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Use of indicators in River Basin Management Planning and Strategic Environmental Assessment processes

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ABSTRACT

River Basin Management Planning (RBMP) and Strategic Environmental Assessment (SEA) processes often rely on the use of indicators to assess the sustainability of planning options, to communicate with stakeholders and to support decision-making. The aim of this research was to investigate the adoption of indicators to support these processes and to analyse indicators integration between them. A conceptual framework was adopted to support a qualitative content analysis of the Portuguese RBMP and corresponding SEA reports. The main findings showed that indicators are generally used in SEA and planning reports. The analysed documents used a large number of indicators, mostly quantitative, and adopted very different approaches for their organization, selection and validation. Usually no participatory process was used in this context. The research supported the identification of areas for improvement, such as the need to promote a stronger stakeholder engagement in the indicator development process, the relevance of using standardized cross-cutting indicators and the call for the identification of a set of critical indicators to be used in both processes.

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River Basin Management Planning; Strategic Environmental Assessment; indicators; conceptual framework; content analysis

1. Introduction

Water resources are one of the most significant drivers of human development (Gleick 2014). Socio-economic development, population growth and climate change determine the diverse levels of water use around the world and establish increasing pressures on water resources (Gleick 2003). Consequently, these problems have resulted in the need to implement major policy reforms at all levels of decision-making (Savenije and Van der Zaag 2008). In this context, integrated water resources management, framed as an overall policy, is becoming increasingly relevant and is often supported by public participation and sustainability-oriented approaches, while envisaging socio-economic development, physical planning and environmental protection (Savenije and Van der Zaag 2008).

Emerging water challenges are acknowledged worldwide and have triggered governments to re-evaluate their outlook on water management (Christian-Smith et al. 2012). In past decades, many countries have promoted innovative water policies and associated assessment processes (Antunes et al. 2009). In the European Union, an ambitious legal framework to support water policy was established by the Water Framework Directive (WFD),

which introduced, among others, the preparation of river basin management plans for the main river basins in the European Union (European Parliament 2000).

Water resources planning is also framed by another relevant environmental policy instrument, Strategic Environmental Assessment (SEA). The purpose of SEA is to ensure that environmental considerations are fully represented and considered in decision-making processes for new plans, policies and programmes (Fischer 2003; Therivel 2004; van-Doren et al. 2013). The SEA process in the European context is framed by the European Directive 2001/42/EC.

The two directives (WFD and SEA) have different yet complementary functions, and they can have synergistic effects (Carter and Howe 2006; Larsen and Kørnøv 2009). The two instruments share important requirements, namely, in terms of data collection, evaluation of alternatives and options, assessment of policies, suggestions for mitigation actions, development of monitoring procedures, and the implementation of appropriate consultation and public participation processes. Carter and Howe (2006) highlight the benefits of exploring the relationship between the WFD and SEA Directives in the context of encouraging the sustainable use and management of water resources.

Indicators are often considered a key element to support both SEA and planning processes (Donnelly et al. 2007; Garfi and Ferrer-Martí 2011). Indicators are special signs that communicate value-added messages to stakeholders in a simplified and useful manner, and they can be derived from a single variable to reflect some attribute or from an aggregation of several variables (Ramos et al. 2004; Ramos and Caeiro 2010). Indicators are used for different purposes (Wong 2005; Morse 2013), such as collecting, processing and using information. Indicators should be developed to add value and to transform information into intelligence and to convey messages with meaning for political action and for the public (Therivel 2004; Wong 2005; Donnelly et al. 2007; Gao et al. 2013a). When properly developed and used, indicators have the potential for effective communication with the general public and decision-makers and for supporting informed decision-making and guiding policy (Donnelly et al. 2007; Niemeijer and de Groot 2008; Mascarenhas et al. 2015). According to Wong (2005), the decision-making paradigm is increasingly strategic and less operational and the focus of the indicators to follow this trend has shifted from a simple and direct approach to complex methodological models of indicator construction. Indicators are also used to measure progress and monitor feedback mechanisms (Donnelly et al. 2007; Niemeijer and de Groot 2008; Mascarenhas et al. 2015) as they provide a platform for involvement, discussion and deliberation (Gao et al. 2013b).

Several authors note the need to use criteria for indicator selection (OECD 1993; Ramos et al. 2004; Therivel 2004; Donnelly et al. 2007; Ramos 2009) and to evaluate the usefulness and robustness of different sets of criteria (Mascarenhas et al. 2012, 2015). Niemeijer and de Groot (2008) present the importance of using causality chains of cause and effect as a way to help structure and understand reality through the use of indicators. Although causal chains are often presented as models for selecting indicators, Niemeijer and de Groot (2008) report that these structures are often used to promote the presentation of indicators rather than to support the formal indicator selection process. According to the same authors, individual criteria, such as the SMART (specific, measurable, relevant and time-bound) model proposed by Schomaker (1997) and the model defined by OECD (policy relevance, analytical soundness and measurability) (OECD 1993), are often used to support the selection process. These criteria are tested in each indicator and confer crucial characteristics for its particular function in the process but do not relate it to the other indicators or to the specific context of the evaluation (Niemeijer and de Groot 2008). Wong (2005) and Mascarenhas et al. (2015) state that isolated indicators are generally pieces of information with low added value and do not convey meaningful messages.

Other key aspects for the construction and applicability of indicators are the type of data used (Ramos et al.

2004; Wong 2005) and its availability, accuracy and validity. The entities that supply data are also considered by Wong (2005) as important factors in indicator construction, selection and updating. Documentation and technical notes related to the construction or selection of each indicator should be made available to interested parties to provide a better understanding of their meaning and to enable the assessment of data availability, as well as the costs incurred to update the indicators (European Environment Agency 2005; Donnelly et al. 2007).

Regarding the use of indicators in the planning and SEA processes, Donnelly et al. (2007) and Gao et al. (2010) note that the number of studies focused on indicators in the SEA process is limited, and they encourage research aimed at identifying and assessing the potential of indicators to support planning, assessment, decision-making and monitoring. Cloquell-Ballester et al. (2006) report that it is not usually possible to use a set of existing indicators to support planning and SEA processes for all purposes. In line with this argument, Donnelly et al. (2008) emphasize the need to establish appropriate indicators that do not only fit the specific goals of each intervention but also communicate complex phenomena in a simple manner, enabling stakeholders to develop an informed opinion. Carefully selected indicators provide a mechanism to control whether the objectives and targets are attained and thus facilitate monitoring of the environmental impacts of plan implementation (Donnelly et al. 2006a; d'Auria and Cinnéide 2009). d'Auria and Cinnéide (2009) also stress that robust indicators provide an opportunity to identify appropriate stakeholders, check the accessibility and quality of data, evaluate alternatives and their potential impacts, identify conflicts and determine a set of appropriate methods and techniques to address significant environmental issues in the area of the plan. They also note that numerous lists of pre-selected indicators may be useful but may also restrict and influence planning and SEA professionals and prevent the development of tailor-made approaches.

Donnelly et al. (2007) state, as advocated above by other specialists, that the selection and development of indicators to support the planning and SEA processes should be based on a set of fundamental criteria to ensure that indicators perform the functions for which they were created and do not produce a biased analysis of the results. In addition, by standardizing the criteria, the indicator selection process should be more streamlined, costs should be reduced, duplication of effort should be minimized and consistency ensured, increasing the benefits of indicators.

In this context, where the use of indicators in planning and SEA is still underexplored, as discussed above, the research described in this paper was mainly focused on studying the adoption of indicators for the planning of water resources and associated SEA processes, as well as on the analysis of indicator integration between both processes. The specific objectives of this research are

threefold: (i) to search for evidence on the use of indicators in water resources planning and SEA processes; (ii) to assess whether the use of indicators in water resources planning and SEA documents show evidence of contribution to crucial functions (characterization and evaluation, communication, decision-making and monitoring); (iii) to check the criteria used for selecting and developing indicators.

To meet the research aim, a conceptual framework, containing the main criteria considered relevant to analyse the use of indicators in River Basin Management Planning (RBMP) and SEA processes, as supported by a literature review, was developed. This framework was used to conduct a content analysis (CA) of the use of indicators in the Portuguese RBMP and SEA reports. This analysis was undertaken in the scope of the WFD requirements, providing relevant and timely information on this matter.

The following sections describe the conceptual framework developed to support the analysis (Section 2), the methods upon which that analysis was based (Section 3), a discussion of the results (Section 4), and finally the main conclusions and recommendations for future developments (Section 5).

2. Methods

2.1. Conceptual framework

The use of a set of indicators is seen as a relevant methodology to evaluate the objectives for RBMP as envisaged in the WFD, which has been gaining increasing relevance (Carter and Howe 2006; Donnelly et al. 2006a; Valenzuela Montes and Matarán Ruiz 2008; European Communities 2009). European and Portuguese legislation does not explicitly require the definition and use of indicators in planning and SEA processes (European Parliament 2001). Nevertheless, there are several reference documents that identify or provide recommendations for the use of indicators to support these processes (Therivel 2004; OECD 2006; Fischer 2007; World Bank 2007, 2011; European Communities 2009; Partidário 2012; European Commission 2013).

The conceptual framework (Table 1) presents a selection of the key aspects and features of indicators, as explored by the literature; additionally, it presents a set of associated criteria developed for the analysis of indicators in planning and SEA processes. This framework is organized around four main clusters of criteria, each one with its own rationale and operational coherence.

The four main clusters are the following: (a) Organization, selection and validation of indicators; (b) Relevance of indicators to promote communication with stakeholders and to support decision-making; (c) Basic information for indicator construction and updating; and (d) Integrating indicators into plans and SEA processes. Each group summarizes key aspects and features for

indicator design and use in planning and related environmental assessments (plans and SEA documents). The rationale for each criterion is supported by the indicated references.

2.2. Case study

The conceptual framework described in the previous section (Table 1) was used to support research of the several documents that comprise the RBMP in Portugal and the corresponding SEA reports.

The analysed documents (dated from 2012, except the Madeira RBMP (RH10), dated from April 2014), were prepared under the scope of the current legal national and European context (European Parliament 2000; European Parliament 2001; Lei nº 58/2005 2005; Portaria 1284/2009 19 de Outubro 2009). The analysed plans include the Technical Reports (TR) of the 10 River Basin Districts and the River Basin Plan (RBP) of Ribeiras do Oeste (RO), as well as the associated SEA main documents, considered as Supplementary Procedural Reports, which comprise the Environmental Report (ER), Non-technical Summary (NTS), Public Participation Report (PPR) and Decision Making Support Information System (DM.SIS). The SEA Scoping Reports (SR) were also analysed. The Environmental Statements (ES) were not reviewed as they were not available at the time the analysis was conducted.

As stated in the WFD, the main spatial unit for river basin management is the River Basin District (RBD). Table 2 presents the structure of the Portuguese RBD, framed by River Basin (RB) and River Basin District Administrations (RBDA),¹ and Figure 1 presents the spatial organization of the Portuguese water management system, which includes 10 RBD. The Portuguese authorities in charge of RBD management are the RBDA.

2.3. Content analysis

The document research was based on the CA technique, defined by Krippendorff (2003, p. 10) as a 'research technique for making replicable and valid inferences from data to their context'. The method consists of a 'set of methods for analysing the symbolic content of any [written] communication. The basic idea is to reduce the total content of a communication to a set of categories that represent some characteristic of research interest' (Norton 2008, p. 433).

CA is a very transparent research method that can be applied to a wide variety of documents, although the validity of the results depends on the quality of the documents reviewed, including their credibility, authenticity, representation and availability (Bryman 2012).

The approach adopted for this research also considered the particular works conducted by GAO (1996) and Neuendorf (2002), which mainly focused on indicators and their assignments and implications for water

**Table 1.** Framework for indicator analysis in planning and SEA processes.

Main clusters of criteria	Criteria for the analysis	Rationale	References
(a) Organization, selection and validation of indicators	<p>Classification of indicators by causal chain frameworks or other conceptual models</p> <p>General criteria for selecting indicators</p> <p>Environmental receptors and targets</p> <p>Participatory processes for indicator selection and validation</p> <p>Entities involved in the selection process</p> <p>Lists of common indicators to be used by different SEA processes</p> <p>Typology of indicators: qualitative or quantitative indicators</p> <p>Identification of conflicts by indicators</p> <p>Identification of trends by indicators</p> <p>Indicators for assessing planning and SEA objectives</p> <p>Adequacy of indicators to inform the public</p> <p>Understanding of indicators by decision-makers and the public</p> <p>Relevance of indicators to support decision-making</p>	<p>The work developed by the Organization for Economic Cooperation and Development (OECD) highlights the relevance of conceptual models for organizing indicators that encompasses economic, environmental, and social aspects and the inter-generational nature of sustainable development. The importance of a conceptual frameworks to classify and systematically organize indicators according to their attributes and characteristics is highlighted by some experts who refer to the importance of adopting causal chain frameworks or other models, such as STRESS (stress-response), PSR (pressure-state-response), DPSIR (driving forces-presures-state-impacts-responses), PSIR (pressure-state-impacts-response) and DSR (driving force-state-response), to facilitate decision-making, establish priorities, improve communication, and identify gaps in data and policies</p> <p>The selection of indicators to support the planning and SEA processes should be based on a set of fundamental criteria to ensure that indicators perform the functions for which they were created and do not produce biased analysis of the results. Individual criteria for selecting indicators are referred to by various works as a requirement for their use. Many isolated indicators can confuse their intended users, mainly the public and decision-makers. A comprehensive set of planning and SEA indicators is the minimal set that represents the phenomena of interest in a way that is both robust and amenable to decision-making</p> <p>Indicators should cover a range of environmental receptors or thematic areas that apply to different situations. In this case, an indicator must respond to a wide range of environmental conditions related to the impact being evaluated in the appropriate time period and geographical scale</p> <p>The information transmitted by indicators must be adjusted to the end users' needs. It is not necessary that all users (e.g. decision-makers, general public) fully understand all the details behind the calculation of an indicator. However, the information conveyed should be clearly understood to support informed decisions and participation. An initial set of indicators should be identified and then refined through discussion with key stakeholders. Engagement of the various stakeholders in the selection of relevant indicators provides a number of key benefits as it allows for the indicators to be understood and used by stakeholders. The validation of indicators by a consensus of experts and of end users is a recommended requirement for indicator validation. Overall, the selected indicators should be considered important by stakeholders</p> <p>To date, many indicator systems have been developed; however, each set is often based on different criteria or designed to cover different geographical areas. The possibility of performing comparisons between different countries and regions suggests the use of general indicator lists. Thematic indicator lists or lists by type of plan have the potential to be a useful planning tool to provide an adequate basis for informing planning action and determining the sustainability of planning outcomes. The development of the indicator core set for the EEA is an example that was guided by the need to identify a small number of relevant indicators for policies that are stable, but not static, and that provide answers to selected priority policy questions</p> <p>In planning and SEA processes, indicators may be presented as quantitative or qualitative evaluation metrics, although quantitative indicators are generally preferred by stakeholders. However, it must also be stressed that qualitative approaches are often advisable in these processes; therefore, qualitative indicators should be a common option</p> <p>In many cases, the plan objectives and the SEA objectives will be in conflict, unless the plan is a conservation or environmental plan. In the SEA process, the indicators used must allow for the identification of conflicts at an early stage so that a compromise may be reached before it is too late</p> <p>Indicators must measure changes in the environment so that they will be able to assess trends. Several works highlight that the sets of historical data available and used in planning and SEA studies are neither sufficiently broad nor robust to allow for the establishment of trends</p> <p>Environmental objectives, targets and indicators are strongly linked and are the tools through which the environmental effects of a proposed plan may be assessed and through which the monitoring system is developed. In this sense, evaluation and monitoring systems are most useful when indicators are linked to objectives</p> <p>Communication is one of the most emphasized goals of indicators and requires the indicator to have the ability to convey relevant information to stakeholders so that the indicators are relevant for communication, in particular with the general public and decision-makers. The comprehensibility of indicators is a criterion that focuses on their clear definition, adequate presentation and evaluation. Contradictory messages should not occur, and if any do occur, they must be explained. Documentation and technical notes of indicator construction should be made available to interested parties for a better understanding of their meaning. A smaller number of indicators will be more understandable for the public. More aggregated information (e.g. indexes) or information presented through indicator matrices is one of the recommended ways to communicate with the public</p> <p>Indicators should have the ability to provide valuable information on complex issues at an appropriate level to make policy decisions, and they should be an important policy tool if their values and information are used by a variety of users and integrated into regular decision-making processes. Reports should make clear mention of the use of indicators to support decision-making, e.g. indicator 'dashboards' or indicator matrices</p>	<p>OECD (1993), RIVM/UNEP (1997), OECD (2000, 2003), Ramos et al. (2004), Niemelä and de Groot (2008), Valenzuela Montes and Matarán Ruiz (2008), Gudmundsson et al. (2010), and Mascarenhas et al. (2015)</p> <p>Gallopín (1996), OECD (2000), Therivel (2004), Donnelly et al. (2007), Valenzuela Montes and Matarán Ruiz (2008), Donnelly et al. (2008), d'Auria and Cinnéide (2009), Gao et al. (2013b), and Mascarenhas et al. (2015)</p> <p>Therivel (2004), Donnelly et al. (2007), da Silva et al. (2012), and Faick and Spangenberg (2014)</p> <p>Kurtz et al. (2001), Bockstaller and Girardin (2003), Cloquet-Ballester et al. (2006), Fraser et al. (2006), Donnelly et al. (2007), Niemelä and de Groot (2008), Ramos (2009), and Ramos and Caeiro (2010)</p> <p>European Environment Agency (2005), Valenzuela Montes and Matarán Ruiz (2008), Ramos (2009), Gao et al. (2010), Gonzalez et al. (2011), and Mascarenhas et al. (2015)</p> <p>Donnelly et al. (2006a), Birkmann (2007), Mascarenhas et al. (2012), and da Silva et al. (2014)</p> <p>OECD (2000), Therivel (2004), Donnelly et al. (2007), and Helbron et al. (2011)</p> <p>OECD (2000), Therivel (2004), Donnelly et al. (2008), and Partidário (2012)</p> <p>Ramos et al. (2004), Therivel (2004), Fischer (2007), Donnelly et al. (2008), and Mascarenhas et al. (2015)</p> <p>Kurtz et al. (2001), Therivel (2004), European Environment Agency (2005), Donnelly et al. (2007), Niemelä and de Groot (2008), Gao et al. (2013b), and Morse (2015)</p> <p>Donnelly et al. (2007) and Mascarenhas et al. (2015)</p>

(c) Basic information for indicator construction and updating	Frequency of data collection to support the indicators Data source and organizations in charge of data management, construction and updating of indicators Information obtained at reasonable costs	A relevant issue regarding the use of indicators is the compiled database and management entities. The major challenge in the development of indicators is how to effectively build valid and good quality data that are suitable for the analysis of a given reality in a satisfactory manner. The types of data collected, the frequency and accuracy of collection, and the availability vary widely from place to place. The availability of data is also a central criterion for the development and periodic updating of indicators Cost is a relevant criterion to consider in the selection and use of an indicator set. This criterion represents the ease of retrieving, processing and updating indicators in monetary and operational terms, as well as the use of human resources. The cost of gathering and processing additional relevant information may become a constraint on the use of indicators. It is therefore recommended to keep the number of indicators to a minimum and to establish a careful selection of indicators to be used to maximize existing resources, as well as to reduce costs The use of indicators is considered relevant to demonstrate the impact on the environment and to enable the prediction of the effects of plans and programs. It is also one of the main challenges for the integration of SEA requirements with planning processes Although indicators are usually considered important in almost every step of the SEA process, the set of environmental indicators should preferably be selected during the scoping stage. A large number of indicators can be a problem, particularly for the implementation of a monitoring programme, and it is recommended to keep the number of indicators to a minimum, enabling the identification of the most relevant environmental impacts of the plan in question While implementing a proposed plan or programme, it could be necessary to review the indicators and replace the ones that have become irrelevant or for which it was not possible to obtain relevant data. If needed, in the mid-term review of a proposed plan or programme, the ability of indicators to record the impact of the plan or programme being implemented should be evaluated. The list of selected indicators should be dynamic and adaptive and should be revised throughout the entire planning process to reflect the objectives and expected sustainability goals	Niemeijer (2002), Gleick (2003), Therivel (2004), Wong (2005), Donnelly et al. (2007), Niemeijer and de Groot (2008), d'Auria and Cinnide (2009), and Juwana et al. (2012) Gallop (1997), Niemeijer (2002), Gleick (2003), Therivel (2004), Wong (2005), d'Auria and Cinnide (2009), Juwana et al. (2012), da Silva et al. (2012), and Mascarenhas et al. (2012) Therivel (2004), Schmidt et al. (2005), Donnelly et al. (2006a), and Gao et al. (2010) Birkmann (2003), Fischer and Phyllip-Jones (2008), Ramos and Caeiro (2010), Gao et al. (2013a), and Polido and Ramos (2015) Therivel (2004), Donnelly et al. (2007, 2008), and Gao et al. (2013b)
(d) Integrating indicators into plans and SEA processes	Differences between the indicators used in the planning and SEA processes Differences between the indicators used in the Scoping Report (SR), Environmental Report (ER) and Non-Technical Summary (NTS) of the SEA processes Differences between the indicators used in the different phases of the planning process		

Table 2. Portuguese River Basin Districts.

River Basin District Administrations (RBDA)	River Basin Districts (RBD)	River Basins (RB)
ARH Norte	RH1 RH2 RH3	Minho/Lima Cávado/Ave/Leça Douro
ARH Centro ARH Tejo	RH4 RH5	Vouga/Mondego/Lis Ribeiras do Oeste Tejo
ARH Alentejo	RH6 RH7	Sado/Mira Guadiana
ARH Algarve ARH Açores ARH Madeira	RH8 RH9 RH10	Ribeiras do Algarve Açores Madeira

resources plans. The CA was mainly qualitative and was based on the definition of variables or criteria (information that the appraiser searches for), categories (possible answers that should be mutually exclusive), and analysis of the selection of material and recording units (portions of text to analyse) (GAO 1996; Neuendorf 2002; Krippendorff 2003).

The CA process started with a detailed verification of each reference to the keyword 'indicator' in each of the reports (TR and NTS indicators in the planning process and SR, ER, NTS and PPR indicators in the related SEA processes). The analysed reports constituted the recording units and established the support for the code assigned to each occurrence of the keyword.

3. Results and discussion

The main results obtained from the CA are presented in Tables 3–6, organized according to the four main clusters included in the framework.

After CA was performed, it was possible to highlight that complete information to support the evaluation to relate indicators and criteria of analysis was mainly available in the TR and ER documents. In the remaining documents (SR, NTS, PPR and DM.SIS), the associations between the indicator sets included in those documents and the indicators used in the TR and ER were analysed.

3.1. Organization, selection and validation of indicators

The different RBD followed very different strategies for the organization, selection and validation of indicators, and several RBMP mentioned a variety of criteria for indicator selection, although their procedures were not explicitly described. Supporting guidance documentation and the adopted technical steps, indicating how the indicator was constructed and used, should be clearly stated to the interested parties to enable better understanding of its meaning (Therivel 2004; Donnelly et al. 2007; Gao et al. 2013a).

According to Gallop (1997), Kurtz et al. (2001) and Donnelly et al. (2007), public participation in the selection of indicators is highly desirable as an obligation of a

Table 3. Content analysis assessment topics grouped by River Basin District: Cluster a. Organization, selection and validation of indicators.

Content analysis as- sessment variables		Total number of indicators	Classification of indicators by conceptual or other models	General criteria for selecting indicators	Participatory processes for indicator selection and validation	Entities involved in the selection process	Typology of indi- cators ^a : qualitative or quantitative indicators	Environmental receptors and targets		Lists of common indicators to be used by different SEA processes			
Categories of analysis	Total number of indicators in the documents	TR	ER	Model identi- fication	Criteria identi- fication	TR, ER	TR, ER	Verification of ref- erences to public participation	Entity identi- fication	TR, ER	Typology identi- fication and num- ber of indicators in the documents	Indicators organized by different environmental recep- tors/themes	Identification of indicator lists
	Documents with responses to the analysed variables	TR	ER	TR, ER	TR, ER	TR, ER	TR, ER	TR, ER	TR, ER	TR, ER	TR, ER	TR, ER	ER
	RH1 River Basin Districts	167	83	TR: DPSIR model	TR: SWOT analy- sis/QSIGA ^b	No explicit reference. However, SR (with indicators) were submitted to pub- lic consultation, including 'Entities with Specif- ic Environmental Responsibilities'	No explicit refer- ence. Regional and national authorities of water planning and cross-cutting areas were listed, but it was not stated if they had any role in the in- dicator selection process	TR and NTS: quan- titative ER and NTS: only 8 were qualitative TR: quantitative ER and NTS: quan- titative	ER: indicators were organized into 'Sustainability factors': Socioeconomic develop- ment; Water resources; Natural values and heritage; Vulnerabilities and risks	TR: The indicators in the planning processes were organized into seven Thematic Areas (TA): Water quality; Water quantity; Risk management and exploita- tion of water resources; Institutional and regulatory framework; Economic Monitoring, research and knowledge; Communication and governance	Indicators of Sustainable Development; Indicators System of Land Manage- ment and Urban Development		
	RH2	163	81	ER: 'Sustainability factors'	ER: Technical documents and indicators of sustainable development								
	RH3	167	83						TR: quantitative ER and NTS: only one was quali- tative	ER indicators were organized into 'Critical factors for decision-making': Biodiversity and natural resources; Spatial planning; Economic competi- tiveness; Natural and techno- logical risks; Governance			No reference
RH4	170	110 ^c	TR: DPSIR model ER: 'Critical factors for decision-making'	TR: Gathering information in an easy and least-costly way; choice of measurable and auditable indicators				TR: only 11 indicators were qualitative ER and NTS: 24 indicators were qualitative					

(Continued)

Table 3. (Continued).

Content analysis as- sessment variables	Total number of indicators		Classification of indicators by conceptual or other models	Criteria for selecting indi- cators	Participatory processes for indicator selection and validation	Entities involved in the selection process	Typology of indi- cators: qualitative or quantitative indicators	Environmental receptors and targets		Lists of common indicators to be used by different SEA processes
	TR	ER	Model identi- fication	Criteria identi- fication	Verification of ref- erences to public participation	Entity identi- fication	Typology identi- fication and num- ber of indicators in the documents	Indicators organized by different environmental recep- tors/themes	TR, ER	
Categories of analysis	Total number of indicators in the documents		Model identi- fication	Criteria identi- fication	Verification of ref- erences to public participation	Entity identi- fication	Typology identi- fication and num- ber of indicators in the documents	Indicators organized by different environmental recep- tors/themes		Identification of indicator lists
Documents with responses to the analysed variables	TR	ER	TR, ER	TR, ER	TR, ER	TR, ER	TR, ER, NTS	TR, ER		ER
River Basin Districts	127	82	TR: DPSIR model	TR: SWOT analysis	No explicit reference. However, SR (with indicators) were submitted to pub- lic consultation, involving 'Entities with Specif- ic Environmental Responsibilities'	No explicit refer- ence. Regional and national authorities of water planning and cross-cutting areas were listed, but it was not stated if they had any role in the in- dicator selection process	TR: quantitative ER and NTS: only 15 were qualitative TR: quantitative ER and NTS: only 12 were qualitative	ER: indicators were organized into 'Critical factors for decision-making': Govern- ance; Water resources; Spa- tial planning; Socioeconom- ic sustainability; Cultural and intangible heritage; Biodiversity and nature con- servation; Vulnerabilities and risks	TR: The indicators in the planning processes were organized into seven Thematic Areas (TA): Water quality; Water quantity; Risk management and exploita- tion of water resources; Institutional and regulatory framework; Economic and financial framework; Monitoring, research and knowledge; Communication and governance	No reference
RO	122	60	ER: 'Critical factors for decision- making'	ER: Robustness and measur- ability						
RH6 RH7	144 142	90 87	TR: PSR model ER: 'Themes for sustainability'	SMART criterion (Specific, Measur- able, Achievable and Agreed, Relevant and Time-related); de- veloped quickly and expeditiously by using easily accessible data			TR: quantitative ER and NTS: quan- titative TR: only seven were qualitative ER and NTS: quan- titative	ER: indicators were displayed as 'Themes for sustainabil- ity': Biodiversity; Natural and cultural resources; Territorial development and competitiveness; Vulnerabil- ities and risks; Planning and governance	OECD guidelines; European and National Indicators of Sustainable Development	
RH8	179	86								

Content analysis as- essment variables		Total number of indicators	Classification of indicators by conceptual or other models	Criteria for selecting indi- cators	Participatory processes for indicator selection and validation	Entities involved in the selection process	Typology of indi- cators: qualitative or quantitative indicators	Environmental receptors and targets		Lists of common indicators to be used by different SEA processes
Categories of analysis		Total number of indicators in the documents	Model identi- fication	Criteria identi- fication	Verification of ref- erences to public participation	Entity identi- fication	Typology identi- fication and num- ber of indicators in the documents	Indicators organized by different environmental recep- tors/themes	Indicators organized by different environmental recep- tors/themes	Identification of indicator lists
Documents with responses to the analysed variables		TR	ER	TR, ER	TR, ER	TR, ER	TR, ER, NTS	TR, ER	TR, ER	ER
River Basin Districts		182	73	TR: SWOT analysis ER: National and international reports on environmental and sustainable development indicators and other indicators used by the regional administration in the planning instruments	No explicit reference. However, SR (with indicators) were submitted to pub- lic consultation, involving 'Entities with Specif- ic Environmental Responsibilities'	No explicit refer- ence. Regional and national authorities of water planning and cross-cutting areas were listed, but it was not stated if they had any role in the in- dicator selection process	TR and ER: mainly quantitative; some indicators had no informa- tion about the typology	ER: indicators recorded as 'Assessment factors': Gov- ernance and citizenship; Economic sustainability and competitiveness; Territorial dynamics; Water resources; Biodiversity and ecosystem services; Vulnerabilities and risks	TR: The indicators in the planning processes were organized into seven Thematic Areas (TA): Water quality; Water quantity; Risk management and exploita- tion of water resources; Institutional and regulatory framework; Economic and financial framework; Monitoring, research and knowledge; Communication and governance	Performance Indica- tors for Wastewa- ter Services; Indicators already defined in Region- al Water Plan of Açores; Indicators of Sustainable Development for Macaronesia region and for Portugal
	RH10	148	74	TR: PSR model ER: 'Critical factors for decision- making'	TR: Suggested criteria at the European level, namely, WISE system (Water Information System for Europe) ER: Same proce- dure as RH9		TR: quantitative ER and NTS: 22 were qualitative	ER: indicators were organized into 'Critical factors for decision-making': Water resources; Biodiversity and nature conservation; Vulnerabilities and risks; Resources knowledge and management; Socioeco- nomic sustainability of water services	Indicators already defined in the Regional Water Plan of Madeira	

Notes: RH1, RH2, RH3, RH4, RH5, RH6, RH7, RH8, RH9, RH10 – Portuguese River Basin Districts; TR – Technical Report; ER – Environmental Report; SR – Scoping Report; NTS – Non-Technical Summary; PPR – Public Participation Report; DM-SIS – Decision-Making Support Information System.

^aQuantitative indicators were measures of quantities or amounts expressed in numeric form. Qualitative indicators were subjective descriptions or categories used to express results in terms of quality, which indicated the judgments, opinions, perceptions or level of satisfaction of people about a particular subject, and were normally presented in a non-numerical scale.

^bIn Portuguese terminology, QSiGA means Significant Issues of Water Management.

^cIn ER of RH4, indicators were presented as 'Critical Factors for Decision-Making' (45 indicators) and also monitoring indicators (80 indicators). Between the two indicator sets, there were 10 similar indicators, so a total number of 110 indicators referring to ER of the RBD were considered.

Table 4. Content analysis assessment topics grouped by River Basin District: Cluster b. Relevance of indicators to promote communication with stakeholders and to support decision-making.

Content analysis assessment variables	Identification of conflicts by indicators	Identification of trends by indicators	Indicators for assessing planning and SEA objectives	Adequacy of indicators to inform the public	Relevance of indicators to support decision-making	Understanding of indicators by decision-makers and the public
Categories of analysis	Reference to conflicts identified by the indicators	Identification of trends by the indicators	Identification of associations between objectives and indicators	Existence of matrices, figures (e.g. flowcharts) or other schemes and tools for indicator communication	Identification of indicator results that are used to support decision-making	Use of normalized indicators, as well as indicators aggregated in classes of quality or impact, in complement to the original units of measurement
Documents with responses to the analysed variables	TR, ER	TR, ER	TR	NTS, PPR	ER, TR, DM, SIS	ER, TR, NTS, PPR, DM, SIS
River Basin Districts	Conflict identification and management through indicator analysis was mentioned on some of the planning reports, but they did not indicate how it was performed. The ER and NTS were not supported by any explicit reference to the existing relationship between conflicts and indicators	The relevance of indicators for trend analysis was mentioned in all plans and SEA reports. However, the method used to establish the relationship was not reported, namely, the reference to the length of the data series used	The analysed documents explicitly state that the proposed indicators were strictly related to the plans and SEA targets. Measures to promote the achievement of each objective and the indicators supporting the evaluation of each measure were presented in each document	Simple matrices were presented in NTS of TR and ER Simple matrices were presented in NTS of ER. In the PPR, some of the comments presented concern to indicators Simple matrices were presented in NTS of ER Simple matrices were presented in NTS of ER. In the PPR, some of the comments presented concern to indicators	It was mentioned in the examined documents that the indicators were important to promote decision-making. The summarized matrix that presents the information of the system of promotion, monitoring, control and evaluation, was presented by using indicators	There was no detailed reference. In most situations, simple matrices were used; however, the indicator presentation was not uniform, sometimes indicators were presented as absolute values, while on other occasions, they were displayed as standardized values
RH1						
RH2						
RH3						
RH4						
RH5						
RO						
RH6						
RH7						
RH8						
RH9						
RH10						

Notes: RH1, RH2, RH3, RH4, RO, RH5, RH6, RH7, RH8, RH9, RH10 – Portuguese River Basin Districts; TR – Technical Report; ER – Environmental Report; SR – Scoping Report; NTS – Non-Technical Summary; PPR – Public Participation Report; DM, SIS – Decision-Making Support Information System.

Table 5. Content analysis assessment topics grouped by River Basin District: Cluster c. Basic information for indicator construction and updating.

Content analysis assessment variables		Frequency of data collection to support the indicators	Data source and organizations in charge of data management, construction and updating of indicators	Information obtained at reasonable costs
Categories of analysis	Documents with responses to the analysed variables	Reference to frequency of data collection	Identification of references to entities and data sources	Reference to cost of data gathering
River Basin Districts	RH1	TR, ER References in documents state that most indicators of SEA were updated on an annual basis. There was no clear reference to the updating of the planning-process indicators	TR, ER In each process, a set of relevant authorities that own the data used to construct and update the indicators was identified. River Basin District Administrations were responsible for managing each RBMP/RBP to produce and compile information to share with the various entities involved in water management	TR, ER There was no formal reference
	RH2	No reference		
	RH3			
	RH4			
	RH5	References in documents state that data collection to update most indicators was conducted on an annual basis for the plan and the SEA indicators		
	RO			
	RH6			
	RH7	References in the documents state that most indicators of the planning process were updated on an annual basis. There was no clear reference to the updating of the SEA process indicators		
	RH8	References in the documents state that data collection to update most indicators was performed on an annual basis for the plan and the SEA indicators		
	RH9			
	RH10			

Notes: RH1, RH2, RH3, RH4, RO, RH5, RH6, RH7, RH8, RH9, RH10 – Portuguese River Basin Districts; TR – Technical Report; ER – Environmental Report; SR – Scoping Report; NTS – Non-Technical Summary; PPR – Public Participation Report; DM.SIS – Decision-Making Support Information System.

Table 6. Content analysis assessment topics grouped by River Basin District: Cluster d. Integrating indicators into plans and SEA processes.

Content analysis assessment variables		Differences between the indicators used in SR, ER and NTS of the SEA processes	Differences between the indicators used in the different phases of the planning process	Differences between the indicators used in the planning and SEA processes
Categories of analysis	Documents analysed	Existence of common indicators	Existence of common indicators	Existence of common indicators
River Basin Districts	RH1	SR, ER, NTS Each ER was supported by indicators. ER indicators were also presented in the SR. The documents stated that indicators were used to characterize the situation in reference, for environmental assessments, to define the monitoring programme and for public participation. In some cases, the indicators used in the ER were not exactly coincident with the proposed indicators in SR	TR, NTS All RBMP used indicators. Overall, the indicators were denoted in the documents as indicators of characterization, diagnosis, and economic and as pertaining to the assessment system, communication and follow-up. However, they were not disaggregated in these classes	TR, ER Some similar indicators were found in the analysed documents
	RH2			
	RH3			
	RH4			
	RH5			
	RO			
	RH6			
	RH7			
	RH8			
	RH9			
	RH10			

Notes: RH1, RH2, RH3, RH4, RO, RH5, RH6, RH7, RH8, RH9, RH10 – Portuguese River Basin Districts; TR – Technical Report; ER – Environmental Report; SR – Scoping Report; NTS – Non-Technical Summary; PPR – Public Participation Report; DM.SIS – Decision-Making Support Information System.

^aIn ER of RH4, the indicators were presented as 'Critical Factors for Decision-Making' (45 indicators) and also monitoring indicators (80 indicators). Between the two indicator sets, there were 10 similar indicators, so a total number of 110 indicators referring to ER of the RBD were considered.

^bIn NTS, the use of indicators was referenced, but the indicator set was not presented.



Table 7. SEA indicators by environmental themes and RBD.

Environmental themes	Total number of SEA indicators used by each RBMP, examples of the most common indicators and respective percentage ^a										
	RH1	RH2	RH3	RH4	RH5	RO	RH6	RH7	RH8	RH9	RH10
Biodiversity (Biodiversity; Biodiversity and ecosystem services; Biodiversity and nature conservation)	Renaturalization of water bodies (km)				5	9	18	17	14	16	67%
	Control actions of invasive species (number)										67%
	Protected areas of the National Network of Protected Areas (%)										33%
	Dams with fishway devices in operation (number)										33%
Governance (Governance; Governance and citizenship; Planning and governance)	Training and information activities conducted (number)			6	8	5	9	9	7	7	71%
	Number of consumer awareness and training actions (number)										43%
	Strategy used for information dissemination of the water resources management (number)										43%
	Communication and dissemination technologies used (model)										29%
Resources (Natural and cultural resources; Natural resources and biodiversity; Natural values and heritage; Cultural and intangible heritage; Resources knowledge and management)	Meetings/workshops of working groups (number)										29%
	Protected abstraction from groundwater and surface waters (number)	13	13	13	8	6	5	30	24		14
	Classified and protected areas associated with water bodies (% of total area)										50%
	Classified heritage (occurrences number)										30%
Water resources	Conservation state (favourable, unfavourable, unknown) (%)										30%
	Water remediation interventions (number)	32	31	32		20	12			22	30%
	Water consumption by sector and by source (hm ³ /year)										21
	State of water bodies (excellent, good, mediocre, bad, unknown) (number)										71%
Socioeconomic development (Socioeconomic development; Economic competitiveness; Socioeconomic sustainability; Socioeconomic sustainability of water services; Economic sustainability and competitiveness)	Water requirements by sector (hm ³ /year)										57%
	Population served by wastewater treatment systems (%)										57%
	Inspection actions (number)										43%
	Level of service in water supply (%)										43%
Spatial planning (Territorial development and competitiveness; Territorial dynamics; Spatial planning)	Quantity of wastewater reused/water requirements (%)										43%
	Vulnerable and/or sensitive areas (number and km ²)	15	15	15	9	11	8			12	29%
	Water use by sector (hm ³)										29%
	Cost recovery level by sector (%)										19
Vulnerabilities and risks (Vulnerabilities and risks; Natural and technological risks)	Cost recovery in water services (euro/m ³)										63%
	Domestic water use/resident population (m ³ /inhabitant)										50%
	Protected areas outline (number)			12	8		7	17	16	26	38%
	Floodplain area (ha)										38%
Total	Measures performed to reconcile territory uses and occupations (number)										57%
	Heritage conservation status related with water (favourable, unfavourable, unknown) (%)										43%
	Areas at risk (% of total area)	23	22	23	10	24	14	16	15	15	29%
	Affected population (number)										14
Total	Alert systems (number)										64%
	Approved dam security plans (number)										36%
	Registered accidents of serious pollution and/or rupture of dams (number)										36%
	SEVESO and IPPC installations (number)	83	81	83	45	82	60	90	87	86	74

Notes: RH1, RH2, RH3, RH4, RO, RH5, RH6, RH7, RH8, RH9, RH10 – Portuguese River Basin Districts.

^aPercentages were calculated in relation to the total number of RBMP with indicators.

Table 8. Planning indicators by thematic area and RBD.

Total number of indicators used by each RBMP, examples of the most common indicators and the percentage that each indicator was proposed ^a											
Thematic areas	RH1	RH2	RH3	RH4	RH5	RO	RH6	RH7	RH8	RH9	RH10
Water quality	62	61	62	45	34	33	44	43	48	67	40
	State of the water bodies (excellent, good, mediocre, bad) (number)										
	Total, diffuse and punctual pollutant loads (t/year)										
	Vulnerable areas (number)										
	Installations with environmental permits (number)										
	IPPC installations (number)										
Water quantity	31	29	31	27	34	32	17	17	23	36	20
	Total water needs by sector (hm ³ /year)										
	Underground and surface water abstractions (number)										
	Total water inflow (hm ³ /year)										
	Total water consumption by sector (hm ³)										
	Storage capacity in reservoirs (hm ³)										
Risk management and exploitation of water resources	20	20	20	22	13	13	23	22	32	22	28
	Average water price (€/year)										
	Areas with high risk of water erosion and fire (ha)										
	Dams covered by the Dams Safety Regulation (number)										
	Riparian galleries and coastline interventions (number; km)										
	Areas subject to drought and water scarcity (ha)										
Institutional and regulatory framework	10	10	10	10	6	6	4	4	6	7	2
	Floodplain area (ha)										
	Serious water pollution incidents (number)										
	Large wastewater treatment plants (number)										
	Water-use licences assigned (number)										
	Inspection actions conducted (number)										
Economic and financial framework	19	19	19	25	18	18	36	36	41	16	27
	Contra ordinations (number)										
	Cost recovery level (%)										
	Water monitoring stations (number)										
	Resident population (number)										
	Number of tourist beds (number; %)										
Monitoring, research and knowledge	18	18	18	30	16	14	10	10	17	27	21
	Water prices (water supply, irrigation, sanitation) (€/m ³)										
	GVA/m ³ of water consumed (by sector) (€/m ³)										
	Seasonal or secondary housing (number; %)										
	Monitored water bodies (groundwater, water surface) (number)										
	Monitoring stations (groundwater, water surface, lakes and reservoirs) (number)										
Communication and governance	7	6	7	11	6	6	10	10	12	7	10
	Activities and developed projects (number)										
	Projects implemented in the scope of water resources (number)										
	Measures to control water quality (number)										
	Information and awareness actions on water resources (number)										
	Participants in CRH meetings (number/year)										
Total	167	163	167	170	127	122	144	142	179	182	148
	Reports on the status of water bodies in the river basin district (number)										
	Consults to the ARH portal (number)										

Notes: CRH – Council of River Basin District; ARH – Portuguese acronym for River Basin District Administrations; RH1, RH2, RH3, RH4, RO, RH5, RH6, RH7, RH8, RH9, RH10 – Portuguese River Basin Districts.

^aPercentages were calculated in relation to the total number of RBMP with indicators.

the highest number of indicators. Indicators related to water resources socio-economic development were also common. In the ER of RH4, a specific set of *ex post* monitoring indicators was presented. *Ex post* monitoring indicators were not specifically identified in the other RBD. Table 7 presents the SEA indicators organized according to environmental receptors, the total number of indicators in each category and examples of the most frequently used indicators.

In the RBMP reports, indicators were organized into seven thematic categories. Table 8 presents the indicators used in the plans, organized into thematic areas. The thematic areas 'water quality' and 'water quantity' presented the highest number of indicators. To characterize, evaluate and follow-up the 'water quality', approximately 30% of the total number of indicators were used in all the RBD. The characterization of 'water quantity' was supported by a large number of indicators, whose percentage ranged from 27% in RH5 to 12% in RH6 and RH7. The indicators integrated in the theme 'institutional and regulatory framework' appeared in smaller numbers, approximately 4% of the total for all RBD, similar to the indicators of 'communication and governance' (4%) in the north and Açores RBDA (ARH Norte e ARH Açores).

In the RBMP reports, indicators were mainly structured through the conceptual DPSIR (RIVM/UNEP 1997) and PSR (OECD 1993) models, although this requirement was not established in the official guidance documents nor in the legal framework.

Figure 2 presents the number of indicators used in the planning process for each RBD and the adopted conceptual model. The adopted indicator models varied between RBD (DPSIR and PSR models). The number of indicators used in each component of the conceptual model also varied between RBD, although, on average, there was a balance between the three components of the PSR model. On average, pressure indicators

represented 30% of the total number of indicators (minimum and maximum of 39 and 60 indicators); state indicators (minimum and maximum of 30 and 81) and response indicators (minimum and maximum of 32 and maximum 79) each corresponded to 27% of the total number of indicators. The impact indicators in the DPSIR model represented 4% of the total number of indicators. Matondo (2002), Valenzuela Montes and Matarán Ruiz (2008), Helbron et al. (2011) and Juwana et al. (2012) stress the importance of using similarly structured indicator models to enable comparative analyses and to support cohesive and global decision-making.

3.2. Relevance of indicators to promote communication with stakeholders and to support decision-making

The analysed documents explicitly state that the indicators used were strictly related to the plans and SEA objectives and targets, in line with the recommendations of Donnelly et al. (2006a).

The relevance of the indicators for trend analysis was mentioned in all RBMP and SEA reports. The possibility of identifying and managing conflicts between planning and environmental assessment objectives by using indicators was also mentioned in some of the planning and SEA reports. However, the methodology and the set of indicators that could support this analysis were not mentioned. In this context, Donnelly et al. (2007) and Helbron et al. (2011) recommended that the set of indicators used in environmental assessment must allow the identification of conflicts in early stages of the planning process to reach a compromise between the planning and SEA objectives before it is too late.

Communication is one of the most emphasized goals of the indicators (European Environment Agency 2005; Niemeijer and de Groot 2008; Gao et al. 2013a).

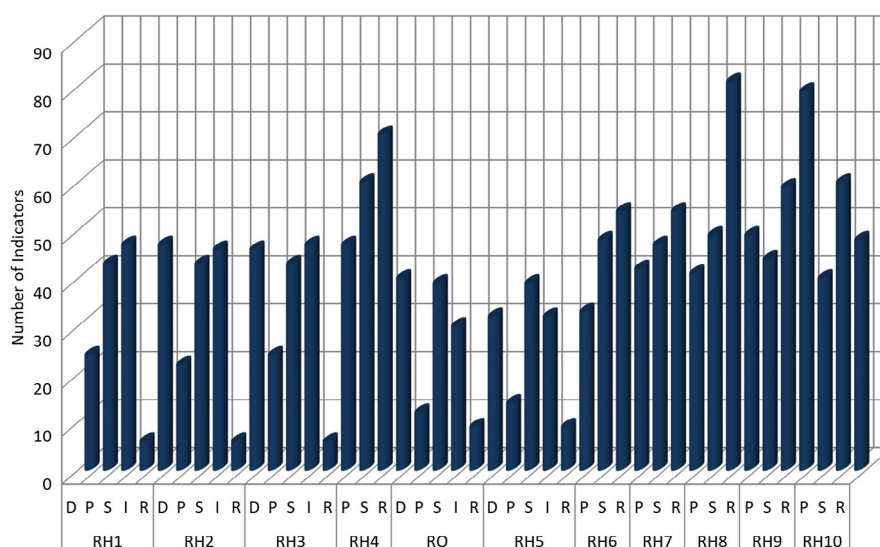


Figure 2. Number of indicators in the planning process in each RBD and conceptual model.

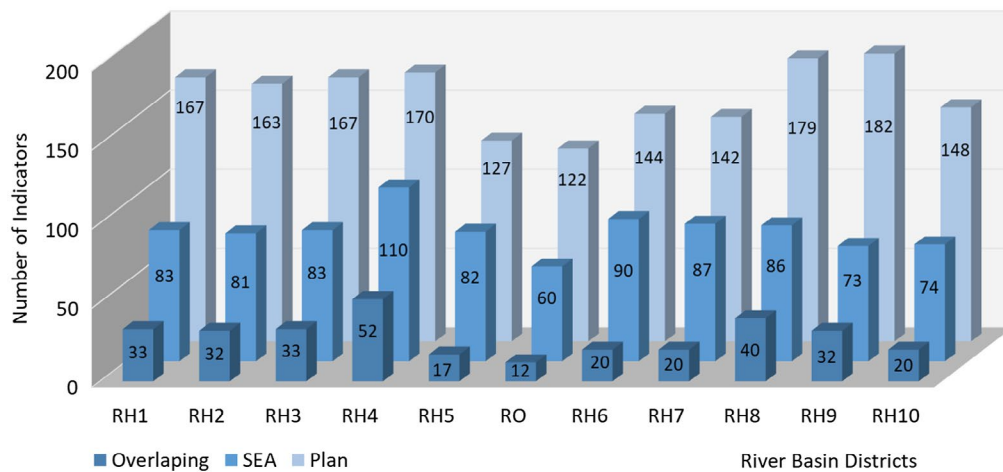


Figure 3. Planning and SEA processes indicators for all River Basin Districts.

Communicating information to the public based on indicators was often mentioned and emphasized in the TR, ER, NTS and PPR. However, there was no explicit reference to the relevance of the indicators for the public participation process. The indicator sets mentioned in the TR and ER were not listed in all NTS, although NTS are the main documents consulted by the public in the consultation processes and are used to communicate the key findings of the technical and environmental reports (Bonde and Cherp 2000; European Parliament 2001; European Communities 2009). On the other hand, some of the contributions submitted by public authorities and other actors reported the indicators, which suggests that the indicators were used in the public participation stage in some situations.

Gallopin (1997), Niemeijer and de Groot (2008) and Mascarenhas et al. (2015) state that the most important feature of indicators, compared to other forms of information, is their relevance to policy and decision-making. In the majority of the technical and environmental reports for RBMP and SEA processes, the relevant information, including objectives, measures, recommendations for implementation and goals, were presented in a final summary matrix based mainly on the indicators. The adoption of this technique is an important step to support an informed decision-making process, as suggested by Ramos et al. (2004), Therivel (2004), Donnelly et al. (2006b) and Gao et al. (2013b).

3.3. Basic information for indicator construction and updating

In all the analysed documents, sets of entities with responsibilities in the coverage area of each plan were identified. In particular, RBDA were responsible for managing each RBMP/RBP to produce and compile information to share with the various entities involved in water management. However, it was not always clearly indicated who was responsible for providing data and information to build and update the plan and SEA indicators.

In the plans and SEA reports, the frequency with which data were collected to update the indicator sets was not always presented; however, most indicators included data collection on an annual basis. This annual pattern follows the suggestion of Therivel (2004) and Niemeijer and de Groot (2008), who stress that data collection should be conducted on an annual basis. However, for some indicators, this rule does not apply.

The cost of data collection was not reported in the TR or ER. However, in some cases, the importance of easy and non-expensive data collection was highlighted, although there was no reference about the operationalization of this criterion. This aspect is one of the concerns identified by Wong (2005) for indicator updating. Mascarenhas et al. (2012) report that the cost criterion represent the ease with which data can be retrieved and used to update indicators in economic, logistical and human resources terms and should be one of the main elements considered in the indicator selection process. (Ramos and Caeiro 2010) state that the costs associated with the implementation of indicators should be anticipated. The cost/benefit ratio of each indicator should be reasonable since the cost may be a constraint to maintaining an existing indicator or adding a new indicator.

3.4. Integrating indicators into plans and SEA processes

In the majority of cases, the indicators did not show important differences between the planning process and the corresponding SEA. This result was mainly supported by the overlap between the two groups of indicators and by the verification of the main features and properties. However, the cross-comparison was not simple since the terminologies used were not fully compatible, raising doubts during the analysis. In addition, the indicator measurement units were not the same in many situations. The overlap rate ranged from 20% for the RBP of RO to 47% for RH4. Figure 3 presents the overlapped indicators between processes. It should be stressed that

the overlap between planning and SEA indicators is a major challenge for the integration of SEA requirements and planning processes, according to Therivel (2004), Schmidt et al. (2005), Donnelly et al. (2006b), Fischer and Philip-Jones (2008) and Gao et al. (2010).

In the RBMP reports, indicators are designated as indicators of 'characterization, evaluation, communication and monitoring'. However, the indicators presented in the documents were not specifically disaggregated according to the abovementioned categories. If the presentation of the indicators for each river basin district followed a typological presentation model and identified, for example, the monitoring indicators of the plans and the SEA process, it would be possible to assess, in detail, the capacity for integration of environmental concerns into the planning processes. In the NTS of TR, references were made to the relevance of indicators to the planning process, but the set of indicators used in the planning process was not presented.

SEA reports stated that indicators were used for the characterization of the baseline, environmental assessment, definition of the monitoring programme and public participation. ER indicators were presented in the SR for all the RBDA and in the NTS for nearly all RBDA (except for RH9). In some cases, the indicators used in the ER were not exactly coincident with the indicators proposed in the SR.

4. Conclusions

Indicators are considered a major tool to support SEA and planning processes, and are used for different purposes, including characterization, evaluation, monitoring, communication and decision-making. Indicators are adopted to add value, to transform complex information and to convey messages with meaning for decision-makers and for the public.

The conducted research provides an understanding of the profile of indicators used to support water resources planning and SEA in the Portuguese case of water resources planning and management. Overall, the analysed RBMP and SEA processes were mainly supported by indicators, and some of those indicators overlapped between the two processes. The indicators were mainly selected by the technical teams involved in the planning processes and SEA, and aimed to respond to water planning and management objectives, through characterization, evaluation and follow-up of the planning actions.

The analysed documents used a large number of indicators, mostly quantitative, and adopted very different approaches for their organization, selection and validation. Usually no participatory process was used in this context. Overall, the SEA themes 'vulnerabilities and risks' and 'resources', and the planning themes 'water quality' and 'water quantity', presented the highest number of indicators.

The indicators used in these processes were mainly a result of non-structured procedures, showing the need to clarify several aspects. Several indicator issues and procedures, such as the indicator selection stage, remain to be further explored. There remain doubts regarding the criteria used in the selection of indicators, as well as the degree of stakeholder engagement in the selection process. The size of the data series, the availability and the management model should also be analysed since they are fundamental aspects of the success of indicator usage in planning and SEA processes.

Further research work should be conducted on the consultation of the stakeholders involved in the planning and SEA processes. Interviews addressing the different actors involved in the planning and SEA processes are one way to use their knowledge to promote process improvements by identifying criteria or sets of indicators to be used. Active stakeholder engagement throughout the entire process of indicator development, including design, implementation, operation and review/updating, is a key aspect to pursue and explore. The commitment to the use of standardized and more cross-cutting indicators between the planning and SEA processes is another recommendation for planners to consider. Also, for identical planning objectives in different RBD, it would be interesting to use similar indicators. The current research points to a set of critical indicators that could be used as a common framework in water management plans and SEA reports that could support comparative analysis of common water planning issues. However, future research is also needed to explore this area, including how to link common and specific tailor-made indicators, and how to operationalize it in practice.

Note

1. RH and ARH are the Portuguese acronyms for RBD and RBDA, respectively.

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