environmental sustainability: Indicators and targets. *Ecological Indicators*, *17*, 4–13. doi:10.1016/j.ecolind.2011.04.033

Nicholson, E., Collen, B., Barausse, A., Blanchard, J. L., Costelloe, B. T., Sullivan, K. M. E., … Milner-Gulland, E. J. (2012). Making robust policy decisions using global biodiversity indicators. *PLoS ONE*, 7(7). doi:10.1371/journal.pone.0041128

Niemeijer, D., & de Groot, R. S. (2008). A conceptual framework for selecting environmental indicator sets. *Ecological Indicators*, 8(1), 14–25. doi:10.1016/j.ecolind.2006.11.012

Niemi, G.J., & McDonald, M.E., (2004). Application of ecological indicators. *Annu. Rev. Ecol. Evol. Syst*. 35, 89–111. NRC.

Norman, E. S., Dunn, G., Bakker, K., Allen, D. M., & de Albuquerque, R. C. (2013). Water Security Assessment: Integrating Governance and Freshwater Indicators. *Water Resources Management*, *27*(2), 535–551. http://doi.org/10.1007/s11269-012-0200-4

OECD - Organization for Economic Cooperation and Development. (1994). *Environmental indicators: OECD core set*. Paris

OECD - Organization for Economic Cooperation and Development. (2004).OECD Key Environmental indicators. Retrivied from http://www.oecd.org/env/indicators-modelling-outlooks/31558547.pdf

OECD. (2014). Green Growth Indicators 2014, OECD Green Growth Studies, OECD Publishing. http://dx.doi.org/10.1787/9789264202030-en

OSE - Observatorio de la Sostenibilidad en España. (2008). *Agua y Sostenibilidad: Funcionalidad de las cuencas*. Ministerio del Medio Ambiente y Medio Rural y Marino. Retrieved from http://www.upv.es/contenidos/CAMUNISO/info/U0637193.pdf

Pellicer-Martínez, F., & Martínez-Paz, J. M. (2016). The Water Footprint as an indicator of environmental sustainability in water use at the river basin level. *Science of The Total Environment*, *In Press,* . doi:http://dx.doi.org/10.1016/j.scitotenv.2016.07.022

Perez, M., Tujchneider, O., Paris, M., & D'Elía, M. (2014). Sustainability indicators of groundwater resources in the central area of Santa Fe province, Argentina. *Environmental Earth Sciences*, 73(6), 2671–2682. http://doi.org/10.1007/s12665-014-3181-1

Pires, S. M., & Fidélis, T. (2015). Local sustainability indicators in Portugal: assessing implementation and use in governance contexts. *Journal of Cleaner Production*, 86. http://doi.org/10.1016/j.jclepro.2014.08.002

Rosén, L., Back, P.-E., Söderqvist, T., Norrman, J., Brinkhoff, P., Norberg, T., … Döberl, G. (2015). SCORE: A novel multi-criteria decision analysis approach to assessing the sustainability of contaminated land remediation. *Science of The Total Environment*, *511*, 621–638. doi:10.1016/j.scitotenv.2014.12.058

Sanò, M., & Medina, R. (2012). A systems approach to identify sets of indicators: Applications to coastal management. *Ecological Indicators*, *23*, 588–596. doi:10.1016/j.ecolind.2012.04.016

Scudder, T. (2005) *The Future of Large Dams: Dealing with Social, Environmental, Institutional and political costs*. London.

Sheppard, S. R. J., & Meitner, M. (2005). Using multi-criteria analysis and visualisation for sustainable forest management planning with stakeholder groups. *Forest Ecology and Management*, 207(1-2), 171-187. doi:10.1016/j.foreco.2004.10.032

Singh, R. K., Murty, H. R., Gupta, S. K., & Dikshit, A. K. (2009). An overview of sustainability assessment methodologies. *Ecological Indicators*, *9*(2), 189-212. doi:10.1016/j.ecolind.2008.05.011

SNZ - Statistics New Zealand. (2002) Socio-economic indicators for the environment. Environmental Statistics Team, Christchurch. http://www2.stats.govt.nz/domino/external/web/prod_serv.nsf/092edeb76ed5aa6bcc256afe0081d84e/94b7f3198c9d9111cc256c1500171ea6?OpenDocument

Spangenberg, J. H. (2004). Reconciling Sustainability and Growth: Criteria, Indicators, Policies. *Sustainable Development*. 12, 74–86.

Spangenberg, J. H. (2008). Second order governance: Learning processes to identify indicators. *Corporate Social Responsibility and Environmental Management*, 15(3), 125–139. doi:10.1002/csr.137

Spangenberg, J. H., Douguet, J.-M., Settele, J., & Heong, K. L. (2015). Escaping the lock-in of continuous insecticide spraying in rice: Developing an integrated ecological and socio-political DPSIR analysis. *Ecological Modelling*, 295, 188–195. doi:10.1016/j.ecolmodel.2014.05.010

Spiller, M. (2016). Adaptive capacity indicators to assess sustainability of urban water systems – Current application. *Science of The Total Environment*, *569–570*, 751–761. doi:http://dx.doi.org/10.1016/j.scitotenv.2016.06.088

Sterman, J.D. (2000). *Systems Dynamics. Systems Thinking and Modeling for a Complex World.* McGraw Hill.

Sullivan ,C. (2001) The potential for calculating a meaningful Water Poverty Index. *Water Int,* 26, 471–480

Sullivan, C., & Huntingford, C. (2009). Water resources, climate change and human vulnerability. *18th World IMACS/MODSIM Congress,* ..., (July), 3984–3990. Retrieved from http://www.kmafrica.com/files/sullivan_ca.pdf

Sullivan, C., & Meigh, J. (2005) Targeting attention on local vulnerabilities using an integrated indicator approach: the example of the Climate Vulnerability Index. *Water Science and Technology, Special Issue on Climate Change,* 51(5) 69–78, 30, 1195-1210.

Sullivan, C., Meigh, J., & Fediw, T. (2002). *Derivation and Testing of the Water Poverty Index Phase 1. Center for Ecology and Hydrology CEH. Natural* ... (Vol. 1, p. 53). Wallingford. Retrieved from http://www.soas.ac.uk/water/publications/papers/file38386.pdf

Sullivan, C., Meigh, J., Ecology, C., & Lawrence, P. (2006). Application of the Water Poverty Index at Different Scales*: A Cautionary Tale*, *31*(3), 412–426.

Taugourdeau, S., le Maire, G., Avelino, J., Jones, J. R., Ramirez, L. G., Jara Quesada, M., ... Roupsard, O. (2014). Leaf area index as an indicator of ecosystem services and management practices: An application for coffee agroforestry. *Agriculture, Ecosystems and Environment*, 192, 19–37. http://doi.org/10.1016/j.agee.2014.03.042

Turner, D. W. (2010). Qualitative Interview Design : A Practical Guide for Novice Investigators. *The Qualitative Report*, *15*(3), 754–760. Retrieved from http://www.nova.edu/ssss/QR/QR15-3/qid.pdf

UN - United Nations. (1992). *AGENDA 21.* United Nations Conference on Environment & Development. United Nations Division for Sustainable Development Rio de Janerio, Brazil

UN - United Nations. (2007a). *Groundwater Resources Sustainability Indicators*. Retrieved from http://unesdoc.unesco.org/images/0014/001497/149754e.pdf

UN - United Nations. (2007b). *Indicators of Sustainable Development : Guidelines and Methodologies*. New York: United Nations. Retrieved from http://www.un.org/esa/sustdev/natlinfo/indicators/guidelines.pdf

UN - United Nations. (2009*). Final Report of the Expert Group on Indicators, Monitoring, and Data Bases* (EG-IMD) (p. 26). Colombella.

UN - United Nations. (2010). The Millennium Development Goals Report. *Change*. Retrieved from https://visit.un.org/millenniumgoals/2008highlevel/pdf/MDG_Report_2008_Addendum.pdf

UN - United Nations. (2010). *UN-Water Task Force on Indicators, Monitoring and Reporting - Final Report - Monitoring progress in the water sector: A selected set of indicators - Annexes: Indicators in use* (p. 47).

UN Water – The United Nations Inter-agency Mechanism on all freshwater related issues including sanitation. (2008). *Status Report on Integrated Water Resources Management and Water Efficiency Plans for CSD16* (p. 53). Retrieved from http://www.unwater.org/downloads/UNW_Status_Report_IWRM.pdf

UN Water – The United Nations Inter-agency Mechanism on all freshwater related issues including sanitation. (2010). *UN-water global annual assessment of sanitation and drinking-water (GLAAS) 2010: targeting resources for better results* (p. 90). Retrieved from http://whqlibdoc.who.int/publications/2010/9789241599351_eng.pdf

UN-HABITAT – United Nations Human Settlements Progamme. (2003). *Guide to Monitoring Target 11: Improving the lives of 100 million slum dwellers* (p. 15). NAIROBI. Retrieved from http://ww2.unhabitat.org/programmes/guo/documents/mdgtarget11.pdf

UN-HABITAT – United Nations Human Settlements Progamme. (2008). *State of the World's Cities 2010/2011: Bridging the Urban Divide*. (Earthscan, Ed.) (p. 244). London: UN-HABITAT.

UN-HABITAT – United Nations Human Settlements Progamme. (2009*). Global Urban Indicators – Selected statistics: Monitoring the Habitat Agenda and the Millennium Development Goals* (p. 123). NAIROBI. Retrieved from http://www.unhabitat.org/downloads/docs/global_urban_indicators.pdf

UNDESA, 2007. Indicators of Sustainable Development: Guidelines and Methodologies, 3rd Edition. UN Department of Economic and Social Affairs , New York.

UNDPCSD - United Nations Division for Sustainable Development Department of Policy Co-ordination and Sustainable Development. (1995). Work programme on indicators of Sustainable Development. United Nations, New York.

UNECE - United Nations Economic Commission for Europe. (2003). *EEA core set of indicators.* Retrieved from http://www.unece.org/fileadmin/DAM/env/europe/monitoring/StPetersburg/EEA%20Core%20Set%20of%20Indicators%20rev2EECCA.pdf

UNECE - United Nations Economic Commission for Europe. (2007). *Guidelines for the application of environmental indicators in eastern Europe*. Retrived from http://www.unece.org/fileadmin/DAM/stats/documents/ece/ces/ge.33/2009/zip.7.e.pdf

Vacik, H., Wolfslehner, B., Seidl, R., & Lexer, M. J. (2006). Integrating the DPSIR - approach and the Analytic Network Process for the assessment of forest management strategies. In I. 978-0-9789478-0-4 Reynolds, K.M. (ed.) 2006. Proceedings of the IUFRO Conference on Sustainable Forestry in Theory and Practice. Edinburgh, Scotland. 5-8 April 2005. Gen. Tech. Rep. PNW-GTR-688. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwes (Ed.), *Proceedings of the IUFRO Conference on Sustainable Forestry in Theory and Practice*.

Van Teijlingen, E., & Hundley, V. (2001). The importance of pilot studies. *Social Research UPDATE*, *16*(35), 33–36. doi:10.7748/ns2002.06.16.40.33.c3214

Vörösmarty, C. J., Douglas, E. M., Green, P. A., & Revenga, C. (2005a). Geospatial indicators of emerging water stress: an application to Africa. *Ambio*, 34(3), 230–6. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/16042282

Vörösmarty, C. J., Green, P., Salibury, J., & Lammers, R. (2000). Global Water Resources: Vulnerability from Climate Change and Population Growth. *Science*, 289(5477), 284–288. doi:10.1126/science.289.5477.284

Vörösmarty, C. J., Revenga, C., Le, C., Bos, R., Caudill, C., Chilton, J. (2005b). *Fresh Water*. Millennium Ecosystem Assessment. Island Press.

WBCSD - World Business Council for Sustainable Development. (2000). *Measuring eco-efficiency: a guide to reporting company performance*. London.

WBCSD & IUCN - World Business Council for Sustainable Development & International Union for Conservation of Nature. (2010*). Water for Business: Initiatives guiding sustainable water management in the private sector* (Geneva and., p. 40). Retrieved from http://www.wbcsd.org/web/water4business.pdf

WHO - World Health Organization. (2002). *Health in Sustainable Development Planning: The Role of Indicators* (p. 42). Geneva.

WHO - World Health Organization. (2006). Weekly epidemiological record. *Relevé épidémiologique hebdomadaire*, 81(31), 297–308. Retrieved from http://www.who.int/wer/2006/wer8131.pdf

WHO & UNICEF - World Health Organization United Nations International Children's Emergency Fund. (2008). *Progress on Drinking Water and Sanitation: Special Focus on Sanitation*. (p. 58). New York / Geneva. Retrieved from http://www.who.int/water_sanitation_health/monitoring/jmp2008.pdf

WHO & UNICEF - World Health Organization United Nations International Children's Emergency Fund. (2010). *Progress on Sanitation and Drinking-water: 2010 Update* (p. 60). New York 10017,. Retrieved from http://www.unicef.org/media/files/JMP-2010Final.pdf

Wilhite, D. (2005*). Drought and Water Crises: Science, Technology, and Management Issues*. (T. & Francis, Ed.) (p. 406). London: CRC Press.

Wilhite, D. a., Svoboda, M. D., & Hayes, M. J. (2007). Understanding the complex impacts of drought: A key to enhancing drought mitigation and preparedness. *Water Resources Management*, 21(5), 763–774. doi:10.1007/s11269-006-9076-5

Wimmer, R., & Dominick, J. (2010) Mass Media Research: An Introduction, 480p., Cengage Learning; 9 edition

Wolfslehner, B., & Vacik, H. (2011). Mapping indicator models: From intuitive problem structuring to quantified decision-making in sustainable forest management. *Ecological Indicators*, *11*(2), 274–283. doi:10.1016/j.ecolind.2010.05.004

World Bank. (2007). *Making the Most of Scarcity: Accountability for Better Water Management Results in the Middle East and North Africa* (p. 235)

WRI - World Resource Institute. (1998). *Watersheds of the World: An Assessment of the Ecological Value and Vulnerability of the World's Watersheds*. Retrieved from http://www.wri.org/publication/watersheds-world

WWAP - World Water Assessment Programme. (2012). The United Nations World Water Development Report 4: Managing Water under Uncertainty and Risk. Paris: UNESCO.

WWAP - World Water Assessment Programme. (2003). The United Nations World Water Development Report: Water for People Water for life. Paris: UNESCO, and London: Earthscan.

WWAP - World Water Assessment Programme. (2006). The United Nations World Water Development Report 2: Water - A Shared Responsibility. Paris: UNESCO, and London: Earthscan.

WWAP - World Water Assessment Programme. (2009). The United Nations World Water Development Report 3: Water in a Changing World. Paris: UNESCO, and London: Earthscan.

WWF – World Wild Fund for Nature. (2010). *Living Planet Report 2010: Biodiversity, biocapacity and development*. Gland.

WWF (World Wide Fund for Nature). (2010). *Living Planet Report 2010: Biodiversity, biocapacity and development* (p. 116). Gland.

Zhang, Z. (2015). Tree-rings, a key ecological indicator of environment and climate change. *Ecological Indicators*, *51*, 107–116. http://doi.org/10.1016/j.ecolind.2014.07.042

Zhao, X., Wu, P., Gao, X., & Persaud, N. (2013). Soil Quality Indicators in Relation To Land Use and Topography in a Small Catchment on the Loess Plateau of China. *Land Degradation & Development*, 61(February 2013), n/a–n/a. http://doi.org/10.1002/ldr.2199

Annex 1 – The 24 indicators that fulfil the majority of the sustainability criteria - selected indicators for our research.

Indicator	Description	DPSIR Frame-work	Criteria average score and standard deviation*				Overall average
			Soc.	Econ.	Env.	Inst.	
Water Poverty Index	Provides a better understanding of the relationship among the physical extent of water availability, its ease of abstraction and the level of community welfare. Evaluates 5 strategic elements: resource, access, management capacity, uses, and environment.	P, S, I, R	**9.8** (0.8)	**8.9** (1.5)	**9.3** (1.3)	**8.8** (2.9)	9.2 (1.3)
Climate Vulnerability Index	Links water resources with human vulnerability assessments, considering the following aspects: geographical vulnerability of the location, water resources available, access to water, how effectively water is used, capacity to manage water, and environmental impacts.	P, S, I, R	**9.4** (1.3)	**7.6** (2.6)	**9.8** (0.8)	**7.9** (3.6)	8.7 (1.6)
Water shortages	Represents the number of people and countries affected by water shortages, the number of countries unable to supply minimum drinking water.	I	**9.5** (1.1)	**8.9** (1.5)	**7.6** (2.7)	**7.5** (3.6)	8.4 (1,3)
Fraction of the burden of ill-health from nutritional deficiencies	Accounts for the percentage of the burden of ill-health resulting from nutritional deficiencies, attributable to water scarcity effects on food supply.	I	**8.9** (1.5)	**8.2** (1.5)	**7.1** (3.5)	**7.4** (2.6)	7.9 (1.6)
Water Reuse Index	Considers consecutive water withdrawals for domestic, industrial, and agricultural water use along a river network relative to available water supplies. A measure of upstream competition and potential ecosystem and human health impacts.	P, S	**9.6** (1.1)	**8.1** (1.5)	**9.6** (1.1)	6.9 (3.2)	8.5 (1.1)
Water Footprint	The sum of water directly used and virtual water. Represents the amount of water required to produce the resources needed by one person, based on lifestyle and consumption.	P	**9.1** (1.4)	**8.6** (1.6)	**9.5** (1.1)	5.7 (4.8)	8.2 (1.7)
Incidence of worms, scabies, trachoma, diarrhea	Represents the number of countries that have presented incidence of worms, scabies, trachoma, and diarrhea above predefined limits. Considers health problems in urban populations linked to contaminated water, lack of water supply, and sanitation.	I	**9.4** (1.3)	6.8 (3.9)	**8.5** (1.6)	**8.2** (2.8)	8.2 (1.7)
Performance Index of Water Utilities	Accounts for the performance of water service providers in urban areas assessed in terms of affordability, quality of water supplied, accessibility to service, quantity of water supplied, and reliability. The level of performance of these utilities dictates how well the cities are being served.	S	**9.3** (1.3)	**7.9** (2.8)	6.3 (3.8)	**9.3** (1.3)	8.2 (1.3)
Access to Improved Sanitation	Represents the proportion of the population (total, urban, and rural) with access to an improved sanitation facility (for defecating).	I	**9.5** (1.1)	6.9 (3.3)	**8.2** (1.5)	**7.6** (2.7)	8.0 (1.4)
Proportion of Urban Population Living in Slums	Provides a measure for identifying the percentage of the urban population living in slums based on an assessment of the following several conditions: access to safe water, access to sanitation, secure tenure, durability of housing, and sufficient living area.	P, S	**9.3** (1.3)	**8.6** (1.6)	6.6 (3.2)	**7.5** (3.6)	8.0 (1.8)
Social and Economic Impacts from Drought	Considers water-related disasters: number of drought and the socioeconomic losses associated with them (deaths, people affected, and property damage).	I	**7.7** (3.5)	**8.4** (2.8)	**9.4** (1.3)	**5.9** (4.1)	7.8 (2.1)
Incidence of cholera	Represents the number of cholera cases per region. The disease is linked to contaminated water and food and occurs more frequently where access to safe drinking water and basic sanitation cannot be ensured.	I	**9.6** (1.1)	**6.6** (3.8)	**8.0** (2.7)	**7.1** (3.3)	7.8 (1.7)

Annex 1 – The 24 indicators that fulfil the majority of the sustainability criteria - selected indicators for our research (cont.).

Indicator	Description	DPSIR Frame-work	Criteria average score and standard deviation*				Overall average
			Soc.	Econ.	Env.	Inst.	
Causes of food emergencies	Considers the causes of food emergencies: comparison between number of countries affected vs. human-induced disasters and number of countries affected vs. natural disasters.	I	**8.1** (2.8)	**7.6** (2.7)	**8.9** (1.5)	6.6 (3.2)	7.8 (1.6)
Ecological footprint	The amount of land required to produce the resources needed by one person, based on land type (arable, pasture, forest, fossil energy land, built-up area, and water area) and consumption (food, housing, transportation, goods, services. and waste).	P	**9.1** (1.4)	**7.3** (3.5)	**9.5** (1.1)	5.2 (4.5)	7.8 (1.8)
Progress towards achieving IWRM target	Categorizes countries into three groups based on ten specific criteria of Integrated Water Resources Management: 1) good progress and being on the road towards meeting the target; 2) only some progress; 3) hardly any progress made.	R	**7.3** (3.4)	**7.1** (3.3)	6.6 (3.8)	**10.0** (0.0)	7.7 (2.2)
Water Provision Resilience	Provides a means of approximating the ability of a city or water provider to maintain or increase the portion of the population with access to safe water. Assesses six aspects: supply, finances, infrastructure, service provision, water quality, and governance.	S, R	**8.0** (2.7)	**7.6** (1.3)	5.6 (3.9)	**9.1** (1.4)	7.6 (1.8)
Major drought events and their consequences	List of major drought events and their associated loss of life and economic losses in the last 100 years.	I	**7.3** (3.4)	**9.1** (1.4)	**8.0** (2.7)	4.9 (4.5)	7.3 (1.6)
Relative Water Stress Index	Domestic, Industrial, and Agricultural water demand per available water supply. This indicator is also known as Relative Water Demand (RWD). RWSI = DIA / Q	P, S	**8.5** (1.6)	**8.7** (1.5)	**7.0** (4.0)	4.9 (4.0)	7.3 (1.5)
Index of Non-sustainable Water Use	It is the result of renewable available freshwater resources (Q) minus geospatially distributed human water demand for Domestic, Industrial, and Agricultural (DIA). INSWU = Q - DIA	P, S	**8.9** (1.5)	**8.5** (1.6)	**8.0** (2.7)	3.2 (3.9)	7.2 (1.4)
Water sector share in total public spending	Represents the percentage of the national budget spent in the water sector for expanding access to water supplies and improving water resources management and governance.	R	**7.3** (3.4)	**7.3** (3.4)	4.7 (3.3)	**9.4** (1.3)	7.2 (1.7)
Country's dependence ratio	The relation between the surface and ground water that inflows from neighbouring countries (or other given geographic divisions) and the total amount of water available at annual bases.	P, S, I	**7.0** (4.2)	**7.2** (2.5)	6.8 (4.1)	**7.5** (3.6)	7.1 (2.1)
Pro-poor and pro-efficiency water fees	Assesses the application of economic and financial tools in water allocation (fees and charges) favoring the poor (pro-poor policy) and efficient water use.	S, I	**7.1** (3.5)	**8.4** (1.6)	4.0 (3.9)	**8.9** (1.5)	7.1 (2.0)
Water topics in school curriculum	Represents the number of countries (or other geographic division) that have introduced water-related content into school curricula.	S	**8.9** (1.5)	2.4 (3.8)	**7.1** (3.5)	**8.3** (2.9)	6.7 (1.8)
Total water storage capacity	The total water storage capacity in artificial storage structures above a minimum size (e.g. 5000 m^3)	P, S, R	4.5 (4.4)	**7.2** (2.5)	**7.1** (3.5)	**7.2** (2.5)	6.5 (2.0)

*Criteria average score and standard deviation: Social, Economic, Environmental and Institutional.

Sources: see Annex 3

Annex 2 - Indicators that comply with two sustainability criteria (bi-dimensional).

Indicator	Description	DPSIR Frame-work	Criteria average score and standard deviation*				Overall average
			Soc.	Econ.	Env.	Inst.	
Existence of legislation advocating Dublin principles for water (1992)	Existence of legislation in issues related to water sustainability and management, participatory approach, gender and economic value (is the base-line for IWRM)	R	6.8 (3.3)	6.8 (3.3)	**7.6** (2.7)	**9.8** (0.8)	7.8 (1.8)
Access to safe drinking water	The proportion of the population (total, urban and rural) with access to an improved drinking water source as their main source of drinking water.	I	**9.8** (0.8)	**7.6** (2.6)	6.4 (3.7)	6.6 (3.8)	7.6 (1.6)
Water use by sector	Water withdrawal by sector as a percentage of total water withdrawal	S	**8.5** (1.6)	**8.5** (1.6)	6.3 (4.3)	6.4 (3.7)	7.4 (1.5)
Burden of water-associated diseases (expressed in DALYs) with Comparative Risk Assessment	Total amount of DALYs related to water-associated diseases. In the poorest regions of the world, unsafe water, sanitation and hygiene are major contributors to loss of healthy life, expressed in DALYs (Disability Adjusted Life Years). The sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability. The Comparative Risk Assessment (CRA), aims to assess risk factors in an unified framework. It provides a vision of potential gains in population health by reducing exposure to a risk factor or a group of risk factors.	I	**9.3** (1.3)	6.3 (3.8)	**7.3** (3.5)	6.6 (3.2)	7.4 (1.7)
Risk reduction and preparedness action plans formulated	Existence of Risk Reduction Plans and preparedness actions implanted to face uncontrolled water-related climatic events (drought, floods, etc.).	R	6.1 (3.7)	6.1 (3.7)	**7.4** (2.6)	**9.8** (0.8)	7.3 (1.8)
Basin Water Dependency	Relation between the number of people that depend exclusively on internal renewable water resources and the total number of habitants.	P, S, I	**9.4** (1.3)	5.6 (3.9)	**8.2** (2.8)	5.9 (4.1)	7.3 (1.9)
Disaster Risk Index	Compares the average population exposed to water-related hazards with average annual deaths caused by these hazards. Risk is model ledusing socio-economical parameters. Multiparameter equation.	S,I	**8.6** (1.6)	**8.2** (1.5)	6.6 (3.2)	5.0 (4.3)	7.1 (1.8)
Cooperation and conflict on Shared basins / aquifers	The number of events related to conflicts or cooperation in shared basins / aquifers. The WWDR, 2003 proposed to classify each event in a 15 levels scale that varies from the conflict side (formal war, extensive military acts, etc) to the cooperation side (water treaties, unification, etc)	R	**7.2** (2.5)	6.4 (3.0)	6.1 (3.7)	**8.8** (2.9)	7.1 (1.7)
Demand changes (sectoral) and distribution	Changes over time in the demand of water by sector (industrial, agricultural and domestic), expressed in annual growing.	P	**8.7** (1.5)	**8.3** (1.5)	5.8 (4.6)	5.6 (4.5)	7.1 (1.6)
Human Poverty Index: 5	HDI consists of three main components; longevity, knowledge and standard of living, and assesses these components as development.	S	**9.1** (1.4)	**7.8** (2.8)	4.2 (4.2)	6.8 (3.3)	7.0 (1.7)

indicators							

Annex 2 - Indicators that comply with two sustainability criteria (bi-dimensional) (cont. 2/6).

Indicator	Description	DPSIR Frame-work	Criteria average score and standard deviation*				Overall average
			Soc.	Econ.	Env.	Inst.	
Number of surface and groundwater users licensed according to the regulations	Number of licenses issued. May be further divided by total number of user.	R	**7.4** (2.6)	6.4 (3.0)	5.8 (4.2)	**8.4** (1.6)	7.0 (1.7)
Industrial use of water per capita	Annual amount of water used by the industrial sector divided by the number of inhabitants at a given region	P	**7.6** (2.6)	**8.7** (1.5)	5.9 (3.4)	5.4 (4.3)	6.9 (1.7)
Child mortality rates: deaths per 1,000 live births	Number of children (presented in relation to 1,000 live births) that died due to causes related to water provision, sanitation, drainage, waste removal and healthcare system (i.e. diarrhoea diseases, etc.).	S,I	**9.6** (1.1)	5.4 (4.3)	5.6 (3.9)	**7.0** (4.0)	6.9 (2.1)
Land cover profile	Distribution of the land cover in a given region according to categories such as: forest, cropland (irrigated and no-irrigated), grassland, wetland, urban area, etc.	S	**7.2** (2.5)	5.6 (3.3)	**9.3** (1.3)	5.3 (3.8)	6.8 (1.9)
Investment in debugging (cleaning up)	Annual budget for water quality programs, including proceedings in treatment and management of public water.	R	4.1 (4.4)	**7.8** (2.7)	6.1 (3.5)	9.1 (1.4)	6.8 (2.5)
Groundwater development indicator	Indicates the groundwater abstraction as a percent of the groundwater recharge component (GAR) of the Total Actual Renewable Water Resources (TARWR). The quantity of groundwater resource susedby major sectors (municipal, agricultural, industrial) depends on the groundwater recharge component (GAR) of TARWR.	S	6.1 (3.7)	**7.7** (1.3)	**8.6** (1.6)	4.8 (4.1)	6.8 (2.1)
Overharvesting – fisheries catch	Overharvesting and exploitation of depletes living resources in relation to the natural restore rate of the fish specie: impacts on biodiversity loss and ecosystem functions. Collapse of fisheries or dramatic decline	P,I	3.9 (4.5)	**8.5** (2.9)	**9.8** (0.8)	4.8 (4.1)	6.8 (2.0)
Budget allocation for water risk mitigation	Total amount of money allocated by public (and private sector, in some cases) each year to deal with water risk mitigation – compared to the total budget of the institutions.	P, I	4.2 (4.2)	**7.6** (2.7)	5.6 (3.3)	**9.5** (1.1)	6.8 (2.0)
Land converted to agriculture	Total forest are a per year converted to agricultural use. As forest land is changed to agriculture use, the products and services provided by that ecosystem (such as timber, water, wildlife, carbon storage, aesthetic beauty, etc.) are reduced/lost.	D, P, S, I	3.9 (4.5)	**8.6** (1.6)	**9.5** (1.1)	4.8 (4.1)	6.7 (1.8)
Knowledge Index (KI)	Average of the rankings of the performance of a country or region in three areas: education, innovation, and information and communications technology.	S	**8.0** (2.7)	6.1 (3.5)	3.7 (3.9)	**8.9** (1.5)	6.7 (1.5)

Metals in groundwater	Indicates the presence of hazardous substances in groundwater. Includes metals and metalloids: Arsenic, Cadmium, Lead and Mercury, naturally occurring and / or as result of human activities. It is an indicator of water quality for human consumption.	I	**7.2** (4.3)	5.3 (3.8)	**10.0** (0.0)	4.2 (4.2)	6.7 (2.1)
Population density	Number of people living per square 33ilometre of the basin.	P	**8.2** (2.8)	6.1 (3.5)	**7.6** (2.6)	4.7 (3.7)	6.7 (2.2)

Annex 2 - Indicators that comply with two sustainability criteria (bi-dimensional) (cont. 3/6).

Indicator	Description	DPSIR Frame-work	Criteria average score and standard deviation*				Overall average
			Soc.	Econ.	Env.	Inst.	
Water source distance from demand centre: > 8 km	Percent of the total population of a given area that its water supply comes from a source over 8 km far from the demand centre.	P,S,I	**9.6** (1.1)	**7.1** (3.3)	4.1 (4.4)	5.8 (4.6)	6.6 (1.8)
Water supply cost related to users I income	Annual cost of water supply paid by user divided by the total annual income of the user (applied to urban, industrial and agriculture uses).	R	**8.4** ()	**9.8** ()	2.0 ()	6.1 ()	6.6 ()
Great natural catastrophes	List of major natural catastrophes: number of occurrences of floods, windstorms, earthquakes and volcanic 33ruption. Ns, that lead to considerable human deaths and significant economic losses.	I	6.9 ()	**7.8** ()	**8.0** ()	3.6 ()	6.6 ()
Water Policy accounts and statements	Existence of water policies-setting goals for water use, protection and conservation.	R	4.7 ()	3.5 ()	**8.5** ()	**9.5** ()	6.6 ()
Pesticides in groundwater	Pesticide active substances, including metabolites and degradation and reaction products that are relevant. Indicator of pollution by agricultural activities	I	4.8 ()	**7.7** ()	**10.0** ()	3.8 ()	6.6 ()
Average per capita food consumption	Per capita food consumption at global and developing country levels, and other specific regions. The indicator shows a global food security situation, and is used as the indicator of food intake.	S,R	**8.3** ()	**8.4** ()	4.9 ()	4.6 ()	6.5 ()
Dependence of agricultural population on water	The Proportion of total population of a region using water irrigation technics (both traditional and modern) to enhance the productivity of agriculture or livestock enterprise.	D	**7.6** ()	**8.8** ()	6.0 ()	3.7 ()	6.5 ()
Status of surface water bodies (in risk)	The indicator measures the risk level of not achieving the environmental objectives proposed by the institutions responsible for the management surface water bodies The indicator is calculated as the ratio of number of surface water bodies located in each of the four risk levels considered and the total number of surface water bodies in each river basin district or the national average.	S	4.3 ()	4.9 ()	**9.5** ()	**7.3** ()	6.5 ()

Population exposed polluted water	Percentage of population exposed to several kind of pollutants (coliforms, industrial substances, acid, heavy metals, ammonia, nitrates, pesticides, sediments, salinization). Poor water quality affects both human health and ecosystem health.	S, I	**9.4** ()	3.9 ()	**9.1** ()	3.6 ()	6.5 ()
Emissions of water pollutants by sector	Indicates the Biological Oxygen Demand (BOD) loads to waterways by sector (agriculture, house, hold, and, industry) as well as the nitrogen loads to waterways due to agriculture.	S, I	5.0 ()	**7.2** ()	**9.3** ()	4.5 ()	6.5 ()

Annex 2 - Indicators that comply with two sustainability criteria (bi-dimensional) (cont. 4/6).

Indicator	**Description**	**DPSIR Frame-work**	**Criteria average score and standard deviation***				**Overall average**
			Soc.	**Econ.**	**Env.**	**Inst.**	
Groundwater as a percentage of total use of drinking water	The indicator expresses the present state and trends of surface water and groundwater use for drinking purposes.	S	**7.5**	5.6	**8.4**	4.5	6.5
Food production trends	Trends in food production: increase in annual production. It is relevant to remember that the amount of water involved in food production is significant.	D, P	6.4	**9.5**	**7.2**	2.6	6.4
Investment in water management	Annual budget for management actions and water infrastructure.	R	3.9	**8.9**	4.2	**8.4**	6.4
Ratio of actual to desired level of public investment in water supply	Ratio of actual to desired level of public investment in water supply.	R	5.4	**8.8**	2.3	**8.9**	6.4
Access to electricity rural and urban coverage for the whole world	Rural and urban households with access to electricity for each country. Access to electricity is a prerequisite for economic and social development and in some case to access water (pumps, etc).	R	**7.6**	**7.6**	4.0	6.2	6.3
Percentage of Health Impact Assessments (HIA) of water resources development and compliance with HIA recommendations	Definition – HIA is a combination of procedures, methods and tools by which a policy, programme or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population	R	**8.6**	3.2	4.0	**9.5**	6.3
Productivity in terms of jobs	Number of jobs generated in irrigated agriculture and industry by each m3 of water abstraction.	S	**8.0**	**9.6**	1.2	6.2	6.3

per m3							
Ammonium in groundwater	Indicates the amounts of ammonium ions present as a result of human activities. It is an indicator of water quality for human consumption.	I	**7.3**	4.8	**9.5**	3.2	6.2
Existence of participatory framework and operational guidelines	Existence of participatory framework for the management of water including operational guidelines to its implementation and follow-up.	R	**8.3**	2.6	4.3	**9.8**	6.2
Amount of underwater or wetland area placed into protected management, including the establishment of no fishing zones	Amount of underwater or wetland area placed into protected management, including the establishment of no fishing zones.	I, R	2.4	5.1	**9.1**	**8.2**	6.2

Annex 2 - Indicators that comply with two sustainability criteria (bi-dimensional) (cont. 5/6).

Indicator	Description	DPSIR Frame-work	Criteria average score and standard deviation*				Overall average
			Soc.	Econ.	Env.	Inst.	
Existence of water quality standards, for effluent discharges, minimum river water quality targets	Indicates the existence of water quantity and quality standards.	S, I	4.9	3.2	**9.3**	**7.0**	6.1
Mining waste pools	This indicator estimates the influence of mining waste pools that contamine water depending on the productive sector (PS), potential storage (PS), permeability (P) and water table depth (WTD). The pressure is significant if the indicator presents values greater than 5.	P	3.2	**7.9**	**9.3**	3.8	6.0
Percentage of compliance of the wastewater treatment plant with current regulations	The indicator is calculated by the ratio of the number of wastewater treatment plants that meet compliance criteria established by the legislation (pollution load expressed in population equivalents) and the total number of wastewater treatment plants existing.	S	4.2	4.2	**7.1**	**8.7**	6.0
Naturally occurring inorganic contaminants fluor and arsenic	Percentage or contaminated water sources and number or people exposed through drinking water supply by naturally occurring inorganic pollutants (Fluor and arsenic) as a critical determinant of chemical contamination of drinking water.	S, I	**7.8**	3.2	**9.5**	3.4	6.0
Intensive crop area	Total agricultural area for the production of crops considered intensive due to their higher water needs. Cropping intensity is estimated as total crop area divided by total cultivated area.	D	3.2	**9.3**	**8.3**	3.2	6.0

Restoration schemes	Existence of restoration schemes/projects focused on freshwater and coastal ecosystems degradation issues.	R	3.2	2.9	**8.8**	**8.8**	5.9
Nutrition productivity	Total generation of food products generated by agriculture (calculated in calories or other nutritional indicator) divided by the total abstraction of water for irrigation.	D	**7.6**	**7.8**	4.5	3.7	5.9
Total investment (private, state, development agencies) in irrigation and drainage	Total investment (private, state, development agencies) in irrigation and drainage, expressed in millions dollars.	S,R	2.9	**9.5**	3.7	**7.5**	5.9
Water availability per capita	Percentage of the world's water resources that a region has divided by the world's population (in %) living in that region.	P,S	**8.5**	3.7	**7.4**	3.2	5.7

Annex 2 - Indicators that comply with two sustainability criteria (bi-dimensional) (cont. 6/6).

Indicator	**Description**	**DPSIR Frame-work**	**Criteria average score and standard deviation***				**Overall average**
			Soc.	**Econ.**	**Env.**	**Inst.**	
Uptake of strategies/legislation for environmental protection	Use of adequate strategies/legislation for environmental protection.	R	2.9	2.9	**7.4**	**9.6**	5.7
Crop Area	Agricultural area used for crop production or pasture.	D	3.5	**9.2**	**7.2**	2.8	5.7
Proportion of water pollution permit holders complying with permit conditions.	Number of monitoring visits with water quality samples not complying with established conditions divided by the total number of visits.	P, S, I, R	4.2	3.0	**7.3**	**8.0**	5.6
Crop-Water Productive Index	Amount of water required per unit of yield. It is a vital parameter to assess the performance of irrigated and rainfed agriculture. Crop water productivity will vary greatly according to the specific conditions under which the crop is grown.	D,P,S,I	2.6	**8.4**	**7.7**	3.4	5.5
Fish consumption (marine, inland and aquaculture)	Average consumption of fish from different sources (marine, inland and aquaculture).	P, S, I	**7.1**	**7.9**	5.5	1.4	5.5
Water used for irrigation	Annual amount of water used in irrigation systems. It can bee classified by source (groundwater and surface), by system type (surface irrigation, spate irrigation, sprinkler irrigation, drip irrigation, local water harvesting, etc), among others classifications.	P, S, I	2.9	**7.6**	**7.5**	3.8	5.5

Consumption of livestock food products	Consumption of food from livestock including meat (beef, pork, poultry), vegetables, crops, dairy products, eggs, milk, etc.	D, P, S, I	**7.4**	**7.5**	4.7	2.2	5.4
Density hydrological monitoring stations	Number of hydrological observing/monitoring stations in a given region / country.	S, R	2.1	2.6	**7.1**	**8.2**	5.0

*Criteria average score and standard deviation: Social, Economic, Environmental and Institutional.

Sources: see Annex 3

Annex 3 - Indicators that comply with one sustainability criterion (one-dimensional).

Indicator	Description	DPSIR Frame-work	Criteria average score and standard deviation*				Overall average
			Soc.	Econ.	Env.	Inst.	
Index of groundwater explotation	Percentage of extracted groundwater per year in relation to the total volume of the aquifer. Pressure is considered significant when the total groundwater extraction exceeds 20% of resources allocated.	P	6.1	6.6	**9.5**	5.8	7.0
Urban Water and Sanitation Governance Index	It is a combination of the fowling 4 indicators. Percentage of departments establishing programme monitoring water and sanitation coverage. Percentage of councils that provide for external audit of the departments. Percentage of departments meeting water quality standards. Percentage of departments with improved public quality control of the service provided.	S	6.3	5.6	6.1	**10.0**	7.0
Groundwater depletion	Is calculated as the total area with groundwater depletion problem (means the area in which regional level decline is observed resulting from excessive exploitation of groundwater) divided per the total area of studied aquifer.	S, I	6.1	6.4	**9.3**	5.8	6.9
Groundwater usability with respect to treatment requirements	Usability of abstracted groundwater that is publicly distributed with respect to treatment requirements.	S,R	5.5	6.8	**8.5**	6.1	6.8
Wetlands: % threatened	Percent of threatened wetlands due to pressures from agriculture, settlements, urbanization and other land uses.	S,I	6.1	6.7	**9.5**	4.8	6.8
Reduced releases of pollution to groundwater recharge zones	Reduction of the amount of pollutants discharged to groundwater recharge zones.	S, I, R	4.8	6.4	**9.8**	6.0	6.7
Index of groundwater abstraction	Evaluates the recharge-discharge aquifer balance and therefore the sustainability of exploitation. The threshold considered is Ind abs > 40%.	P	5.6	5.8	**9.5**	4.8	6.4
Nitrate in aquifers	The indicator measures the concentration of nitrate in groundwater in mg/l. It is an indicator related to the pressure from farming activities and the chemical status of groundwater. High concentrations of nitrates in surface water and groundwater may affect its fitness for potable uses.	S,I	4.8	6.9	**10.0**	4.0	6.4
Renewable groundwater resources per capita	Total amount of groundwater resources (m3 per year) per capita at a national, regional or natural (aquifer, basin) level that comes from a renewable source.	D, S	6.0	6.8	**8.8**	3.9	6.4
Groundwater vulnerability	The concept of groundwater vulnerability is based on the assumption that the physical environment (the soil properties, lithology and thickness of the unsaturated zone and groundwater level) provides some degree of protection to groundwater against natural influences and human impacts.	P,S	5.5	4.8	**9.8**	6.0	6.4

Annex 3 – Indicators that comply with one sustainability criterion (one-dimensional) (cont. 2/8).

Indicator	Description	DPSIR Frame-work	Criteria average score and standard deviation*				Overall average
			Soc.	Econ.	Env.	Inst.	
Percentage of undernourished people	Percentage of people not having access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.	S	**9.5**	6.5	2.9	6.5	6.4
Disability-Adjusted-Life Year (DALY)	Is a summary measure of population health, integrating mortality with morbidity and disability information in a single unit. Is an indicator of the time lived with a disability and the time lost due to premature mortality.	I	**9.0**	6.9	4.3	5.2	6.4
Area of wetland drained	Transformations of wetlands due to human uses: area of wetland drained	S,I	6.8	4.8	**9.5**	4.2	6.3
Trends in freshwater habitat protection	The percentage of area of different types of freshwater habitat set aside for protection.	S, R	4.5	4.0	**10.0**	6.8	6.3
Food imports/exports between regions	Amount of food imports/exports for individual countries and between regions The indicator shows the difference between production and consumption and also the virtual water flow between regions.	S	6.6	**9.1**	3.9	5.4	6.3
Groundwater quality	This indicator can be applied to both natural and anthropogenic contamination, as presented below:A) For natural quality contamination: Relation between the total area of aquifers with groundwater natural-quality problem divided by the total area of studied aquifers; B) for anthropogenic contamination: Relation between the total area with increment of concentration for specific parameter divided by the total area of studied aquifers.	S,I	6.6	4.6	**9.3**	4.6	6.3
Non-point source pollution programs implemented (area treated with best management practices; kg reduced)	Area treated with best management practices as a result of implemented nonpoint source pollution programs The goal of these programs is to minimize nonpoint source pollution from new land use activities and to reduce pollution from existing activities.	R	4.5	4.5	**9.1**	6.8	6.2
Number of dams in basin and in main stem of river	Number of large and major dams in each basin.	D,R	3.8	6.3	**8.5**	6.3	6.2
Discharges to groundwater	Includes waste water and cooling water discharge in aquifers. Moreover, landfill underground pollution: storage of CO2 and brine. Direct discharges are a important source of point pollution of groundwater.	P	4.5	5.8	**10.0**	4.2	6.1
Water table	The steady decline of water table (in free water aquifers) or the level of groundwater in confined aquifers, are the main impact indicator of excessive water extraction.	I	5.0	6.1	**9.8**	3.7	6.1

Annex 3 – Indicators that comply with one sustainability criterion (one-dimensional) (cont. 3/8).

Indicator	**Description**	**DPSIR Frame-work**	**Criteria average score and standard deviation***				**Overall average**
			Soc.	**Econ.**	**Env.**	**Inst.**	
Runoff: % used by humans	Relation between the total annual abstraction of water and the total annual runoff at a given basin.	S, I	6.0	6.1	**9.5**	2.9	6.1
State Hydrological index	This indicator provides information on hydrological drought resulting from the rainfall deficits. The hydrological drought may lead to periods of scarcity.	S	5.4	5.2	**9.5**	4.3	6.1
Mentions of water in international agenda,CC, WB, GEF, WSSD	Number of times that water issues appears in the main international agenda – i.e. Climate Change negotiation, UN initiatives, GEF projects, World Bank activities, World Summit on Sustainable Development, etc.	R	3.7	4.5	6.3	**9.5**	6.0
Loss of original forest	Indicates the difference between the original forest extent and the current forest extent.	S	4.3	5.8	**9.3**	4.5	6.0
Total Actual Renewable Water Resources (TARWR)	TARWR = (External inflows + Surface water runoff + Groundwater Recharge) – (Overlap +Treaty obligations).	S	4.2	5.6	**9.3**	4.8	6.0
Increased stakeholder awareness and documented stakeholder involvement in water use decisions	Evaluates how is the stakeholders awareness and documented involvement in water uses decisions.	R	5.8	4.5	4.5	**9.1**	6.0
Agricultural water use (by country)	Annual amount of water (including irrigation and green water – rainfall, snowfall, etc) used by the agricultural sector. It is usually compared to industrial and domestic use (expressed in %).	P,S,I	5.2	**8.8**	6.3	3.5	6.0
Water lending for irrigation and drainage	Annual amount of water lending for irrigation and drainage and costs associated.	P,S,I	2.9	**8.8**	6.6	5.3	5.9
Formation and empowerment of regulatory or other institutions	Formation/creation and empowerment of regulatory institutions to control / monitor the use of water resources and the protection of the ecosystems.	R	3.4	3.4	6.8	**10.0**	5.9
Existence of institutions responsible for water management, that are independent of sectorial water users.	Existence of institutions (water resources authorities) responsible for water management (including issuing abstraction and discharge licenses), that are independent of sectorial water users (irrigators associations, etc.).	R	5.5	3.5	5.0	**9.5**	5.9
Private sector involvement and stakeholders responsibility established and implemented	Existence of legal framework and local capacity to promote / regulate the involvement of private sector and stakeholders responsibility in the management of water resources.	R	4.5	5.3	4.0	**9.8**	5.9
Asset ownership properly defined	Existence of legal framework to asset ownership in order to have water rights properly defined.	R	5.4	4.2	4.2	**9.6**	5.8

Annex 3 – Indicators that comply with one sustainability criterion (one-dimensional) (cont. 4/8).

Indicator	**Description**	**DPSIR Frame-work**	**Criteria average score and standard deviation***				**Overall average**
			Soc.	**Econ.**	**Env.**	**Inst.**	
Unaccounted for Water (Water Losses)	Unaccounted-for-Water (UfW) is the difference between the water delivered to the distribution system and the water sold. It has two basic components: physical losses, such as water lost from pipes and overflows from tanks, and commercial losses, which include water used but not paid for.	P	4.2	**9.1**	3.9	6.1	5.8
Water Productivity	Economic value generated per cubic metre of water withdrawn by sector / user	P	4.4	**9.6**	4.1	5.1	5.8
Existence of law for judicious distribution of water	Existence of laws for determining equitable allocation of water – defining the rules needed to achieve policies and goals.	R	6.5	5.0	1.8	**9.8**	5.8
Water Availability index (WAI)	This index is used to forecast water availability in the short term (i.e., days). It combines water quantity and quality data, evapotranspiration, soil moisture, and surface water and ground water flux information into no parameterized variables in mathematical formulations. Water quality is based on the calculation of another index called Potential Use Index, which enables one to classify the water in terms of its measured quality and to determine its suitability for a defined use.	S	4,7	4,2	**9,3**	5,0	5,8
Price of water charged to farmers for irrigation	Cost of using irrigation water to farmers compared with their incomes.	S, R	4.5	**9.3**	4.5	4.7	5.8
Sources of Contemporary Nitrogen Loading	Total and inorganic nitrogen loads as deposition, fixation, fertilizer, livestock loads, human loads and total distributed nitrogen to the land and aquatic system.	S, P	5.6	4.2	**9.5**	3.5	5.7
Salinization in groundwater	The conductivity is used as a parameter indicative of saline and is an indicator of total dissolved ions. The increase in salinity often indicates the presence of discharges, over-exploitation of the aquifer or seawater intrusion or inland saline aquifers, due to changes in flow by exploitation.	I	4.2	5.6	**10.0**	2.9	5.7
Percentage of poor people living in rural areas	Number of poor people living in rural areas (RPP) / Total population (TP).	S	**8.6**	5.6	2.7	5.7	5.7
Prevalence of underweight children under five years of age	Percentage of children under five years old whose weight-for-age is below minus two standard deviations from the median of the NCHS/WHO reference population.	I	**9.5**	5.2	2.4	5.5	5.7
Withdrawals: % of total annual renewable freshwater	Relation of the total annual abstraction of water and the total annual renewable freshwater (both superficial and groundwater).	S	4.7	4.5	**9.8**	3.7	5.7

Annex 3 – Indicators that comply with one sustainability criterion (one-dimensional) (cont. 5/8).

Indicator	Description	DPSIR Frame-work	Criteria average score and standard deviation*				Overall average
			Soc.	Econ.	Env.	Inst.	
Area of arable land (whole world)	Amount (expressed in million hectares) of arable land in the world in relation to population (arable land per person or hectares per 100 inhabitants).	P, S, I	5.8	**7.4**	6.8	2.6	5.6
Rate of recovery	Measures water fees actually collected as percent of the total collectable charges billed by the water utility.	D, R	5.5	**8.3**	2.9	5.8	5.6
No. of water resource scientists	Number of scientists that develop research on water related themes.	R	3.5	4.0	6.8	**8.3**	5.6
Biological water quality (based on community response)	Biological water quality indicators provide a complementary measure to chemical water quality and are useful in assessing intermittent pollution or impacts of unknown contaminants.	S,I	4.5	2.9	**10.0**	5.0	5.6
Prevalence of stunting among children under five years of age	Percentage of children under five years old whose height-for-age is below minus two standard deviations from the median of the NCHS/WHO reference population.	I	**9.5**	5.1	2.3	5.3	5.6
Artificial induced recharge	Volume of resources available artificially introduced into aquifers by irrigation returns or by reversing the flow (of the river to the aquifer) due to intensive exploitation of groundwater.	P	3.2	6.3	**8.5**	4.2	5.6
Capability for hydropower generation	Gross theoretical capability of hydropower generation, technically exploitable capability and economically exploitable capability.	S	3.2	**8.9**	5.1	4.9	5.6
Mortality rate of children under-five years of age	Probability of dying between birth and exactly five years of age expressed per 1000 live births.	I	**8.4**	4.6	3.1	5.9	5.5
Volume of desalinated water produced	Volume of desalinated water produced per year.	R	4.2	**7.1**	6.8	4.0	5.5
Mechanisms for sharing within country (allocations/priorities) both routinely and at times of resource shortage	Existence of legal / institutional mechanisms for sharing water within country (allocations / priorities) both routinely and at times of resource shortage.	R	4.1	3.7	4.2	**9.8**	5.5
Extent of land salinized by irrigation	Area of soil salinized by irrigation as a percentage of total irrigated land.	S	2.9	6.3	**8.5**	4.0	5.4
Compliance with water quality standards for key pollutants	Number of rivers / aquifers that meet water quality standards for key pollutants.	I, R	3.9	2.7	**9.3**	5.8	5.4
Drinking Water Quality	Share of samples failing drinking water quality standards in the total number of drinking water samples.	S,I	5.5	3.2	**8.1**	5.0	5.4

952 Annex 3 – Indicators that comply with one sustainability criterion (one-dimensional) (cont. 6/8).

Indicator	Description	DPSIR Frame-work	Criteria average score and standard deviation*				Overall average
			Soc.	Econ.	Env.	Inst.	
Fragmentation and flow regulation of rivers	A complex calculation of the negative impact on ecosystems of altering waterways by dams, water transfers and canals.	S, I	2.6	4.2	**10.0**	4.8	5.4
Ecological Flow	Percent of actual flow of a river in relation to the estimated ecological flow.	S	3.5	3.5	**9.8**	4.8	5.4
Biological assessment (perturbation from reference condition)	In biological assessment, reference conditions are established by identifying least impaired reference sites, characterizing the biological condition of the reference sites, and setting threes holds for scoring the measurements. The basic procedural steps for biological assessment are as follows: 1. Sample the biological groups (assemblages) selected by the program; 2. Calculate chosen metrics using relative abundance and other measurements; 3. Compare each to its expected value under reference conditions and assign a numeric score; 4. Sum the scores of all metrics of an assemblage to derive a total score for the assemblage; 5. Compare the total score to the biological criterion based in part on the expected total score under reference conditions.	S,I	4.0	3.2	**10.0**	4.3	5.4
Compliance with environmental objectives. Status of groundwater bodies	According to the pressure and impact analysis, this indicator evaluates the risk of ground water bodies failing to achieve the environmental objectives in a specified period.	P, S, I	2.4	3.2	**10.0**	5.8	5.3
Institutional strengthening and reform (post-1992)	Existence of institutional strengthening and reform of national / regional water management model for the implementation of IWRM and Dublin principles.	R	3.7	2.9	4.7	**10.0**	5.3
Percent of protected area	Percentage of protected area divided by the total of a given area.	S	1.8	2.9	**9.8**	6.5	5.3
Per capita food consumption (and its broken down into cereals, oil crops, livestock and fish)	Average per capita food consumption per year (and its breakdown into categories: cereals, oil crops, livestock, fish, etc.).	P,S,I	**7.8**	6.9	5.9	2.4	5.2
Defined roles of government (central and local)	Existence of legal framework that defines with clarity the roles of central and local governments to manage water resources.	R	3.7	2.9	4.2	**10.0**	5.2
Irrigated land as percentage of cultivated land	Area under irrigation as a proportion of total cultivated land.	S,P	2.9	**8.6**	5.8	3.5	5.2
Relative importance of agriculture in the economy	The share of the country's GDP derived from agriculture.	S	2.9	**9.5**	4.5	3.9	5.2
Trends in ISO 14001 certification	Number of companies receiving ISO 14001 certification per the total number of companies	R	2.0	5.2	5.6	**8.0**	5.2

Annex 3 – Indicators that comply with one sustainability criterion (one-dimensional) (cont. 7/8).

Indicator	Description	DPSIR Framework	Criteria average score and standard deviation*				Overall average
			Soc.	Econ.	Env.	Inst.	
Access to information, participation and justice	Proportion of countries with strong, intermediate or weak access to information, participation and justice. (to water related themes).	R	6.9	2.5	2.5	**8.9**	5.2
Organic pollutants load	Concentrations of the follow organic pollutants: COD: chemical oxygen demand; NH4-N: ammonium; PAH: polycyclic aromatic hydrocarbons; DEHP: diethylhexylphthalate; EE2: ethinylestradiol; E2: estradiol; EDTA: ethy-lenediamine tetraacetic acid.	S, I	4.9	3.2	**9.4**	3.2	5.2
Climate Moisture Index (coefficient of variation)	CMI is a statistical measure of variability in the ratio of plant water demand to precipitation. It is useful for identifying regions with highly variable climates as potentially vulnerable to periodic water stress and/or scarcity.	S	3.5	4.5	**9.1**	3.5	5.1
Importance of groundwater for irrigation	Percentage of land under irrigation relying on groundwater	S, P	3.2	6.5	**7.1**	3.8	5.1
Seawater intrusion in groundwater	The indicator measures the concentration of chloride in mg / l in groundwater. It is a status indicator that measures the degree of salinization of coastal groundwater bodies due to seawater intrusion and its suitability for different uses such as drinking or irrigation water.	P, S	4.2	4.0	**9.5**	2.7	5.1
Area equipped for irrigation vs. total arable land	Percent of the arable land that is equipped for irrigation (by country or geographical division).	P, S	2.4	**8.1**	5.8	4.0	5.1
Biological contaminants (E. coli/thermotolerant coliform)	Presence of biological contaminants in water (E. coli/thermotolerant coliform) Escherichia coli and thermotolerant coliforms are of major importance as indicators of fecal contamination of water.	S, I	6.4	1.7	**9.1**	2.7	5.0
Proportion of water allocation permit holders complying with permit conditions	Number of monitoring visits not complying with conditions divided by the total number of visits.	P, S, R	4.2	3.0	3.7	**8.2**	4.8
Organic pollution emissions (BOD) by the industrial sector	Proportion of organic water pollution (calculated in BOD), generated by industrial sector.	I	3.4	5.4	**9.1**	1.2	4.8
Numbers or presence/absence of non-native (alien) species	Is an indicator that evaluates the ecosystem condition by measuring the number of introduced species, focusing on aquatic species (e.g. fish, molluscs, benthic organisms, plants).	S, I	2.2	3.5	**9.8**	2.7	4.5

Annex 3 – Indicators that comply with one sustainability criterion (one-dimensional) (cont. 8/8).

Indicator	Description	DPSIR Frame-work	Criteria average score and standard deviation*				Overall average
			Soc.	Econ.	Env.	Inst.	
Number of endemic fish	Total number of fish endemic species in a river basin. This indicator should be taken as general indicator of fish diversity.	S	1.1	5.3	**9.3**	2.2	4.5
Areas covered or half covered in water	Percentage groundwater mass: area covered by humid, swampy, or intertidal zones, lakes, lagoons, reservoirs, coastal lagoons, estuaries, seas and oceans.	P	2.3	2.9	**9.8**	2.6	4.4
Impact of Sediment Trapping by Large Dams and Reservoirs	This indicator evaluates the residence time of water held in large reservoirs, sediment trapping efficiency of large reservoirs and determinates how many years takes to full-fill a reservoir with water transported sediment.	P	1.8	3.2	**9.1**	3.5	4.4
Freshwater species population trends index	A measure of change and trends in the populations of freshwater species.	S	1.6	3.7	**9.3**	2.7	4.3
Head of cattle	Number of head of cattle (cattle, sheep, swine and goats).	D	2.6	**7.9**	4.9	1.4	4.2
Use of water in thermal towers and competition with other uses	Total annual amount of water used in thermal towers. It is usually compared with others industrial uses (presented in percent).	P	0.5	**8.7**	4.4	3.2	4.2
Number of Amphibian Species	Number of Amphibian Species in each basin. Amphibians are a sensitive biological indicator of environmental quality.	S	1.6	2.4	**9.8**	2.2	4.0
Ministerial statements mentioning water	Number of ministerial statements that mention water.	R	1.7	1.2	3.4	**9.5**	3.9
Nivale reserve	Volume of water stored as snow.	S	1.3	2.4	**8.8**	2.1	3.7
Biological oxygen demand (BOD)	Is the quantity of oxygen necessary for biological and chemical oxidation of water-borne substances.	S	2.4	1.2	**9.1**	1.7	3.6
Water impounding reservoirs (dams): supply volume m3 per year	Annual amount of water impounded in dams and others reservoirs.	S	4.2	6.5	6.8	6.1	5.9

*Criteria average score and standard deviation: Social, Economic, Environmental and Institutional.

Source: Aldaya & Llamas (2008), Bradfor (2008), Cap-Net UNDP (2008), Carneiro et al. (2006), Ding et al. (2010), Eurostat (2009), Falkenmark & Lindh (1974), FAO (2003), GWP (2004a), GWP (2004b), GWP (2006), Grey & Sadoff (2006), Hoekstra (2009), Hoekstra (2010), Hoekstra and Hung (2002), IISD (1999), Lawrence et al (2002), Lovarelli et al. (2016), Maneta et al (2009), Milman & Short (2008), MMA (2006), OECD (2004), OSE (2008), Pellicer-Martínez & Martínez-Paz (2016), Scudder(2005), Sullivan (2001), Sullivan and Meight (2005), Sullivan and Huntingford (2009), Sullivan et al (2002), Sullivan et al (2006), UN Water (2008), UN Water (2010), UN-Habitat (2003), UN-Habitat (2008), UN-Habitat (2009), UN (2007a), UN (2007b), UN (2009), UN (2010), UNECE (2003), UNECE (2007), Vörösmarty et al (2000), Vörösmarty et al (2005a), Vörösmarty et al (2005b), WBCSD & IUCN (2010), WHO (2006), WHO/UNICEF (2008), WHO/UNICEF (2010), Wilhite (2005), Wilhite et al. (2007), World Bank (2007), WWAP (2003), WWAP (2006), WWAP (2009), WWAP (2012), WRI (1998).