Using indicators for improved water resources management

Guide for basin managers and practitioners

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The authors hope that the shared knowledge and technical expertise of all the experts who contributed has produced a tool that will be useful for basin managers and other practitioners who wish to strengthen sustainable basin management through the use of appropriate and well-formulated indicators.

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Cover: Orinoco River. Source: Meridith Kohut

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Acronyms

CAP-NET	Cap-Net UNDP International Network for Capacity Development in Sustainable Water Management
CCA	Causal Chain Analysis
CI	Conservation International
CIESIN	The Center for International Earth Science Information Network, the Earth Institute at Columbia University
CREAM	Clear – Relevant – Economic – Adequate – Monitorable
DPSIR	Driving forces – Pressures – State – Impacts – Response
GEF	Global Environment Facility
GWP	Global Water Partnership
INBO	International Network of Basin Organizations
IWRM	Integrated Water Resources Management
KPI	Key Performance Indicators
LHI	Luc Hoffmann Institute
MR	Monitoring and Reporting
MRC	Mekong River Commission
OECD	Organisation for Economic Co-operation and Development
ORASECOM	Orange-Senqu River Commission
SAP	Strategic Action Programme
SDGs	Sustainable Development Goals
SEEA	The System of Environmental-Economic Accounting
SMART	Specific – Measurable – Attainable – Relevant – Time-bound
SPICED	Subjective – Participatory – Interpreted and communicable – Cross-checked and compared – Empowering – Disaggregated
TDA	Transboundary Diagnostic Analysis
TWAP	Transboundary Waters Assessment Programme
UMCES	The University of Maryland Center for Environmental Science
UN	United Nations
UNSD	United Nations Statistics Division
VBA	Volta Basin Authority
VTA	Value and Threat Assessment
WRM	Water Resources Management
WWF	World Wildlife Fund

Executive summary

Indicators are widely used in water resources management and planning for a variety of purposes. Quantitative and qualitative indicators have been used to organise relevant water resource information, track progress of key variables over time and ensure compliance with various standards, such as those of water quality, ecosystem health and economic performance of water utilities. By distilling key data and trends to a manageable amount of information, indicators help bridge the gap between science and policy and influence decision makers who form the practices and policies that affect water resources planning and management.

Following the mantra 'You can't manage what you can't measure', indicators and their use have proliferated in recent decades at all scales – from project-level reporting to national environmental accounting to tracking progress at the global level. A recent example is the adoption of the 17 Sustainable Development Goals under Agenda 2030 and the associated 169 targets and 232 indicators (UNSD 2017). While these developments can be seen as positive, with an increased focus on science- and data- informed decision making, they also pose the challenge of needing increased resources to collect growing amounts of data, ensure compliance and reporting against various commitments, and ensure data comparability over time and across spatial units. It is therefore necessary to reconcile indicators that are meaningful for the given purpose and scale with their sustainability over time and compatibility with wider regional, national and global standards and trends.

This guide has been developed to help basin managers, decision makers and other water resource management practitioners navigate this increasingly complex 'jungle of indicators'. It provides them with the necessary scientific, technical and communication guidance on use of indicators for better basin resource planning and management.

Acknowledging that there is no one-size-fits-all when it comes to water resource management indicator use, this guide focuses primarily on the process of indicator selection, application and communication. It also covers key elements that can help ensure that the indicators selected are meaningful and well designed and their results communicated in a way that has most impact.

The following aspects of indicator selection and application are covered:

- Conceptual frameworks underlying and guiding indicator selection and organisation
- Essential criteria for selecting 'good' indicators
- Stakeholder engagement in indicator selection and design
- Interplay between local indicator frameworks and national, regional and global reporting and monitoring frameworks
- Communication of indicator results to various audiences

Finally, this guide proposes a **comprehensive indicator framework for Integrated Water Resources Management, based on an extensive review of indicators** currently used at various scales of basin and water resources management. This review, covering more than 1,600 indicators, provides a snapshot of the current state of indicator use for water resources management and informs on common trends and challenges. The framework does not aim to select the specific indicators but rather provides an overview of the types of indicators currently in use and that should be considered in designing basin management and monitoring frameworks. This framework is also accessible as a free online tool, Water Indicator Builder[1], with supporting indicator library.

1 The Water Indicator Builder is an online tool that enables users to explore and create indicator frameworks to support management and decision-making for improved water resources management. It offers a comprehensive, built-in indicator framework that users can modify and build on, as well as a growing library of indicators for creating new, customised indicator frameworks. http://www.waterindicatorbuilder.com/home.

The interactive Water Indicator Builder can be used to further explore the proposed framework and redesign it based on user preferences and needs.

A key step in preparing this guide was to explore the **'realities' of using indicators for water resources management through in-depth interviews with a number of practitioners and basin managers**. These interviews highlighted some of the learnings and challenges of indicator use through basin experiences on the ground and are included in case study boxes throughout the guide. They also helped to reveal some of the common challenges in indicator application which this guides strives to address. The key steps of indicator selection, application and communication discussed in this guide are summarised in Figure 1. The sequence of the various steps is only indicative and should be tailored for the specific purpose and resources at hand.

This guide draws heavily on the indicator use experiences of the partner organisations (UN Environment-DHI Centre, World Wildlife Fund-US, Conservation International, Global Environment Facility, University of Maryland Center for Environmental Science and the Luc Hoffmann Institute). The authors hope that distilling these experiences, as well as those of the basin and resource managers interviewed, in a pragmatic way can help pave the way for more effective and targeted use of indicators to inform and guide basin planning and management processes. This includes preparing basin management plans, long-term strategies, Transboundary Diagnostic Analyses (TDAs), Strategic Action Programmes (SAPs) and similar programmes and assessments.

Figure 1. *Structure of the Guide.*

Chapter 1

Indicators for river basin planning and management

1.1 What are indicators and why are they useful?

Indicators are produced and used worldwide across all levels and sectors by public, private and civil society for a variety of purposes from knowledge provision to administrative control. Indicators are generally expected to enhance the rationality of policy-making and public debate by providing an objective, transparent, robust and reliable information base (Lehtonen 2015), representing a state or trend over a given area and time period.

Indicators can be any quantitative or qualitative measure that is used to assess the state of a process, system or entity or its performance relative to a benchmark. They identify relative positions to facilitate comparison and, if measured over time, help identify trends over time and help assess progress of certain interventions, or, on the contrary, inaction (OECD 2008).

Often, indicators are used as proxies for complex phenomena that cannot be measured and monitored based on direct observations. It is important to remember that, in many cases, indicators only provide an indication of the phenomena at hand, with varying degrees of precision. Correct application of indicators therefore requires acknowledging the contextual factors and distortions that affect the interpretation of the indicator results. For example, Gross Domestic Product (GDP) measures a country's economic performance by synthesising a large amount of complex information into a single number. Indicators can be a valuable management tool distilling complex information into a standardised format that, if well designed, is easily interpreted by managers and decision makers. Such indicators can then be used to trigger action to address specific issues, monitor the effectiveness of policies and promote accountability.

Taking water quality as an example, many environmental management agencies apply some sort of water quality index, combining indicators of several different pollutants into a single score that anyone, including the public, can interpret as being 'good' or 'bad', in comparison to a pre-defined benchmark or threshold. The thresholds may be based on biophysical parameters (e.g. microbiological standards for drinking water to protect human health) but they also reflect normative decisions about what is being measured and why (e.g. water resource efficiency targets). Therefore thresholds, and the criteria defining the various levels along the scale between 'good' and 'bad', can vary from country to country, from basin to basin, and from one organisation to another. In the same way, management responses to indicator results can differ – from penalties for non-compliance to broader changes in governance frameworks aiming to address the problem drivers. The specific type of response depends on available resources but also on the underlying intentions of introducing the indicators in the first place.

Indicators help bridge the gap between science and policy and consequently, involve a mix of objective and subjective criteria. So it is important to recognise that, while there may be widely agreed upon methods to develop certain indicators, and scientific knowledge is valuable in this process, decision makers, along with societal norms and values, affect which indicators are seen as appropriate for a specific purpose or target in their context, and ultimately how they are used. In the same way, the choice of indicators is affected by the different perspectives, narratives and objectives of the stakeholders. This is clearly demonstrated by the wide availability and use of indicators in water management globally for a broad set of objectives that range from equitable benefit sharing to managing uncertain flows to sustainable management of ecosystem services.

BOX 1.1

Examples of common types of indicators

Quantitative indicators are those that indicate quantity or change in quantity based on a number such as a value, ratio, index or percentage. Such indicators show a specific number value of the desired question or issue and can be tracked over time. While the values can be interpreted in the context of the measurement, well-designed quantitative indicators should show very clear measures, regardless of who takes these measurements and when, so they are as objective as possible (MEASURE Evaluation 2017). Examples include:

- Percentage of human population served by wastewater collection
- Mean temperatures and temperature ranges in area X
- Intensity of water use in % – percentage of total renewable freshwater resources withdrawn
- Population growth rate in %
- Extent or change in extent of forested areas over specified time (in ha or %).
- Human Development Index (and other poverty measures)

Qualitative indicators often deal with aspects that cannot be measured by a single number and may include methods such as interviews, focus groups, or surveys. These indicators may represent more subjective aspects of the status or change such as opinions, perceived threats or improvements, beliefs and so on. While there is a greater risk of subjective interpretation and personal opinions impacting the results, the value of qualitative indicators lies in their ability to demonstrate the impacts of interventions or change as actually felt by local communities or other stakeholders. Qualitative indicators can contain numbers but they differ in what the numbers represent. Examples of the ways qualitative indicators are measured include:

- Likert scales, e.g. How much do you agree with the statement that floods are becoming more severe in your community? Very much; to some extent; don't agree; strongly disagree; don't know (HIP 2010).
- Ratings scales, e.g. What is the degree of stakeholder participation in water resources planning and decision-making? (very low to very high).

While quantitative indicators are often seen as more objective and 'robust', qualitative indicators can provide highly valuable information on the context-specific impacts of certain phenomena, trends over time, causes, or the impacts of certain interventions on the ground, as they are experienced by local communities. They do not, however, lend themselves to easy comparisons in different study locations due to differing perceptions and cultural settings.

1.2 Indicator use for river basin planning and management

Sustainable river basin-level planning and management is an attempt to put into practice the tenets of integrated water resources management (IWRM). This is described as 'coordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems' (GWP 2000). This ambitious goal highlights the many dimensions that decision makers must be concerned with and, by extension, elements that should be reflected in baseline assessments and monitoring programmes for basin management plans. Indicators offer a way to structure, quantify, and standardise such assessments. But beyond this, an integrated set of indicators can also be used to merge knowledge and bring together stakeholders from different sectors and scales, to identify priorities for interventions and communicate complex information to a wider audience (see Table 1.1).

These uses are not mutually exclusive. In fact, one of the strengths of developing indicators with a system-wide view of river basin planning and management is that the same set of indicators can serve multiple purposes. But different user groups (resource managers, policy makers, civil society organisations or private sector players) will prioritise these uses differently and the composition and presentation of the indicators may need to be adapted depending on the use. In general, the more technical the audience, the greater the demand for information (i.e., indicators, sub-indicators). As this information is transmitted to more general audiences (decision makers and the public) it must be condensed and

TABLE 1.1

Applications of indicators in river basin planning and management (Adapted from Vollmer *et al.* 2016).

Use	Description
Benchmarking, monitoring	Monitoring is often described as a primary way to 'operationalize' IWRM and sustainable development more generally – translating abstract principles into measurable (and manageable) elements. Indicators can provide a quantitative baseline of the state of the environment alongside related socioeconomic factors. This baseline includes thresholds that may be scientifically derived, like limits on pollutant concentrations or those established through a process of setting goals. The baseline and thresholds then offer a means of monitoring changes or progress towards these goals.
Facilitating cross-sectoral understanding and governance	Indicator development for basin level management encourages, if not requires, integrating knowledge from different sectors related to water. In this case, the process is just as important as the product, involving dialogue among many different stakeholders, helping them to jointly establish goals, identify problems, and negotiate the tradeoffs that are implicit in balancing competing uses and priorities within a river basin. Ideally, indicators should reveal the extent to which conditions in the basin are being influenced by management plans and programmes of the various user groups.
Goal setting and prioritising interventions	Beyond comparing performance over time, indicators are commonly used to facilitate comparisons of key metrics across spatial units (e.g. sub-basins) or among the priorities the indicators themselves represent (e.g. resource allocation for 'domestic supply' versus 'agriculture'). They help highlight inequities within a river basin, deficiencies that could benefit from strategic public investment, or exposure to water-related risk from external factors such as climate change. Priorities can include short or long-term interventions, as well as real-time decisions on resource allocation and management, responding to emerging or pressing issues.
Accountability and facilitating public awareness	Indicators summarise a substantial amount of data and information into a coherent 'big picture' and are often useful as a public communication tool to raise awareness on progress towards or threats to overall welfare. This may be a primary use for river basin organisations seeking to produce 'State of the Environment' or 'Basin Health' reports for basin stakeholders and external audiences. It is also a way to measure the effectiveness of chosen policies, providing transparency and accountability, particularly if the public has been involved in the goal-setting process. Such uses may also extend to use of the indicators by (and for) educational institutions and academia to further test, use and communicate the various indicators and their results.

synthesised. Condensing may require selecting a subset of indicators, while synthesising may involve combining indicators into a final index score, representing the general state and health of the resources.

River basin organisations, resource managers and related technical specialists such as hydrologists or civil engineers are likely to be primary or 'active users' of indicators for river basin planning and management. Active users are those involved in assembling the data (through monitoring programmes, modelling, surveys and other means) and performing indicator calculations. This requires judgement on whether data are sufficient to meet the criteria of sound indicators and decisions about suitable proxies if the preferred indicator is not feasible. Once constructed, the indicators can be used to monitor the effectiveness of a basin management plan and inform decisions on basin resource development. Depending on the geographic scale of the indicators, major water user groups (utilities, industries, municipal governments, or farmers) may also be active users, using the indicators to help assess their impacts and dependencies within a basin.

There is a much larger group of 'passive users' who will be less involved in developing the indicators, though their input into the process is valuable. Passive users will typically rely on the summary outputs of the indicator process to answer questions such as "What is the state of this basin's health?", "What are the trends regarding this basin's health?", "What are the greatest water-related risks stakeholders are facing?", and/or "Have recent policies had a measurable impact on improving conditions within the basin?". Passive users may include the general public, policy and decision makers, development or government agencies, environmental organisations or businesses with an interest in the general trends of development for various reasons. National policy makers may want to compare performance across basins within a country or identify issues requiring transboundary cooperation. Private sector actors (investors and industries) may use the indicators in their assessment of corporate water risk within a basin. Development agencies may view these same risks as areas requiring aid and multilateral investment, again relying on the indicators to help identify priorities. Finally, civil society organisations and the public more generally can use the same indicators to track progress on the issues relevant to them and hold decision makers accountable.

INDICATOR CASE STUDY

Orange-Senqu IWRM plan – informing investment decisions for coordinated basin development

The Orange-Senqu River basin extends over four countries, Botswana, Lesotho, Namibia, and South Africa, and covers an area of 1,000,000 km^2. The Orange-Senqu River Commission (ORASECOM) brings together the four countries with the mandate to promote equitable and sustainable development of the Orange-Senqu River's resources. It provides a forum for consultation and coordination between the riparian states to promote integrated water resources management and development of basin resources.

Various sets of indicators are used in the work of the ORASECOM. These include performance indicators for the basin organisation itself – evaluating how ORASECOM performs against the key mandate. Examples of such performance indicators may include International Network of Basin Organizations (INBO) Basin Organisation Performance indicators – e.g. minimum programmes that the river basin organisation is expected to tackle, financing or performance against key functions. A core set of metrics (monitoring and evaluation metrics of the basin in the case of ORASECOM) has been chosen that are collected and updated in time for commission delegate meetings to enable tracking of performance against basin development priorities. These metrics include institutional management indicators (contribution of countries against desired level of investment), but also key hydrological and modelling variables.

Another set of indicators has been developed under the recently completed basin Integrated Water Resource Management (IWRM) plan. These include more diverse indicators pertaining to both national and bilateral-level issues and priorities, as well as basin-wide development objectives. Examples include indicators on monitoring and modelling basin climate variables, floods, environmental flows etc.). The process of developing the objectives, targets and actions under the IWRM Plan and the corresponding indicators was to a large extent simultaneous due to time constraints and the need for coordination with national-level financing institutions.

While developing the IWRM plan has been a lengthy process, requiring coordination and collective decision on priority indicators (different parts of the basin face different challenges so some countries may need additional tailored indicators), it has already yielded a coordinated decision for siting and prioritization of a new dam based on common priorities in basin. The basin-level information (and governance arrangements) are also beneficial on a bilateral level, for example, in bilateral hydropower generation agreements, or resource development schemes.

Key lessons to date confirm the need for a basin-level forum for discussion amongst riparian countries on coordinated basin development and investments. While basin organisations do not necessarily have the mandate to make such decisions, they provide a key forum for convening the riparian states and the necessary basin-level monitoring and reporting frameworks that can lay the scientific basis for the policy decisions.

Source: Thamae, 2016
More on ORASECOM: http://www.orasecom.org/

1.3 Linking indicators to decision making

There is a growing demand for indicator development that is relevant to decision making for river basin management at different scales (Poff, *et al.* 2016), (Clark, *et al.* 2016). Policy makers and practitioners are demanding useful and usable knowledge that improves decision making by expanding alternatives, clarifying choice and enabling decision makers to achieve desired outcomes and improve society (Clark, *et al.* 2016). This demand makes indicators an important tool for governance[2] and management applications, various modes of which are discussed in the previous sections.

Nevertheless, experience shows that linking indicators and the knowledge they provide to decisions on resource management and development, remains one of the biggest challenges. It is often difficult to ensure and demonstrate that the resources invested in indicator collection and calculation generate real impact on future decisions about resource management and development. One of the reasons is the nature and complexity of the processes underlying water resources governance.

It is particularly important to understand and acknowledge that decision making in river basin governance and management [3] is multi-scale and involves multiple actors. It is rarely sufficient to simply identify drivers of degradation and corresponding management responses, based on what science tells us. For example, it is well known that water governance involves many actors with varying ability to make or influence decisions impacting on the condition and function of the basin. Yet in many basins, management decisions have commonly been taken and implemented by centralised regulation driven by single-sector economic objectives (Lankford and Hepworth 2010). Such management, in so-called, 'silos', is still prevalent, where sector-based (e.g. energy, water provision, agriculture), often powerful, authorities divide responsibility and authority in river basin management and resource development (Stirling 2014). Such decisions are in turn rarely aligned with overarching integrated management frameworks on a basin scale.

It is therefore one thing to provide useful indicators in useable formats but there may be other barriers to address within the decision processes that sometimes have little to do with science. Ensuring links between science or the objective measurements (indicators) and decisions on the ground therefore requires a thorough understanding of the decision processes themselves. This includes understanding in what ways indicators are likely to inform management and planning specifically and requires first an understanding of who is demanding what indicators and for what purpose. Secondly, but no less importantly, the nature of the decision context and how decisions are made in that context is critical for determining how indicators can be useful and if they will be used.

Acknowledging this, the indicator use guidance included in this document discusses best practice behind indicator selection (such as key criteria for selection of good indicators and organising indicators in appropriate frameworks). It also covers crucial processes surrounding the selection and use of indicators such as stakeholder involvement, value definition and communication of indicator results to decision makers and other stakeholders.

Special attention is given to decision-making management contexts that have proved to be particularly challenging in basin-level resource management. These include management of shared resources in transboundary basins, further discussed in chapter 7.

2 Governance here refers to the strategic task of setting goals, direction, limitations and accountability frameworks ('the what') and management is the decision-making processes for allocating resources in implementation operations ('the how').

3 Some parts of this discussion are derived from the dialogue and collaborative work of 21 high-level researchers, practitioners and policy makers to provide thought leadership on the nexus (Gallagher, *et al.* 2016).

Chapter 2

Where to start: conceptual indicator frameworks

2.1 Why are indicator frameworks important?

A conceptual framework provides a way to identify, categorise and organise the factors deemed most relevant to understanding the state of water resources in a basin (McGinnis 2011). A framework offers definitions of variables and highlights important relationships among these variables. In short, it provides a roadmap for selecting indicators that are fit for purpose. There are several fundamental reasons for using a conceptual framework to select indicators in river basin planning and management. Arguably the most important reason is that the framework helps users define (and understand) the problems they want to address. Is reducing climate vulnerability a top priority or are stakeholders primarily concerned with existing allocation and transboundary management issues? The framework ought to reflect the users' goals for conducting an assessment and as described in the next sections, there are different types of frameworks available depending on these goals.

The framework should be based on sound theory that in turn helps select indicators in accordance with their policy relevance. It explains why particular indicators are needed for issue identification, policy analysis and tracking performance (OECD 2008). For example, if land use and land cover are being tracked as indicators, what is their connection to other hydrologic indicators in a given basin? If measuring processes (e.g., 'degree of implementation of IWRM principles'), are these processes clearly defined and linked to outcomes for the basin? Can changes in the indicators be reliably and credibly traced to policy?

Relying on sound theory and clearly outlining the connections between indicators and problems on the ground is critical for indicators in river basin planning and management because they will be used as a measure of the 'success' of a particular policy or approach.

Simplicity is also important and a conceptual framework can help users to stay focused and to identify a set of indicators that collectively measures phenomena of interest without being exhaustive or redundant. As the number of indicators increases, so too will the administrative costs of collecting and maintaining data, and the difficulty of interpreting and attributing changes to indicators. River basin planning and management also involves a wide range of stakeholders, many with technical backgrounds and familiarity with hundreds of indicators from their respective fields. It is imperative, then to identify the indicators that are required by legal frameworks, are the 'most informative' to the key stakeholders and that are closely related to policies or interventions. Collectively, the indicators should maximise unique, relevant information while minimising redundancy (Cairns, McCormick and Niederlehner 1993).

Finally, using a conceptual framework can help promote transparency about what is being measured and why. This transparency serves dual purposes. For both internal (including among departments within the same organisation) and external audiences, transparency is essential to the perceived credibility of the indicators. After all, indicator selection reflects personal and institutional biases for what must be known, technical considerations and knowledge constraints as well as progress on society's goals and is therefore unavoidably normative. There are many subjective decisions involved in selecting indicators and for topics such as good governance, even the indicators themselves may reflect subjective measurements. A conceptual framework provides a way to communicate the logic and rationale behind these decisions.

2.2 Commonly used types of indicator frameworks

As noted earlier, general goals such as those articulated for IWRM (coordinated development, maximised economic and social welfare, equitable distribution, and sustained ecosystems) must be translated into more specific, measurable elements, to enable interventions to be implemented on the ground.

Identifying an appropriate framework begins with identifying specific problems that stakeholders face within the basin and collective goals for improving or maintaining conditions. For example, if basic water and sanitation needs are still unmet or perceived to be at risk, a framework that makes these concerns central would be most appropriate. In other cases, stakeholders may be primarily concerned with achieving good ecological health of their water bodies. We review six general frameworks here, each offering a specific approach to problem statement and organising logic.

Among these frameworks, there are inevitable overlaps in terms of technical concepts as well as specific indicators. Most of the frameworks are anthropocentric[4] but they vary in their emphasis on human needs and socioeconomic drivers. Some tend to be more normative and action-oriented (i.e., directed towards specific policies and/or outcomes) while others are more diagnostic and help users analyse a situation without prescribing specific interventions. The frameworks also vary in their complexity, particularly the degree to which they help analysts account for interactions between social and ecological systems or their contextual drivers. We summarise these frameworks below (see also Table 2.1) and briefly discuss their strengths, limitations, and most suitable applications[5]. In many instances, end users may want to design their own framework and so these summaries are meant to be an illustrative review of some leading 'templates' that can be customised.

DRIVER-PRESSURE-STATE-IMPACT-RESPONSE (DPSIR) AND CAUSAL CHAIN ANALYSIS (CCA)

The DPSIR and CCA frameworks have been used in various forms to develop sustainable development indicators since the late 1980s. Both employ a causal logic that links socioeconomic drivers to environmental outcomes. With the DPSIR framework, human economic activity (D-driver) generates pollution or other stressors (P-pressures) that affect the environment (S-state) and human

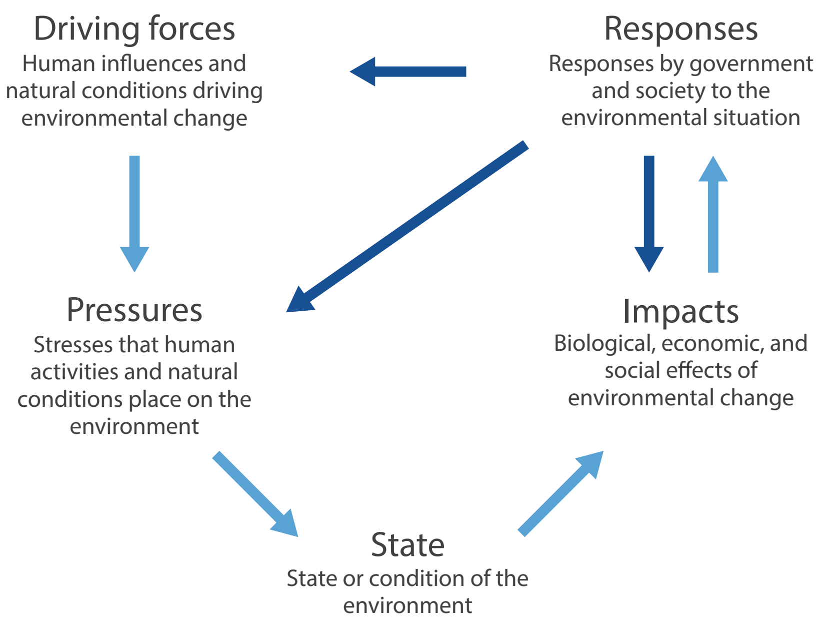

Figure 2. *DPSIR conceptual framework (State of the Gulf of Maine Report 2017)*

4 Placing the sustained human socio-economic activities at the centre of the framework.

5 For a more comprehensive review see Vollmer *et al.* (2016). Assessing the sustainability of freshwater systems: A critical review of composite indicators.

use of the environment (I-impact), requiring policy and management interventions (R-response). It has most commonly been applied to develop state of the environment reports and environmental monitoring programmes.

The Causal Chain Analysis framework treats environmental (or socioeconomic) problems in a basin as an ordered sequence of events, striving to identify and link the causes with the effects. As such, the CCA framework relies on similar indicator organisation logic as the DPSIR but places more emphasis on identifying and remedying the 'root causes' of environmental problems. One of the major strengths of this approach is that it encourages users to think through both the biophysical and socioeconomic processes that lead to the environmental state of a basin. Management goals are typically set to environmental state indicators (e.g., a target water quality index value by a specified date) but they may also be tied to the underlying socioeconomic drivers.

Despite being widely used, these frameworks are subject to criticisms. One is that they assume linear cause-effect relationships, which tend toward oversimplification of complex human-environment interactions. Another is that indicator categories are inconsistently defined (Gari, Newton and Icely 2015). Additionally, the first framework has been criticised for not clearly distinguishing drivers and pressures from one another and for impacts being too focused on human health. Analysts have argued for a broader definition that accounts for human welfare as well as positive environmental impacts (such as ecosystem services). The above are exemplified by a common challenge in using DPSIR frameworks. The same indicators may be identified for one of the 'steps' or dimensions of the framework, often have a complex array of interactions with other indicators and can be interpreted to represent various aspects, depending on the perspective.

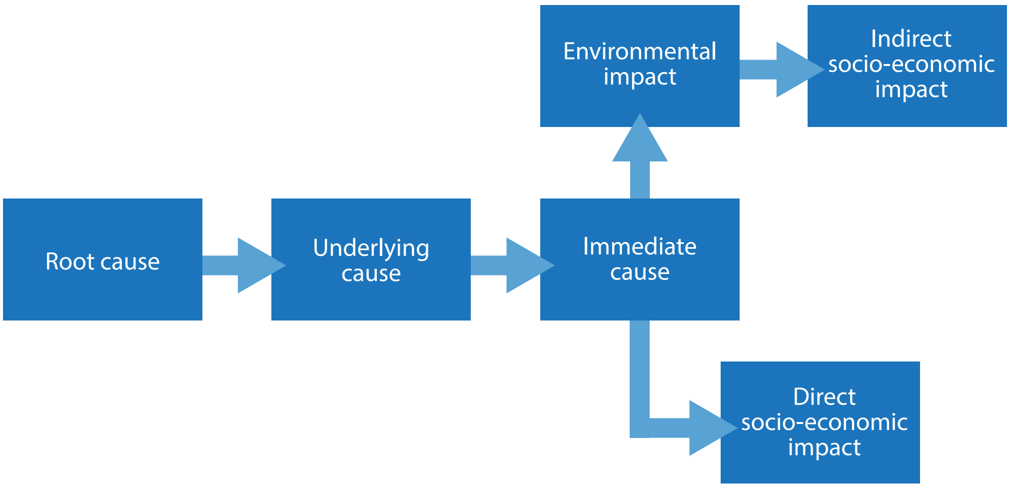

Figure 3. *CCA Framework (IW:Learn 2014).*

ECOLOGICAL HEALTH

The ecological health framework places the state of the (in this case, freshwater) ecosystem at the center of the analysis. Its fundamental assumption is that a river or lake system needs to stay within a range of 'healthy' ecological conditions to function sustainably and continue providing the benefits people rely on. Ecological health frameworks use a variety of biophysical and chemical proxies to compare a freshwater ecosystem to a historical (or pristine) reference point or a threshold based on an ecosystem's ability to sustain its supply of goods and services. The latter reference point is subjective and requires a discussion of the appropriate thresholds

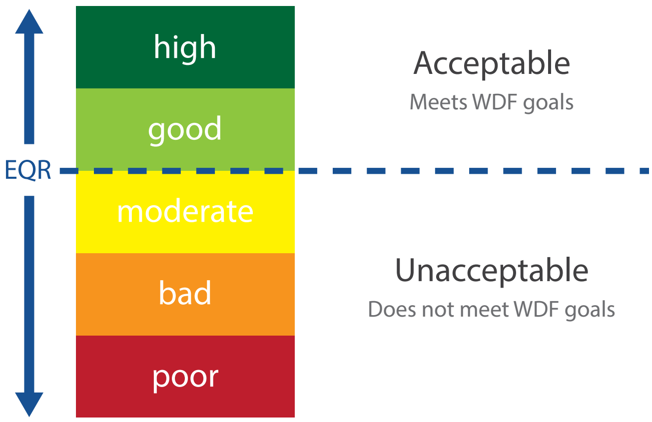

Figure 4. *The water body quality classes as defined by the EU Water Framework Directive (Miccoli, Lombardo and Cicolani 2013)*

as well as acceptable or desirable levels of ecological function to be able to provide ecosystem services. The European Union Water Framework Directive's requirement that water bodies meet 'good ecological status' provides a clear example of this. In addition to measuring the state of the ecosystem (typically, according to its physical, chemical, and biotic properties), ecological health frameworks may also account for the immediate pressures being placed on the ecosystem.

Ecological health indicators usually require direct examination of biota and reference points are determined regionally or locally, but this also limits their application in areas where data and resources are sparse. For this reason, although being based on sound science and theory, such indicator frameworks can be challenging to implement and maintain over time, unless resources can be dedicated to field measurements. The ecological health framework also typically refers to (but does not quantify) ecosystem services. Instead, the emphasis is on measuring and maintaining healthy aquatic ecosystems with the assumption that they will be able to provide the services people rely on.

GOVERNANCE AND INSTITUTIONAL PERFORMANCE

It is increasingly being recognised that the governance system – the structures and processes that guide decisions within a basin – is not only critical to influencing the state of the environment but can be measured in its own right. Developing indicators for governance and institutional performance requires many more subjective decisions than when measuring biophysical or even socioeconomic characteristics. Indicators within these types of frameworks are 'means-oriented', often based on notions of 'good governance' and prescribing practices that are believed to embody good governance. They can be used to track the performance of institutions such as river basin organisations or water authorities, often measuring progress towards implementing principles of integrated water resource management (IWRM). In 2012, the United Nations Environment Programme (UNEP) published a comprehensive national-level assessment of more than 130 countries, measuring their progress towards implementing IWRM (UNEP 2012).

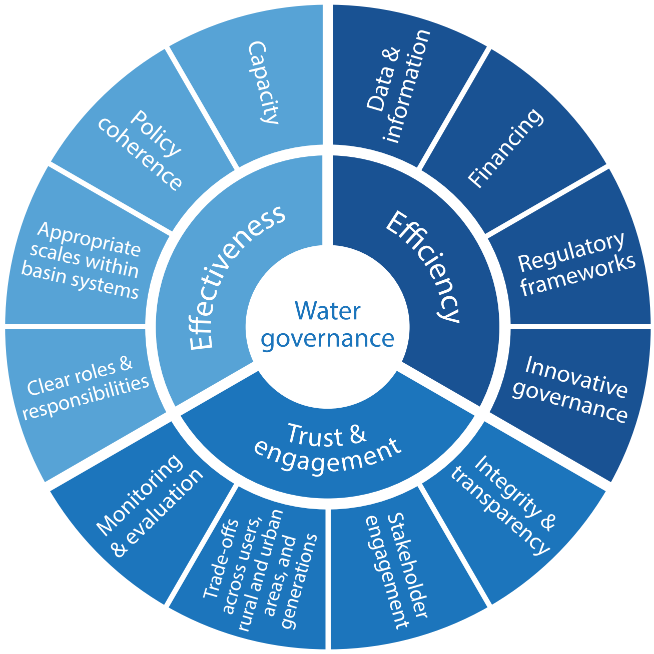

Figure 5. *Example framework of good water governance principles (OECD 2015)*

Frameworks in this category generally draw from the categories and expansive list of indicators proposed by Bruce Hooper in 2006 (Hooper 2006), although several international organisations have proposed definitions and assessment categories for (good) water governance [6]. These include general categories such as coordinated decision-making, goal completion, financial sustainability, training and capacity building, and are primarily qualitative assessments or binary (is policy X in place?). As such, they often require surveys and interviews to collect primary data for populating the indicators. While these data-collection exercises can yield useful information, indicators of institutional performance and governance are not always easily linked to measurable outcomes for social, economic or biophysical goals. They may also include information that institutions are reluctant to share for a variety of reasons including the fear of potentially exposing themselves in a negative light, for example, scoring low on key indicators.
For this reason, governance and institutional performance indicators tend to be tracked in parallel to other efforts measuring more conventional indicators like water provision and quality. It could be argued that one of the most direct ways to measure performance and impacts of governance is through the progress made on biophysical aspects such as water quality and ecosystem health. See chapter 9 for further information on governance indicators.

6 Including UN Environment, UNDP, OECD

RISK ASSESSMENT

Risk assessment is a familiar approach in the fields of water and environmental resource management. Risk assessments typically consist of two major steps – hazard identification and vulnerability characterisation. This involves identifying potential water-related threats (e.g. natural hazards, physical scarcity or pollution) and characterising the societal (or environmental) susceptibility to harm, based on the likelihood of exposure to hazards, the severity of potential outcomes, and capacity to adapt. There are a number of variations of similar frameworks, some looking to separate the dimensions of risk in three categories – Hazard, Vulnerability and Exposure (in this case the two dimensions of Vulnerability are looked at in more detail, i.e. separating the Vulnerability as the coping capacity and ability to respond, and Exposure as assets and people that are exposed to hazards). Concerns about climate change are driving further interest in water-related risk assessments. Management goals are oriented toward reducing risk, however it is conceived, and may require setting targets for either reducing exposure or enhancing a population's ability to adapt.

Risk assessments can make use of existing data though in many countries (particularly developing countries with weak climate and water data infrastructure) comprehensive risk assessments often require collecting and systematising data scattered across various authorities or collecting the necessary data and establishing the necessary data infrastructure around such assessments. Quantifying risks often also requires that decision makers identify thresholds or maximum acceptable levels of risk (and damage) such as the minimum reliability for a municipal water supply system, or the amount of flow that must be reserved for ecological purposes. While several quantitative models exist to help decision makers better characterise water-related threats, scaling these threats according to actual exposure and adaptive capacity is more challenging. This is partly due to the difficulty of quantifying the exact impacts of climate change on water resources and predicting future societal developments. The Water Vulnerability Index illustrates an attempt to holistically measure water-related risk, combining resource-supply indicators (including probabilities) with indicators of human exposure (such as economic vulnerability and water access) (Sullivan 2011).

Risk	=	Hazards	x	Vulnerability
The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, disrupted economic activity, or damaged environment) resulting from interactions between natural or human-induced hazards and vulnerable conditions.		A potentially damaging physical event, phenomenon, or human activity that may cause the loss of life or injury, property damage, social and economic disruption, or environmental degradation.		The conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards.

Figure 6. *Example risk assessment framework (International Federation of Surveyors 2006).*

SYSTEM SUSTAINABILITY

A system sustainability framework emphasises human dependence on water resources, the links among social, economic, and environmental sub-systems (i.e., the 'three pillars' of sustainability), and the intergenerational aspect of sustaining a resource base. River basin management goals under this framework would include targets for maintaining freshwater environmental integrity while meeting societal needs and economic demands for water. Like the DPSIR and CCA approaches, the system sustainability approach attempts to account for causal links, although this framework also calls for more explicit accounting of the 'system' being assessed and all of the feedbacks and interactions within that system. In practice, it may begin with constructing a causal loop diagram to map the system dynamics and interactions with each node and the positive and negative feedback.

Consequently, as a set of indicators this framework can be more challenging to construct and more complex to understand than the other frameworks described here. The complexity depends on the degree of integration of the indicators. At their simplest, practitioners may select a variety of indicators under headings like 'Society', 'Economy', 'Environment'. However, such an arbitrary approach lacks the theoretical and quantitative underpinnings that more robust conceptualisations offer. Analysts and researchers, on the other hand, may focus on quantifying relationships between these different indicators and the thresholds or tipping points that signal the system is no longer sustainable. This approach may be of limited use to decision makers who must act on incomplete information and need a concise and interpretable set of indicators.

VALUE AND THREAT ANALYSIS

The value and threat assessment (VTA) framework requires direct engagement of stakeholders (e.g. in a workshop setting) to define the values within the basin that are to be protected/restored and the threats that are causing degradation to those values or impeding their restoration. These values and threats help refine and prioritise the list of potential categories that require selection of indicators for monitoring. One technique for achieving this through direct stakeholder engagement is to have stakeholders draw on a basin map the features (ecological, social and/or economic) they consider to be of value to that basin. They are then asked to draw what is threatening these values and/or the basin as a whole. This provides a geographical representation of where values and threats exist in the basin which can be transcribed into a list of values and threats that can be ranked in order of priority through voting by the group. Such an approach enables input from every participant and forms the conceptual framework for moving forward with indicator selection.

The strength of the approach lies in drawing on stakeholder knowledge and identifying issues of direct importance to basin stakeholders, ensuring the relevance of selected indicators and strengthening the sustainability of the indicator use and data collection. The direct engagement of stakeholders may however translate to higher resource intensity than some of the other approaches outlined above. Ideally, the process should be facilitated to ensure best practice science-based indicators are considered and issues represented do not weigh unevenly towards some aspects more than others (e.g. with heavy representation of one type of actor).

A summary of conceptual indicator frameworks is presented in Table 2.1.

Figure 7. Value and threat assessment for the Missouri River basin.

TABLE 2.1

Summary: Types of conceptual frameworks and their applications.

Framework	Strength	Limitation(s)
DPSIR/CCA	Uses cause-effect logic; decades of applications in environmental management	Simplistic, unidirectional (linear) relationships; less balanced treatment of issues besides environmental degradation
Ecological Health	Strong scientific underpinning; oriented towards consumptive and non-consumptive uses of water resources	Data intensive; less balanced treatment of human concerns
Institutional Performance	Highlights importance of governance issues; most amenable to setting tangible and achievable management goals	Data intensive; weak conceptual and empirical underpinnings
Risk Assessment	Decades of application in water resources management	Hazard identification and vulnerability characterisation are not easily integrated; goals narrowly defined to reducing risk
System Sustainability	Emphasises interactions and integrative aspect of indicators	Complex to develop; complicated to understand; limited empirical underpinnings
Value and Threat Analysis	Stakeholder driven process that results in a level consensus amongst stakeholders	Results depend on which stakeholders have been consulted. Requires sound stakeholder mapping

The above frameworks represent only one set of options based on frequently used indicator frameworks for basin management. Other frameworks may be considered depending on the needs and purpose of the indicator selection. Regardless of the exact indicator framework selected, creating effective indicators to support decision making in river basin governance and management is more likely to be useful and usable if the underlying frameworks:

1. **Reflect social, economic and environmental goals in river basin governance and management.** Current progress in sustainability science suggests that key indicators should be included for the five capital assets: natural capital, human capital, manufactured capital, social capital, and knowledge capital (Clark, *et al.* 2016).
2. **Are effective at breaking tunnel vision so that they support identification of critical issues, risks and solution entry points across the social, environmental and economic systems in river basins.** Combine existing information and analytical tools to allow for holistic, cause-effect analysis at appropriate scales for specific problems or decisions being made.
3. **Fit into existing systems of knowledge, technologies and governance as defined by the stakeholders.** Challenges related to engaging end users of indicators demonstrate the need for participatory processes that engage users and stakeholders as equal partners throughout the design and development process so that the science being produced or synthesized actually is used (McIntosh, *et al.* 2011)(van Kerkhoff 2014)(Clark, *et al.* 2016). Care should be taken to reduce the disproportionate focus on the priorities of power groups or players within society (e.g. key players in one or more high-value economic sector) if critical stakeholders are not to be disempowered.
4. **Are flexible enough to be reviewed and altered as critical issues change in river basins so they remain supportive of decision making.** Maintaining relevance to the current and future challenges for decision makers requires flexibility and adaptive capacity, both for the frameworks themselves and processes surrounding them. This also enables streamlining of processes, where needed, addressing emerging needs for new data collection, and increases likelihood of application in decision making in practice.
5. **Add clarity to help navigate complexity.** Indicators can be useful in explaining, defining and navigating complexity provided they add clarity. A refined formulation of the problem becomes: which minimum set of indicators provide the needed information while still sufficiently incorporating the complexity of the systems required in planning and management processes?
6. **Are fit for purpose.** Selecting and applying indicator frameworks should fit the purpose and circumstances of the basin, ensuring a balance between sound theory and a pragmatic approach that helps to achieve the goals

INDICATOR CASE STUDY

Monterrey Water Fund—the importance of early investment in a good framework

Organisation: FEMSA Foundation and the Latin American Water Fund Partnership*

**FEMSA Foundation, the social investment arm of FEMSA (a consumer company comprising Coca-Cola FEMSA, FEMSA Comercio, FEMSA Strategic Businesses and a strategic investment in Heineken) makes social investments focusing particularly on water and early childhood development. In 2011 as part of its water strategy, FEMSA Foundation along with the Global Environment Facility (GEF), the Inter-American Development Bank (IDB) and The Nature Conservancy (TNC), established the Latin American Water Funds Partnership. The partnership has been working to create and strengthen Water Funds through knowledge dissemination, strategic tools, capacity building, technical support, funding and networking.*

The Monterrey Water Fund (FAMM, the Spanish acronym) was created jointly by the private and public sector, civil society and academia in 2013 to maximise the environmental services provided by the San Juan river basin. It now has more than 60 registered members. This case study looks at the lessons emerging from the development of the FAMM. This particular water fund enables upper watershed investments to reduce the risk of flooding and improve infiltration, protecting the water sources for the metropolitan area of Monterrey.

The Monterrey Water Fund has been using Key Performance Indicators (KPIs), covering both technical and management areas of the Fund's work. The purpose of the indicators is to demonstrate the impacts and efficiency of the interventions to investors and communities (e.g. quantifying the impacts of conservation actions upstream on sediment loads and nitrogen concentrations downstream) and ensure continued support and investment in the Fund's activities. While the indicators play a key role in demonstrating the investment case for the Water Fund's operations, there are a number of challenges that require innovative approaches to design an effective indicator framework. These include:

- Collection of meaningful data and reliable estimates of ecosystem impacts (and the actual changes in the watershed) may take several years for some indicators whereas investors and communities are eager to see results of the interventions throughout all stages of the project.
- Even where indicator information is available, the process of selection takes time. It is crucial to understand the causes of the problems, align reporting with existing national and regional standards, and to agree on indicators with local stakeholders and data holders.

One way that FAMM is addressing these challenges is by creating a tiered indicator framework approach, targeted to various phases and stakeholders of the project. The framework included a set of broader indicators in the initial phases of establishing the Fund that helped convey relevant issues to stakeholders to ensure buy-in (e.g., indicators related to the expected benefits of the Fund). At the same time, monitoring mechanisms were established to collect and analyse information relating to the ecosystem impacts of on-ground interventions, ensuring that the Fund is able to demonstrate impacts in the mid- and long term.

Key lessons in indicator application from FAMM can be summarised as follows:

1. Investing in the initial phases of monitoring framework design (understanding and defining the problem and selecting indicators relevant for the aim of the operations) is crucial for the selection of KPIs. Selecting the right KPIs is essential to track the success of the projects, which in turn is a deciding factor for the sustained financial and community support for the operations.
2. In addition to new investment in monitoring and reporting infrastructure, it is paramount to establish a strong alliance with academia, local authorities and other data holders to leverage existing knowledge and build capacity to collect data in the future. Working closely with local champions is particularly important to ensure the buy-in of the indicators framework and, ultimately, the Fund.

Source: (Crespo, Moreno and Ruiz 2016 - interview). More on Monterrey Water Fund: http://www.fondosdeagua.org/en/monterrey-water-fund and http://famm.mx/

Chapter 3

Selecting the right indicators

3.1 Criteria for indicator quality assessment

In the previous chapter we discussed how a well-designed conceptual framework can provide focus and lay the foundation for indicator selection to ensure that limited resources address key priorities. The next step is the selection (or where necessary, the design) of the indicators themselves.

There are many indicators potentially available to monitor each issue and the number is growing rapidly with developments in science (e.g. possibilities offered by earth observation data for water resources) and emerging local and regional water monitoring arrangements. Often the challenge is to narrow them down to a minimum set. While a suitable conceptual framework will help refine initial indicator selection, there will likely still be many more options than are necessary or desired.

Too many indicators can cloud interpretation and exceed financial and human resources for collection and analysis while too few will result in insufficient information to characterise the system as outlined in the framework, potentially leading to erroneous conclusions and ill-advised policy decisions. At a minimum, there should be a sufficient number of indicators to answer the question of whether basin management is moving towards the right direction and the set outcomes, goals or targets to be achieved (Kusek and Rist 2004). The key set of indicators should reflect the key components identified during the development of the conceptual framework or the set outcomes, goals or targets. For example, if the main concern is water quality, a minimum set of indicators measuring key water quality parameters should be included in monitoring activities.

It is also important to narrow the selection to best possible indicators for the purpose – i.e. ones that are scientifically robust but also meaningful in the context of the intended use. Choosing the wrong indicator can not only be inefficient in providing the necessary information but also lead to distorted decisions, and by giving unnecessary attention to some aspects, lead to counterproductive actions or unintended consequences. For example, solely focusing on the number of illegal fishing reports as the key output may lead to under-reporting of incidents. On the contrary, improved accountability and enforcement efficiency may lead to a higher number of illegal fishing incidents reported which does not necessarily signify an increase in illegal fishing but rather increased efficiency of the responsible authorities. Meaningful, in this context, also includes indicators that are relevant and clearly understandable to stakeholders, as this can increase the chances of triggering action on the ground.

Various guidelines and criteria can be used to support and facilitate indicator screening and quality assessment. Some of the more widely used ones include SMART, SPICED and CREAM criteria for selecting good quality indicators. These are briefly introduced in this chapter.

SMART INDICATORS

The SMART approach is one of the most popular sets of criteria for assessing indicator quality and is considered best practice for developing monitoring and evaluation indicators. SMART most commonly (minor variations in formulation can be found across applications) stands for (Lennie, *et al.* 2011):

- **S**pecific (to what is being measured)
- **M**easurable (also reliable, comparable, contextually appropriate and unambiguous)
- **A**ttainable (also achievable, feasible, cost-effective)
- **R**elevant
- **T**ime-bound (also sensitive, i.e. the change in values can be tracked over time)

There are a number of 'SMART' questions that can be asked to screen the initial list of indicators and assess their quality in meeting the criteria. A few example questions are given below, to initiate the assessment.

Specific: the indicator measures what it sets out to measure through a clear link to the issue at hand

- Is the link between indicator and the issue it measures clear and proven?
- Is the indicator clear and not vague in its definition?
- Does the indicator measure exactly what it sets out to measure, focusing on a specific aspect or objective?
- Can indicator results be clearly linked to the desired objectives and goals of the project/intervention?
- Does the indicator measure specifically the aspect or element that it is supposed to measure, without confusion?
- Are there other factors that may interfere in deriving information from the indicator measurements?

Measurable: the indicator is defined precisely and the interpretation of the measurements is unambiguous.

- Can the indicator proposed be measured in the system of interest?
- Can the indicator be measured in a way that allows for tracking change?
- Is a baseline available to enable tracking change?
- Can the indicator be quantified or measured adequately in qualitative terms (e.g. social and governance indicators are often qualitative)?
- Is the indicator methodology developed in a way that the results of the indicator are verifiable and the same regardless of which institution develops data and when repeated over time? (i.e. different institutions would measure it in the same way).
- Are indicator results comparable over time and various locations?
- Are indicator results contextually and culturally appropriate and can they be collected, particularly for qualitative indicators?
- Do suitable thresholds for this indicator exist? Can these be applied to the current context? Thresholds are specific goals, upper or lower limits, or standards specific to each indicator that help to classify the condition of the indicator. Some examples of what can be used as threshold include national or international guidelines, institutional goals, reference conditions, socio-economic requirements, historical benchmarks, or professional judgement. Professional judgement is used in places where it is difficult to identify thresholds for indicators.
- If no threshold is available, can one be developed?

Attainable: information required for indicator calculation can realistically be measured and collected[7].

- Are the indicators cost effective to collect and analyse and feasible in terms of resource requirements?
- Are desired spatial and temporal frequency of measurements achievable?
- Is there the (local) institutional capacity and willingness to collect the necessary data?
- Can indicator measurements be integrated into the relevant data systems, providing full benefit of the data collection?
- Is there an embargo on the data (e.g. until it is published?).
- Is there historical data to calculate trends in the past?
- Will the indicator be measured in the future so that change can be detected?

Relevant: the indicator is relevant to the objectives of the project/programme and provides information necessary for improved decision making and management. Does the indicator reflect, or have a connection to management goals and actions?

- Does the indicator reflect or have a connection to management goals and actions?
- Can a response in this indicator be linked to management actions?
- Is the indicator relevant to/consistent with existing reporting mechanisms at the local, basin, country and international level (e.g. existing basin reporting systems, national reporting, environmental accounts, Sustainable Development Goals).
- Is the indicator relevant to stakeholder wishes and needs, and identified priorities?

Time-bound: the indicator tracks change over a specified period of time and delivers necessary information to assess progress towards objectives.

- Can indicator data be collected and calculated in due time to inform of change and effectiveness of interventions?
- Can indicator data be collected and calculated in time to inform of change and effectiveness of interventions?
- Is the indicator sensitive to change in environmental and/or management factors?
- Will the indicator reflect changes in water resources in a timely manner for reporting? For example, some ecological processes may take a decade or more to show measurable change, making them unsuitable for tracking on an annual basis.

Assessing indicators against SMART principles is a great starting point in developing a set of quality indicators providing key elements for assessing indicator options and selection. indicators providing key elements for assessment of indicator options and selection.

7 N.B. Data availability is not always a prerequisite and sometimes choosing an indicator which does not have data can be a useful way to drive demand for collection of data that may not already exist.

CREAM INDICATORS

CREAM indicator criteria have initially been applied to the selection of indicators for performance assessment, e.g. designing indicators for project monitoring and evaluations systems to assess performance and outputs of the project activities (Campo 1999).

CREAM in this context stand for following criteria:

- **C**lear
- **R**elevant
- **E**conomic
- **A**dequate
- **M**onitorable

To assess whether the indicators of interest meet the CREAM criteria, a number of questions could be asked [8]. A few guiding example questions are provided below.

Clear: the indicator is precise and unambiguous.

- Is the indicator defined in a way that is precise and unambiguous, regardless of who is using it?
- Can the definition of the indicator be interpreted in more than one way or related to more than one of the project objectives?

Relevant: the indicator is relevant to the subject it sets out to evaluate.

- Does the indicator represent key measurements for the issue or goal at hand and present the best possible information in the given setting (considering what is feasible)?
- Are indicator results and associated interpretation affected by other issues influencing the outcome?

Economic: the costs of obtaining indicator information can be met.

- Can the information necessary for indicator calculation be collected at a reasonable and feasible cost?
- Is the proposed indicator cost effective in relation to what it measures?

Adequate: the indicator provides necessary information to assess performance and change.

- Does the information produced by the indicator provide necessary data on progress against desired goals or targets in a clear way?
- Does the indicator provide enough information to draw necessary conclusions?

Monitorable: the indicator can be monitored and results validated independently.

- Does the indicator provide information that enables monitoring of progress over time?
- Is the indicator developed in a way that allows for independent validation e.g. same interpretation and measurements regardless of who collects the data and when?

CREAM criteria are similar to those provided by SMART guidelines but offer somewhat broader guidelines on aspects such as ‘adequate’ and ‘monitorable’ compared to ‘specific’ and ‘measurable’ (Bours 2014). These broader definitions can be helpful in measuring complex processes, where for example the available data are not perfect but good enough to provide the necessary information – thus ‘adequate’ or where key aspects of monitoring are difficult to quantify (measure) yet progress can still be assessed and change monitored by applying qualitative approaches.

8 Partly derived from (Kusek and Rist 2004), Ten steps to a results-based monitoring and evaluation system), World Bank; and https://www.linkedin.com/pulse/20141031111752-18927814-from-s-m-a-r-t-indicators-to-cream-and-spiced

SPICED INDICATORS

Both SMART and CREAM indicator development criteria tend to focus mainly on the quantifiable aspects of the indicators while there are aspects of 'good' indicators that can be more challenging to quantify, e.g. the processes surrounding indicator selection and application in practice. The third set of assessment criteria introduced below focuses on the processes surrounding indicator data collection and use.

SPICED stands for indicators that are:

- **S**ubjective
- **P**articipatory
- **I**nterpreted and communicable
- **C**ross-checked and compared
- **E**mpowering
- **D**isaggregated (and diverse)

While the primary focus of SMART criteria is on the qualities of the indicators themselves, SPICED criteria are well suited for participatory processes, as they focus on the approach to indicator use and ways in which stakeholders can be more engaged in the processes of change through indicators, as opposed to impact monitoring alone (Lennie, *et al.* 2011).

SPICED indicator evaluation criteria can be particularly helpful in evaluating indicators designed for participatory projects, using qualitative ones.

Examples of questions that could be asked to evaluate indicators against SPICED criteria are included below:

Subjective: indicators take into account the special insights and subjective experiences of local stakeholders and give weight to them.

- Is there any 'anecdotal' information emerging from stakeholder dialogues/workshops that may be significant for key data collection?
- Is the selected indicator considered to be relevant by stakeholders, in their subjective view on the values and priorities of the project?
- Have stakeholders been consulted on potential improvements to the data collection and indicator development methodology, based on their local experiences?

Participatory: Indicators are developed together with the stakeholders that will be involved in assessing them.

- Have stakeholders been consulted about the local perceived importance and feasibility of the specific indicator?
- Have stakeholders been involved in developing the indicator methodology and proposed monitoring procedures?
- Have stakeholders responsible for data collection for monitoring been consulted and involved in developing the indicator and monitoring plans?

Interpreted and Communicable: The objectives and indicators of the project can be explained to all relevant stakeholders and those not involved in the indicator development process (including broader regional and global audiences).

- Is the indicator methodology and rationale conveyed in terms that are understandable to broader audiences (drawing from local experiences but the relevance is clear in a broader context of water management)?

- Is it clear how the indicator contributes to achieving universal environmental or socioeconomic objectives?

Cross-checked and compared: Indicators and objectives should be cross checked with various methods in use and progress to date.

- Do changes in the indicator correspond to the desired or expected direction of change on key issues?
- Do relevant stakeholders testify to the direction of changes reflected by the indicator?
- Do the indicator results correspond with the intended or expected direction of development based on a comparison using different information sources, related indicators and methods?

Empowering: Process of indicator selection involves stakeholders and empowers them to take a more active part in the process of change and contribute to the direction taken

- Does the indicator engage relevant stakeholders and provide them with an opportunity to reflect upon and engage in the management of key water challenges?
- Do the surrounding processes of indicator data collection and validation solicit feedback from key stakeholders on a regular, ongoing basis and provide opportunity for reflection on progress?

Diverse and disaggregated: Diversity of stakeholder groups are considered in indicator and objective selection and conscious efforts are made to select indicators that may reflect their different priorities (also ensuring that the information can be aggregated across these groups, e.g. gender aggregated information).

- Does the indicator(s) reflect the priorities and key challenges of key socioeconomic groups and the vulnerable groups of society?
- Can the indicator be disaggregated by gender, age, income level etc.?

The SPICED criteria can be considered a useful supplement to SMART or CREAM indicator assessment criteria as the focus is on the indicator application process rather than the indicator itself. This would be especially true in designing participatory projects and processes where ongoing stakeholder engagement is a central part of the desired outputs and outcomes of interventions. All three indicator assessment sets generally apply to both quantitative and qualitative indicators, but it is recommended to include at least a basic set of quantitative indicators to ensure progress can be measured unambiguously.

The three indicator quality assessment criteria approaches are summarised in Table 3.1.

These criteria can help assess and refine basin indicators but should not limit the selection of additional criteria that are seen to be relevant in the local context of the basin. It is also possible to mix and match the criteria across various approaches, tailoring the quality assessment to the priorities of the stakeholders and management goals.

For example, it is always strongly encouraged to select indicators for which data can be collected for by key socioeconomic groups and by gender. This includes weighing whether indicators can be ***disaggregated by gender, age, ethnic group, social status, income etc.*** where this data can provide important information about the impacts of interventions and project activities. Such general criteria could be included in the list of desired qualities of the indicators, regardless of the approach chosen.

The qualities of indicator should also be viewed against the broader management and policy contexts that they will be used in. This includes other national, regional and global reporting requirements and their specific indicators. Combining or using existing indicators under such reporting arrangements can help maximise resource efficiency, help avoid duplication of efforts, and ensure that both local and broader reporting requirements are met[9].

9 Read more in Alignment with global, regional and national processes

TABLE 3.1

Commonly used indicator quality assessment criteria.

Acronym	Stands for	Advantages	Limitations
SMART	**S**pecific (to what is being measured) **M**easurable (also reliable, comparable, contextually appropriate and unambiguous) **A**ttainable (also achievable, feasible, cost-effective) **R**elevant **T**ime-bound (also sensitive)	• Can be more practical for monitoring and meeting specific project output requirements • Generally accepted and widely used set of criteria • Assessment can be done relatively quickly and cost-efficiently	• Often can be perceived (and be) a top-down approach, selecting indicators based on e.g. desk studies rather local realities • Does not necessarily require stakeholder participation
CREAM	**C**lear **R**elevant **E**conomic **A**dequate **M**onitorable	• Particularly suitable for performance assessments and results-based monitoring • The slightly broader definitions of 'Adequate' and 'Monitorable' can accommodate qualitative and quantitative indicators equally well	• The broader categories can also create an ambiguous interpretation of some of the concepts that may differ depending on setting and user
SPICED	**S**ubjective **P**articipatory **I**nterpreted and communicable **C**ross-checked and compared **E**mpowering **D**isaggregated (and diverse)	• Indicators (and targets) reflect local realities and values and are realistic. Bottom-up approach, helps understand what positive change means for local communities • Supports higher levels of stakeholder support and engagement in indicator application in the long term • Possibilities to include otherwise little known, but locally important, indicators in monitoring • Increased ownership of processes and empowerment of local actors to lead	• Resource and time intensive processes, usually more resource intensive indicators than the above • Facilitation still needed to ensure that selected indicators also reflect best practice in science • More suited (and necessary) for qualitative indicators

Overall, it is important that the selected indicators reflect the priorities and intended use in the basin with reasonable accuracy. Often the 'perfect' indicator is not feasible in practical application but a relevant, affordable and accurate substitute can be an acceptable alternative until the priority becomes a possibility. This also relates to the existing technical and institutional capacity to adopt and implement the selected indicators. Many basins and countries still lack the necessary capacity to approach basin management issues from an IWRM perspective. However, it is also important to remember that the local capacity is relative to the complexity of the indicator frameworks proposed (Campo 1999) – the more complex the indicator set proposed, the more likely that successful implementation will be limited by those constraints. The level of complexity should be balanced with what is feasible in the given setting.

For the sustainability of indicator application, the selection process should strive to strike the right balance between scientifically robust, quality indicators and indicators that reflect the values and priorities of the basin stakeholders and the intended users of the information. Chapter 5 discusses how to support this through stakeholder engagement in the indicator selection process and application.

BOX 3.1

Indicator disaggregation by gender

Indicator data, aggregated based on gender (or ethnic group or age) can provide valuable insights into the community dynamics and those groups of society that may be more affected by certain changes, e.g. those in the surrounding environment. Women are particularly important stakeholders in the water sector, including their role and household responsibilities in providing clean water and sanitation, and the effect that the lack of this has on women's access to health and education (Seager 2015). Due to their pivotal role in households, women also often possess the local knowledge crucial to understanding and evaluating water resource dynamics. Ultimately, gender-disaggregated data can influence the broader decision making pertaining to implementing IWRM and the broader socioeconomic agenda on poverty, women's empowerment, health, and more.

This requires that data is collected disaggregated by sex and age. Sex-disaggregated data are particularly relevant in addressing water governance evaluations, such as aspects of equity and empowerment. The report *Sex-disaggregated indicators for water assessment, monitoring and reporting* provides a useful long list on World Water Assessment Programme's Sex-disaggregated Priority Indicators (Seager 2015). Some examples include:

- Number of male and female (M/F) paid staff in public water-governance agencies
- Percentage of households without water on the premises, by sex of the main person responsible for collecting drinking water and by type of household
- M/F perceptions of the adequacy of current water supply/availability in both quality and quantity in the household
- M/F perceptions of/knowledge of current total household use of water, by category of use and by primary user (more in the report).

Similarly, water indicator data disaggregation by ethnic group, income, age, disability status, race, etc. can indicate whether some communities or groups of society are more exposed, or affected disproportionately (e.g. due to cultural differences or religious beliefs). Such information may inform whether additional efforts need to be focused on specific communities, societal groups, but also on the progress that is being made on various socioeconomic targets pertaining to facilitating equality and inclusion (e.g. the Sustainable Development Goals agenda).

Disaggregation by ethnic groups can however be affected by language barriers or differences in perceptions of the same questions from community to community, so comparisons should be made with caution.

INDICATOR CASE STUDY

Selecting indicators to support the Nile Basin Decision Support System

The Nile Basin Initiative (NBI) is an intergovernmental partnership of 10 Nile Basin countries -– Burundi, DR Congo, Egypt, Ethiopia, Kenya, Rwanda, South Sudan, The Sudan, Tanzania and Uganda. One of the primary purposes of the NBI is to provide a platform for the basin countries to discuss and agree on sustainable development of the basin resources, including provision of the necessary information and analysis to support decisions on resource development.

The Nile Basin Decision Support System (NB DSS) is an analytical tool that was jointly developed by NBI and basin Member States. The NB DSS serves a number of purposes, including communication, information management and analysis of water resources. It provides a framework for sharing knowledge, understanding how the river system functions, evaluating alternative development and management strategies, and supporting informed decision making on a basin scale.

Water data, transformed to relevant indicators, form an important part of the NB DSS system. Indicators are used to evaluate the state of the resources (e.g. for the State of the River Nile Basin Report), as well as for monitoring and evaluation against key objectives and, importantly, scenario development to evaluate alternative approaches to resource use and problem solving (e.g. understanding future water demand and availability).

The lessons from establishing the NB DSS show that there are a number of context-specific criteria for indicator selection that need to be taken into account to cater for the specific needs of the basin (in this case, a transboundary basin), beyond the widely acknowledged SMART criteria. Furthermore, the selection process itself is fundamental in establishing a set of commonly agreed and respected indicators on a basin scale.

First, a certain level of standardisation was necessary to operate and enable decision support system functioning on a basin scale. A key component of the decision support is formed by scripts and toolsets for data processing, modelling, scenario management, optimisation and multi-criteria decision making. To ensure that indicator results can be generated and compared across the basin, standardising calculation scripts and calculation methodologies has shown to be essential. In the case of NB DSS, standardising this relationship between data and indicators has been particularly important, given the high number of countries using the common decision support system.

Secondly, there are often existing (or perceived) sensitivities surrounding information sharing and the issues that it may convey, and these need to be duly recognised, particularly in transboundary basin contexts. In the NB DSS, this has created the need to strike a balance between the sensitivity of information and selection of indicators that are true to the issues relevant in the basin (e.g. using relevant proxy indicators to avoid exposure of sensitive information). Choosing indicators that can accommodate both these demands has been important to ensure common engagement of all countries.

Thirdly, striking a balance between flexibility and standardisation in indicator selection has shown to be important in design of a relevant DSS for the Nile Basin. Accommodating this allows both, an acceptable level of scientific robustness and relevance of indicators to all member states of the basin. For example, upstream and downstream countries often have different development priorities and concerns, thus prioritising different indicators (e.g. capacity of energy production upstream versus environmental variables downstream). These are both valid concerns and ones that need to be addressed via indicator selection in the common, shared basin decision support system. In the case of NB DSS, the answer has been to agree on a pool of commonly accepted indicators, from which countries can select ones relevant to their needs. This has proved to be a better alternative to that of an agreed limited set of indicators.

Lastly, the process surrounding indicator selection and lines of decision support is key to productive basin-level dialogue on resource management and development. Time invested in understanding and agreeing upon the process itself should therefore be prioritised. The following indicator selection process can be lengthy and complex, for a number of reasons, some of which pertain to items outlined above. However, the selection of, and a consensus on a set of common indicators in itself has been a major achievement, signalling common agreement on a number of priority issues and development objectives on a basin scale.

Source: Abdulkarim H Seid, Head of Water Resources Management Department at the Nile Basin Initiative Secretariat, 2016 (Interview).

Chapter 4

Alignment with global, regional and national processes

4.1 The relevance of regional and global reporting frameworks

Selecting indicators in any basin should first and foremost consider local relevance and data collection feasibility (see more on the crucial criteria in chapter 3). However, there are also a number of ways in which other existing indicator-based processes can influence basin-level data collection and reporting needs. Some examples include:

- Existing national-level reporting requirements and standards which require basin-level reporting on specific indicators to national authorities
- Regional monitoring frameworks for national governments (or utilities) which may require countries to report their national values on specific indicators (e.g. European Water Framework Directive)
- Global reporting mechanisms the respective country adheres to, for which specific indicators need to be reported (e.g. Sustainable Development Goals)
- Change in overall policy direction that may require monitoring of specific changes on the ground

The existing global, regional and national indicator-based reporting and management frameworks should not strictly dictate or limit indicator selection at the basin level (unless direct reporting is required) but there may be a number of benefits in establishing a good understanding of, and alignment with the broader indicator frameworks within which basins are operating. The benefits of linking local indicator selection to national, regional and global indicator frameworks include:

- Cost savings from streamlining and consolidating various existing reporting requirements
- Possibility of embedding indicators with already established track records, data collection mechanisms and historic baseline, if choosing selected indicators from existing reporting frameworks, e.g. nationally
- Opportunities for filling gaps in existing reporting frameworks to improve the understanding and record of basin level metrics (given that national reporting mechanisms often struggle to collect meaningful data from the appropriate hydrological units)
- Creating opportunities for national, regional and global comparison and standardisation for key water resources monitoring and reporting indicators
- Monitoring implementation progress and impacts at the basin level of national-level goals and targets, identifying any deviations and differences among basins in a country
- Establishing coherency with overall policy direction of the country or region on a global level
- Importantly, increased chances for sustained financing and thereby sustained use of consistent indicators beyond the time span of initial (often project-based) implementation. Linking to long-term national and international commitments and indicators can help secure long-term funding for the indicators by linking to broader priorities and specific commitments, and their corresponding national or international financing sources.

Alignment with the broader frameworks can prevent unnecessary fragmentation of water reporting between national and basin level. That said, it is important to recognise that many national-level indicators serve a specific purpose and will not be relevant or necessary for basin-level reporting and daily management. In the same way, many basin-level indicators are tailored for basin management and resource allocation and are not needed for national-level reporting mechanisms. Alignment with the larger-scale indicator frameworks should be considered for the thematic areas and issues only where relevant and information collected can inform and drive improvements on ground.

There is an increasing number of regional and global reporting frameworks for water. Several of these are described below. These are used as examples of the type of links that may exist between basin and global, regional and national reporting frameworks. No specific national frameworks are reviewed here, but alignment of these should be evaluated in the country context of the given basin.

4.2 Examples of regional and global water monitoring and reporting initiatives

UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS

Scope: Global

Description: For more than 15 years, the global sustainable development agenda was guided by the Millennium Development Goals (known as the MDGs). With the MDGs coming to an end in 2015, world leaders adopted a new global agenda – the 2030 Agenda for Sustainable Development which includes 17 Sustainable Development Goals (SDGs), building on the MDGs' success. The 17 SDGs outline a global agenda for sustainable development for the next two decades. The goals cover various aspects such as ending poverty, fighting inequality and injustice, and tackling climate change by 2030, and many more. Each goal has a set of specific targets, progress on which will be reported on using globally relevant indicators. SDG 6 is dedicated to water, sanitation and inland water ecosystems.

Indicators: The 17 goals cover 169 targets and a set of indicators is proposed to monitor progress on each target. A preliminary proposal from the Global Goal on Water and Sanitation (SDG 6) includes six targets with associated indicators (one to two key indicators per target). The preliminary set of water goal indicators include the following:

- Indicator 6.1.1: Proportion of population using safely managed drinking water services
- Indicator 6.2.1: Proportion of population using safely managed sanitation services, including a hand-washing facility with soap and water
- Indicator 6.3.1: Proportion of wastewater safely treated
- Indicator 6.3.2: Proportion of bodies of water with good ambient water quality
- Indicator 6.4.1: Change in water-use efficiency over time
- Indicator 6.4.2: Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
- Indicator 6.5.1: Degree of integrated water resources management implementation
- Indicator 6.5.2: Proportion of transboundary basin area with an operational arrangement for water cooperation
- Indicator 6.6.1: Change in the extent of water-related ecosystems over time

Relevance: SDGs include globally agreed targets and indicators that the majority of countries will be reporting on over the next 15-20 years. For countries, reporting on these targets helps establish a global baseline and allow international comparability, thereby creating opportunities for tracking progress at different scales and comparing national progress with that of other countries. Indicator reporting on a local level (such as basin level) can improve coherency between global and national policy directions and local decision-making and management, as well as help record tangible changes on the ground. Basin-level reporting on key indicators can also help possible key areas/basins within a country that may contribute to progress or hamper reaching national targets, and therefore help inform more targeted interventions.

Further information: https://sustainabledevelopment.un.org

SYSTEM OF ENVIRONMENTAL-ECONOMIC ACCOUNTS (SEEA)

Scope: Global (initial application in pilot countries only)

Description: The SEEA has been adopted by the UN Statistical Commission as the international statistical standard for environmental-economic accounting. SEEA-Water, in turn, is a SEEA sub-system, providing concepts, definitions, classifications, tables, and accounts for water and water-related emission accounts. SEEA-Water also provides guidance on water accounting in national environmental accounting systems, including the International Recommendations for Water Statistics (IRWS) for national information systems for water, in support of design and evaluation of Integrated Water Resources Management (IWRM) policies (UNSD 2016).

Indicators: The International Recommendations on Water Statistics focus on international comparability of water statistics amongst countries and over time, and specifically for supporting integrated water resources management (i.e. multipurpose information systems) (UN 2012). The recommendations provide general guidance on datasets, data sources and statistical best practice, and discuss a selected number of globally used indicators in more detail (specifically, water indicators from the World Water Assessment Programme (WWAP) and Millennium Development Goals). The list is not exhaustive but provides methodologies for calculating some of the most common global water indicators.

Relevance: IRWS is primarily targeted at producers of national official statistics and does not require reporting on per se but it provides valuable information on indicators and metrics that are well suited for international comparison, as well as valuable guidance on methods for data collection and best statistical practice. A number of useful data sources are also included in the publication. The scope of IWRS is limited to selected aspects of water statistics (e.g. does not include surface and groundwater quality, environmental flows, drinking water quality and health and gender statistics). The recommendations can therefore be used to learn of best international statistical practice in cases where such alignment is desirable.

Further information: http://unstats.un.org/unsd/envaccounting/water.asp

EUROPEAN UNION WATER FRAMEWORK DIRECTIVE

Scope: Regional

Description: The Water Framework Directive[10] (WFD) is the legal framework of water resources management in EU countries. The directive establishes the framework for water resources management on an EU level, based on the natural geographical and hydrological units, and sets specific goals (and deadlines) for member states to protect their aquatic ecosystems. The directive addresses inland surface waters, transitional waters, coastal waters and groundwater and establishes the basic principles for water management, including public participation in planning and economic approaches, such as the recovery of the cost of water services (European Commission 2016). All member states are required to set up national monitoring programmes on the health status of their water bodies (status following a scale of: high, good, moderate, poor and bad). Indicators: The directive sets out an overall common approach for monitoring water quality, requiring monitoring and management plans on a basin level, using a common evaluation scale of high to bad status. The choice of the specific methods and indicators is made locally (in country), taking into account the differences in the level of development of the national water monitoring systems. Data on key indicators however is collected by the European Environmental Agency and key water datasets related to WFD are also available on Eurostat (The EU statistical portal).

Indicators: The directive sets out an overall common approach for monitoring water quality, requiring monitoring and management plans on a basin level, using a common evaluation scale of high to bad status. The choice of the specific methods and indicators is made locally (in country), taking into account the differences in the level of development of the national water monitoring systems. Data on key indicators however is collected by the European Environmental Agency and key water datasets related to WFD are also available on Eurostat (The EU statistical portal).

Relevance: On a regional level the WFD provides baseline information on a number of indicators for countries but importantly, also indicators that are reported on at basin level (e.g., datasets on river basin district statistics for key water resources indicators).

10 Its official title is Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy.

These can provide examples of indicator use to track progress in the ecological state of water bodies, as well as a number of socio-economic indicators, useful for comparison and experience sharing.

Further information: http://ec.europa.eu/environment/water/water-framework/index_en.html and http://ec.europa.eu/eurostat/web/environment/water

AMCOW MONITORING AND EVALUATION FRAMEWORK FOR THE WATER SECTOR IN AFRICA

Scope: Regional

Description: The project has established a harmonised national and regional water sector monitoring and reporting system for AMCOW (African Ministers Council on Water) to report annually to the African Union on the state of implementation of water policies at a continental level. The monitoring and reporting framework is designed to track progress against the political commitments made concerning water and sanitation. At the recommendation of political leaders in Africa, the framework is aligned with the water and sanitation-related SDG targets and indicators.

It is envisaged that while meeting the monitoring and reporting needs at the African Union level, the data collected will also serve for reporting on the water and sanitation-related SDGs at the global level. This includes establishing a national and regional monitoring and reporting system based on a common framework of indicators and methodologies, and reporting guidelines with the production of an annual progress report.

Indicators: The indicator list includes 43 core indicators measuring progress against political commitments and 35 'water facts' ('state of the water resources' indicators) providing context and backdrop for water resources management challenges.
The indicators cover seven main themes of water management performance that countries have been reporting on to date.

Relevance: The regional scheme is relevant for all water managers of the AMCOW countries and provides a common list of 'state of water' and 'water performance' indicators to be monitored and reported on in the region. Basins (and countries) can also refer to the list of indicators for baseline data and indicator themes relevant to the region.

Further information: http://www.amcow-online.org/ and www.africawat-sanreports.org

4.3 From local to national, national to basin and basin to global monitoring – the challenge of aggregation

Aggregation of indicator results to the desired spatial unit and the comparability between basin level (hydrological unit) and the national level (administrative unit) remains a common challenge for water resources reporting. Most of the global and regional schemes described earlier rely on national-level reporting on (usually) relatively simple water indicators. This in turn requires simple and accessible water metrics that can be easily understood and communicated by decision makers on a national level (e.g. water availability versus use). Such indicators serve their purpose to some extent, but there are limitations to indicators aggregated to a national or other political unit. There are also resource development decisions that require more in-depth detail and understanding of basin interactions. Many of the conventional national-level water indicators do not capture the complexity nor follow the natural boundaries of hydrological systems. Large variations can occur from basin to basin even within the boundaries of a single political or administrative unit.

National-level indicator data are relevant for a number of purposes. They inform policy making and resource allocation, as well as allow comparison with other countries for purposes of benchmarking. They also serve the purposes of the specific audience, which often is national-level decision and policy makers. These indicators and their associated metrics will continue to be crucial in water policy making. There is however an increased recognition by water managers and policy makers alike of the need for basin-level data. Tracking progress on basin-scale indicators can inform water allocation and day-to-day management, infrastructure development and new investments, as well as 'diagnose' any existing or emerging environmental issues in the basin.

A major challenge lies in reconciling these two levels of information and avoiding fragmentation and isolation between national and basin-level reporting. This is crucial to ensure that local-level monitoring schemes are relevant for day-to-day management but are also able to communicate to national-level decision makers and policy makers. Coordination contributes to efficiency of resource use in data collection and monitoring and to the best possible use of the wealth of information that already exists within well-established national and global datasets. Establishing a baseline, in particular, is one of the most important aspects of applying indicators meaningfully for monitoring change and management efficiency.

Initial success with transboundary assessments shows how we can bring complexity, multi-sector ownership, resource endowment and economic opportunity together at scale (de Strasser *et al.* 2016). There are several approaches that can help to bridge the scale gap, without needing two different sets of water indicators.

These include approaches that can help synthesise indicator data across scales:

1. **Use of various spatial resolutions for the same indicators (where relevant).** This includes basin-level aggregation of data for indicators already in use nationally or globally, using locally observed data, where available, and exploring new opportunities for data collection available through Earth Observations data. Examples include indicators such as water stress, where national-level accounting (e.g. water available per capita) can be further explored through gridded basin-level information, understanding the differences of water distribution and stress conditions within a country.
2. **Weighted aggregation**. There are certain indicators for which national-level data are well established and widely used, without further disaggregation to the basin level (particularly prevalent for many socio-economic indicators) depending on the intended indicator use (not necessary for global comparisons amongst countries. With developments in gridded information also for these variables (e.g. CIESIN's Global Rural-Urban Mapping Project or gridded population datasets[11]), it is possible to aggregate national-level data to basin-level indicators, using appropriate weighting methods. For example, by using the relative concentration of the proportion of population in a basin or other variables that are

11 The Center for International Earth Science Information Network (CIESIN) is a center within the Earth Institute at Columbia University. More at http://sedac.ciesin.columbia.edu/)

meaningful in the context of the specific indicator. For the most part, these are imperfect calculation methods, though they can give a fair indication of the geographical spread of the problem. Some examples of such aggregation methods can be found in the GEF Transboundary Waters Assessment Programme's River Basins (TWAP RB) component (UNEP-DHI and UNEP 2016).

3. **Modelled results**. Ongoing developments in hydrological and socioeconomic scenario modelling methods allow for data aggregation on a variety of scales and can be used to generate basin-level data for a wide range of indicators across scales such as indicators on flood or drought risks. There are inherent uncertainties with modelled data which vary depending on model design and input data characteristics but models have become widely used and acknowledged tools for decision and management support. New developments in data and methods are making such models increasingly reliable.

4. **Proxy indicators**. Proxy indicators based on different metrics but signifying the same or related aspects of the problem can be used as a substitute where basin-level data are not available to the same extent as in national-level reporting. Many socioeconomic, and particularly economic metrics, are well reported on a national level but are challenging to aggregate on smaller administrative, or even hydrological units. In this case, proxy indicators and proxy data can be used to explore some issues. For example, the GEF TWAP RB [12], used the satellite observation data for luminosity of night-time lights as a proxy indicator for economic activity in the basin. Proxy indicators should be used with caution, only when data are not available or too costly/impossible to obtain and only when the data provided by proxy is deemed to provide at least an approximate indication of the desired measurements (Kusek and Rist 2004).

While there is no perfect substitute for basin-level data, where only national records are available, it is relevant to explore the options for aggregation. Similar methods can be explored for aggregating basin to national-level indicator results. It is also important to note that not all indicators are relevant and needed for both scales. However, there are key sets of indicators that are relevant across the board and ensure a direct and measurable link between national-level policy and its impacts on the ground and vice versa. These should be selected and applied where possible, at least to the extent that they represent the relevant thematic aspects, if direct replication is not possible.

12 More on TWAP River Basins component indicators at *http://twap-rivers.org/*

Chapter 5

Stakeholder engagement in indicator selection processes

5.1 How stakeholder engagement strengthens indicator use in basins

Stakeholders in the context of basin water management are those parties, organisations and individuals who would either be directly affected by water management practices and projects, or who in some way influence the outcomes (positively or negatively). Basin stakeholders include land owners, water managers, farmers, water utilities, power utilities, private businesses that consume or discharge into water and water policy and decision makers at various levels. Stakeholders could also be broader water users that depend on the ecosystem services in the basin and will be directly affected by any changes in basin health or resource allocation.

Stakeholder engagement is the process of involving the organisations or people who may be affected by or who can influence the successful implementation of water management actions or policies. Engaging stakeholders helps ensure ownership of the information and recommendations, and ultimately shapes the direction of indicator application and any resulting changes in resource management. Involving stakeholders also helps to develop a better understanding of perspectives across user groups, form a joint understanding of the current state and future vision for the basin, as well as agree on solutions for complex issues.

Stakeholder engagement in indicator selection and application can have multiple benefits and can take place in different ways and at various stages of the process. Some of the key benefits of stakeholder engagement include:

1. **Ownership**: The acceptance of and use of information presented by indicators is largely affected by how much individuals or local institutions (including those tasked to collect indicator information) feel they understand and have played a part in selecting the indicators (e.g. indicators represent the information that the users require and deem to be relevant).
2. **Data and information access**: Involving critical data owners can play an important role in facilitating access to the information that is necessary to calculate indicators, or to spur the collection of new information, where needed. Community stakeholders (particularly those that have lived in the area for longer periods of time) are often able to provide valuable information that is not recorded by authorities, particularly that relating to longer term changes and trends. But while local stakeholders are often best placed to account for the changes in pressures over time, they may be less aware of the cause-effect relationships of these changes on a broader scale.
3. **A better shared understanding**: The process of co-creating indicator frameworks also allows for the involved parties to build an understanding of the issues to be addressed through the use of indicators and to negotiate priorities among these issues. It can help identify where there are shared or conflicting values, building a common vision for the basin.
4. **Making connections across sectors and jurisdictions**: The diversity of stakeholders involved makes connections across sectors and administrative boundaries on a basin level. Although this is not a necessary objective of indicator monitoring and application, it is important to consider and can be explored when for example, organising stakeholder workshops for indicator selection at a basin level.
5. **Transparency**: Stakeholder participation in the process of selecting and ultimately applying the indicators is important to ensure transparency. It can

often be felt that indicators are imposed on end users through a top-down process without a thorough explanation of what is measured and why. It is also important that stakeholders validate the methods used to calculate the indicators and make sure that the methods proposed are realistic to implement in their local context (e.g. are indicators realistic for the local agencies responsible for data collection and results calculation).

6. **Accountability**: Stakeholder involvement in indicator selection and application ensures higher confidence in the results as stakeholders understand and support the key indicators selected. It also increases the accountability demands to those authorities that implement the key activities – through active involvement stakeholders may feel more ownership of the process and demand greater accountability from those tasked with implementing the indicators and associated activities.

There are two key issues at the crux of achieving these outcomes: understanding ***who* are the stakeholders** that will be involved in the process and ***how* these stakeholders will be involved**. Considering who these stakeholders are and what their role(s) are in indicator selection depends on what the indicators will be used for (e.g. allocating resources, informing policy or management and planning processes). The who and how is further explained in the following sections.

INDICATOR CASE STUDY

Mekong River Basin in Kratie and Stung Treng Provinces, Cambodia

The Luc Hoffmann Institute (LHI) project Linked Indicators for Vital Ecosystem Services (LIVES) was created with the support of the Nomis Foundation to develop and test linked indicators for joint governance, planning and management of food, energy and water resources in response to the challenge of 'silo planning'. LHI used a transdisciplinary research process to test methods for identifying linked indicators that would reflect the interdependencies between food, energy and water in river basins, provide evidence of this nexus and promote an integrated approach to natural resources management and development planning.

LHI piloted this approach in the Mekong Flooded Forest Landscape (MFF) of Cambodia, in partnership with WWF Cambodia, WWF-US and the University of Maryland Center for Environmental Science. The MFF Landscape is a 56km remote section of the Mekong River mainstream that passes through Kratie and Stung Treng provinces in northeastern Cambodia. The landscape was officially designated by the Royal Government of Cambodia as a management and conservation site for biodiversity and fisheries resources in 2013. However, in past years, the government has implemented policies to increase energy capacity through hydroelectric dams on the Mekong river – putting at risk food and water supply for local rural communities along the river. The project aimed at driving stakeholders to think about the trade-offs between current policies, think about striving for a balanced development and select indicators that would help them track progress towards sustainable outcomes.

The LIVES approach that was piloted in the MFF involved causal loop diagrams, developed with government stakeholders, to map the links between sectors, values and threats analysis to identify what stakeholders value most, and system dynamics modelling to weigh which links and values would drive change in the ecosystem in the future and to simulate the results and trade-offs of those changes. These processes led to a selection of indicators based on the links that would best reflect change across sectors and on availability of information.

All of the processes to select indicators were stakeholder-driven. LHI and WWF involved approximately 60 government officials from both provinces. The project brought international academics from the University of Maryland Center for Environmental Science and University of Bergen and international experts from KnowlEdge Srl. and WWF who shared knowledge and built the capacity of local WWF and government staff. Likewise, local stakeholders provided local knowledge and shared knowledge among each other, contributing to quicker and more accurate results.

Besides instigating a sense of enthusiasm and ownership by contributing to the output of the project – as opposed to receiving a finished report – stakeholder engagement allowed LIVES to capitalise on the knowledge of actors from different sectors. Through dialogue, stakeholders reached a shared comprehensive understanding of how food, water and energy systems interconnect in the MFF and identified a set of linked indicators. In addition, stakeholders profited from having a platform to discuss environmental, water-related and development issues with various actors – with whom they would not normally interact.

Engaging multiple stakeholders from different sectors (and different departments within provincial governments) in the selection of indicators also presented a few challenges that provided valuable insights for future replication of LIVES. It was important for the project team to have all stakeholders feel comfortable and included in the processes that were being implemented to select indicators. The project started by training local WWF and government staff to lead the workshops in Khmer – rather than English. Interactive activities, including games to have participants identify values and risks, proved to be successful in keeping the audience engaged and energetic. In order to capture the knowledge and opinions of those who did not feel comfortable speaking, facilitators also encouraged participants to give written input.

By implementing processes that were inclusive, representative and accessible, and that allowed a shared and comprehensive understanding of how water, energy and food interconnect, stakeholders selected 12 context-based linked indicators. Engaging government stakeholders can spark a sense of commitment and accountability around the selected indicators. In July 2016, when speaking to his local government colleagues, the Deputy Provincial Governor for Kratie Province declared the results could easily become regulations because "these findings have been obtained by all of you." Moreover, the shared learning from LIVES on the importance of indicators to measure progress towards sustainable basins, ecosystems and development is being included in new national legislation in Cambodia.

Source: LHI, 2017

More on LIVES: http://luchoffmanninstitute.org/research/linked-indicators-for-vital-ecosystem-services/

5.2 Stakeholder mapping and selection

The decision of which and how many stakeholders to include in the indicator selection and definition process will depend on what the desired outcomes of indicator use will be. The stakeholder selection process can in many ways be part art, part science. The selection often includes value judgements that need to be made when weighing how many groups to include against efficiency of the overall indicator selection process.

A stakeholder analysis or mapping exercise is a helpful starting point in formulating the final selection of whom, how and when to involve in the process. There are a multitude of both formally defined and informal approaches to stakeholder mapping and analysis. A stakeholder analysis would typically be undertaken during the data and information stock-taking exercise in the initial phases of the process and consider power, influence and the specific needs and/or support of each of the stakeholders.

Some examples of approaches for stakeholder analysis are included in Table 5.1.

TABLE 5.1

Examples of approaches for conducting stakeholder analyses.

Institution	Resource Link	Description
Organisation for Economic Cooperation and Development (OECD)	*www.oecd.org/gov/regional-policy/OECDSurveyTechnicalNote.pdf*	General Guidance on Stakeholder Engagement for Inclusive Water Governance
United States Agency for International Development (USAID)	*https://www.usaid.gov/gbv/toolkit-annex*	Identifies stakeholders with an interest in the gender-based violence programme who could influence results and/or that the crisis may impact
Overseas Development Institute (ODI)	*http://www.odi.org/publications/5257-stakeholder-analysis*	Framework to develop a stakeholder analysis for shaping policies
World Bank	*http://www1.worldbank.org/publicsector/anticorrupt/PoliticalEconomy/stakeholderanalysis.htm*	Framework to develop a stakeholder analysis for anticorruption procedures
World Health Organization	*http://www.who.int/management/partnerships/overall/GuidelinesConductingStakeholderAnalysis.pdf*	Framework to develop stakeholder analysis for health reforms

Traditionally, stakeholder analysis approaches are designed to identify and analyse several major groups of stakeholders which are not necessarily exclusive:

1. Those who will be affected by the decisions made (those who will be affected by the indicators and decisions made based on indicator results)
2. Those who possess the necessary information or data
3. Those who have critical knowledge and/or expertise to implement indicators
4. Those who can affect the quality, legitimacy and salience of the selected indicators.

The four groups of stakeholders are shown in Figure 8. Often the last three are grouped under one heading of those who can affect the salience of the indicators (implementation of the indicators).

Understanding key stakeholder groups and the individual players is a necessary starting point for the stakeholder analysis. Based on this information, further decisions can be made on whom to engage, when in the process and how.

Figure 8. Main stakeholder groups in a basin.

As part of the stakeholder mapping exercise, it may be helpful to (Kusek and Rist 2004):

- Establish main issue areas that are relevant for the given context (e.g. water resources, energy production, agriculture, environmental protection).
- Analyse the organisational structures and stakeholders groups within the given context (e.g. government agencies, local authorities, NGOs, farmer associations). This includes broader mapping of their links to other sectors (i.e. the water-food-energy nexus).
- Identify their relationship, involvement and dependency in the management and use of basin resources.
- Identify existing power structures and relationships, e.g. groups that should be given priority or special attention (such as vulnerable groups that depend on resources but have little voice, particularly influential organisations or government offices), primary and secondary decision makers, those who have been involved in management in the past or could obstruct proposed changes (OECD 2015).
- Identify the most pressing challenges and concerns of each of the stakeholder groups along with their mode of interaction with the basin.

In selecting the stakeholders, it is important that all groups receive fair representation and all major stakeholders groups are given a voice, not only the most active or powerful ones. Resource and time availability to a large extent determine the breadth of stakeholder representation and engagement, but it should be a priority to ensure that at least minimum representation is established from all of the key stakeholder groups while engaging a manageable number of participants.

5.3 Stakeholder engagement process

Once key stakeholders are identified and selected, building trust is important to the eventual acceptance of indicators. There are various stages of activities during which stakeholders can be consulted and actively involved, but often the most effective way to build trust and a sense of ownership is to include the critical stakeholders throughout all stages of the process of indicator selection and implementation.

At its most basic level, **indicator selection and implementation can be broken into four steps**:

1. Conceptualisation
2. Indicator selection and calculation
3. Indicator validation
4. Indicator communication

Below, we consider the role of stakeholder engagement and how it may vary throughout these steps.

It is important to note that it is not necessary for all stakeholders to be involved in all portions of the process of selecting and calculating indicators. Local knowledge of the context should be used to gauge the need for in-depth participation throughout the process. As a minimum, the generation of the conceptual framework (i.e. what values should be reported on and/or tracked) and final communication of indicator results should include broad enough representation to ensure the legitimacy of decisions.

The various modes of stakeholder engagement in these four steps are further discussed below.

1. CONCEPTUALISATION

Conceptualisation (see more on the importance of conceptual frameworks in chapter 2) refers to the process of building a common understanding of the system that is to be assessed and the priorities on what aspects of that system need to be tracked. This includes collecting stakeholder opinions (and stakeholders should play a substantive role in this as it is likely to be the main factor in fulfilling the objective of creating a shared understanding of the key issues and making connections across sectors and jurisdictions. The inclusion of all four of the previously described groups of stakeholders in this step is likely to be critical to the eventual ownership of results and ensures that as a first step, a common understanding of the problems and desired change is established. This may include reaching consensus on outcomes of basin management interventions. Here positive framing of desired change or a positive vision for the future of the basin is recommended, as opposed to direct problem statements (Kusek and Rist 2004).

Activities with stakeholders in this stage may include:

- Workshops focusing on identifying key concerns, values and desired changes in basin management, development and benefit sharing amongst stakeholders
- Focus groups or interviews with selected stakeholders on the same
- Collecting supplementary information from targeted stakeholders via email, telephone or other methods
- 'Town hall' meetings or open comments and feedback campaigns on specific issues, inviting public opinion

These forms of stakeholder engagement essentially allow for gaining local insights and inputs into the priority problems faced in the basin and desired direction of change (by, where possible, formulating consensus outcomes for change).

2. INDICATOR SELECTION AND CALCULATION

The choice of the specific indicators is a step where the degree of stakeholder involvement can widely vary depending on the local context, and resource availability. Key issues to consider when deciding on the level of stakeholder participation are the feasibility of accommodating the inputs of various stakeholder groups to avoid unrealistic expectations further in the process and importantly, the technical capacity of stakeholders to select appropriate indicators and any underlying interests of specific stakeholder groups. It is natural that some stakeholders prioritise one issue over others, depending on their key interests so this should be accommodated in a balanced way. This can be done through selecting a diverse set of stakeholders but also by involving qualified facilitators and representatives from (local) scientific and basin management entities that are able to add broader, integrated perspectives to the group. This also includes involving the scientific community and stakeholder groups who possess relevant data and information and the knowledge of the basin.

Additionally, decisions on which data sources will be used for indicator calculation can be a sensitive issue in certain political contexts and may require the inclusion of specific institutions and strong facilitation at key moments in the discussion.

Ways in which stakeholders may be engaged in this stage include:

- Workshops with selected representatives (including broader stakeholder groups, but also the scientific community, basin managers and potential data holders)
- Meetings, workshops, or solicited feedback from selected experts and the local scientific community

Figure 9. *Development of a workshop to conceptualise different indicators (Source: UMCES)*

3. INDICATOR VALIDATION

Validating the indicator results with stakeholders can provide important quality assurance. It is central to the acceptance of indicator results and fruitful use of results for decision making and, eventually, changed basin management practices and policies. Credibility of the process and acceptance of results can be significantly improved if stakeholders involved in the conceptualisation step also review results and provide inputs or voice concerns on, for example, any misrepresentations or overseen issues with indicator calculation methodology. Such processes could involve selected stakeholders and engagement via informal consultations and can be useful in drawing on local knowledge to validate whether indicators are delivering the information they are meant to deliver. It is, however, crucial to distinguish between concerns of methodology and those related to the results themselves. Any stakeholder validation process should maintain scientific integrity, ensuring that the results of indicators remain independent, presenting the objective findings based on agreed methods.

Ways of engaging stakeholders in validation process could include:

- Sharing draft calculations and methods for open review, or for review with selected stakeholders
- Arranging formal or informal meetings to present findings and solicit stakeholder comments before finalisation
- Formal or informal interviews with selected stakeholders (e.g. in selected hotspots) to verify the on-ground realities of initial indicator results
- Engagement with the local scientific community to cross-check initial indicator results with existing alternative, or related data on a local level

4. INDICATOR COMMUNICATION

Communicating indicator results to decision makers and the general public is one of the most important steps in crossing the 'science-policy' bridge and applying indicator results in driving positive change. It also reduces the risks of misinterpreting indicator information. Investing in a well-designed communication strategy and involving stakeholders at this stage are important steps of the process. Typical means of communicating indicator results include web-based information platforms, written reports, social media and television or radio interviews.

Care should be given to clearly defining the target audience and tailoring outreach materials for maximum impact. For example, politicians or legislators may require succinct and easily understandable key pieces of information, whereas the scientific community may be more interested in the detailed results, data sources and methods. The general public, in turn, may require more active engagement through communication channels that involve radio, television, social media or in-person outreach campaigns. Selected stakeholders can also be effective messengers for communicating results to the right audiences (e.g., indigenous or community leaders, local schools, local policy makers, local television and radio programmes).

Activities with active stakeholder participation at this stage may include:

- Workshops and presentations with invited key stakeholders (e.g. local authorities, decision and policy makers)
- Preparation of targeted outreach materials and engagement of stakeholders in communication dissemination
- Discussions, interviews with local media or local experts
- Providing opportunities for stakeholders to actively engage with indicator results (e.g. interactive data portals, possibilities to submit feedback, comments or additional datasets for existing indicators).

It is of paramount importance to take stakeholder views and values into account during the indicator selection and implementation process for a number of reasons discussed earlier. It is, however, also important to maintain necessary focus and approach stakeholder inputs in a structured way – i.e. while stakeholder interests and inputs are important, the focus should always remain on selecting indicators that are useful for basin managers and decision makers in shaping better resource management. One should always ask the question: “Will the information provided by this indicator be useful as a tool for improved basin management?”

A more detailed discussion on indicator results communication tools is provided in chapter 6.

***Figure 10**. Web-based platform of indicators for the Chesapeake Bay Basin (UMCES 2013).*

INDICATOR CASE STUDY

Orinoco River Basin—engaging stakeholders to identify values and corresponding indicators

The Colombian Orinoco River Basin Report Card, developed with several national Colombian organisations, is the first of its kind carried out through the Basin Report Card Initiative, a partnership between the World Wildlife Fund and the University of Maryland Center for Environmental Science. River basin report cards have been shown to be a powerful instrument to describe ecosystem status, increase public awareness, and inform and influence decision makers to take action to improve or maintain the health of a river basin. The process of developing report cards is highly participatory and includes the following five steps: identification of values and threats, selection of indicators, definition of thresholds, calculation of scores, and communication of results.

Stakeholder engagement underpinned the choice of indicators for this project. Following stakeholder mapping to identify parties related to the hydrology of the basin (e.g. management, tourism, industry, livelihood, researchers), representatives were invited to several workshops held at different sub-basins within the larger Orinoco River basin. At each workshop, values of the basin, and threats to these values, were identified. This list of values and threats set the framework upon which indicators were chosen. Stakeholders were asked to identify suitable indicators, based on SMART criteria which resulted in 29 potential indicators being identified by the end of the workshops. These indicators as outlined in the figure below were able to be grouped into six overall categories – based in this instance on the general themes of the values, threats and indicators.

Of this expansive list of potential indicators, 11 were shortlisted to measure the health of the Orinoco River Basin, based ultimately on actual data availability and suitability. The status of these 11 indicators was evaluated by comparing data to thresholds also determined in consultation with the same stakeholders. The report card approach combined results for individual indicators into a score for each sub-basin within the Orinoco River Basin in Colombia (ecoreportcard.org/report-cards/orinoco-river).

5.4 Tackling the challenges of stakeholder-focused processes

Active stakeholder engagement in indicator selection and application processes has multiple benefits. However, there are aspects that make such approaches challenging. The key challenges include:

- **Costs**—Organising stakeholder workshops and face-to-face meetings is a rewarding and important process but also requires resource investments and coordination efforts. These include making sure all stakeholders are able to convene at the same time and premises, workshop expenses are covered etc. The number of participants and coordination efforts incur much higher costs than top-down, expert analyses or desk study-based indicator selection processes though the potential benefits often outweigh the costs.
- **Expectations**—Once involved (contributing their time and knowledge), the stakeholders gain a higher level of engagement in and accountability for the process. This is relevant for uptake and sustainability of indicator use but may also mean that stakeholder expectations need to be carefully managed. Not all stakeholder priorities or proposals can be accommodated, which can create disappointment in participants. The focus should be put on creating processes that require stakeholders themselves to achieve a consensus on a limited set of priority issues and manage their expectations. This also includes managing multi-stakeholder discussions in a way that prioritises facts and priorities over the individual opinions and strong voices.
- **Time**—Participatory stakeholder processes require significant time. This includes the time needed for the actual workshops and on-ground activities, but often more so the preparatory efforts in identifying the right individual stakeholders, contacting them and negotiating the modes of engagement. The preparatory phase often involves being able to negotiate a basic level of stakeholder support for the indicator processes in the initial stages of the projects to be able to ensure their participation in subsequent phases.

Preparatory work can help maximise resource efficiency in stakeholder engagement, as well as maximising benefits of the process on 'both sides' – including stakeholders themselves. This includes paying attention to:

- **Understanding the culture.** The approaches which worked in one community will not necessarily work in other communities and local knowledge should be used to design a process best suited for the current cultural and socioeconomic setting, even within the boundaries of a single basin.
- **Being a good listener.** It is important to listen to stakeholders, note their concerns and values and understand the sources of their concerns. Even when not strictly based in science, these may yield important information on the local circumstances. Feeling that their opinion and insights matter, also helps build sustainability and ownership of the work.
- **Building ownership early in the process.** Be aware that local communities (particularly data holders and decision makers) will have to implement and use the indicators in the long term. Creating a sense of ownership and active involvement is crucial throughout the process.
- **Involve local champions.** Identifying local authorities and individuals that are willing to engage, and whose opinion carries weight in local communities, can be one of the most efficient ways to ensure stakeholder engagement. Providing information (or training) to these individuals (and gaining their approval of the process) can ease the channels of communication and eventual engagement of other stakeholders significantly.

Choosing the right means and channels of communication for the process and the indicator results is important for leveraging the greatest possible benefits from the process. Targeting communications to specific stakeholder groups is discussed in more detail in the following chapter.

Chapter 6

Communicating results

6.1 Developing a communication strategy

Effective communication is critical to ensure that the indicator information is used for action on the ground. Investing insufficient time and resources in communication can hamper the effectiveness and uptake even of very well executed and robust indicator assessments. This in turn can compromise the sustainability of indicator use in the basin, with results being lost and future assessments failing to build on work already done, wasting valuable resources.

Developing a targeted communication strategy is necessary in making full use of the information that indicators can deliver. Indicators only reach their full potential if they can be periodically monitored, and for this, sustainable funding is needed to ensure they continue to produce information over extended periods of time. An effective indicator communication strategy can help build stakeholder support (and engagement) to ensure that the results influence decision makers and the general public to improve basin resource management and address any existing or emerging threats to basin health.

When designing a strategy for communicating indicator results, it can be helpful to address the following questions:

1. **Who will use the indicators?**
   This helps understand the key audiences for communicating indicator information and the relevant local stakeholder communities. This analysis can draw on earlier stakeholder mapping exercises, if such have been done, to identify key groups that need to be communicated to. Differentiation is important, as the means of communication (and its purpose) are likely to differ amongst the groups. It may also be beneficial to identify the level of influence of your audiences (linked to question 3 below) on the factors affecting basin health and resource management and development.
2. **How will they use them?**
   A key aspect in tailoring communication means to the various stakeholders is to understand the culture and likely behaviour of the audiences – i.e. what is the utility of the results for the audience, and are the results likely to inform (or should inform) their actions. Earlier conversations or interactions with stakeholder groups can help to gauge their interest and understand what is their likely level of interaction with the indicator information. This also helps to select the best means of communication, further discussed in section 6.2.
3. **What actions or behaviour do you want to influence?**
   Finally, the communications strategy should consider the desired changes in behaviour or management amongst the various stakeholder groups that are needed to improve basin sustainability. This helps to tailor the products and prioritise resources for outreach and communication products, often necessary given the broad range of stakeholder groups. For example, if the information emerging from the assessment points to an urgent need for improved land use practices, then stakeholder groups relevant to land use could be prioritised in the communication and outreach strategy. This also relates to the earlier identification of stakeholders that have a relatively greater influence over basin resource management than others.

Relating to all three questions above is necessary to establish transparency and communicate not only the indicator results themselves but also the key assumptions and uncertainties that may affect the use of results. For example, indicator results impacted by one-off events, as opposed to gradual change, should be disclosed. Where aggregated indicators are used, users should have easy access to supporting underlying methodologies, data tables and maps to better understand and interpret the synthesised results. In the same way, the definitions and key concepts used should be transparent (e.g. response to vulnerability of basins and their people can be better understood and directed, when the vulnerability components, such as the exposure and adaptive capacity, are analysed and evaluated separately).

Once these questions can be answered satisfactorily, the communication strategy should select the most appropriate means and channels of communication and outreach for the various stakeholders.

The following section discusses in more detail typical stakeholder groups and the specific communication products that may be most suited to them.

INDICATOR CASE STUDY

What do stakeholders really want to know?

Indicator case study interviews conducted in preparing this guide all point to the importance of tailoring communication to the audiences as a major factor for success of basin monitoring and reporting and assessment schemes. Tailoring communication means not only presenting indicator results but also explaining the rationale and intended use of indicator data, to ensure community commitment and support, particularly for long-term projects.

For example, in the Volta Basin Observatory indicator refinement and data collection stakeholder workshops, the key question asked by stakeholders was on the practical application of the information collected. While explaining the relevance of, for example, monitoring sediment levels or environmental flows from an ecosystem and ecosystem service point of view is important, this alone is not enough to ensure support and buy-in. Stakeholders need to understand the community impacts of the collected information – how it will affect decision making and what activities are expected to result from it (e.g. reforestation, conservation, alternative income generation projects, capacity building activities). It is through direct links to community scale impacts that basin-level governance and decision-making benefits can be translated. It also proved to be important to reiterate these objectives and impacts on a regular basis (through annual stakeholder workshops) to maintain the momentum and relevance of basin-level management activities of the Volta Basin Authority.

In another example, indicator selection for the Monterrey Water Fund demonstrated the need to cater for various audiences with different primary interests. For investors in the water fund a primary motivator was evidence of the ecosystem impacts of the interventions, for example knowing if the water quality actually improves as a result of upstream activities and seeing the changes in sediment levels in the basin, and this required a set of targeted technical indicators. Meanwhile, other types of information were more relevant for local communities – e.g. communicating the overall improvement in watershed ecosystem health, showing the opportunities for income generation and capacity building as a result of the Fund's activities and reduced risks to crops from flooding and droughts. With varying availability of indicator data throughout the project, it was also necessary to develop a tiered approach in meeting these information needs, particularly in early stages of the projects.

In both examples understanding the main values and concerns of various audiences is key to delivering targeted and relevant information on the need for, as well as the results of the indicators.

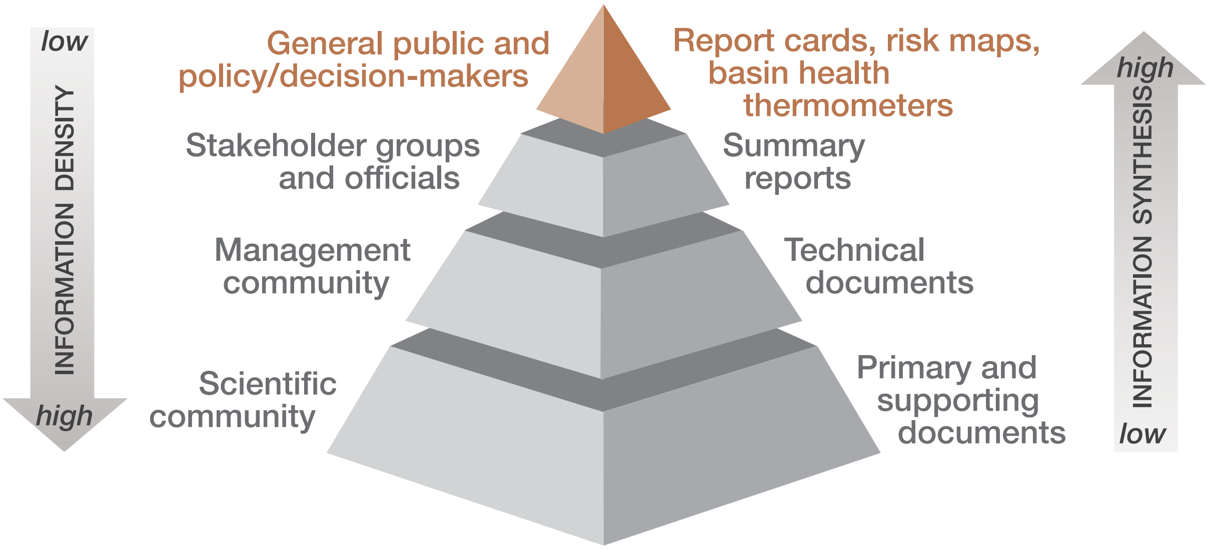

Figure 11. *Tiered representation of major audience groups and corresponding sample communications formats (Source: UMCES).*

6.2 Tailoring communication to specific audiences

Indicators are only useful and effective if they are clearly understood by their intended users. Different audiences and desired actions or uses will require different information and formats. The following section provides some examples of targeted information and considerations for maximising the effectiveness of indicator results.

There is a general hierarchy of information synthesis that is necessary for different users and can be helpful for communication products for key audiences (see overview in Figure 11). Generally, scientists need less synthesised information whereas politicians require the highest level of information synthesis within this hierarchy, with a wide variety of other stakeholder groups within the mid-range. Targeting more than one of the following groups is usually necessary to ensure the overall salience, credibility and legitimacy of indicators and maximise the potential to affecting decision making and management. For example, simplified high-level communication of indicators to politicians without corresponding documentation of methods for scientists can easily undermine the overall credibility and therefore use of the indicators.

The following sections briefly discuss the four different key audiences for communication of the indicator assessment and results.

1. POLITICIANS, POLICY MAKERS, MEDIA AND THE GENERAL PUBLIC

Communicating results to 'top-tier' audiences such as politicians, the general public, high-level policy makers and the media requires the most information synthesis – the more simply the indicators are communicated, the better. Above all, indicators and the results they represent must be clear and have logical, intuitive interpretations for audiences without them having to undertake further analysis. It should be possible for this group of users to understand what a specific indicator means by just looking at it. Typically, this group will need to know what the indicators mean, what they should be concerned about in relation to the indicators and whether urgent actions are needed to improve and/or maintain the status of these indicators. If communicated effectively, indicators can provide the impetus for raised awareness and education on issues, which can help shape policy priorities, drive resource allocation and even change the behaviour of certain stakeholders.

Indicator information should be translated into a language that this audience can easily understand. The language may vary based on the region and context and the specific group. Some possible communication products or methods to consider include:

- ***Dashboards, basin health and risk maps, or scorecards*** – outreach products which clearly communicate and summarise the indicator value for the audience in an engaging way. Well-designed visual products and selected key metrics are particularly important for these audiences, for example, using red to show 'bad' indicator values in a basin, basin health thermometers, or risk maps.
- ***Executive summaries and summaries for policy makers*** – condensed information products describing the main findings and potential policy and management implications (and changes needed) of the indicator results. They should distil only the key findings and recommended direction for improving key variables, as appropriate.
- ***Outreach via public media such as television and radio interviews, social media, online and printed articles, or thematic programmes on indicator findings*** – outreach channels that can reach large audiences relatively quickly, focusing on key findings and challenges requiring urgent action. The broad exposure of indicator results and any urgent findings may also drive wider public discussion and quest for action from policy makers. Developing a narrative or specific personal stories may be a good way to capture the attention of the audience, as opposed to the indicator results alone.

2. ADMINISTRATIVE OFFICIALS, INVESTORS, DEVELOPMENT AGENCIES AND CIVIL SOCIETY ORGANIZATIONS

This group is very similar to the previous one in its need for highly synthesised information presented in language that is easy to understand within the local context and interpreted relatively quickly. It differs from the previous group in that it often needs additional information on the context of the indicator information and the findings. This helps evaluate the need for interventions, the potential benefits or the implications of inaction/business as usual. These stakeholders are generally concerned with prioritising investments or efforts in order to maximise overall benefits in relation to their objectives (economic growth, environmental protection etc.). In addition to short and visual communication products, other useful products could include:

- ***Executive summaries and summary reports*** - including not only indicator results but also context-specific interpretation of the results that can be used to guide decisions.
- ***In-person meetings*** – meetings or workshops may be particularly beneficial with these audiences, as they provide the opportunity to respond to particular questions that are relevant to the audiences, but may not always be obvious to the indicator information holders.

3. RESOURCE MANAGERS, DECISION MAKERS, TECHNICAL STAFF

This group requires information in a format that can be easily integrated into their specific decision context. The documentation can be more technical than for the previous two audiences, but still requires synthesis so that the information can be directly acted on, or at least the necessary background information easily accessed. The information presented (with the consensus of the relevant stakeholders) must be concrete, reliable, up to date and have scientific integrity so that the resource management and allocation decisions can be supported and informed by the indicators.

Communication products for these user groups (which could eventually take on a more active role as regular users and contributors to indicator information), could include:

- ***Technical documents and reports*** - these documents should make clear at what point action X should be taken in response to a given indicator or indicators. They should also include sufficient background so that the users feel confident with the assumptions and methods that went into producing the indicator.
- ***Data portals, information systems and online decision-support systems*** – dynamic information products that allow for interaction with indicator data, but also manipulation of information that is based on the specific demands of the resource managers, often with possibilities to add new, emerging, information. This could also include possibilities to alter indicators (to a limited extent) based on underlying datasets.

4. SCIENTISTS, ACADEMIA

Reaching out to this group ensures the overall credibility of the indicators used and requires the most comprehensive reporting, particularly the methodological aspects of indicator calculation. Engaging the scientific community (especially locally) earlier in the process can also help identify any methodological limitations, faults and potential improvements that can enhance indicator robustness. Modes of communication specifically to the scientific community might include:

- ***Technical meetings*** – meetings with technical experts or one-on-one consultations early in the process can provide critical peer review, improvement of, and buy-in to the chosen indicators and methods.
- ***Technical reports, including both primary and supporting documentation*** – documentation should clearly communicate all assumptions, methods of indicator calculation, references, data sources and, depending on the context, provide access to the underlying datasets. This documentation can also be shared with the scientific community in the early stages of indicator formulation, if an external review is possible and desired, involving experts within the local, regional and/or global context of the indicators being considered.
- ***Data portals, information systems and online decision-support systems*** – the scientific community can benefit from data and information systems to explore data and test their validity (e.g. against local data). For this group of users, it is important that information and data portals convey both the indicator results and the underlying indicator metadata (and where possible, the datasets).

Additional means of in-person communication are always encouraged across the stakeholder groups and even bringing the various stakeholder groups together. This may involve workshops, private meetings with influencers and top decision makers, local champions, etc. Arguably, however, these are often limited options given the resources required against audience reach.

Regardless of the communication means or channels chosen, it is always helpful to provide a narrative that specific stakeholders can relate to. As well as communicating the indicator results it is helpful to provide supporting information that helps stakeholders understand the risks these present to their livelihoods and basin health, or the benefits of addressing the risks through changing local policies, resource user behaviour or introducing new projects in critical areas of the basin.

Chapter 7

Special focus on transboundary basins:

Challenges in indicator use and learnings from transboundary diagnostic analyses and strategic action programmes

7.1 The challenges of managing transboundary rivers

The world's 286 transboundary river basins cover 151 countries and more than 40% of the global population (UNEP-DHI and UNEP 2016) and are therefore of key environmental and socioeconomic importance. Transboundary rivers cross national borders and link countries in a complex web of environmental, political, economic and security-related interdependencies. There are many challenges in transboundary river basin management including differences in national water management regimes, development priorities and culture, and geographical differences such as a country's location within the basin, its upstream dependencies and downstream impacts. Meaningful implementation of integrated and sustainable water management practices in these basins requires special attention and resources for coordination across the various political, legal, institutional and technical settings.

Examples of specific challenges to basin-level coordination in resource management and development in transboundary basins include:

- A lack of institutional and management frameworks to coordinate approaches at a transboundary scale
- A high number and variety of stakeholders (e.g., Ministries of Foreign Affairs, international governmental organisations, water authorities)
- Perceptions of limited gains from investing in basin management frameworks
- National security concerns in sharing (perceived) sensitive information
- Existing political tensions or conflicts over resources
- An imbalance in power amongst riparian countries
- Lack of data in one or more countries, or lack of mechanisms for information sharing across borders
- A lack of understanding or agreement on basin-level management benefits

While the challenges are complex and sensitive, there is an urgent need for cooperation and implementation of IWRM approaches, particularly in transboundary basins. Climate change, population growth and growing demand for scarce resources is likely to put more pressures on countries to provide for their populations. Uncoordinated resource development can lead to degradation and loss of critical ecosystem services for everyone in the basin, and consequently to tensions and conflict.

7.2 Facilitating transboundary management through indicators

Data and information exchange in transboundary basins is widely acknowledged as key to enabling basin-level decision making and sustainable resource development, with the principles of data sharing being incorporated in many transboundary legal agreements.

Opening a discussion on integrated basin-level resource management and development in itself can be valuable as it inherently creates a dialogue on the data and the common goals and values for basin development. Any basin-level indicator selection process then further builds on the common value discussion and its likely outcomes, covering priority issues, development goals and priority intervention areas.

There are a number of ways in which common basin-level indicators can formalise such agreements and facilitate transboundary basin-level management in the long term. These include, but are not limited to:

- Establishing a common vision and goals for resource development amongst riparian countries
- Improving the understanding of environmental issues to be addressed and their root causes
- Identifying future risks and risk distribution across the basin, along with priority areas for intervention
- Informing prioritisation of infrastructure investments and their siting, in view of maximising benefits
- Avoiding unintended consequences due to poor resource development projects
- Providing an opportunity for a changing discourse in the basin – from competition over limited resources to a dialogue that leads to cooperation and shared benefits (UN-Water 2008)
- Increasing efficiency of climate change adaptation strategies (for both floods and droughts) through coordinated action such as transboundary flood early warning systems.

Experiences to date show that basin-level information collection, indicator calculation and decision support systems have already played an important role in decisions regarding siting of new dams and water allocation projects (see more in the indicator case studies throughout this guide). Such coordinated decisions not only reduce the risks of unintended impacts downstream (e.g. impacts of dams on protected or high-value ecosystems) but also reduce risks of conflict over water sharing into the future, because decisions have been taken jointly.

Despite the wide range of transboundary cooperation benefits, the practice of transboundary basin level management is lagging, often due to non-technical obstacles such as political tensions or lack of open forums for dialogue and data sharing (Plensaeng, Wehn and van der Zaag 2014). It is often perceived that sharing water and climate data across borders may expose vulnerable national information – issues particularly sensitive amongst up-stream and downstream countries.

Even where there is the political will for coordination, basins may face technical challenges in establishing common information sharing and decision-support infrastructure. These may include a lack of necessary data in one or more of the riparian countries or differences in calculation methods and metrics, which may make key data incompatible, even if collected. Given the vast differences that often exist in the economic development and human capacity amongst riparian states, it is not uncommon that data collection ranges from highly advanced to near non-existent within the same basin. There are also powerful institutional and cultural challenges such as addressing the beliefs and perceptions of national staff and key officials about the benefits of transboundary cooperation and resource development.

These factors should be considered and addressed simultaneously to ensure that indicator based frameworks which do exist are well implemented and actively used for better decision making. This can be facilitated by giving appropriate attention to and investment in common data sharing and exchange infrastructure and creating forums for formal cooperation, dialogue and discussion. These could be river basin organisations, data exchange protocols, and high level transboundary legal agreements that help strengthen technical implementation on the ground (such as those of international conventions). Further sections of this chapter look at the experiences of indicator use in transboundary basin diagnostic analysis under the GEF Transboundary Diagnostic Analysis/Strategic Action Programme (TDA/SAP). They are drawn from a thorough review of Transboundary Diagnostic Analysis documents in more than 10 transboundary basins across the world. The aim is to highlight the types of indicator frameworks and indicators that have been used in a number of transboundary basins to date. These experiences provide insight into common trends and similarities in indicator use and may provide guidance and inspiration for other transboundary basins wishing to establish common basin-level indicator frameworks for monitoring and development.

INDICATOR CASE STUDY

Volta Basin - “No water charter—no water security”

The Volta River Basin in West Africa covers an estimated area of 400,000 km² over six countries – Benin, Burkina Faso, Cote d’Ivoire, Ghana, Mali and Togo, and is home to more than 19 million people. The Volta Basin Authority (VBA) has the mandate to support the coordinated development of basin resources and promote integrated water resources management.

The Volta Basin Observatory (Observatory for Water Resources and Related Ecosystems) was established with the objective of promoting the sustainable use of water resources and related ecosystems in the basin. The main aim has been to establish an information system that allows for improved ‘diagnostics’ and management of the basin and acts as a decision support tool for basin infrastructure development. The project has been supported by various international donors and has benefited from expert advice on selecting relevant indicators for resource monitoring. Recommendations included a set of indicators for inclusion in the observatory’s information system, covering technical (environmental), socioeconomic and governance aspects.

Further to expert suggestions, indicator lists were refined and finalised in country stakeholder consultations, adding relevance and detail to the indicators selected. Notably, governance indicators have been left out in the final selection of indicators, due to the estimated difficulty in retrieving governance-specific information from countries. In stakeholder forums, the following question emerged as the one most common across stakeholder groups: “What are the data going to be used for and what projects will be implemented as a result of the VBA activities?” If a link to socioeconomic benefits to communities could be visibly demonstrated (e.g. reforestation projects, income generation activities, ecosystem restoration), a commitment to data collection was easier to establish.

Despite communication and data-exchange protocols being in place (established between the VBA and the respective water authorities), the collection of data from countries proved to be challenging for a variety of reasons, including non-technical such as a lack of resources and willingness to engage in the project. Almost a year into the data-collection process, this led to the adoption of a more informal approach, engaging university students in data collection from the field. This alternative approach has been a success to date, also reviving interest in some of the countries in data sharing between the national focal points and VBA sources.

The case of the Volta Basin Observatory has shown that the problem of national data collection remains a big challenge in transboundary basins, but not necessarily due to a lack of the data. Institutional and political challenges in engaging the local and national authorities (in the case of VBA, even despite existence of established data exchange and sharing protocols) can play an equally, if not more important role in basin-level information sharing arrangements. Therefore, in some basins, higher political level commitments are crucial to ensure compliance with any operational data-sharing protocols and commitments, and to provide a legal basis for enforcing such commitments.

The VBA sees a strong need for legal transboundary agreements on the common development of basin resources. It is therefore working towards the development of a high-level water charter signed by the heads of basin states, and a water law aligned and accepted by all that can be used to support the operational agreements amongst responsible authorities. The experiences from the development of the VBO have also shown that there is a need for ‘thinking outside the box’ in addressing data challenges in the intermediary stages of development of monitoring and reporting schemes.

Source: Sanoussi, 2016 (interview). More on the Volta Basin Authority: http://www.abv-volta.org

7.3 GEF International Waters TDA/SAP process

The Global Environment Facility (GEF) International Waters Focal Area was established to support countries in managing their transboundary waters (surface water basins, groundwater basins, and coastal and marine systems) with the specific aim of fostering transboundary cooperation and collective management of these resources. The Transboundary Diagnostic Analysis (TDA) and Strategic Action Programme (SAP) processes have played a central role as strategic planning tools used in the development of GEF International Waters projects over the last few decades.

The TDA/SAP approach to the strategic planning of transboundary resource management is a collaborative process, with the TDA and SAP representing two interconnected phases. TDA helps basin countries to identify (and agree upon) priority environmental challenges of transboundary nature. The TDA outcomes create the factual basis for further formulation of the SAP. The SAP process in turn negotiates the strategic priorities for action and identifies the actions to be taken to address priority challenges in the basin (Figure 12).

An important aspect of both processes is the engagement of stakeholders from basin countries which creates a platform for transboundary dialogue and collaboration in identifying transboundary problems and their underlying causes. Bringing together basin countries and stakeholders for dialogue is in fact often one of the most important outcomes of the TDA-SAP process.

Guidelines for conducting the TDA/SAP process are outlined in the TDA/SAP Manual (GEF 2016) but the aim is to be ‘non-prescriptive’ and allow each transboundary basin to customise the process according to its needs, acknowledging the individual circumstances of each transboundary basin. The GEF manual provides a simple, step-wise approach for the process leading up to the production of the TDA and SAP reports and policy outcomes.

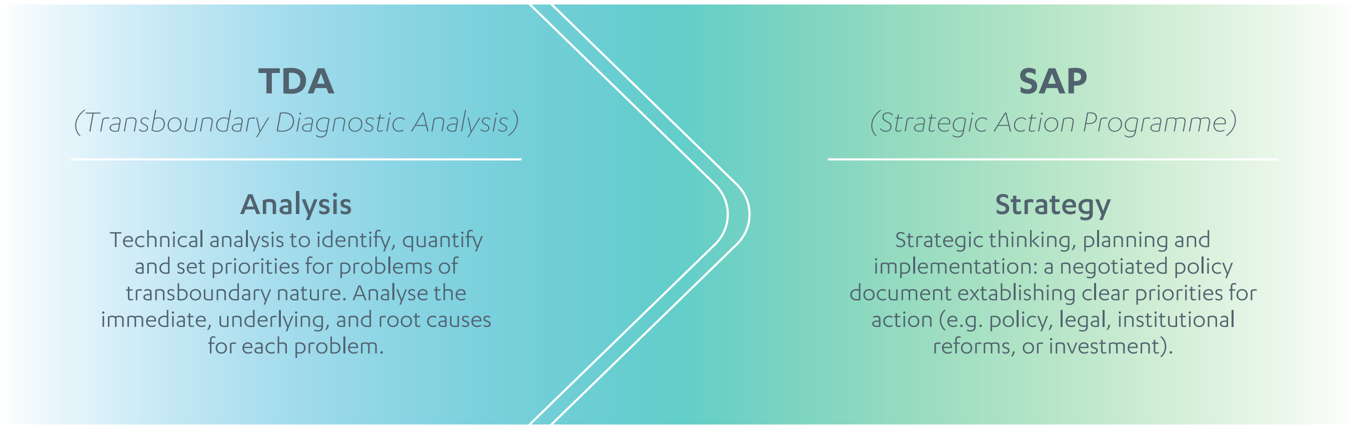

***Figure 12**. TDA/SAP Process.*

Though very different in scope and detail, most TDA reports include the following:

- Definition of the water system
- Boundaries and characteristics of the transboundary basin (hydrological and socioeconomic)
- Description of the basin-specific methodological approach used in the TDA/SAP process
- Identification of the main transboundary environmental problems
- Prioritisation of the identified issues
- Causal chain analysis of the priority issues
- Analysis of governance and management frameworks in the basin
- Thematic report(s) on selected issues (e.g. governance, economic analysis, stakeholder analysis, analysis of environmental goods and services)

Most SAP documents are built around the strategic priorities basin stakeholders have agreed upon during the SAP process. Typical outcomes described in the SAP documents include:

- Vision and goals formed during the SAP process
- Description of options for solving the transboundary priority challenges
- Identification of strategic priority actions
- Implementation plan and prioritised projects and sites for intervention
- Analysis of the institutional arrangements (and responsibilities) surrounding the SAP process and projects

In order to help distinguish between actions with national benefits and those addressing transboundary concerns, a key element of the SAP should be a well-defined baseline that incorporates descriptions of monitoring, review and reporting arrangements, including selected monitoring and evaluation indicators and budgets highlighted in the TDA/SAP guidance.

Water-related indicators play a significant role throughout the TDA-SAP process in providing the scientific basis for problem formulation and a reference point for monitoring the effects of interventions over time. For these reasons, it is particularly interesting to understand which indicators have been supporting these different objectives in transboundary basins to date.

In preparing this guide, a review of indicator use in the TDA-SAP process was undertaken, and is further described below.

7.4 Review of indicator use in basin TDA documents

The aim of this review was to record which indicators and indicator categorisation approaches have been used in TDA-SAP outcome documents to date. The TDA documents were of specific interest as they serve as the 'scientific' basis for strategic action plan development. The indicators (or broader indicator categories) used in establishing a baseline and identifying and quantifying transboundary challenges can help shape the direction taken for long-term actions on the ground. The review aims to discover the similarities and common trends in the TDA reports, with respect to indicator use. Indirectly, these emerging similarities or discrepancies in indicator use can also help understand how indicator selection and application directs and affects the proposed management interventions, and, vice versa, how a lack of monitoring on specific aspects or indicators may inhibit addressing important issues in transboundary basins.

The list of 10 TDA documents reviewed and the (indicative) number of indicators recorded from each TDA document are summarised in Table 7.1.

Not all TDA documents outline a specific indicator framework on the basis of which the metrics are selected, or define the metrics presented as 'indicators'. Consequently, in some instances the review had to rely on an interpretation of what is an indicator in the given context. The working definition of an 'indicator' for the purposes of this review can be summarised as a "variable that measures the status or change of one or more aspects of the transboundary water system", applied in cases where specific 'indicator' use was not highlighted. Examples include precipitation, runoff, climate and socioeconomic data that were presented in the TDA reports without being explicitly identified as key indicators. In these cases, the presented metrics have been recorded as indicators based on the working definition outlined above. As a consequence, the indicator count for all TDAs is indicative only, accounting for the number of various metrics recorded in each of the TDAs to support the scientific basis for diagnostic analysis and further strategic action.

While the TDA-SAP process, and therefore the findings of the TDA-SAP, are limited to transboundary basins, the indicator findings are relevant on a broader scale, including rivers basins that do not cross international borders. This applies particularly to indicators used to understand and measure environmental problems or key climatic and hydrological variables.

TABLE 7.1

(Indicative) number of indicators recorded from each TDA during review.

No	Transboundary basin	Year	Indicative number of identified indicators*
1	San Juan	2000	60+
2	Bermejo	2000	40+
3	Dnipro	2003	100+
4	São Francisco	2003	30+
5	Kura-Arask	2006	70+
6	Danube	2006	40+
7	Senegal	2007	40+
8	Cubango-Okavango	2011	70+
9	Volta	2013	100+
10	Orange–Senqu	2014	90+

* NB: The working definition of an 'indicator' for the purposes of this review is a "variable that measures status or change of one or more aspects of the transboundary water system". See further explanation in text.

A summary of the key findings of the TDA review is presented below.

INDICATOR FRAMEWORKS

The review shows that indicator-based information forms a central part of the TDA outcome documents. Information derived from relevant basin-level indicators is used to identify and analyse environmental and socioeconomic issues, as well as to understand and document their relationships. Most TDA documents present a vast amount of information (much of it using relevant indicators of basin health and socioeconomic drivers and impacts) and the majority of TDA reports use of Driver-Pressure-State-Impact-Response (DPSIR) or Causal Chain Analysis (CCA) frameworks to guide the analysis and structure the information. The DPSIR indicator framework is used in many basins to describe and document the observed environmental issues and their immediate impacts on environmental state and people. The driver (D) and pressure (P) indicators from this framework further inform cause-chain analysis, where such is undertaken.

In several of the transboundary basins a CCA approach is used to further examine the agreed priority issues. The CCA is used to link the immediate causes of problems (e.g. pollution from fertilisers) with their underlying causes (lack of proper management/ awareness) and the root causes (e.g. governance issues). The overall aim of the CCA is to identify where a change in management and policy could make a positive difference further down the 'chain', paving way for implementation of SAP. An example of CCA application can be found in the Bermejo basin TDA. Here, socioeconomic and ecological indicators are used to highlight and assess the basin's environmental problems.

Similarly, in the TDA of the Cubango-Okavango, key indicators are identified for each of the four major transboundary water challenges, linking their underlying causes and socioeconomic impacts. Here an integrated flow assessment forms an essential part of the TDA, exploring the relationship between water use and changes in hydrological flow, and consequent changes in ecology and socio-economics at specific sites in the basin using three water use scenarios (high, medium and low use). The selected indicators are then used to capture these interactions and the cause-effect relationships.

In some instances, TDA documents make use of both approaches. The TDA in the Dnipro basin, for example, includes a formulation of an indicator-based approach for the state of the environment report and environmental impact assessment in the basin. A suite of indicators are used to identify priority transboundary issues relating to the major areas of concern. The indicator-based assessment in this case used a suite of DPSIR indicators. The same indicators are also recommended as monitoring tools in the Strategic Action Programme (SAP) and National Action Plans (NAPs).

Where causal chain analysis (also known as 'root cause analysis') is not undertaken, the TDA documents tend to structure information and environmental problem analysis around thematic groups of issues. Examples include water requirements, water quality, climate and biodiversity.

INDICATORS

The review shows some consistency in indicators used to identify and describe major environmental issues, though with considerable variations in terminology (e.g. mean annual flow, flow patterns, stream flow or area of irrigated farmland, irrigated agriculture). This points to general agreement over key water resources management and environmental health indicators and the fact that many of the surveyed transboundary basins are facing similar environmental challenges.

The review also shows that the same (or a very similar) indicator can be used to describe various aspects of transboundary problems. An example is assigning an erosion indicator to root causes of environmental problems in some cases while treating it as a manifestation of environmental problems in others, depending on the indicator framework used or the interpretation in the specific basin context. As such, there does not appear to be a consistent (documented) approach to indicator selection within the causal chain framework (no evidence found in TDA documents).

Governance and management indicator groups are the least consistent amongst the TDAs reviewed. This is partly due to the varying administrative and managerial frameworks in place in the transboundary basins, but also the global challenge of well-defined and operational water governance indicators, particularly when it comes to monitoring implementation. This manifests in somewhat vague definitions of the governance indicators and weak assessment criteria, often limiting the governance assessment to a broad identification of the governance arrangements in place, without setting any implementation or performance criteria that could be monitored over time. For example, most TDAs surveyed include indicators which could be broadly referred to as 'enabling environment' indicators, relating to policies and agreements in place (bilateral and multilateral agreements, strategic partnerships, conventions) in the basin, but without further mention of enforcement or resulting effects on the ground.

But there are several categories for which indicators appear to be more consistent. These include:

- Land cover and land use change
- Hydropower generation, capacity and demand
- Protected areas and wetlands
- Pollution sources
- Demographic and health indicators

Across these general categories, basins have selected either the same or very similar indicators for diagnostics assessment and documentation.

TDA REVIEW SUMMARY

All of the surveyed TDAs take departure in indicator-based analyses to identify the most critical environmental problems at a transboundary level. Not all basins highlight the specific frameworks guiding indicator selection though the majority have taken a somewhat structured approach to documenting key environmental and socioeconomic issues. The indicator approaches in most cases include some variation of the DPSIR framework and/or CCA methodology.

The TDA review findings underline the importance of key environmental and socioeconomic indicators in both understanding the baseline situation in a transboundary context and identifying and prioritising key environmental problems in agreement with all stakeholders. Key indicators also play a role in linking the environmental problems with their underlying causes and impacts on the environment and society.

In the context of the continuity from TDA to SAP, with TDA paving the way to action, the selection of good indicators is particularly relevant as they establish a baseline and potentially, monitor the future impacts of actions under the SAP and guide the interventions selected. Once established, the indicator frameworks also support decision making on an ongoing basis, informing responses to emerging challenges and helping to monitor the efficiency of interventions.

Related to the latter, a known challenge in the context of transboundary water management is the data comparability and compatibility between countries resulting from different approaches and national standards for sampling, monitoring, analysing and reporting on water resources. Taking this into account during indicator selection at the early phases of the TDA process can help to reconcile some of these differences when monitoring impacts of interventions later on.

Lastly, one of the key principles of the TDA/SAP approach is the so-called adaptive management cycle. This involves assessing the problem (through the TDA), formulating a strategic plan with robust indicators (SAP), implementing the actions identified in the SAP and finally monitoring the outcomes, both short-term and long-term, and adapting the plan accordingly. With TDA/SAP paving the way for implementation and monitoring of outcomes, establishing robust indicators for baseline and monitoring early in the process through a transboundary agreement can help to ensure such consistency.

EXPERIENCES IN INDICATOR USE FROM OTHER WATER RESOURCES MANAGEMENT FRAMEWORKS

In addition to the review of indicator use in GEF Transboundary Diagnostic Analysis Reports, a review was undertaken to investigate indicator use in various other (selected) indicator-based assessments, and monitoring and reporting schemes for water resources management. The main aim of this review was to document and understand the ways in which indicators have been used to inform existing regional, basin-scale and global assessments and monitoring and reporting frameworks. It also identified similarities (and differences) in indicator application, as well as the types of indicators used in these frameworks. Various scales of indicator application were included in this review to understand the potential impacts that the assessment (or reporting) scale may have on indicator selection (e.g. global commitments for reporting). This analysis also helps to show the opportunities for down- and upscaling of indicator results to the various levels of assessment, and data collection.

The list of initiatives covered by this review is not exhaustive and only aims to provide a broad sample of indicator uses in other frameworks and scales (basin and beyond). These include periodical global water resources status assessments as well as basin level frameworks designed for real-time decision support in resource management. The broader findings of this review demonstrate similar trends in use of specific types of indicators as well as weaknesses in others (e.g. governance indicators), based on documentation of more than 1,600 indicators.

Further details of the TDA review findings as well as this general review can be found in Appendix I.

For more information on GEF International Waters Programme and TDA/SAP process, visit IW Learn (*http://iwlearn.net/*).

Chapter 8

Building a comprehensive indicator framework for integrated water resources management

This guide has introduced the 'good practice' elements in designing indicator frameworks for water management including the necessary considerations for forming these frameworks, assessing the quality of the indicators to be used, as well as stakeholder engagement and communication of the results. Regardless of the purpose of the indicator application, designing a feasible and meaningful indicator framework requires striking the balance between a robust yet limited selection of relevant indicators. This is equally true for indicator frameworks designed specifically for a limited purpose (e.g. water quality monitoring or utility performance assessment), as well as key indicator sets in connection with IWRM planning and implementation tracking in basins.

There is no single indicator framework or long list that can fulfil this requirement, even if sufficient resources are available for implementing a more comprehensive framework. Basins are often dealing with very different challenges and may choose to employ indicators for various purposes and different strategic priorities (e.g. while energy production and monitoring of water for environmental needs may be a focus in one, water quality may be a prime concern in another). This guide does not set out to recommend a single indicator framework as the 'best practice' for comprehensive basin management.

However, there are important lessons to be learned from indicators already in use around the world. These can be especially helpful for those looking to build an indicator framework 'from scratch'. Learning from experiences of indicator use elsewhere can save time and resources in preparatory phases and help avoid unnecessary fragmentation of data (that further complicates international and national comparisons and progress tracking), adding further complexity to the 'indicator jungle'. Furthermore, alignment with indicators used elsewhere and the related national, regional and global reporting commitments, have a number of benefits, already discussed in detail in chapter 4.

To better understand the landscape of indicator use for water management today, an extensive review was undertaken to inform this guide. The main aim of this review was to document the types of indicators used for various levels of water management assessment and monitoring frameworks, and identify those aspects where there appear to be some level of consistency (i.e. same indicators used to monitor and assess a specific issue). It also looked at dimensions of water management that appear to be challenging when it comes to indicator-based assessment[13].

The review has shown that there is little consistency across basins and other levels of assessment on the level of specific indicators – i.e. different indicators and their methodologies are used to report on and monitor similar issues. Further, the conceptual indicator frameworks that were covered in the review focus on monitoring and reporting on different issues. The complexity and extent of indicators included in any one assessment naturally depends on resources available for monitoring activities but also on the quality of readily available data, including necessary historically available time series, where appropriate. It is widely known that data availability often influences the choice of indicators used.

13 The review findings are discussed in more detail in Annex I: Review of various indicator frameworks for WRM.

The indicator use review undertaken to inform this guide has not resulted in a long list of 'best practice' indicators. It was, however, possible to identify some consistencies and links on the broader indicator thematic 'group' and 'subgroup' level, representing the key issues or aspects of water management that various basins (and beyond) have identified to be relevant for indicator-based monitoring and assessment. These indicator thematic groups reflect issues that dominate and often appear relevant in the various frameworks surveyed, indicating some form of best practice internationally, and issues that are considered to be relevant amongst managers and practitioners, as reflected by their inclusion in the monitoring and assessment frameworks.

As a result, this guide has distilled a 'generic' thematic indicator categorisation system or framework, which can serve as a checklist for those wanting to design comprehensive and multifaceted water resources management and monitoring indicator frameworks. The framework presented here is shaped through the lens of integrated water resources management, looking at potential issues and indicators that may pertain to resource management in an integrated manner – including those of related sectors (e.g. energy, agriculture) and socioeconomic variables. This categorisation aims to reflect all major thematic indicator categories and subcategories that appear in the various indicator frameworks surveyed and can serve as a starting point for creating a (comprehensive) indicator framework.

This thematic indicator framework represents just one possible option for a comprehensive water resources monitoring and management indicator categorisation system with the understanding that some categories or subcategories of indicators can be irrelevant in certain contexts. Similarly, some context-specific categories can be added, depending on the relevant basin issues and the aims specified within management and monitoring systems in a particular basin.

Climate	Water Quantity	Water Quality	Extreme Events	Ecosystems	Populations	Governance	Technical Capacity	Investments	WR Economic Sectors
Current Climate	Water Availability	Drinking Water	Flood Risk & Management	Land Use & Land Use Change	Demo-graphics	Management & Cooperation Frameworks	Data & Monitoring	Infrastructure & Development	Agriculture / Irrigation
Climate Change	Water Stress	Ambient Water Quality	Drought Risk & Management	Biodiversity	Health	Stakeholder Engagement	Human Capacity	Capacity Investments	Hydropower
Climate Vulnerability	Water use, Demand and Allocation	Pollution Sources	Other Extreme Events	Protected Areas	Employment	Conflict Management		Cost Recovery	Industry
		Wastewater Treatment	Disaster Preparedness	Land Degradation		Equity & Gender		Funding Sources & Mechanisms	Municipal Sector
						Awareness & Access to Information			Tourism
									Economic Benefits & Losses

Figure 13. Comprehensive thematic indicator framework for IWRM

The proposed thematic indicator framework can be used in the following ways:

1. Establishing an overview of groups and subgroups to be considered when selecting indicators. This can be particularly helpful where managers and stakeholders are new to indicator use for resource management and in basins where no indicator-based monitoring or management schemes are in place (i.e. avoiding 'starting from scratch').
2. Building on the proposed framework by adding and removing indicator categories (and subcategories) in a way that tailors the framework to the specific needs of the users (and the purpose of the scheme itself). The overall principle is to start from a larger set of indicator thematic categories and sub-categories and narrow this down to a smaller, relevant set.
3. Creating an indicator selection 'checklist' to make sure that relevant aspects of resource management are considered by including for example at least one indicator per category/ subcategory.

To implement and test this indicator selection and framework-building approach, an online Water Indicator Builder tool has been developed and is available to all interested stakeholders. The tool allows for customisation of the thematic framework, through deleting, adding and editing indicator thematic groups and subgroups.

An important additional feature of the tool, is the possibility to add indicators representative of the various subgroups and groups of the thematic framework. It includes a database of indicator metadata sheets of a broad set of representative indicators from the surveyed frameworks, as identified by the review. Each indicator metadata sheet contains basic information on the application, purpose and methodology of the indicator. External indicators and their associated metadata sheets may also be added to the frameworks by users. In this way, users can test and contextualise their customised frameworks by assigning possible indicators to the selected indicator categories and subcategories[14].

It is acknowledged that stakeholder engagement is crucial in all stages of the indicator selection process. This helps to ensure that indicators are relevant for the specific location and builds a stronger case for the sustainability of application (bottom-up as opposed to top-down processes). The development of indicator-based frameworks should always seek to balance the scientific robustness of a comprehensive monitoring scheme with the relevance of indicators to local socioeconomic and environmental conditions as seen as appropriate by stakeholders.

INDICATOR CASE STUDY

Comprehensive MRC indicator framework for managing the Mekong Basin

The Mekong River Commission (MRC) is employing a comprehensive indicator framework to support basin management and planning. The aim of applying such an agreed framework is to ensure that there is a unified and integrated approach to assessing the positive and negative impacts of development in the basin, as well as define long-term management objectives.

The development of the Mekong River Commission Indicator Framework (MRC IF) began in 2012 under the leadership of the former Basin Development Plan (BDP) Programme in consultation with other MRC programmes and member countries. The third draft was prepared in December 2015 based on feedback from national consultations, former MRC Programmes and the BDP scenario assessment team. Recently, the four Mekong member states agreed on the current draft as a 'living document', with some key comments for further improvement, at a regional working session in Phnom Penh, Cambodia.

The purpose of the MRC IF is to provide a unified and integrated approach to assessing the impacts of current and proposed water development projects and the management actions needed within the basin to achieve the development aims of the 1995 Mekong Agreement.

14 Further information on the tool and its functionalities is available at http://www.waterindicatorbuilder.com/home

The indicator framework will be used as the basis for:

- MRC State of the Basin reporting
- Assessment of basin-wide development plans and scenarios
- Collection and sharing of data and information needed for MRC activities agreed in the MRC Strategic Plan, enabled by improved implementation of the MRC Procedures for Data and Information Exchange and Sharing, PDIES
- Decentralisation and strengthening of primary data collection at the national level.

All these form the foundation for updating the Mekong Basin Development Strategy (BDS) every five years.

The MRC Indicator Framework is structured as a hierarchy of indicators within the five dimensions of social, environment, economic, climate change and cooperation. Within these dimensions, a hierarchy of 15 strategic indicators, 72 assessment indicators and approximately 250 supporting monitoring parameters has been established.

The 15 strategic indicators, agreed by the member countries, are summarised below:

Dimension	Strategic indicators
Social dimension Reflecting the intent to promote social development and the well-being of all riparian countries	• Living conditions and well-being • Livelihood and employment in MRC sectors • Overall social condition
Environment dimension Reflecting the need to protect, preserve, enhance and manage the environmental and aquatic conditions and maintenance of the ecological balance exceptional to the Mekong Basin	• Water flow conditions in mainstream • Water quality and sediment conditions in mainstream • Status of environmental assets • Overall environmental condition
Economic dimension Reflecting the intent to promote economic development and the well-being of all riparian countries	• Economic performance of MRC sectors • Contribution to basin economy • Total economic benefits
Climate change Recognising that this has great bearing on the long term sustainable development, utilization, conservation and management of the Mekong Basin water and related resources	• Greenhouse gas emissions • Climate change trends and extremes • Adaptation to climate change
Cooperation dimension Reflecting the intent to promote or assist in the promotion of interdependent sub-regional growth and cooperation among the community of Mekong countries and to provide an adequate, efficient and functional joint organisational structure to implement this agreement	• Equity of benefits derived from the Mekong River system • Benefits derived from cooperation • Self-finance of the MRC

Strategic indicators will inform high-level decision makers and stakeholders on key issues related to the development and management of the Mekong Basin. The assessment indicators provide the basis for evaluating the strategic indicators and provide planners with the basis for assessing alternative development scenarios. The monitoring parameters are intended to provide the basis for relevant and quality assured data sets from which assessment and strategic indicators can be quantified and to support MRC's other studies and assessments.

The current draft of the framework is already being used in ongoing preparatory work for the 2018 State of Basin Report and for environment, social, economic and scenario assessments under the Study on the

Sustainable Development and Management of the Mekong River Basin requested by the MRC Council of ministers (council study). The MRC Indicator Framework will enable a more effective implementation of the MRC procedures, primarily through the improvement of the PDIES. Using the framework in the coming years will provide a wealth of practical experience to further refine the framework.

The benefits of introducing a unified indicator framework for the MRC are many, the key ones being:

- Improved focus of MRC activities – The framework creates a basis for linking high-level strategic concerns with more detailed technical assessments and data collection requirements, leading to greater efficiency of effort in fulfilling the MRC mandate.
- Balanced approach to IWRM – The framework will underpin efforts to broaden and deepen understanding of basin issues in promoting integrated water resources management.
- Better informed decision makers and other stakeholders – Decision makers and the broader public will be more comprehensively informed of development conditions and emerging issues within the Mekong Basin, leading to improved identification of management actions and development opportunities that should be taken up in subsequent planning cycles.
- Improved basin-scale planning – Use of the framework will ensure that a comprehensive planning approach is adopted, consistent with the strategic concerns of the member countries. Member countries will be able to better monitor the predicted impacts with those that subsequently materialise, improving the quality of basin-scale planning.
- Better rationale for data collection, monitoring requirements and decentralisation – The framework will provide a transparent rationale as to what data is needed by the MRC and for what purpose (reducing data collection burden under the PDIES). This in turn will facilitate ongoing discussions on defining core river basin management functions and decentralisation requirements.
- A more accountable MRC – A unified indicator framework, as well as contributing to the benefits above, will lead to a more accountable MRC, which is measurable against the development aims set out in the 1995 Mekong Agreement.

Source: MRC (2015), MRC Indicator Framework for Managing the Mekong Basin, Basin Development Plan Programme; So Nam (MRC Chief Environment Management Officer, Environmental Management Division), Anoulak Kittikhoun (MRC Chief Strategy Pa Partnership Officer, Office of CEO), Prayooth Yaowakhan (MRC Ecosystem and Wetland Specialist, Environmental Management Division)

Chapter 9

Addressing the challenges of governance indicators

9.1 Why governance?

Over the past two decades there has been increasing recognition that water-related crises are crises of governance, not just problems of inadequate supply or climate variability (Rogers and Hall 2003). Governance here is understood as the range of political, social, economic and administrative systems in place to develop and manage resources and service delivery (GWP 2000). It includes multiple tiers of government, their formal regulations and policies, as well as market forces, public-private alliances, and informal mechanisms such as community norms. Where the underlying governance system is weak, stakeholders are unable to efficiently and effectively respond to pressures like pollution, growing water demand, and land use change. Moreover, integrated water resource management (IWRM), by definition, requires a rethinking of existing water governance frameworks to support cross-sectoral interactions and coordination of a wide range of public and private stakeholder groups.

So although water governance is a means to an end – efficient, equitable and sustainable use of water resources – assessing the governance system's performance towards this end is useful and often necessary for understanding the root causes of problems within the wider water management system. Measuring aspects of governance can help identify performance gaps related to everything from data and information management to financial capacity. Governance indicators can also be useful in benchmarking, goal setting, and monitoring, which in turn can help inform financial resource allocation and increase transparency for the general public. One fundamental challenge, of course, is that few basin authorities (or their respective governments) have already invested in data collection and assessment methods for water governance. This was well reflected in the indicator review undertaken to support this guidance document, where water governance indicators tend to be less prominent, and at times left out completely. This is partly due to the difficulties in measuring and quantifying governance aspects in a meaningful way, but also because of the relatively recent acknowledgment of the crucial importance of the governance impacts on the resource availability and quality on the ground.

The following section provides a brief review of existing efforts to develop water governance indicators and the approaches to collecting relevant data.

9.2 Dimensions of water governance

Each governance system is unique and context-dependent so assessments need to be flexible and resist being overly prescriptive. When assessing water governance, it is helpful to begin by breaking it down into different components that can be assessed, and then progressing to identifying potential indicators and their metrics. Different methodologies have emerged, and they often use principles of 'good governance' as a basis, including:

- **The governance framework**, sometimes referred to as the 'enabling environment' of policies, laws, regulations, and norms that guide action
- **Engagement**, specifically the ways that stakeholders participate in shaping decisions, the transparency of decisions, and the accountability of decision-making bodies
- **Performance**, which may be divided into effectiveness and efficiency

Clearly, assessing water governance requires a blending of subjective and objective information. Introducing ethical issues such as transparency, accountability, responsibility, and equity makes water governance more complex and also requires defining vague terms such as transparency and accountability (Tortajada 2010). The table below summarises how some recent assessment methods have defined the various components and key terms.

While there are several common themes, it is clear that these are highly inter-related, making categorisation efforts a subjective exercise. The selected categorisation should be driven by the specific objectives of including governance indicators in an assessment, as well as the priorities of those who will use the indicators.

TABLE 9.1

Examples of water governance assessment methods and their components

Method	Major dimensions/components
UNDP Guidance on Water Governance Assessment (Jacobson, *et al.* 2013)	Governance principles: Transparency, accountability, and participation with regards to institutional performance as well as stakeholder relations Institutions and stakeholders: Formal and informal 'rules of the game' and the actors (stakeholders) who respond to institutions and can change the rules Performance: 'Value-chain' analysis applied to case-specific issues or problems, such as water resource allocation, considering inputs, outputs, outcomes, and impacts
OECD Principles on Water Governance (OECD 2015)	Effectiveness: Defining clear sustainable water policy goals and targets at different levels of government, implementing those goals, and meeting expected objectives or targets Efficiency: Maximizing benefits of sustainable water management and welfare at least cost to society Trust & Engagement: Building public confidence and ensuring inclusiveness of stakeholders through democratic legitimacy and fairness for society at large
Freshwater Health Index (freshwaterhealthindex.org)	Enabling Environment: Policies, regulations, market mechanisms, and social norms used in governing and managing freshwater resources Stakeholder Engagement: Ways stakeholders interact, and the degree of transparency and accountability around these interactions Vision & Adaptive Governance: Capacity to apply information to set policies and develop plans for the basin Effectiveness: Outcomes from water-related policies, regulations, and investment decisions
Sustainability Wheel (Schneider, *et al.* 2014)	Justice: Contributing to social justice through resource distribution, fair governance processes, and consideration of the pre-existing conditions that affect different groups' capabilities to access benefits from water Adaptive Capacity: Ability to flexibly respond and adapt to changing supply and demand, in both proactive and reactive ways
Systems Framework for Analyzing and Assessing Water Governance Regimes (Larson, Wiek and Keelera 2013)	Civil engagement and democratic governance: Participation and collaboration among relevant stakeholders Inter-generational and intra-generational equity: Guaranteeing residents have access to safe water, ensuring fair distribution of benefits and costs, facilitating involvement in decision-making, and providing representation for future generations Precaution and adaptability: Anticipating potential problems and mitigating or responding to them
Asia Water Governance Index (Araral and Yu 2010)	Legal: Water laws, water rights, legal accountability, decentralization, and framework for integrated water resource management Policy: Financing of water investments, water pricing policy, linkages with other policy areas, non-government participation Administration: Organisational basis of water administrative bodies, their functional capacity, accountability and regulatory mechanisms, and application of science and technology

Examples of the variety of governance indicators recorded in the indicator review illustrate such differences, and the contextualisation of the governance indicators for the specific purpose and location:

- Levels of engagement: Number and economic value of the incremental national benefits from projects of basin-wide significance in other countries (MRC[15])
- Degree of interdependence: Proportion of benefits derived from cooperation to total net economic value of all MRC sectors (MRC)
- Degree of implementation of governance mechanisms for integrity and transparency (AMCOW ME[16])
- Degree of implementation of gender-specific objectives for water resources management (AMCOW ME)
- Degree of implementation of equitable and efficient water supply and wastewater tariffs (AMCOW ME)
- Number of meetings of government agencies with water interests to consult and collaborate on water management (Cap-Net[17])
- Degree of integrated water resources management (IWRM) implementation (SDG Indicator 6.5.1)
- Proportion of transboundary basin area with an operational arrangement for water cooperation (SDG Indicator 6.5.2)
- Perceived change over the past 20 years in the importance of water for energy (WWDR-14[18])
- National energy policy/strategy/plan with water resources management component (WWDR-14)
- Legal framework – the degree of correspondence/alignment of existing international freshwater treaties, in basin, with key legal principles of international water law (TWAP RB[19])

A subset of water governance assessment methods constrains their focus to management and performance issues, often centring on a river basin organisation-type entity as the primary coordinator of IWRM. These indicators may overlap with the broader frameworks listed earlier, but more commonly, management-specific indicators go into greater detail on the day-to-day operations of the river basin organisation. They may also include a focus on the involvement of stakeholders in basin management procedures, as well on the equity, gender issues and other locally relevant socio-economic aspects.

Some examples of indicators assessing performance are outlined in Table 9.2 (selected examples only).

15 Mekong River Commission Indicator Framework for managing the Mekong Basin (MRC 2015)

16 Africa Water Sector and Sanitation Monitoring and Reporting (African Water Facility 2017)

17 Implementing Integrated Water Resources Management at River Basin Level (Minimum Indicator Set for Water Resources Management) (Cap-Net 2010)

18 Environmental Indicators of the United Nations World Water Development Report 4 (WWAP 2012)

19 Transboundary Waters Assessment Programme, Transboundary River Basins assessment (UNEP-DHI and UNEP 2016)

TABLE 9.2

Examples of basin/RBO management and performance indicators

Source	River basin organisation Management and Performance Indicator examples
Network of Asian River Basin Organizations (NARBO) Performance Benchmarking 14 Indicators relating to dimensions of Mission; Stakeholders; Internal Business Processes; Finance; and Learning and Growth (OECD 2015) (Inocencio, *et al.* 2008)	Scorecard assessments on RBO indicators such as: • Planning maturity • Water allocation • Data sharing • Customer involvement/feedback • RBO governance • Cost recovery • Financial efficiency • Organisational development
Key Performance Indicators of River Basin Organisations Study of total of 115 indicators for RBOs (Hooper 2006)	• Existence of ongoing funding for river basin management • Funding exists for staff training in coordination practices • Evidence of water pricing used to recover some or all of development costs • Demonstrated use of national land and water policies in water planning documents and practices • Evidence of training programmes to improve the skill levels of river basin managers and stakeholders, specific to their situation • Evidence that information is accessible to relevant stakeholders • Existence of an accountability mechanism for the RBO to higher authorities and citizens
MRC Indicator Framework MRC Indicator framework for managing the Mekong Basin (MRC 2015)	Self-finance indicators: • Proportion of MRC budget (Core + Programme) funded by national contributions during current period • Ratio of Associated Project Budget to MRC budget during current period
Cap-Net Indicators for Implementing IWRM at River Basin Level (Cap-Net 2010)	Economic and Financial Management Indicators: • Bill collection ratio • Charges and fees for water allocation favour the poor and promote efficient water use Information management indicators: • Water management information is available to managers and other stakeholders as required • Database established in formats compatible with other river basin organisations Stakeholder participation indicators: • Formal stakeholder structures established with clear roles and responsibilities in water resources management • Basin stakeholders (male and female) represented in decision making bodies at all levels

INDICATOR CASE STUDY

Understanding the importance of deep governance in the Amazon River Basin

This case study summarises some of the key experiences concerning governance and institutional performance problems from the execution of the GEF-sponsored ACTO/UNEP/GEF-AMAZON Project: Integrated and sustainable management of transboundary water resources in the Amazon River basin considering climate variability and climate change.

The Transboundary Diagnostic Analysis (TDA) of the Amazon Basin was developed based on 11 national TDA workshops, with the participation of over 470 representatives from institutions of the eight ACTO (Amazon Cooperation Treaty Organisation) member countries and the contributions of scientific and demonstration activities implemented in the context of the GEF Amazon Project.

The national TDA workshops generated some intense debates but despite the immensity and socioeconomic diversity of the Amazon Basin, the countries rapidly came to a consensus concerning the main transboundary problems (MTP) and their root causes. The identified MTPs are summarised in the table below, all of which were relatively easy to identify and pair with the specific strategic actions. They are also measurable, a baseline can be established and indicators are available.

Main Transboundary Problems	Strategic Actions
Water pollution	Implementation of a regional water quality monitoring system for the main rivers of the Amazon Basin with special attention to mercury monitoring
Deforestation	Conserving and using water resources sustainably in the headwaters and lowlands of the Amazon Basin where grassland and wetland ecosystems prevail
Loss of biodiversity	Monitoring and reducing the vulnerability of bioaquatic ecosystems of the Amazon Basin
Extreme hydroclimatic events	Development of a hydrometeorological monitoring network in the Amazon Basin; Implementation of a forecast and warning system for extreme hydroclimatic events (droughts and floods)
Erosion and sedimentation	Monitoring erosion, sediment transport and sedimentation in the Amazon Basin to help mitigate negative effects and maximise positive ones
Changes in soil use	Action programme to respond to the impacts of current land occupation and land use dynamics on water resources in the Amazon Basin
Loss of glaciers	Developing and implementing adaptation measures to deal with the consequences of retreating glaciers in the Andes of the Amazon Basin
Insufficient water management	Supporting the strengthening of institutional and management frameworks to improve water resources management

The situation was different when it came to the root causes identified in the national TDA Workshops. All of the root causes pointed to serious deficiencies in governance and institutional performance.

Despite the surprising consensus of the TDA workshops in the different countries, the underlying problems of inefficient governance were very difficult to grasp and define through concrete indicators. The reason was that governance and institutional performance are directly related to political structures, conflicting economic and social interests, hidden agendas and undeclared conflicts of different levels and characteristics.

These issues – defined as **deep governance** by the GEF Amazon project – cannot be addressed directly in the scope of the specific projects, or measured by traditional indicators. Rather these need to be identified, analysed and understood by the project coordination and taken into account in forming the strategic actions. Understanding the significance and dimensions of deep governance enabled the regional project coordination to develop feasible strategies, realistic risk analysis and avoid ineffective use of project resources.

It also showed that specific guidelines and discussion techniques used during the TDA workshops could be helpful to unveil the different issues of deep governance and to establish a hierarchy of relevance and importance of the hidden problems and conflicts of interests.

Source: Norbert Fenzl (Regional Coordinator of the GEF-Amazon Project, 2017). More on GEF AMAZON http://otca.pagina-oficial.com/projects/details/20

9.3 Measuring governance indicators

One of the greatest challenges in governance assessments is the difficulty in quantifying governance indicators in ways that can be easily compared and tracked over time. Establishing a governance assessment baseline and progress over time often relies on qualitative data that may be subject to opinions, context and personal interpretations. That said, progress has been made and, increasingly, quantifiable indicator options are used for governance assessments.

Naturally, objective and quantitative data for such assessments are ideal to enable not only objective tracking of progress over time, but also comparison across spatial units within a country and internationally. However, where not possible, perception-based qualitative data can be useful, if such data are systematically collected.

Means to collect governance indicator information may include surveys, utility and organisation records, analysis of official information, stakeholder consultations and expert assessments. Incorporating scales, checklists, gradients and other approaches to classify and organise the information may provide support to some degree of data quantification (e.g. by percentage, number, degree), even where inputs are not necessarily objectively measured.

In most cases, various methods of data collection can be brought together in a supplementary way to provide the necessary information on relevant dimensions surrounding governance and the corresponding indicators.

To assess the **framework conditions** or the aspects of the enabling environment surrounding water management and governance, document reviews can often provide a reasonably objective and transparent assessment. This includes identifying the rules, policies and institutions currently in place, and the legal and institutional arrangements under which these institutions operate. Such assessments can be supported by, for example, using a checklist of whether key desired elements or conditions are met. For example, the GEF Transboundary Waters Assessment Programme River Basin assessment Legal Framework indicator assesses the degree of correspondence/alignment of existing international freshwater treaties (in basins) with six key legal principles of international water law, assigning a corresponding score (UNEP-DHI and UNEP 2016).

In most cases, the full governance picture cannot be achieved (and tracked) purely based on the existence or non-existence of key policy and management frameworks. Changes on the ground depend on the **progress of implementation** of the policies drafted, or the programmes approved. Tracking of this can be done through an assessment of the various levels of desired implementation and the application of laws, policies or frameworks in place, by using various scales or gradients, or corresponding scoring. Examples of such scale used for the SDG Indicator 6.5.1 is included in Figure 14.

Such step-wise assessments may provide more insight and detail on the actual level of implementation of the laws and policies, and, importantly, help track progress over time.

1. Enabling Environment						
	Degree of implementation (0-100)					
	Very low (0)	**Low (20)**	**Medium-low (40)**	**Medium-high (60)**	**High (80)**	**Very high (100)**
1.1 What is the status of policies, laws and plans to support Integrated Water Resources Management (IWRM) at the national level?						
a. National water resource policy, or similar	Development not started of not progressing	Exists, but not based on IWRM	Based on IWRM, approved by government and starting to be used by authorities to guide work	Being used by the majority of relevant authorities to guide work	Policy objectives consistently achieved	Objectives consistently achieved, and periodically reviewed and revised.

Figure 14. Exempt from SDG Indicator 6.5.1 – Degree of integrated water resources management implementation (0-100) country questionnaire.

For meaningful application of any governance indicator, it must be seen in the context of the **desired impacts on the ground**. In other words, the laws and policies are put in place with the aim to achieve certain tangible changes – from improvements in water quality, to greater empowerment of women and economic growth for communities. In the context of measuring such changes via application of governance indicators, there are two ways to think of the impacts:

1. Impacts within the larger governance system (e.g. participation and stakeholder engagement, representation)
2. Impacts on the overall socioeconomic and environmental system (increased compliance and reduced risks of water contamination, improved state of environment etc.)

As much as possible, governance indicators should strive to assess both through appropriate indicators. These two dimensions are also inevitably linked so, for example, an improvement in stakeholder engagement could eventually lead to a reduction in water-related conflict.

As a means to an end, improvements across recognised dimensions of water governance in basin or in-country (or globally) are ultimately about realising changes to socioeconomic and environmental outcomes. Improvements in governance frameworks are seeking to improve the water resource and ecosystem quality, and the quality of life of the people. Recognising and understanding these connections when designing indicator-based approaches, links back to a broader conceptual framework design. Through the design of appropriate indicator frameworks, the impact of water governance interventions should become apparent in changes to other indicators of concern (e.g., improved access to safe drinking water). In the long term, it is also then through other key indicators within environmental and socioeconomic dimensions that the real impacts of governance interventions should become apparent.

Conclusion and perspectives

Strategic planning and policy development are largely based on the assumption that we can easily identify the issue and the options for action. If actors in river basins are trying to solve structured problems with clear, agreed problem definitions or formulations and solutions (Pidd 2003), then indicators can be sufficient. The on-ground realities have shown that the processes surrounding basin management and specifically linking science and decision making can be far more complex. Not all decisions on basin management and development are informed by science (and indicators). Even where established indicator frameworks are present, the link from the information they convey to decisions can be weak. This confirms that basin resource management processes are often subject to a political process of bargaining, negotiation and compromise to understand and manage shared resources (Gallagher, *et al.* 2016) and can range from highly static to highly adaptive.

In this context, science (and indicators) in conjunction with local, traditional and experiential knowledge can be useful in shaping the norms and rules, regulations or institutions for both management and governance. These science-policy-practice processes require patience as they are not step by step, but are iterative and involve constant negotiation (McNie 2007) (Kuruvilla and Dorstewitz 2010) (Wyborn 2015) and must take into account multiple context specific dimensions such as institutional, culture, politics or demographics (Hall 1977).

This guide has suggested some ways in which the link from indicators to on-ground decision making can be strengthened through the design of 'better' indicators, as well as thoughtful stakeholder engagement and outreach processes. It has introduced the necessary building blocks and best practice in designing indicator-based management and monitoring frameworks that are effective and sustainable. This information was supplemented by in-depth interviews with a number of basin managers and the corresponding basin case studies, giving an insight into the most common challenges in indicator applications in practice, as well as the success stories.

The account of these experiences is further supported by an extensive review of various indicator-based frameworks in use for water resources management and assessment. The findings of this review have also resulted in a proposed comprehensive indicator framework, covering the various aspects of IWRM which can be used as a tool to inspire and guide the design of other indicator frameworks, tailored for the specific circumstances of the use. The framework is also available for interactive exploration and use, via the Water Indicator Builder online tool[20].

In this guide we have also discussed the challenges surrounding the measurement of governance and meaningful use of indicators assessing the governance structures surrounding water management, including that of stakeholder engagement, transparency, and accountability – all necessary dimensions of IWRM. The fundamental importance of efficient and well-designed governance and institutional frameworks in driving change in basins has also been stressed by a number of basin managers interviewed. This is especially true in furthering integrated water resources management which requires creating the enabling environment for coordinated resource management, across space and the variety of stakeholders. Ultimately, comprehensive indicator frameworks for assessment of IWRM dimensions should strive to include indicators that assess both the frameworks and processes within basin management and the desired outputs. It is also through inclusion of governance indicators and tracking these over time that conclusions can be drawn on correlations between improvements in governance and tangible changes in basin ecosystem health and the well-being of its people.

Good data and well-designed indicator-based monitoring and reporting systems are almost always costly. Selecting a set of limited, key indicators is a

20 http://www.waterindicatorbuilder.com/home

precondition for the feasibility of implementation and financial sustainability of such systems. The costs of collecting and analysing indicator information should always be critically assessed, including considerations of the expected benefits of the implementation and whether the benefits outweigh the costs (Campo 1999). This does not necessarily imply an objective cost-benefit quantification, however, the intended benefits and their links to indicators should be made clear. In other words, such systems should be designed to drive change with the help of specific indicators in a very deliberate way. The lack of clear direction and understanding of the links between indicators and the desired change they are to drive, has too often resulted in unsustainable and inefficient indicator systems. Therefore, investing due time and resources, particularly in the design phase, is well justified given that indicators cannot be replaced easily (as several measurements are needed to establish baseline and trends).

As information systems and the capacity to collect basin-level data increases, one way of allowing indicator data, status and trends to effectively inform policy making is by using them within decision support systems (DSS) for river basin management. DSS constitute a set of processes, guidance, analytical tools and technologies designed to assist with problem structuring and strategic planning when the nature and impact of problems are uncertain and contested, as in river basins (Nilsson *et al.*, 2008); (McIntosh, *et al.* 2011). Because users and stakeholders can reproduce the decision procedure, play with assigning weighting to different indicators and, perform sensitivity analysis (McIntosh, *et al.* 2011), and create scenarios to test decision recommendations, the hope is that the "salience, credibility, and legitimacy" of the analysis is supported (Cash *et al.* 2003). The current interest in such approaches presents a timely opportunity to explore how indicators can become more relevant – more useful and usable – for the multiple actors in river basin governance and management[21].

Finally, any basin indicator framework should be implemented with a clear objective, always in the context of the local culture and socioeconomic circumstances. While there are important benefits in, and sometimes formal requirements for, aligning processes and indictors with broader regional and global monitoring frameworks, the desired local outcomes and beneficiaries should be clearly defined. This requires defining the local values, challenges, goals and targets in a participatory manner. This is of paramount importance to gain the necessary commitment of local stakeholders – both in maintaining the indicators and in committing to change of practices on the ground to meet the desired ecosystem health and socioeconomic targets. In the same way, it is always important to keep in mind that ultimately the formulation of indicators and the indicator frameworks is a deductive process (Kusek and Rist 2004). This starts with identifying the problems and desired outcomes for the future direction of basin management, where indicators, targets and other steps in the process are defined, and used as supporting *tools* to drive and achieve the desired change.

21 A volume on Decision Support Systems for River Basin Management will be developed to further explore how useful and usable indicators can inform policy making.

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Annex 1

Review of various indicator frameworks for WRM

ABOUT THE REVIEW

A review of a limited set of various indicator-based water resources assessment and reporting frameworks was undertaken in preparation of this guide. It serves three overall purposes:

1. To provide an overall snapshot of differences in types of indicators and indicator frameworks used elsewhere (outside the TDA-SAP process)
2. To identify existing similarities (and differences) in framework organisation and types of indicators selected
3. Through a record of the specific indicators used, to point to potential opportunities and limitations in upscaling (or downscaling) indicator results, and related data

All of the above purposes and particularly the record of the specific indicators used have contributed to the development of the generic, comprehensive indicator framework presented in chapter 8.

The summary of the frameworks included in this review is included in Annex Table 1.

The review analysed the following aspects of indicator application:

- Approach to classifying indicators used (e.g. thematic groups and subgroups, causational)
- Number of indicators used
- Specific indicators used
- Consistencies of indicator categorisations and selected indicators across the various assessments (most frequently used indicators/ types of indicators)
- Gaps in indicator usage for specific issues

The review broadly covers four types of indicator-based assessments and monitoring frameworks[22]:

1. Indicator use for basin-level information and water resources monitoring systems to support resource management and decision making on an ongoing basis (such as indicators for basin-level decision support and information management systems)
2. Indicator use in support of diagnostics of existing or emerging issues for baseline and tracking progress over time (such as GEF transboundary diagnostic analyses, river basin level report cards)
3. Broader application of indicators on basin or national scales to assess the state of water resources regionally and globally, and to help establish macroscale priority intervention areas (such as World Water Development reports, Transboundary Waters Assessment Programme)
4. Indicator frameworks as best practice and guidelines (e.g. Cap-Net IWRM Indicators, African ME Guidelines)

More than 1,600 indicators were mapped and categorised in broader thematic groups as a result of this review. A summary of the main findings across these thematic groups is presented below.

INDICATOR CATEGORIZATION AND THEMATIC GROUPS

While most indicator frameworks surveyed apply some type of indicator categorisation system, few appear to use a specific conceptual framework to guide indicator selection. For instance, most decision support/information system documents include indicators covering various thematic areas of water resources management without highlighting the conceptual links between these areas or the selected indicators. In many cases, indicator selection appears to be a result of stakeholder consultations and priority issue identification in collaboration with basin organisations, rather than selection guided by a specific conceptual framework.

22 The review conducted for this guide focused on indicators relevant for basin and national-level water resources assessments. It does not cover indicators specific for utility performance (e.g. utility performance indicators).

ANNEX TABLE 1

Title	Description	Scope
GEF TWAP RB	Review of indicators used in the GEF Transboundary Waters Assessment Programme's River Basins component assessment	Transboundary basins (global comparative assessment)
WWF-US and UMCES Report Cards	Indicators used within the Basin Report Card Initiative by WWF-US and the University of Maryland Center for Environmental Science	Basin to sub-basin scale
WWDR-4	Environmental Indicators of the United Nations World Water Development Report 4 (2012)	Various
WWDR Water and Energy	Environmental Indicators of the United Nations World Water Development Report "Water and Energy" (2014)	Various
WWDR Water for a Sustainable World	Environmental Indicators of the United Nations World Water Development Report "Water for a Sustainable World" (2015)	Various
ECOWAS Regional Water Observatory	Indicators proposed for the ECOWAS Regional water observatory (Observatoire Régional de l'Eau en Afrique de l'Ouest Analyse des performances de la gestion de l'eau au niveau national)	National
African ME	The African Water and Sanitation Monitoring, Evaluation and Reporting Format (to support African countries and AMCOW in preparing their annual water and sanitation reports to the African Union Summit on implementing Sharm El Sheikh Commitments on water and sanitation)	National and regional
Cap-Net IWRM Indicators	Implementing Integrated Water Resources Management at River Basin Level (Minimum Indicator Set for Water Resources Management)	Basin
INBO	INBO Performance Indicators for African Basin Organizations	Basin
Freshwater Indicator Review for the LIVES project - Health and Wellbeing component	Indicators included in the WWF-US review paper on freshwater indicators., covering three major groupings: Bio-physical state, Human Health and Social; Economic Development and Governance	Various
Mekong River Commission	MRC Indicator Framework for managing the Mekong Basin (strategic and assessment indicators and the supporting monitoring parameters that are being employed by the MRC for planning and managing the Mekong Basin)	Basin
Zambezi Water Resources Information System (ZAMWIS)	Proposed long list of relevant measures/indicators (not finalised)	Basin
Volta Basin Observatory	Volta Observatory Water Resources Information System – proposed list of indicators	Basin
Niger Basin Observatory	List of proposed indicators for the Niger Basin Observatory, 24 indicators validated by the member countries of the NBO	Basin
Nile Basin Vulnerability Assessment	Adaptation to climate-change Induced Water Stress in the Nile Basin: A Vulnerability Assessment Report	Basin
SDG6	Proposed Indicators for water and sanitation related targets of SDG6	National

A notable exception is the relatively frequent application of the DPSIR[23] conceptual framework in indicator selection. Variations of the DPSIR approach have been used in for example, the TWAP indicator framework formulation, though without strictly following the DPSIR components. Each World Water Development indicator is also assigned to a category within the DPSIR framework. This cause-effect-response approach, or a variation of it, has also been applied in a number of TDA assessments[24]. An indicator review confirms the difficulty of straightforward application of the DPSIR framework in complex environmental assessments, where the same indicator can convey information on multiple DPSIR components simultaneously, depending on the perspective and specifics of interpretation. This is exemplified by assignment of the same indicator to various steps of the DPSIR framework (e.g. agricultural withdrawals as a signifier for both driver and pressure). These challenges are also observed in basin-level indicator frameworks, where assigning indicators to represent DPSIR aspects is often a theoretical exercise that helps highlight and understand the cause-effect relationships of environmental degradation drivers and consequences, rather than a relevant categorisation approach in the practical deployment of indicators. Despite these challenges, the DPSIR approach remains one of the most frequently used conceptual frameworks for indicator selection and classification, the merits and challenges of which are discussed in more detail in chapter 2.

The remaining indicator frameworks surveyed appear to be based primarily on thematic indicator selection, including indicators covering various relevant aspects of environment, socioeconomics and governance – often as identified through stakeholder consultation processes. These typically cover thematic areas of water resources (hydrological indicators), ecosystems, governance, health, and WASH indicators. The thematic groups selected often depend on the immediate priority issues at hand, so there is no real consistency in the types of thematic groups covered, given the variety of issues that the basins (and countries) are to address. For example, some indicator frameworks are heavily geared towards climate change impacts and challenges, while others do not address this at all. Similarly, some indicator frameworks include a number of indicators pertaining to pollution sources and wastewater treatment, while in others these indicators are absent.

The following considerations appear to be instrumental in the selection of indicators:

- ***Data availability or feasibility of collection*** – overall one of the most important criteria for final indicator selection. Considers the feasibility of data collection with regards to immediate data availability (baseline) or the existing technical capacity to collect and process data;
- ***Stakeholder priorities*** – as mentioned earlier, the existing challenges in basin and priority environmental issues play an important role in indicator selection. Indicators are often identified (and prioritised) through stakeholder consultations e.g. indicators selected as a result of stakeholder workshops/consultations. It is important to note that the composition of 'stakeholders' in this context may be open to broader interpretation. Stakeholders could be relevant country ministry and water authority representatives and selected experts, without necessarily opening the consultations for wider user groups. In other cases the discussions may be open to wider groups of stakeholders including farmers, environmental organisations, and others. Such consultations may also include a multitude of criteria as a basis for selection, including some of the ones outlined here.

CONSISTENCIES IN CATEGORIES AND INDICATORS

One of the goals of the indicator review was to identify indicators (or indicator groups) that show trends of repeated and widespread global use. Such information can contribute to a greater understanding of which indicators have proven to be feasible for data collection across various scales and are generally acknowledged to provide reasonable information representing key environmental and socioeconomic issues. The indicator analysis also highlights areas for which there is little consistency or lack of indicator application, pointing to potential gaps in research and/or data availability.

Overall, with indicator selection often being strongly guided by data availability or short/long term data collection feasibility, the most commonly used indicators represent basic hydrological and climate variables (rainfall, stream flow, temperature) and

23 Driver-pressure-state-impact-response

24 For more information on TDA assessments, see chapter 7.3

socioeconomic indicators relating to population, water supply, sanitation and health. The rest of the thematic indicator groups show a high degree of variation. The results of the analysis are summarised below across broader thematic groups represented by the reviewed frameworks.

a) Climate and climate change indicators

Indicators pertaining to current climate conditions and climate change are generally well represented in all frameworks reviewed. On an indicator level, there is also a fair degree of consistency in the application of metrics related to monitoring temperature and precipitation patterns over time. These often encompass a water balance component and the quantification of variables that impact water balance such as temperature, in order to identify extremes that can influence human activities and well-being. Examples include widely used indicators such as the Climate Moisture Index (CMI), Precipitation/Rainfall Index, and Coefficient of Variation for CMI. The wide use of these metrics indicates both general agreement on them as universally relevant indicators for water resources management, but also reasonable data availability in order to establish baselines and long-term monitoring efforts.

Notably, the inclusion of climate risk and vulnerability indicators is far less consistent. While the issue is to some extent addressed in a number of frameworks, the indicators chosen for quantification vary greatly by complexity, methodology and scale of application. Some use complex, aggregated measures that rely on geospatial, ecological and economic data (such as the Climate Vulnerability Index). Others use more simple indicators that are, for example, reliant on household surveys and best applied at regional scales (such as the Livelihood Diversification Index). And others relate to specific vulnerabilities, such as water storage or population-based predictions of water availability and risks.

b) Water resources quantity/availability indicators

All surveyed frameworks contain a set of indicators relating to water resources availability, use and demand. Depending on the scale and detail of the assessments (basin-level monitoring or global/regional assessments), indicators range from monthly statistics of observed water data to indicators such as national Total Actual Renewable Water resources per capita. The latter are often drawn from known international data sources, such as national water statistics provided by the FAO Aquastat. Overall, there is some level of consistency on key basin-level variables across frameworks surveyed – particularly in indicators of stream flow, rainfall, groundwater levels, reservoir storage and availability of renewable water per capita – which attempt to assess the current state of water resources as a function of human use and allocation. With some variations in methodologies, most of these appear in the frameworks surveyed.

The majority of frameworks also include indicators measuring water stress (covering overall water stress on a national scale or per capita, but also groundwater development intensity in a number of cases). Sectoral water use, demand and allocation is addressed in some of the frameworks, though in most cases seems to be limited to simple accounts of sectoral use and demand. Few account for environmental water requirements, instead focusing on impacts for human activities and incorporating metrics of human demand.

c) Water quality indicators

As is the case with water availability indicators, nearly all frameworks include one or more indicators measuring aspects of water quality. There is no real consistency amongst the indicators selected, which appear to be tailored to scale and geography, as well as prioritised basin-specific issues. Consequently, the global assessments often rely on broad coverage datasets available through databases such as the Joint Monitoring Programme (WASH indicators) and acknowledged global datasets relying on modelling approaches (e.g. nutrient loading models). Basin-level assessments focus on locally relevant and measurable indicators such as salinity, sediment levels and other ambient water quality indicators.

Indicators generally seem to cover one or more of the following aspects of water quality: ambient water quality indicators (nutrients, sediment, salinity), drinking water and sanitation (Joint Monitoring Programme indicators) and pollution sources and wastewater treatment (wastewater treatment capacity, percentage of water treated etc.). A lack of comprehensive global datasets for water quality is a known challenge in the water sector but there are developing initiatives that seek to fill these gaps, such as the United Nations Environment Programme's Global Environment Monitoring System (GEMS).

d) Ecosystem indicators

Ecosystem-related indicators do not appear prominently in all of the frameworks analysed. Where present, these typically represent some measure of protected areas, often measuring the extent of wetland areas in a basin or country. For example, Cap-Net indicators and PAN-African ME guidelines do not include any indicators relating specifically to species richness, diversity or general ecosystem health. The lack of these indicators in some regional and basin-level frameworks is worrying, as water quantity and quality indicators alone cannot tell the full story of the impacts that water resources management has on basin ecological health.

The TDA review found that several transboundary studies included an assessment of invasive alien species that are considered particularly harmful and water-intensive within the specified geographies. Further focus was placed on rare or endangered species (as measured by the IUCN Red List Index), which highlights geographic ecotones or areas of particular ecological interest and vulnerability. This variability in the assessment of biological diversity could be attributed to regional variations in climate, topography and other biophysical parameters that dictate species distribution—explaining the absence of these overarching indicator groups in some global frameworks.

Most of the frameworks also incorporate land use and land cover indicators, addressing drivers of change and their consequent impacts on both natural and socioeconomic systems. These parameters are often described within the context of irrigation and land degradation, with emphasis placed on economic consequences (e.g. income lost from reduced efficacy) and consequences for water use and demand given future population projections.

Resulting changes to freshwater ecosystem health are best understood when interpreting hydrological and ecosystem-related indicators simultaneously. Ecosystem health indicators are relevant variables on a global scale, relating to reporting commitments on global conventions such as Ramsar and the Aichi Targets of the Convention on Biological Diversity (CBD). It is also worth noting that on a global level terrestrial and freshwater ecosystem health indicators will be addressed though monitoring mechanisms under international conventions (e.g. Ramsar and CBD) and the targets under the global SDG on Water.

e) Population indicators

Population and health indicators are some of the most well established and consistent measures globally. The review includes several examples such as population growth and density monitoring, economic indicators of GDP, as well as health and sanitation indicators based on Joint Monitoring Programme and UN Human Development Index data. One or more of these parameters can be found in nearly all of the indicator frameworks reviewed. While data availability on the national scale is good for the most part, challenges remain in aggregating these indicators to relevant hydrological units, i.e. basin level, taking into consideration the variations within countries and especially between urban and rural areas. In the past years, important advances in this area have been made by projects such as Global Rural-Urban Mapping Project and Gridded Population of the World, providing a grid-based aggregation of population data that can then be aggregated to the basin level as necessary[25].

f) Governance and socioeconomic indicators

Governance indicators remain the most challenging to monitor at all spatial scales. Within the frameworks included in this analysis, the two main types of governance indicators used include indicators relating to conflict monitoring and management (including transboundary cooperation mechanisms), and the existence of enabling policy and regulatory environments for IWRM/sustainable water management. Indicators covering other important aspects of governance are sparsely found and include examples such as stakeholder engagement, gender and equity. The overall picture supports the well-known challenges of monitoring water governance-related variables, and particularly being able to account for impacts of governance measures on the ground (i.e. monitoring the impacts of an enabling environment for water sustainable water management). In many cases, governance assessments and indicators are of a narrative nature, describing the governance architecture in place as a form of baseline assessment, though offering little possibilities for monitoring possible improvements over time, at least not explicitly. This underlines the need for governance indicators that could not only measure the presence of enabling environments and governance structures, but also their impacts on resource governance and management.

25 CIESIN, more on http://sedac.ciesin.columbia.edu/data/sets/browse

g) Economic and investment indicators

Where present, water-reliant economic sectors such as hydropower and agriculture are addressed with indicators typically measuring the sectoral contribution to for example national GDP or direct capacity and (power) production metrics. Examples of agricultural indicators include irrigation efficiency and extent of irrigated agriculture. For the energy sector, examples include actual installed capacity or increase in capacity as one of the short- or long-term management targets. Few frameworks include financial and economic indicators relating to operational efficiency (e.g. cost recovery rates) and infrastructure investments, and generally are those with a focus on (utility) performance indicators.

Investment indicators are used sporadically – only in a couple of frameworks with no visible consistency. The most typical examples include planned investments in development of water infrastructure.

h) Human and technical capacity indicators (including data and information management)

This overall thematic group covers indicators relating to technical and human capacity, particularly relevant in strengthening local ability in sustainable resource management. There appears to be little focus on monitoring improvements over time across these aspects of water resources management, with only a handful of frameworks considering improvements in capacity, whether human or technical. Notable exceptions include the CEDEAO national water performance indicators, which include indicators such as Number of water monitoring stations and personnel involved in water management of water resources. Surprisingly, very few of the river basin-level frameworks include such indicators in their monitoring assessments. Nevertheless, the review identified a number of well-formulated indicators for data and information management which could have the potential of being applied across various geographies and therefore form the basis for recommendations.

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