SELECTING INDICATORS FOR BASIN HEALTH REPORT CARDS

A review of indicator use and guidance for the development of future report cards

Authors
Anna Canny
Natalie Shahbol
Michele Thieme
Alexandra Fries
Heath Kelsey
Simon Costanzo

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Dear user,

We are excited that you are interested in using or learning from this document about basin report card indicators or the application of indicators. This document is a living document and is expected to change as more indicators are developed. Please contact us on your plans to use this guide so that we may follow up and learn from each other. Thank you for your interest in this guidance document and wishing you the best in achieving healthy river basins!

Please contact us at wwf.umces.partnership@umces.edu

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HEALTHY RIVERS FOR ALL

Front cover: Mara River, Slovenia. Photo courtesy of Matevž Lenarčič/ WWF-Adria.

SELECTING INDICATORS FOR BASIN HEALTH REPORT CARDS

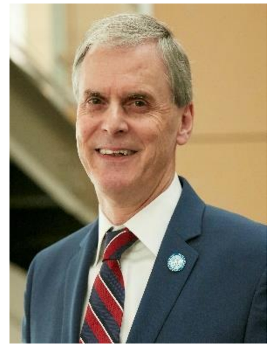
Foreword

Freshwater is vital to life on our planet, and yet freshwater ecosystems such as rivers and lakes are under threat now more than ever. To protect freshwater resources, we need to have a clear picture of a river basin's health across a range of areas, and over time, to know if it is improving or to address where and why it is getting worse. Indicators provide a way to assess the status of ecosystem health and to track progress over time across different countries and basins all over the world. Through the *Healthy Rivers for All* partnership with the University of Maryland Center for Environmental Sciences, WWF works to engage a wide range of basin stakeholders - basin managers, civil society, local communities, private sector, and governments, in selecting and applying indicators for measuring the overall health of a river basin. Each indicator in a river basin report card provides insight into the basin's health through a single perspective. Having multiple indicators provides a richer picture of the basin through a greater depth of field. To paint the most vivid and holistic picture, ecological, community, social, and economic indicators can be integrated in a river basin health assessment.

WWF hopes that this guidance will facilitate the use of multiple indicators and the basin report card approach more broadly in basins around the world. By applying this guidance, basin managers and the broader water community will be empowered with information on the status of the river basin and will be able to develop targeted solutions and make informed decisions to protect and conserve critical freshwater resources and the river basins we all care about and depend on —for current and future generations.

WWF

Dr. Melissa D. Ho
Senior Vice President, Freshwater and Food
World Wildlife Fund



The global environmental challenge of climate change and population pressure that water managers face is *the* issue facing humanity. We urgently need more and better tools to manage these environmental challenges, and this tool on selecting indicators for river basin report cards can be applied globally. The Healthy Rivers for All partnership between the World Wildlife Fund and the University of Maryland Center for Environmental Science has been a long-lasting and productive effort, which has resulted in this tool on selecting indicators for basin health report cards. This tool is the culmination of practical experience that the Healthy Rivers for All team has amassed in conducting projects in North and South America, Africa, and Asia. The previous tool, "Practitioner's Guide to Developing River Basin Report Cards," produced by the Healthy Rivers for All team, has been translated into multiple languages and used to develop report cards around the world. I anticipate that this tool will also resonate with water professionals and be applied widely. A key to the success of the Healthy Rivers for All partnership has been the shared vision of providing people with the tools to create science-based, stakeholder-driven report cards. These report cards can serve as a foundation for building good water governance. The report cards that are co-produced with stakeholders, using approaches and methods outlined in both of tools, serve to provide both transparency and accountability for those entrusted in water governance. The utilization of the tools and approaches presented here will help ensure that river basins of the future are healthier for both people and nature.

University of Maryland Center for Environmental Science Integration and Application Network

Dr. Peter Goodwin
President,
University of Maryland Center
for Environmental Science

About this guide

This Guide is developed to supplement the Practitioner's Guide to Developing River Basin Report Cards. It is intended for those developing indicators that can help understand the health of a basin report card or those who are developing a basin report card.

For an overview of basin report card indicators and those commonly used, turn to Chapters 1 and 2. To understand how indicators are selected, visit Chapter 3. To delve into each of the common indicators in more details, view Chapters 4-9. To learn about indicators that are new and emerging, see Chapter 10. The end of this guidance document provides concluding thoughts, references, and an annex with additional information about basin report cards completed and in progress.

Stretch of the Rio Grande in Boquillas Canyon, Texas. Photo courtesy of Day's Edge / WWF-US.

Acronyms

AWQI	Arizona Water Quality Index
BRC	Basin report card
CDC	Center for Disease Control and Prevention
EJI	Environmental Justice Index
EPA	Environmental Protection Agency
GDP	Gross domestic product
GIS	Geographic information system
IBI	Index of biotic integrity
IWRM	Integrated Water Resource Management
IWRMP	Integrated Water Resource Management Plan
PDSI	Palmer Drought Severity Index
SDG	Sustainable Development Goal
SES	Social-ecological systems
UMCES	University of Maryland Center for Environmental Science
UN	United Nations
WHO	World Health Organization
WQI	Water Quality Index
WWF	World Wildlife Fund

Rufiji River, Selous Game Reserve, Tanzania. Photo courtesy of Jonathan Caramanus / WWF.

1

What is a basin report card indicator?

Chapter 1. What is a basin report card indicator?

Introduction

In this chapter, we introduce the concept of indicators and provide an overview of how they are used in basin report cards (BRCs). We include a summary of the range of indicators used and some of the limitations of indicators. A full list of BRCs that have been included in this review can be found in Annex 1.

What is a basin report card indicator?

Indicators are the foundation of BRC development. They are powerful tools for describing the health of a basin and for communicating information (e.g., Figure 1). An indicator can be comprised of a single variable or an output value (index) which combines a set of multiple parameters.[1]

Indicators communicate important qualitative and quantitative information which can inform value judgements.[2] This information can be used to evaluate the effectiveness of management policies and interventions and alert people to impending changes.[3] When linked to various management goals and values systems, indicators can help basin managers understand their local watershed and make decisions accordingly.

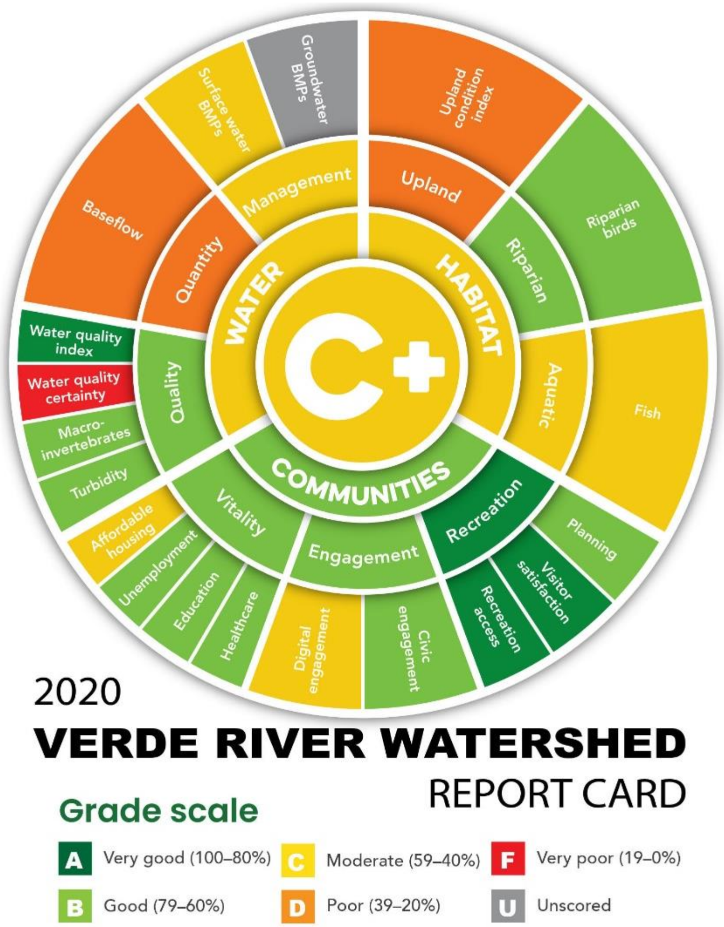


Figure 1. *BRC indicator used for Verde River Watershed Report Card.*

What are the limitations of indicators?

While indicators can help provide information about the health of a basin, they also have limitations. For example, there are many ways to measure system function and health, but they may only represent a narrow view of that system. It is important to remember that individual indicators only tell part of the story. Therefore, it is vital to use a suite of indicators to get a more complete understanding of a basin's health.

There are some general limitations regarding the use of indicators to understand the complex, multidimensional dynamics of a river basin. Though the simplification of complex systems is a necessary process, some degree of caution must be exercised to ensure that metrics are not overly reductive and therefore misleading.[3]

While reliable data and measurements are key to successful management using indicators, indicators can be influenced too heavily by the technical perspective on what can be measured, rather than what should be measured, particularly due to limited data on qualitative data. In an Integrated Water Resources Management (IWRM) scenario, this can lead to situations where the conditions that are measured are not fully descriptive of the actual state of the basin or relevant for water policy processes, while conditions that really matter cannot be measured properly with quantitative approaches.[4]

Most indicators have tended to be quantitative in nature, although qualitative measures have become more common, especially when integrating social and cultural measures, which may obtain data from interviews, and surveys. Data for these indicators can often be translated from text to quantitative information, but the underlying information is based on qualitative concepts, opinions, and perceptions (for example, an indicator that uses surveys that ask users to rank the degree to which they agree with a statement relating to management effectiveness, importance, or quality).

Tiger habitat in Bardia National Park, in Bardiya district, Nepal. Photo courtesy of Narendra Shrestha/WWF-UK.

2 Categories of indicators

Chapter 2. Categories of indicators

Introduction

This guidance document showcases indicators that have been used in University of Maryland Center for Environmental Science (UMCES) and World Wildlife Fund (WWF) BRCs and provides a reference for future BRC development. The range and categories of indicators have significantly expanded and become more representative over the decades. In this chapter, we highlight the common indicators and their categories and emerging types of indicators that plan to be included in future report cards.

Indicators used

BRCs have grouped indicators by six major categories: Water Quality and Quantity, Landscapes and Ecology, Management and Governance, Economic, Social and Cultural, and Health and Nutrition. Many of the indicators reviewed here are important to both ecosystem and human interests (Figure 2). The way they are framed can determine whether they fall in the biophysical (Water Quality and Quantity, Landscapes and Ecology) or human-related (Management and Governance, Economic, and Social and Cultural, Health and Nutrition) categories.[5]

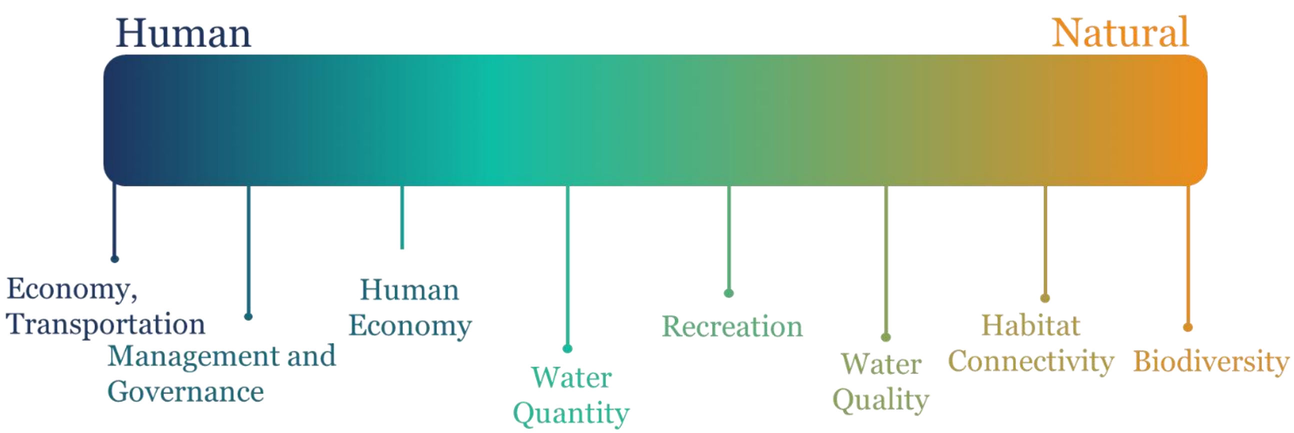


Figure 2. *Range of indicator focuses.*

Changing indicators

The use of indicators has been common in assessments of environmental health for at least half a century, but several key developments over the past three decades have prompted a change in the way indicators are used.

First, the idea of IWRM has been on the rise since the 1990s. IWRM is defined by the Global Water Partnership as "a process which promotes the coordinated development and management of water, land, and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems".[6]

Figure 3. *United Nation's 2030 Sustainable Development Goals.*

A related international framework, the United Nation's 2030 Sustainable Development Goals (SDGs), also provides a suite of relevant socio-economic and environmental indicators (Figure 3). There are 17 SDGs, 269 associated targets, and 230 associated indicators that are proposed for adoption at global and local scales.[7] The goals, which span from human rights to improved infrastructure, reinforce the idea that sustainability spans many sectors and further embrace IWRM, even going so far as to include "Degree of integrated water resources management implementation (0-100)" as an indicator.[8]

Prescriptive vs. adaptive indicators

Another way to categorize indicators is by distinct or context-specific indicators. Prescriptive approaches define how the world should be and what actions ought to be taken.[9] They typically measure system components which can be directly affected by management decisions.[10] The uniformity of prescriptive indicators can be useful in cases where practitioners are unable to develop feasible place-specific indicators.[11] They can also be a vital component of applying national or international goals for sustainable resource management, including SDGs.[12] Since they are dependent on standardized methods, thresholds, and data, they are useful for comparison between different basins as well. Examples of prescriptive indicators include drinking water quality and land use.

Adaptive indicators set standards based on regional conditions or observed responses in the basin. These indicators are developed and implemented through an iterative process which incorporates new system information.[9] Adaptive indicators allow the incorporation of local knowledge and resources. Examples of adaptive indicators include time spent collecting water, health of tribal fisheries, and status of traditional livelihoods.

The choice to use a prescriptive or adaptive indicator approach may also depend on the timeline and budget. Prescriptive indicators are generally easier to use since they have predetermined methods and thresholds. In general, an adaptive approach to increase local relevance is recommended, but there are instances where a prescriptive approach is preferable, for example where large-scale direct comparisons between regions is an objective. In many cases, a mix of prescriptive and adaptive indicators will be used in any one report card.

Lagging vs leading indicators

While indicators have traditionally used past occurrences to select indicators (i.e., lagging indicators), the use of indicators to predict a future state (i.e., leading indicators) is becoming more commonly included in BRCs.

Lagging indicators are concerned with changes that have already happened–they are indicators that measure the ultimate effect of factors on that part of the system. For example, dissolved oxygen may be a lagging indicator of water quality, while implementation of nutrient management practices may be a leading indicator of water quality. Most indicators included in BRCs are lagging indicators.

Leading indicators are those that reflect likely changes in a future condition. They can be considered "management" indicators, in that they inform proactive actions.[13] They measure factors which may shape a basin's response to future conditions. For instance, they can be used to predict the first signs of a significant shift in the ecosystem.[14] This predictive function can be useful for making management decisions before permanent changes set in.[3] Though leading indicators are an important metric, they can be difficult to develop and measure. Examples of leading indicators include availability of natural options for water-dry season storage, protected forested area, and forest management practices.

A combination of both leading and lagging indicators offers the most robust picture of basin health by including both current conditions and future directions. The addition of leading indicators to future report cards could support basin managers to track and achieve management goals.

Overlook of the Rio Conchos. Photo courtesy of Day's Edge / WWF-US.

3 Selecting Indicators

Chapter 3. Selecting indicators

Step 1: How do we select an indicator?

The process of selecting specific indicators should reflect the report card objective, and local and regional values/threats particular to the river basin. As identified in the Practitioner's Guide, the three major factors that influence indicator selection include:

Approach
During a workshop, stakeholders identify top values and threats and develop comprehensive lists of potential indicators for each. After discussion and feedback with the group, indicators are then narrowed down.

Guiding principles
Too many indicators can cloud interpretation, require more resources than available, and reduce the influence of each indicator relative to the score, while too few indicators can also cause a report card grade to be overly sensitive to a change in indicators. Stakeholder discussions are used to arrive at a succinct list of indicators that best represents the values within the category.

Flexibility
Not all indicators are necessarily applicable to the entire basin. Therefore, indicators not relevant to a sub-basin can be replaced with another representative indicator.

Participants of Tuul River Report Card basin health report card development who helped select indicators. Photo courtesy of Tuul River Basin Health Report Card.

Step 2: How do we use the data for an indicator?

Reliable data is the foundation of a robust and informative indicator. With all datasets, it is important to scrutinize the suitability of the data for making accurate conclusions. Some considerations for including data are the ability of the data to account for natural variance and the temporal extent of the data in terms of its ability to reflect trends and the situation on the ground.

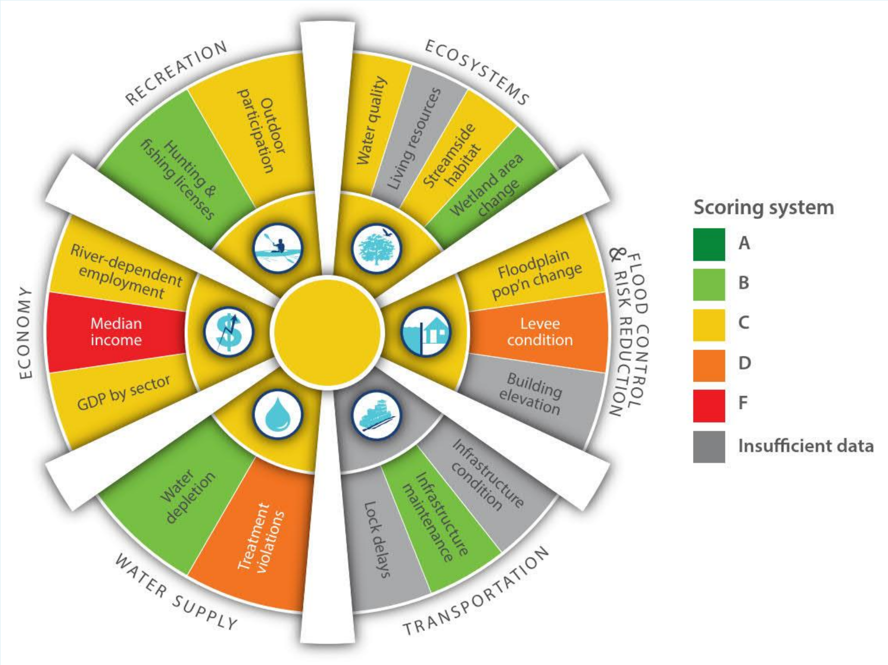


Figure 4. *Example of potential indicators greyed out in Mississippi River Watershed Report Card.*

Around the globe, availability of data on water quality and quantity is limited. Overall, however, biophysical metrics, such as water quality and habitat, have an associated set of common indicators, and the consistent use of these indicators has led to more consistent monitoring and data collection in these categories.[5] Data for human-focused categories of basin health is more inconsistent, as interactions with basin ecosystems vary significantly in different cultural contexts. For many human-focused indicators, proxy data must be used. For some indicators, it is helpful to set strict selection criteria for datasets beforehand. This can help to ensure that the data used is well-suited for making accurate assessments. For instance, the Arizona Water Quality Index (AWQI) sets standards for datasets used in the construction of the index. These criteria include datasets with all water quality parameters present, a minimum of three data values for each core parameter, and data coverage for each parameter across seasons.[15] This strategy, which was used in the Verde River Watershed Report Card, is explained further in Box 1.

Several BRCs have highlighted critical data gaps that exist in the basin either through recommended next steps or by including “greyed out” indicators that lacked data availability. These “suggested,” or “potential,” indicators in report cards have been used to motivate data collection to fill these critical gaps. This was seen in several of the basins reviewed, including in Mississippi River Watershed Report Card (Figure 4).

Box 1: Water Quality Certainty

The Arizona Water Quality Index (AWQI), a unique way of using a WQI, incorporated index stability score, which serves as a proxy for the reliability of a given index calculation. The index stability score considers the adequacy of the dataset based on statistical sufficiency, the natural variability encompassed in the dataset, and the data representativeness, which considers factors like the distribution of data sets across different seasonality and the incorporation of both base and storm flows. Under the index stability score, water quality sub-indices which do not meet the quality assurance standards are considered water quality "scores" rather than water quality indices.

The index stability score is calculated using a geometric formula:

$$Index\ Stability\ Score = L_c * p_G * \frac{\sqrt{C_1^2 + C_2^2 + C_3^2}}{1.732}$$

Where $C_1 = 100 * \frac{n}{30}(\text{Satistical sufficient sub} - \text{score})$

And $C_2 = 100 * (1 - (\frac{CoV}{\sqrt{n}}))$ (Natural Variability sub-score)

And $C_3 = 100 * \left(\sum_{i=1}^{n} \frac{i}{n}\right) + \sum_{i=1}^{2} W_i * x_i$ (Data Representativeness sub-score)All scores result in a value between 0 and 100. This extra attention to data is a unique step to ensure that assessments made using a given dataset are as accurate as possible.

Step 3: How do you set a threshold?

One of the most challenging parts of indicator selection and analysis is establishing thresholds for evaluation. A threshold is the standard of evaluation for most indicators in BRCs. A threshold is typically a specific goal or an upper or lower limit which is applied to the condition being measured.[16] For both the upper and lower limits, a selected "exceedance" is the point above or below which negative impacts on a "healthy basin" are observed. Other thresholds are "proportional," which means they are set as the percentage of a desired whole. For example, if the goal is to have seagrass covering an area of 50 km^2 and 25 km^2 is covered, then 50% of the end goal is achieved. The threshold in this case is 50 km^2.

Thresholds are a key aspect of report card scoring, as indicators are scored based on their relationship with their assigned threshold. In some instances, local stakeholders decide what is achievable, and this becomes the "A" standard. In others, the standard is what is considered healthy from an ecological or public health standard. An example of a Threshold Decision Tree is presented in Figure 5.

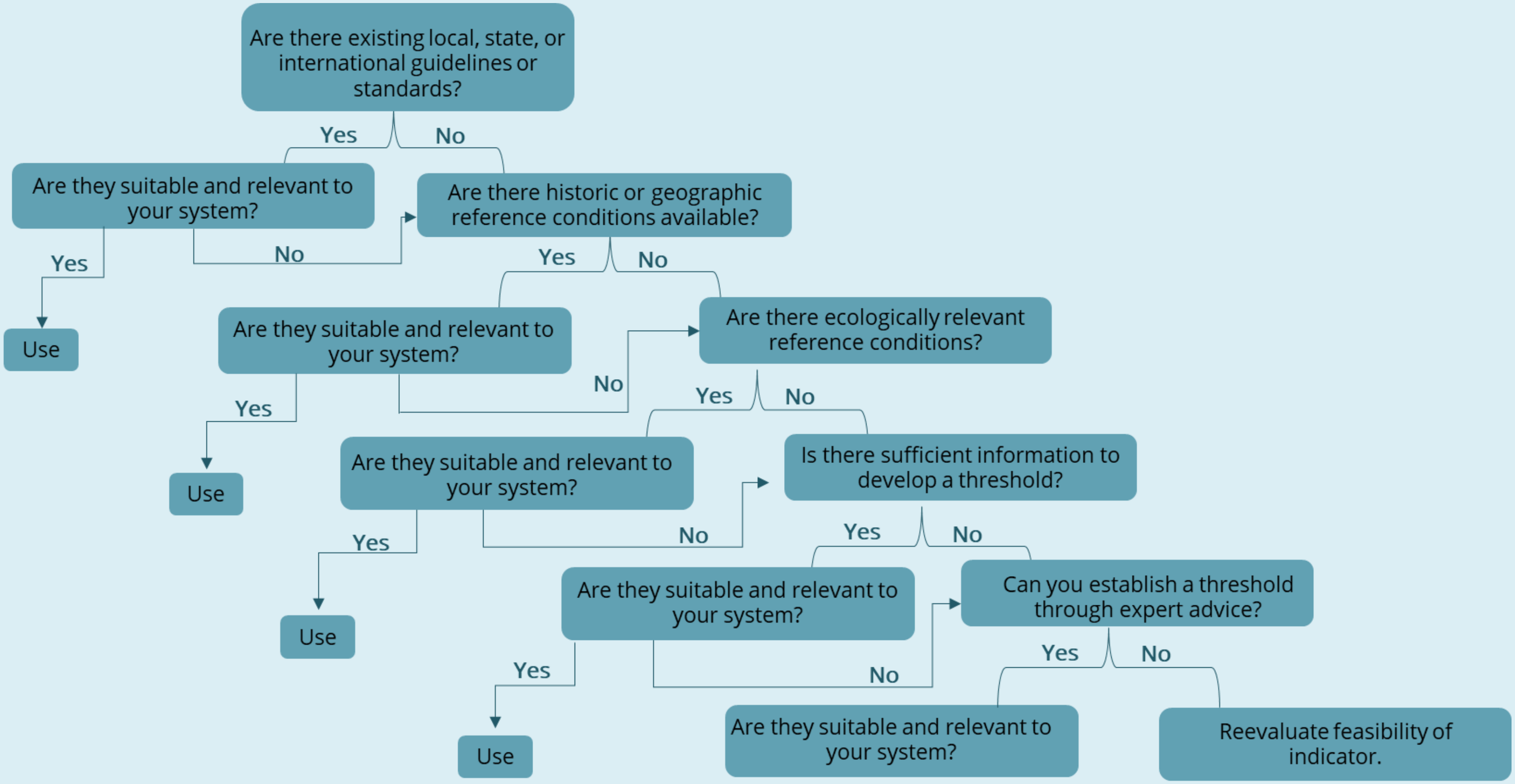


Figure 5. *Threshold Decision Tree adapted from Costanzo et. al, 2017*

Step 4: How does it add up?

1. Which values are important for your basin?
2. Are there available data for measuring your values?
    a. Yes→Set threshold.
    b. No→What are recommendations or ways to collect data and incorporate in the future?

Siltation of Taquari River, Mato Grosso do Sul, Brazil. Photo courtesy of Jaime Rojo/ WWF-US.

4 Water quality and water quantity indicators

Chapter 4. Water quality and water quantity

Introduction

Water quality and quantity indicators were the most common indicator category used across reviewed report cards (see Figure 6 for common indicators). All river basin report cards employed indicators in this category. The basic methods for measuring water parameters are well-established, and in some cases, institutionalized. Many state and national governments have practices in place for regular water monitoring and water quality standards.

Water quality describes a measurement which assesses the suitability of water for different purposes using physical, chemical, or biological considerations. It is a multivariate and multi-attribute concept which includes dissolved, colloidal, thermal, and suspended material components.[17] This means that accurate depictions of water quality typically require more than one indicator.

Water quantity broadly describes the hydrologic regimes of surface water, amount of water, flow cycles of groundwater, and quantification of human needs for consumptive practices.[18] Surface and groundwater parameters are often evaluated separately. Quantity of water is both a major driver of ecological health and an important foundation of human survival and well-being.

One of the challenges in the use of water quality and quantity indicators is balancing multiple uses of water resources when selecting indicators and thresholds. Most basins around the world serve multiple uses at once, including agriculture, industry, recreation, and drinking water. A "healthy" basin for one of these categories may not be healthy for another, and thus selecting indicators in this category requires some consideration of inevitable trade-offs.

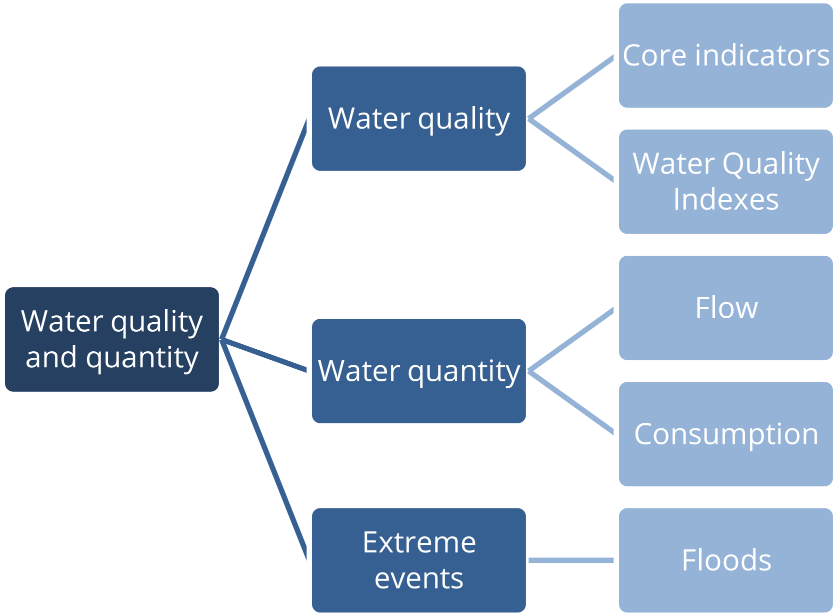


Figure 6. *Common water quality and water quantity*

Common indicators

Water Quality

Core indicators

The selection of water quality indicators is primarily based on stakeholder values and concerns, augmented by science and understanding of water quality issues. Often, there is more than one use, but management goals or government mandates may outline a single priority which will determine the most appropriate water quality parameters. The BRCs consistently relied on some combination of six core water quality parameters: temperature, pH, dissolved oxygen, turbidity/water clarity, nutrients, and bacteria (Figure 7).

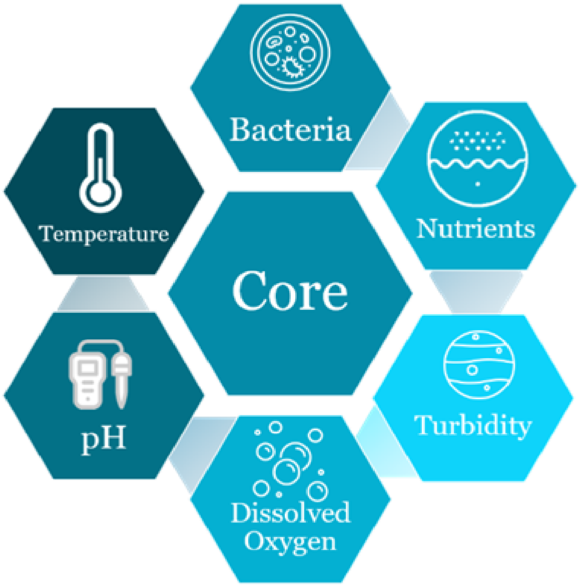


Figure 7. *Core water quality indicators.*

Water Quality Index

Though all report cards elected to use some metrics of water quality, most elected to use disaggregated water quality indicators, such as the six core indicators. A Water Quality Index (WQI) allows many water quality parameters to be summarized as one value. WQIs are useful for minimizing data volume and simplifying understanding of water quality status. WQIs are developed specific to a region and in the past three decades have generally been developed by universities and government agencies. In Table 1, examples of the different types of WQIs can be found. There are four major categories of indices used:

- Public indices, which assess general water quality (e.g. the National Sanitation Foundation)[19]
- Specific water use indices which assess water quality based on a specific standard, such as industrial use, drinking water, or recreational use (e.g., Oregon[20] and British Columbia[21])
- Design or planning indices, which are designed to address specific interventions and decision-making
- Statistical indices which use mathematical models alone.

Table 1. *Examples of different types of WQIs used in BRCs.*

WQI	Basin Report Card	Features
Oregon Water Quality Index	Willamette River Report Card	Measures ambient water quality of rivers for general recreational use, including fishing and swimming. The sub-indicators are temperature, dissolved oxygen, biochemical oxygen demand, pH, ammonia + nitrate nitrogen, total phosphorus, total solids, and *Escherichia coli (E. coli)* bacteria.
Arizona Water Quality Index	Verde River Report Card	Incorporates chemical parameters and makes assessments based on the proportion of parameters which exceed their respective standards relative to breadth of individual water quality results. It also accounts for the magnitude of deviance from the strictest standard for the parameter of interest. Different reaches of the Verde River were assigned different designated uses, and thus had slightly different parameters for their WQI.
Canadian Water Quality Index	Tuul River Basin Report Card	Accounts for multiple measures of variance, including scope, frequency, and magnitude in water quality. In the Tuul River basin, sub-indicators including bacteria, stomach bacilli, *E. Coli*, and coliform bacteria combined with chemical indicators such as ammonium, nitrate, and nitrite, were used to assess drinking water and hygienic water quality requirements as set by the Mongolian National Standards for quality and security assessment.
IDEAM Water Quality Index (local)	Orinoco River Watershed Report	Measures the superficial water quality using sub-indicators of dissolved oxygen, total suspended solids, chemical oxygen demand, electrical conductivity, pH, and the ratio of total nitrogen to total phosphorus, and it is calculated on an annual basis.

Water quantity

As with all indicators, the selection of water quantity indicators depends on local priorities. Water quantity indicators primarily refer to measures of flow and water consumption. Natural flow regimes are the fluxes in water quantity and timing of water flows which are expected in an unaltered basin. Major components of a flow regime include magnitude, frequency, duration, timing, and rate of change.[22] In addition, environmental flows should be included as a part of flow calculations.

Different flow measurements can assess levels of water quantity which are vital for habitat protection and can indicate impacts of infrastructure of drought, climate change, and surface or groundwater withdrawals. Minimum or baseflows may be important for maintaining general aquatic health, maximum or peak flows can reveal the level of human impact on a basin, and other target flows can assure streamflow based on more specific criteria, like minimum flows required for the recovery of a threatened species. In addition, environmental flow assessments can be a good source of potential indicators.[23] Examples of indicators used to measure water quantity include:

Environmental flow

Environmental flow, or e-flow, refers to the water provided in an area to maintain ecosystems and their benefits.[24] The Lower Kafue River Basin Report Card measures e-flow by measuring the flow of the Lower Kafue between 1977 and 2013 against a target flow.[25]

Neotropic cormorant (Phalacrocorax brasilianus) feeding from the Cuiabá river, Pantanal. Photo courtesy of Andre Dib / WWF-Brazil.

Baseflow

Baseflow measures river flow during periods with the lowest discharge or smallest influx of precipitation and/or snowmelt. They can be used as a complement to dry season or summer stream flows, as groundwater levels are less sensitive to precipitation events.

Summer or dry season flows

Summer or dry season flows typically compare dry season flows to thresholds for health of aquatic organisms or historic summer flows.

Species-specific criterion flows

Specific criterion flows are designed to create the best conditions for recovery or stabilization of a species of interest.

Peak flow

Peak flow indicators can be used to assess the impact of human interventions on natural flows. Peak flows are often important ecologically to trigger migrations to spawning grounds or signal the start of other parts of a species' life cycle.

Metrics of water consumption go one step further than water quantity indicators alone by relating available water to human demands:

Water supply and demand

A Water Use Index evaluates the balance between the availability of water in the watershed, environmental flow requirements, and water demand by different economic sectors.[26]

Water depletion

Water depletion is a measurement of surface water quantity, assessed with the Water Stress Index. The Water Stress Index is the ratio of total withdrawals to total renewable supply in a given area.[27]

Groundwater use

The groundwater use indicator compares actual use of groundwater to the allowable use as a percentage.[28] In the Tuul River Basin Report Card, amount of groundwater used in different regions was compared against the sustainable limit of groundwater exploitation.[28]

Extreme events

Extreme events, such as droughts and floods, are region-specific indicators that can incorporate the impacts felt by climate change. Though uncommonly used, the following report cards provide examples of how to quantify extreme events:

- The Tennessee River Report Card[28] uses a drought indicator, the Palmer Drought Severity Index, to estimate water supply by using precipitation and surface air temperature as inputs and adjusting for precedent conditions.
- Flood indicators use floodplain population change, levee condition, building elevation and emergency calls during flood events, and flood insurance. Flood indicators were used in the Mississippi River Watershed[27] and San Antonio River Basin[29] report cards.

Data resources and sources

Water data can broadly be split into two categories, snapshot data or continuous monitoring. Basin snapshot data are measurements made at a single point in time, such as once a month, once a year, or once every five years. Continuous monitoring is used most often in rivers evaluating flow regimes or climate data. While continuous monitoring provides more information, it is limited by cost, need for maintenance, and access to technology. The most common sources of data include the following:

National governments

Many of the report cards reviewed relied on national water quality surveys, which were usually reported annually. In places with institutionalized environmental monitoring, the collection of water data is mandated and standardized.

Basin authorities and volunteers

Basin authorities and watershed networks have filled in knowledge gaps about local water resources. These local coalitions can establish monitoring programs that align with community goals and objectives. In fact, it has become a popular practice for watershed councils and networks in the United States to hold a yearly "snapshot day," which employs community volunteers trained to collect sound water quality data.

City or municipal water institutions

These institutions commonly collect data on human uses of water, and thus provide data from a water access or water treatment perspective, but these data types can be used to build water quality and quantity indicators.

Meteorological stations and flow gauges

Data sourced from meteorological stations is commonly used for rivers reporting on factors like precipitation. These indicators are employed less often, but they can be extremely useful for filling in data gaps. Water flow gauges, which are commonly set up semi-permanently, are also vital for metrics of run-off, streamflow, and other water quantity measurements.

Flooded area near the Port of Manaus, capital of the Amazonas state, during Negro river's record water level, on May 31, 2021. Photo courtesy of Marcio James / WWF-Brazil.

Methods of analysis

There are four major ways the data is used to analyze the health of water quality and quantity indicators:

Pass-Fail Binary

Measurements in line with the thresholds are assigned passing scores, while those which exceeded the threshold are assigned failing scores.

Historical records

Measured values are compared to long-term averages or specific conditions at one point in time. Often, averages are used as a proxy for expected conditions, especially for measurements of flow. As for historic baselines, they are used to contextualize both basin improvement and degradation. In addition, Measures of water consumption can be analyzed through the lens of “sustainable” withdrawals, by generating a ratio of demands or consumption to basin capacity. Similarly, to measure biological health, water resources can be assessed for their suitability with regards to biological demands for certain species.

Categorical scales

Qualitative categories are assigned scores in accordance with quantitative thresholds, and then used to analyze the metrics for different categories.

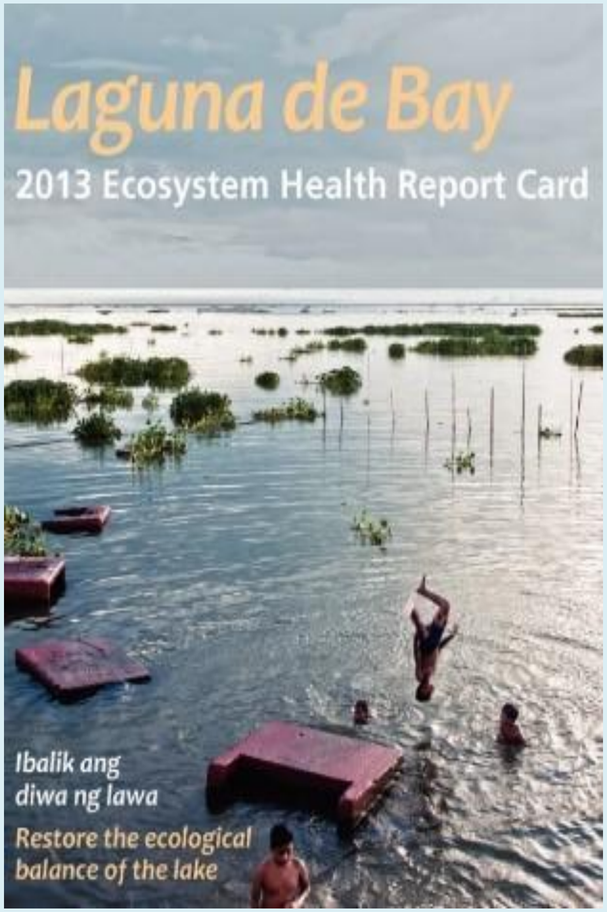
Resources

- UN Water Monitoring progress in the water sector: A selected set of indicators
- WHO Health Indicators of sustainable water
- Global Runoff Data Centre
- EPA Water Data and Tools
- USGS Water Resources

CASE STUDY

Laguna de Bay Ecosystem Health Report Card, Philippines (est. 2013)

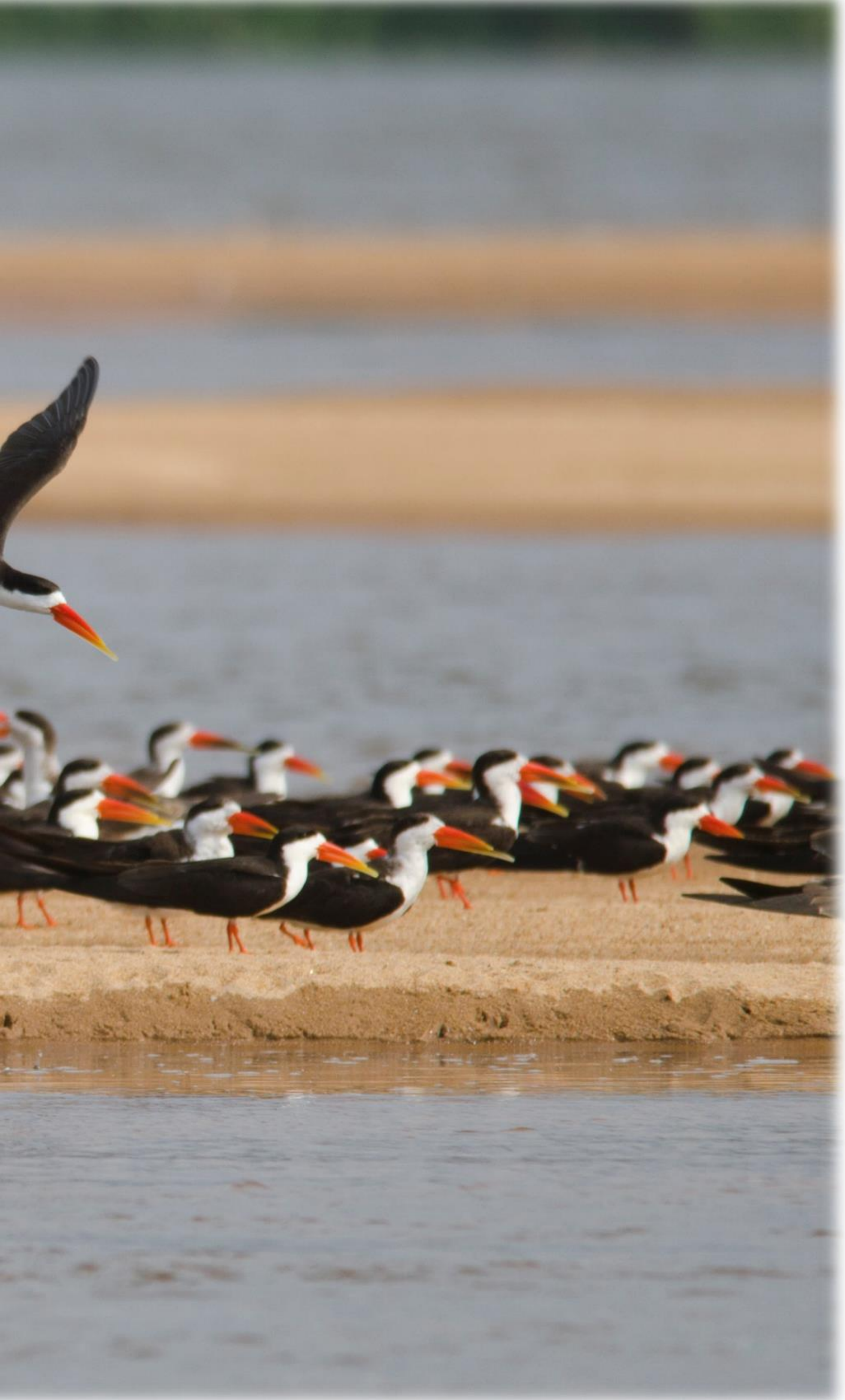
In the development of the Laguna de Bay Ecosystem Health Report Card (2013), in the Philippines, there was notable debate over the appropriate water quality threshold. The Laguna de Bay is a multi-use water source, which is utilized for agriculture, aquaculture, and fisheries, in addition to drinking water for some people. The Laguna de Bay Report Card selected indicators in two main categories, water quality and fisheries. The water quality indicators selected included nitrates, phosphates, dissolved oxygen, biological oxygen demand, chlorophyll a, and total coliforms.



Initial workshops for the development of this report card suggested the use of historic data on water quality, collected from between 15 and 20 years of monitoring. However, when scored against historic averages, water quality scores were extremely low. Stakeholder feedback revealed that the scores developed by historic standards were not reflective of the region's national regulatory mandates. In the second round of evaluations, all water quality indicators were compared to Department of Environment and Natural Resources standards for Class C waters, which are suitable for recreation and fisheries. The bay's final score under these conditions was 76%, a C-.[30]

The case of Laguna de Bay represents a common practice in the place-based application of indicators by illustrating the way in which political and/or government perspectives can influence the way indicators are used. In this case, users opted to return to regulatory thresholds, over historical standards, in order to be compatible with their national mandate.

Endangered African skimmers (Rynchops flavirostris) breeding on the lower Sanaga River, Cameroon during the dry season. Photo courtesy of Jaap van der Waarde / WWF Netherlands.



5 Landscapes and ecology

Chapter 5. Landscapes and ecology

Introduction

Maintaining healthy landscapes and ecological diversity is crucial for the maintenance of both biodiversity and cultural diversity, and the impacts of human activity on landscapes at the watershed scale have the potential to shape hydrologic conditions. Human-induced changes to landscapes alter energy flows, matter fluxes and nutrient dynamics, and movements of organisms as a function of habitat size and type.[11]

Landscapes and ecology indicators are the second most common indicator category employed in the BRCs (see common indicators in Figure 8). Landscape indicators are derived from landscape ecology, the study of the interactions between spatial patterns and ecological processes. Landscape indicators are built from data on land cover, management, and functionality.[31] They can be used to assess land use change, habitat functions, and landscape aesthetics. Increased availability and ease of access of remotely sensed data is also making it easier to conduct assessments and conduct automated or semi-automated updates over time. This makes them well-suited for understanding rapid environmental changes. Similarly, ecology indicators can be used to assess the health and biodiversity of a river system by understating the presence of different species and their abundances.[32]

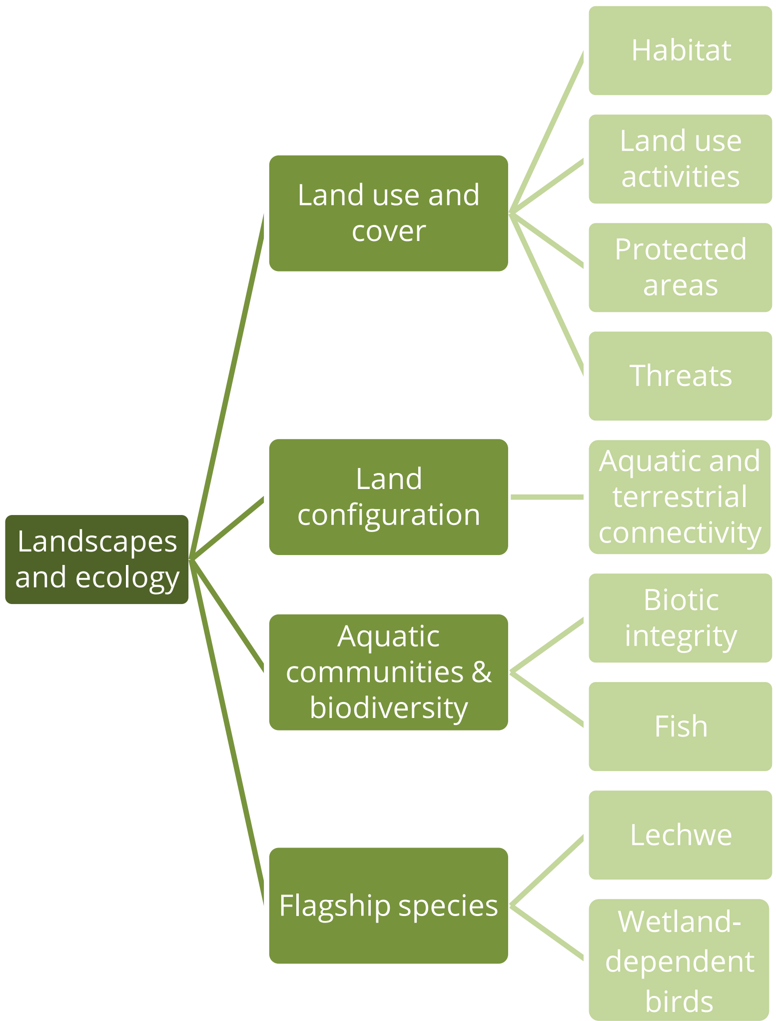


Figure 8. *Common landscapes and ecology indicators.*

Common indicators

Land use/land cover

Land use refers to human activities on the land, while land cover refers to the ecological state and physical appearance of the land surface based on classification schemes. As a whole, land use/land cover indicators are concerned with the abundance and variety of land composition types[33] and are often interpreted differently for each basin.[34]

Habitat

Common habitat types considered included natural forest, wetlands, and aquatic habitats, such as benthic grasses. Assessments of habitat varied greatly among the basins reviewed, with some indicators measuring degree of restoration and some measuring the amount of habitat available.

Land use activities

Types of land use most cited in the basins reviewed include agriculture, development, forestry, mining, and conservation.

Protected areas

Protected areas exist at different levels of restriction, with some areas being managed closely for conservation and some being protected from development but allowing for extractive activities, including mining and forestry. Protected areas are one of the few leading indicators used in the BRCs, as they anticipate future development threats.

Threats

The only indicators of threats to landscape included in BRCs are metrics of wildfire occurrence. For some regions, periodic fire is a natural part of ecology, but understanding changing trends in fire occurrence can be a useful metric for monitoring changing drivers on a landscape level, as well as possible climate change impacts.

Land configuration

Land configuration indicators are focused on the arrangement, position, and orientation of landscape patches. Both terrestrial and aquatic connectivity metrics were used in the BRCs reviewed. Connectivity can monitor persistence of ecological processes and the viability of organisms. For example, connections between different ecosystems and habitat patches in rivers, forests, wetlands and across other ecosystem types allow organisms to move freely and to complete critical stages of their life cycle.

Aquatic communities and biodiversity

Biodiversity and biotic integrity indicators are among the most common metrics used for assessing the health of aquatic communities and biodiversity. The following indicators are most commonly used in this category:

Biotic integrity

Biotic or biological integrity is the capacity of an aquatic ecosystem to maintain a healthy community of levels of composition and diversity that are like the expected natural biota of a pristine ecosystem. The index of biotic integrity (IBI) is commonly used to measure biotic integrity. The IBI is a multi-metric index designed to simplify a diverse set of biological information, and it can be used to identify associations between human influence and biological attributes. It typically incorporates several biological metrics which are responsive to changes.

Benthic macroinvertebrates consist of aquatic organisms including snails, mussels, worms, and insects that live in the benthic environment, which refers to the stream or river bottom. This class of organisms are a good measurement of aquatic biotic integrity because they are responsive to both short, episodic events and longer-term cumulative impacts.

Fish
Measurements of fish abundance are an important resource related to livelihoods, human health and nutrition, recreation, and culture.

Flagship species

Wetland-dependent birds
For some regions, birding is culturally significant and can promote nature tourism. Indicators focused on birds monitored numerous aspects of population health.

Lechwe
In the Kafue Flats, Lechwe, a water-dependent type of antelope, was assessed using historical data.[25] Lechwe are only found in waterlogged environments.

Data resources and sources

Data collection for landscapes and ecology can be based on field data for environmental monitoring or remotely sensed data sources. Data resources for landscapes and ecology have gone through an evolution over the past decade as remote sensing has improved. The most common data sources for landscape and ecology indicators include:

Lechwe in Mahango Game Reserve, Bwabwata National Park, Namibia. Photo courtesy of Patrick Bentley / WWF-US.

Government databases
In nations with government agendas for environmental protection or departments of agriculture or development, some amount of landscape data is typically readily available. Data is usually available on an annual scale, though sometimes it is collected every five or ten years.

Geographic information system (GIS) and remote sensing
Satellite imagery, GIS, and remote sensing data have revolutionized the creation of landscape indicators. On a global scale, remotely sensed satellite data can assess land cover in large aggregate categories, such as forest and cropland. Additionally, the greenness of vegetation, soil moisture, and vegetation stress calculated through these data sources can build an understanding of climate impacts. For the development of indicators in BRCs, this

data is most often used for measuring land use changes, habitat connectivity, and threats to landscapes, including wildfires and possible losses of soil moisture.

Citizen science
Wildlife observation for recreation, as well as some livelihood-based assessment in the case of fisheries, can be used to measure species or groups of particular interest. In recent years, mobile technology has changed the collection of data for citizen science through the introduction of applications like eBird, an app for recording and identifying bird species.[35]

Methods of analysis

There are four major ways the data is used to analyze the health of landscapes and ecology indicators:

Comparison to reference sites
Reference sites are generally locations within the basin with excellent landscape conditions, and these sites can be used to create a gradient of biological condition for analyzing habitat metrics. Comparisons to reference sites are often based on categorical scales, which make quick assessments of conditions like riparian vegetative cover and macroinvertebrate health in comparison to "undisturbed" reference sites.

Comparison to total land use
Total land use can be calculated as a ratio percentage, as in the ratio of land for human activity to "natural" land cover. Similar methods can be used to assess the size of habitat patches.

Comparison to historic land use
Methods of analysis are centered around percent change in these habitats, and most rely on satellite data for analysis.

Comparison to expected ecological conditions
Knowledge of the expected abundance and distribution of native species can be used to evaluate population health for species of interest as well as to make assessments of the threat of invasive species. Analysis often relies on a percent ratio of observed to expected species or native to non-native species. Some methods focus on the difference between observed and expected species to assess changes.

Resources

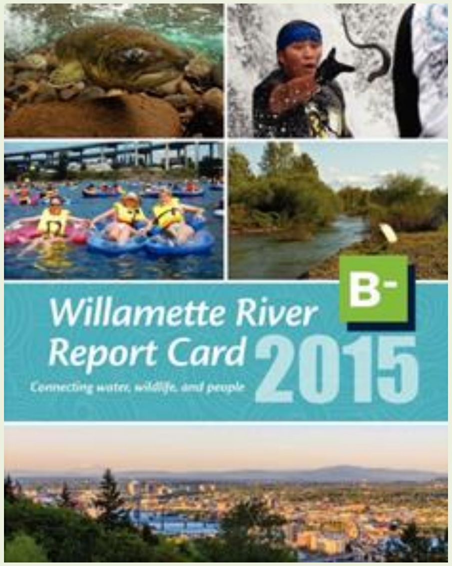
- WWF *Landscape Elements*
- USDA Forest Service Watershed Condition Framework

Local citizens being trained for snow leopard conservation in Shey Phoksundo National Park. Nepal. Photo courtesy of DNPWC/WWF Nepal.

CASE STUDY

Willamette River Report Card, United States (est. 2015)

The Willamette River Report Card (2015) for the Willamette River Watershed in Oregon, United States, used two iconic species as indicators. The Juvenile Chinook and the Bald Eagle are two characteristic species of the Willamette River, though they have notably different population statuses.



The Juvenile Chinook is considered a threatened species under the U.S. Endangered Species Act, and in the Willamette River Watershed, dams, loss of habitat, and loss of riparian shade have combined to create conditions which can have negative impacts on migration, reproduction, and juvenile status of the Chinook salmon.

The Bald Eagle, on the other hand, is often considered a conservation success story, with their populations in the United States rising over the past few decades. As it stands, they are considered a least threatened species by the Endangered Species Act.
The markedly different statuses of the Chinook salmon and the Bald Eagle in the Willamette River Watershed illustrate that indicators are versatile and can represent the state of health of different types of ecosystems within the basin.

A person fishing in a river near Simjung, Nepal. Photo courtesy of Karine Aigner/WWF-US.

6

Management and governance

Chapter 6. Management and governance

Introduction

Management and governance indicators assess the structures and processes which guide basin management, including legal frameworks, formal and informal institutions, and citizen engagement (Figure 9). Metrics of management and governance can help to highlight existing weaknesses in data collection methods, finance allocation, planning, or enforcement. Management and governance indicators can sometimes provide a baseline of institutional performance that can be improved over time. One of the biggest challenges for this category is with setting thresholds, as there is no universally accepted set of criteria for measuring management or governance status.

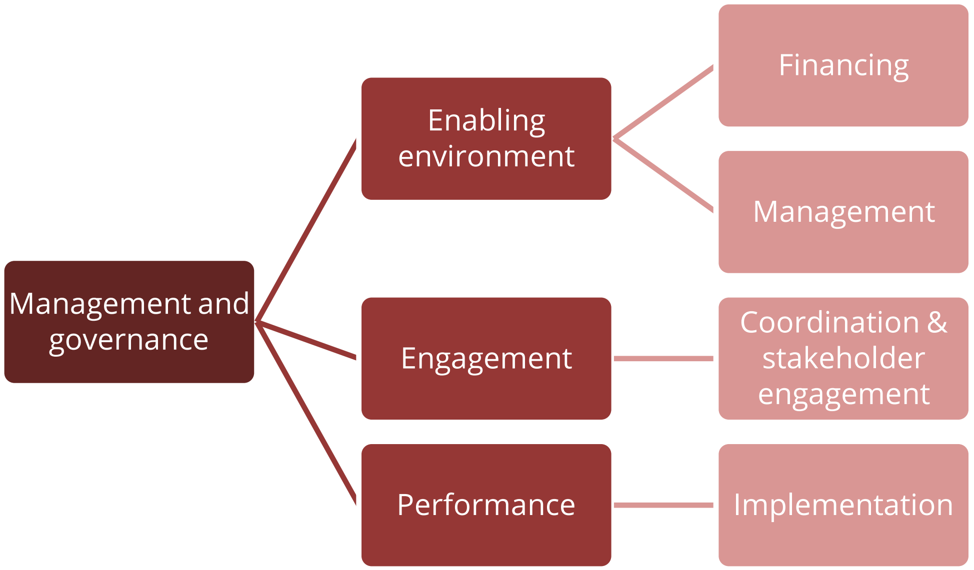


Figure 9. *Common management and governance indicators.*

Common indicators

Enabling environment

Enabling environments refers to the “policies, laws, regulations, and norms” which make up a particular scheme of management and governance.[16] Most BRCs focus on financing and management:

Financing
Financing indicators are concerned with the ability to raise funds and the allocation of those funds for the management of watershed resources and services. Therefore, indicators of funding are vital for understanding the capacity to properly manage, protect, or restore a basin’s health.

Management
Management indicators combine organizational, managerial, and institutional conditions. Management arrangements in the context of water resources may

include licensing and permitting as well as management of watershed natural or built infrastructure assets (e.g., dams, canals, floodplains, lakes, wetlands).[36]

Engagement

Engagement is concerned with the interactions between stakeholders and government institutions and considers factors like stakeholder influence and mechanisms for transparency and accountability.[37]

Coordination & stakeholder engagement

Coordination indicators are centered around information sharing, open debate, and decision-making which involves diverse stakeholders. Indicators of coordination examine cooperation among various actors in the basin, including government institutions at multiple hierarchical scales, civil society, universities, non-profits, and the private sector.

Performance

Measurements of management and governance performance depend on if a basin plan or regulations have been put in place and if the basin management plans or regulations are working.

Implementation

Implementation indicators measure progress towards an achievement of an agreed upon threshold or management objective. Indicators on this category measure changes in basin conditions as a result of policies in place. The Tuul River Basin Report Card, developed in 2019, included implementation as a means of measuring management.[28]

Mumbuca Quilombo, an indigenous community of Cerrado, Brazil meeting with WWF. Photo courtesy of Ana Paula Rabelo / WWF-UK.

Data resources and sources

Common data types for management and governance indicators include survey results, utility and organizational records, and expert assessments. Data collection for management and governance indicators can be challenging. A lack of objective goals or lack of transparency from institutions can be a contributing factor to the challenge of identifying appropriate indicators and data sources. The following data sources are commonly used for management and governance indicators:

Government or utility datasets
Data can be sourced from management and governance institutions themselves. Financial data can also be provided by government agencies in most cases, including information on national budgets and regional taxation.

Expert opinion
Because thresholds for management and governance are challenging to set, some basins utilize standards provided by experts. These types of data are relevant for best management practices and monitoring recommendations. Some BRCs focus on international organizations, while others use specialized scientists in their local governments.

Methods of analysis

The most common methods of analysis for governance and management indicators include:

Presence or absence of desired management and governance policies
Evaluation in this category compares policy in practice to the policy written into law. A common way to quantify this is the ratio of the existing conditions to the desired conditions. Analysis methods transform binary assessments, the presence or absence of a desired policy, into degree of achievement, i.e., 70% of the policy goals or goal achieved. Thresholds for this category are most often set by the management and governance institutions themselves.

Quantitative analysis of qualitative criteria
Methods of analysis relied heavily on expert opinion or existing literature. The best example of this method was observed in the analysis of the 'Surface Water Best Management Practices' indicator in the Verde River Basin Report Card. This indicator was developed by assigning values to irrigation ditches across the region for desired sustainability criteria including control structure, flow measurement, and lining and piping.

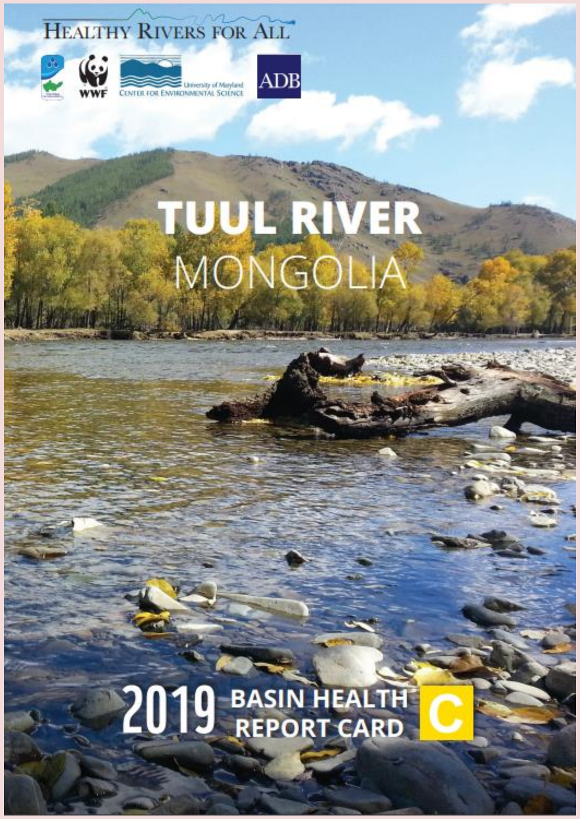
Resources

- OECD Water Governance Indicator Framework
- UNDP User's Guide on Assessing Water Governance
- Ecologic Water Governance Assessment Tool

CASE STUDY

Tuul River Basin Health Report Card, Mongolia (est. 2019)

The development of the [Tuul River Basin Health Report Card in Mongolia (2019)] recognized changing management arrangements in recent years as a result of Mongolian water laws implemented by the national government. In 2012, Mongolian water law created a nested approach which established basin authorities to develop integrated water resources management plans (IWRMP) and monitor their implementation.



The IWRMP of the Tuul River basin has two phases of implementation: Phase I (2013-2015) and Phase II (2016-2021). The “Implementation of Integrated Water Resource Management Plan” indicator in the Tuul River Basin Report Card assessed the implementation of Phase I by examining the occurrence of 242 activities outlined in the plan. The results of the assessment revealed that 40-56% and 35-38% of activities listed in the IWRMP were implemented in different regions. This left the basin with an overall score of 40%, or a ‘C’.

Although implementation plans are in place, the ‘C’ score in this category shows that even though the Tuul Basin authority is the primary author of the IWRMP, the completion of many activities relied on parliamentary action. The successful execution of the plan requires inter-sectoral coordination, active participation of relevant stakeholders.

Mirera Karagita community members collecting water from a water kiosk in the Lower Catchment, Lake Naivasha, Kenya. Photo courtesy of WWF / Simon Rawles.

7 Health and nutrition

Chapter 7. Health and nutrition

Introduction

Health and nutrition indicators represent the status of human health within a basin. Environmental conditions and human health are inextricably linked. Health indicators focus on the health of the basin population, including access to water and sanitation, prevalence of waterborne diseases, and access to healthcare. Nutrition indicators developed by the Center for Disease Control and Prevention (CDC) or World Health Organization (WHO) are generally focused on malnutrition. In the basin context, nutrition indicators are focused on nutrition provided by basin resources (Figure 10).

Common indicators

Fish consumption advisories

In areas where too much fish consumption can lead to an excess intake of Polychlorinated Biphenyls (PCBs) and heavy metals such as mercury, measuring the number of consumption advisories can measure how often residents can safely consume fish. This indicator was used in the Willamette River Report Card.

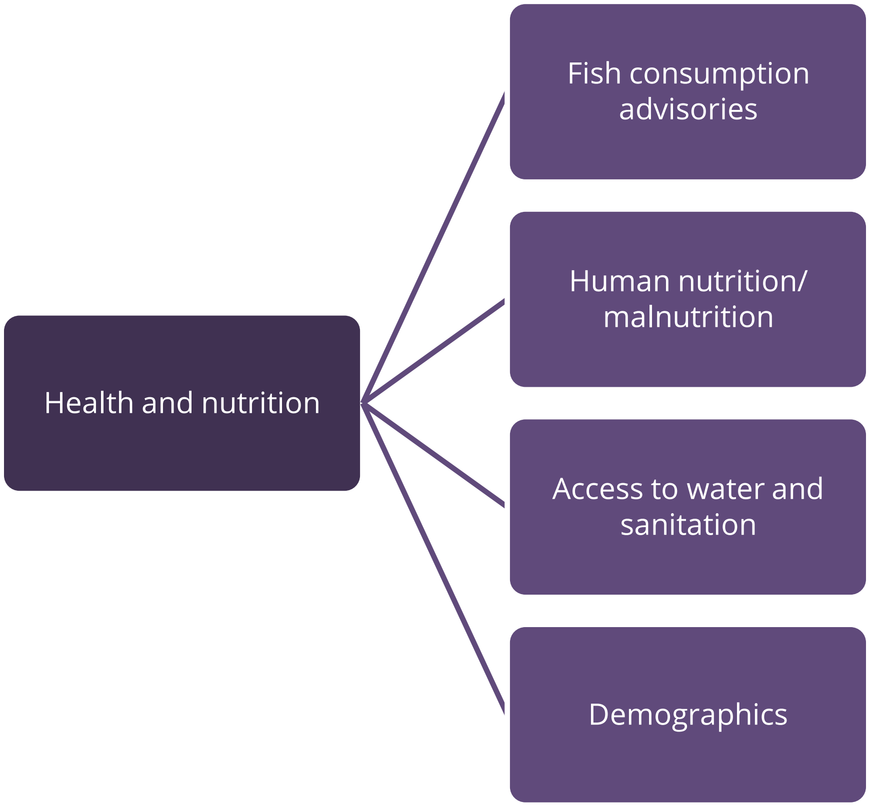


Figure 10. *Common health and nutrition indicators.*

Human nutrition/malnutrition

These indicators give insight on nutritional status and health within a population and can also help predict future illness and death.

Access to water and sanitation

These indicators are directly in-line with SDG Goal 6 (i.e., ensure access to water and sanitation for all). The relationship between water and poverty is agreed upon by experts, as lack of access to clean water and sanitation is generally believed to reinforce poverty.

Demographics

Using basic demographics gives a general snapshot of the health and disparities within a basin. Demographic indicators used include affordable housing, unemployment, education, and access to healthcare.

Dried fish harvested in Suri Thani, Thailand. Photo courtesy of Nicolas Axelrod-RUOM / WWF-US.

Data resources and sources

All human health indicators in this review used government datasets, including censuses and national surveys. One unique aspect of the methods of analysis associated with health indicators was the setting of lower limit thresholds to reflect unacceptable conditions, or in other words, levels at failing scores are automatically assigned. For instance, any region with less than 50% of children having a healthy body weight received a failing score for the Human Nutrition indicator in the Orinoco Basin River Basin Report Card.

Methods of analysis

Common methods of analysis for health and nutrition indicators include:

Comparison to national averages or standards

This method uses the percentage of population that has access to a service (e.g., healthcare) and compares it to a state or national average. Scores are normalized based on the state or national average. For example, the SDG Goal 2 uses national data to measure and achieve goals on ending hunger, achieving food security, and improving nutrition and sustainable agriculture.

Comparison to historic records
This method measures values compared to historic records during a specific time period.

Pass-fail binary
Measurements in line with the thresholds are assigned passing scores, while those which exceed the threshold are assigned failing scores.

Resources

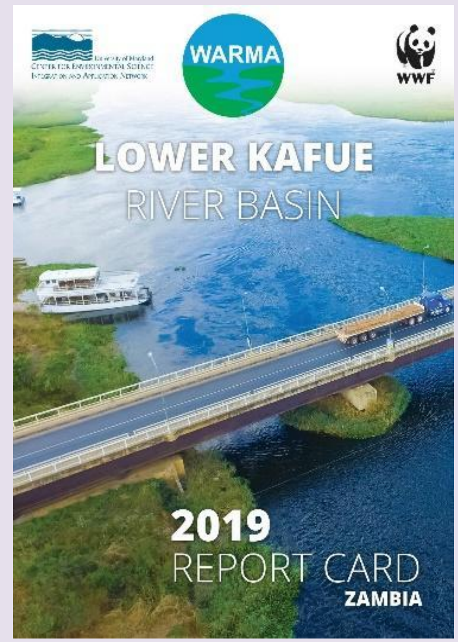
- CDC Nutritional Status Indicators
- U.S. Department of Health and Human Services, Office of Disease Prevention and Health Promotion, Healthy People 2030

CASE STUDY

Lower Kafue River Basin Report Card, Zambia (est. 2019)

The Lower Kafue River Basin Report Card (2019) highlights the importance of human health and nutrition in evaluating the health of its basin. In this report card, three indicators of health and nutrition were included: disease burden, severe malnutrition, and access to sanitation. Overall, this category received a failing score. The assessment of these indicators points toward critical management interventions needed specific to health and nutrition.

In addition to the three health and nutrition indicators included, two additional indicators, tick-borne diseases outbreaks and access to clean drinking water were identified as indicators to include in the future. Bringing awareness to the types of indicators that can be added, but there is currently a lack of data for, also highlights the links between the health of humans and the river basin.



Elephants surround a tourist in Tarangire National Park, Tanzania. Photo courtesy of James Morgan / WWF-US.

8

Social and cultural

Chapter 8. Social and cultural

Introduction

Social and cultural indicators are a relatively recent addition to the process of BRC development, and they measure many different human interactions within the basin system (see common indicators in Figure 11). Water resources development is inextricably linked to the development of societies and economies. In these coupled systems, degradation of freshwater ecosystems can have social and cultural impacts. Potential social and cultural impacts associated with a degraded watershed include loss of traditional practices, increasing conflict, loss of Native languages, feelings of powerlessness and frustration, declines in mental health, changes in knowledge sharing practices, degradation of sacred sites and historic landscapes, and loss of stewardship.[39]

Social or cultural indicators are designed to account for complex human behaviors, to reflect changing values and norms, to integrate the diverse perspectives of multiple stakeholders, and to predict water outcomes to some extent.[40] Challenges with social and cultural metrics include difficulty identifying existing metrics, constraints of technical undertakings, and lack of relevance to decision-makers.

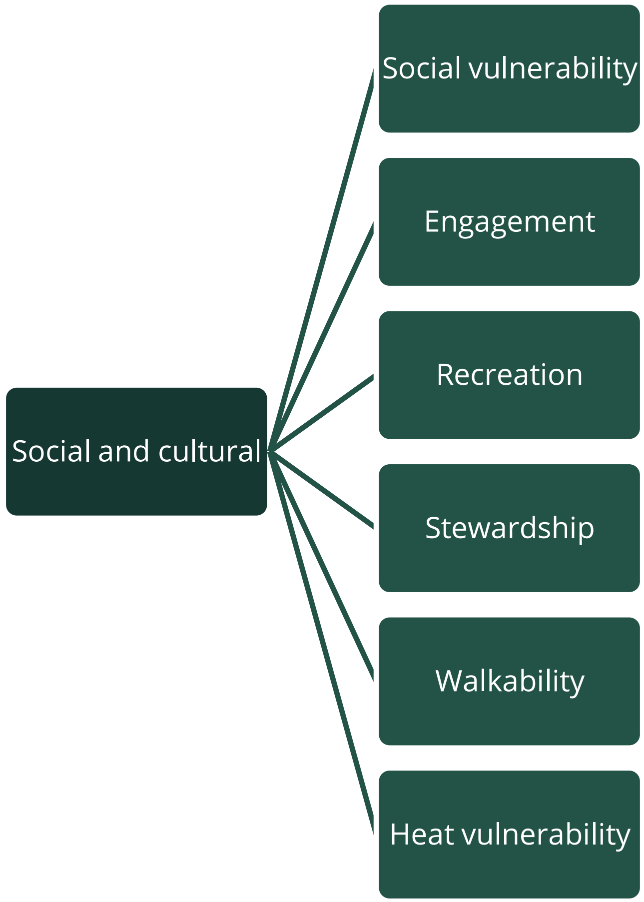


Figure 11. *Social and cultural indicators used in BRCs.*

People celebrating Eid during a heavy tidal surge in Chaktai, Bangladesh. Photo courtesy of Jashim Salam / WWF-UK

Birdwatching in Kaeng Krachan National Park, Thailand. Photo courtesy of Hkun Lat / WWF-Aus

Common indicators

Social Vulnerability

Social vulnerability is the potential negative effects on communities caused by external stresses on human health.[41] The only indicator of social vulnerability used in the basins reviewed was the Social Index developed for the Chesapeake Bay Report Card. This index uses data on social vulnerability from the CDC, which measures the ability of a community to recover from hazardous events. Some of the measurements in this index include socioeconomic status, household composition, and minority status.

Engagement

Citizen engagement with the basin or with basin governance can be considered a social indicator. The engagement indicators used in BRCs considered digital engagement in the form of Google searches related to the basin.

Recreation

Recreation in the form of boating and paddling, swimming, fishing, bird watching, and other activities is considered an important value for many basins. In general, the relationship between ecological health and recreation quality is not linear and depends heavily on recreation type.

Stewardship

Stewardship measures whether actions people take positively or negatively impact the ecosystem.[42]

Walkability

Walkability measures two metrics, the total number of people that can walk to a park and how many people in diverse groups can walk to a park.

Heat vulnerability

A Heat Vulnerability Index was used in the Chesapeake Bay and Watershed Report Card. This index identifies places where there is greater vulnerability of people to heat-related and flood-related risks, which are often in neighborhoods with race-based housing discrimination.

People walking in Uhuru Park, near the central business district of Nairobi, Kenya. Photo courtesy of WWF / Juozas Cernius.

Data resources and sources

Most of the indicators in the social and cultural category were developed under the constraints of available data, as is common for indicators in this category. Government databases are the most common data sources for measuring social and cultural indicators. Recreation indicators used state or national datasets to assess factors including trails access and number of park visitors. Other basins adapted water quality data collected by state monitoring programs or basin authorities to fit recreation interests like paddling and angling.

Methods of analysis

Because social and cultural indicators can include personal biases and perspectives, there is an added layer of complexity in establishing a common ground for analysis in this.[43] Methods of analysis for social and cultural indicators relied heavily on ratios of measured realities to idealized goals.

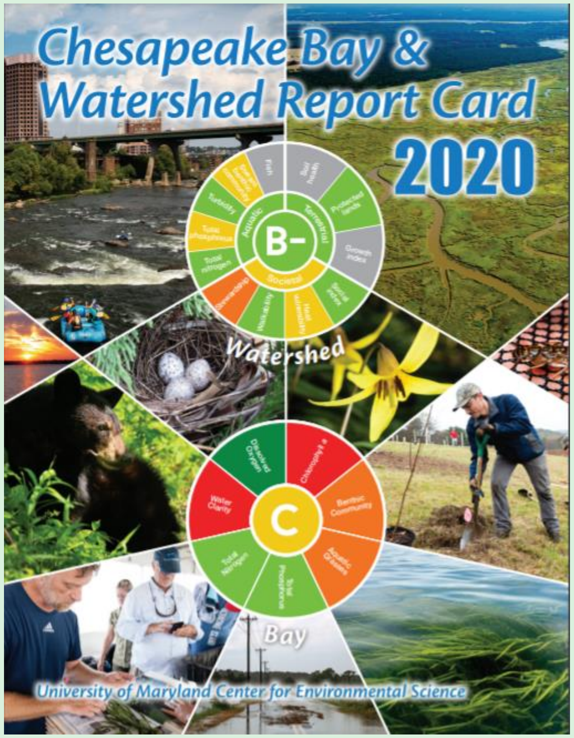
Resources

- OECD Better Life Initiative Compendium of OECD Well-Being Indicators
- UNESCO Culture for Development Indicators

CASE STUDY

Chesapeake Bay and Watershed Report Card, United States (est. 2006)

The Chesapeake Bay and Watershed in Maryland, USA, is the basin with the most report card iterations in this review. The region is home to 18 million citizens who exert significant influence on basin conditions. The importance of quantifying this impact and the motivation for impactful behavior is increasingly recognized as a priority in developing indicator frameworks. Thus, social and cultural indicators have gradually been incorporated through the evolution of BRCs over the years. The most recent addition is the Citizen Stewardship Index.



The Citizen Stewardship Index was developed in 2017 by the Chesapeake Bay Program. In the 2020 iteration, the Citizen Stewardship Index was incorporated in the grade for the first time and will be used as a baseline and tool for use in advancing stewardship throughout the watershed. The Citizen Stewardship Index assesses stewardship behaviors and attitudes of watershed residents across categories of behavior, volunteerism, and civic engagement. The score includes a composite of evaluations of 19 individual behaviors, including, but not limited to, stewardship behaviors, motivations for those behaviors, and beliefs about the importance of individual actions.

Sampans meet at the early morning market in the Mekong Delta, Vietnam where rivers converge. Photo courtesy of Elizabeth Kemf / WWF.

9 Economy

Chapter 9. Economy

Introduction

Healthy basins provide ecosystem services that contribute to the economy indirectly or offer services that cannot be easily quantified in economic terms. Using economic indicators to capture these hidden benefits can be challenging but essential to ensure that goals for economic growth can be achieved without threatening the diverse values offered by basins.[44] Essential sectors including transportation, agriculture, and tourism often rely on water flows or quality and managing water use among these diverse demands is critical for supporting a robust economy. Economic indicators aim to quantify the performance of these industries as well as the other aspects of the general economic well-being of basin communities. Common indicators of economy are shown in Figure 12.

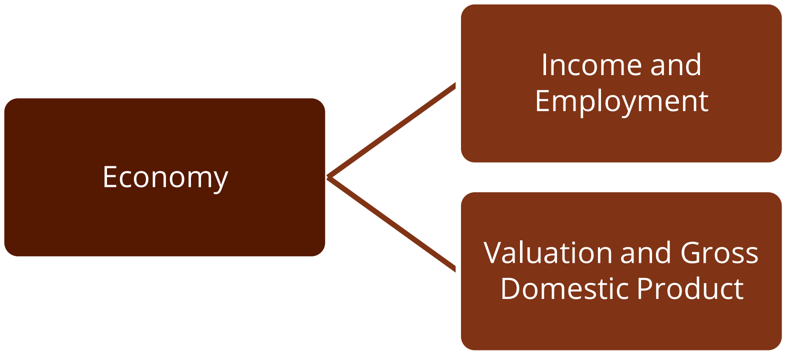


Figure 12. *Common economy indicators.*

Common indicators

Income and employment

In order for communities in the watershed to thrive, its citizens must have access to livelihood and income opportunities. Income and employment indicators can give a better understanding of a basin's economic well-being.

Valuation and gross domestic product (GDP)

Developing an understanding of the demands of different economic sectors through industry indicators is essential for prosperity and long-term growth. Indicators in this category examine local industries through metrics of valuation and/or GDP.

Data resources and sources

Economic data is commonly collected by national governments. Commonly used datasets include:

Census data or equivalent
Indicators of employment and income are most often developed using the census or equivalent programs. Some report cards filter data by river dependent employment and income, while others evaluate general economic conditions using the basin as a spatial boundary.

Government datasets
Indicators of industry often used GDP, which is a common economic assessment that measures the monetary value of goods and services produced.


Sand dredging boats on Dongting Lake, China, on a waterway connected to the Yangtze River. Photo courtesy of Justin Jin / WWF-US.

Methods of analysis

The most common methods of analysis for economic indicators include:

Comparison to national averages or standards
Because many regions lack basin-specific economic policies, it is often difficult for stakeholders to come to a consensus on thresholds for employment, GDP, and income. As a result, a common method of analysis for economic metrics is comparison to national averages. The averages are analyzed using a maximum-minimum normalization, with scores scaled linearly between an unacceptable standard, which would receive a failing score, and an idealized standard, which would receive an "A." In other cases, assessments can be made based on a ratio comparing the measured value to the minimum standard.

Comparison to industry capacity
This typically appeared as an assessment of a given year's economic performance in comparison to the maximum industry capacity or an average standard of industry performance as a summary of past years. Production value for a given sector is analyzed as a percentage of either the maximum performance observed in past years or a particularly high rate of average performance for past years, such as the 80 percentile of past economic performance.

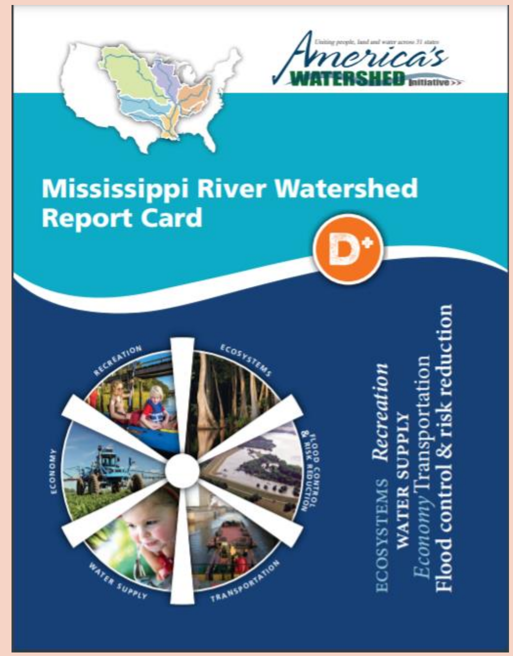
Resources

- [UN World Water Development Report Water and Jobs (2016)]
- [The World Bank Water Supply, Sanitation, and Hygiene (WASH) Poverty Diagnostic Initiative]

CASE STUDY

Mississippi River Watershed Report Card, United States (est. 2015)

In the Mississippi River, transportation is a critical service of economic and social significance. In fact, The Mississippi River Watershed is the most economically important river transportation corridor in the United States.



The Mississippi River Watershed report cards measure lock delays, infrastructure condition, and infrastructure maintenance. By combining these three indicators and evaluating the status of existing transportation features, lock and dams, and the planning process for system maintenance, this report card generates an evaluation of both current conditions and future threats.

The evaluation of transportation also reveals the linkages between different indicator categories. Though the benefits and potential losses associated with transportation systems fall under the economy category, planning and funding for maintenance of the system is dependent on governance. Some values for a basin will inevitably fall into two or more categories, and making explicit linkages between them, as was done here for the infrastructure maintenance indicator, leads to stronger systems

The Rufiji River snakes through the Tanzanian countryside. Photo courtesy of Brent Stirton / Getty Images / WWF-UK.

10 Areas of innovations

Chapter 10. Areas of innovations

Introduction

The use of indicators in BRCs is a powerful strategy for understanding, communicating, maintaining, and improving basin health status in basins across the globe. This framework will continue to be a powerful asset for facing challenging water crises which will continue to evolve over the next few decades. Nevertheless, the method of using indicators to understand basin health is constantly evolving. Highlighted in this section are a few emerging themes around advancements that are being taken into account as a part of the basin health report card process to create a more holistic picture of basin health.


Two women in a dugout canoe on the Barotse floodplain. The guage next to the boat shows the impact of the drought as during flooding season, it would usually be submerged in water. Photo courtesy of Jasper Doest / WWF.

Gender

In most of the world, women are the primary users of water for domestic purposes, including drinking water supply and subsistence agriculture. Additionally, they are the users most likely to access public freshwater resources such as lakes and rivers.[45] In some cases, these sources of water are distant, which can make water management tasks very time-consuming. This creates an inextricable link between women's relationships with water resources and their lack of access to health and education.

One of the most prevalent trends in water resource management currently is the call to incorporate gender in water resource management approaches. Gender mainstreaming refers to integrating perspectives, roles, and representations of both women and men into development initiatives and interventions. In water resources management, gender considerations provide insight into how gender roles and power dynamics are influenced by water, sanitation, and hygiene conditions in a basin.

Gender indicators have important implications for IWRMPs, strategies for poverty reduction, women's empowerment, public health initiatives, and the intersections of these categories. Indicators which use data aggregated by sex can clarify understanding of community dynamics and highlight the needs of those most vulnerable to water resource challenges. Gendered indicators are important for all SDGs, but they are especially relevant for Goal 5 (gender equality) and Goal 6 (clean water and sanitation). Ideally, gender indicators will inform decision-making and policy design which alter unequal gender relations for the benefit of women.[46]

Areas that gender indicators can be developed include:[46]

- Water governance
- Safe drinking water, sanitation, and hygiene
- Gender specific knowledge storage and transmission
- Water for agricultural uses
- Water industry and business
- Human-rights based management
- Water, migration, displacement, and climate change
- Indigenous and traditional knowledge and community water rights
- Water education and training

Indigenous perspectives

The incorporation of Indigenous perspectives in the selection and development of indicators will be crucial for the construction of BRCs that are effective, inclusive, and just. Indigenous territories cover roughly 24% of the world's land and include 80% of biodiversity.[7] As industry and development push further into native territories across the globe, Indigenous people are becoming increasingly involved in water issues.[7] The inclusion of Indigenous people is especially vital given a consideration of the ultimate role of BRCs in planning and management of water resources, as historic decision making and power structures have historically limited Indigenous agency in development and self-governance.[7]

Indigenous perspectives are an alternative to the Western perspective which has long dominated management of freshwater resources. Though it is impossible to make accurate generalizations about all Indigenous cultures, most view water as close to a living being, while the Western perspective frames it as more of a resource.[7]

Uru Eu Wau Wau territory member at Jamari River. He is the head of the surveillance Uru-Eu-Wau-Wau team responsible for overseeing the Indigenous land and recording illegal invasions and illegal deforestation. Photo courtesy of Marizilda Cruppe / WWF-UK.

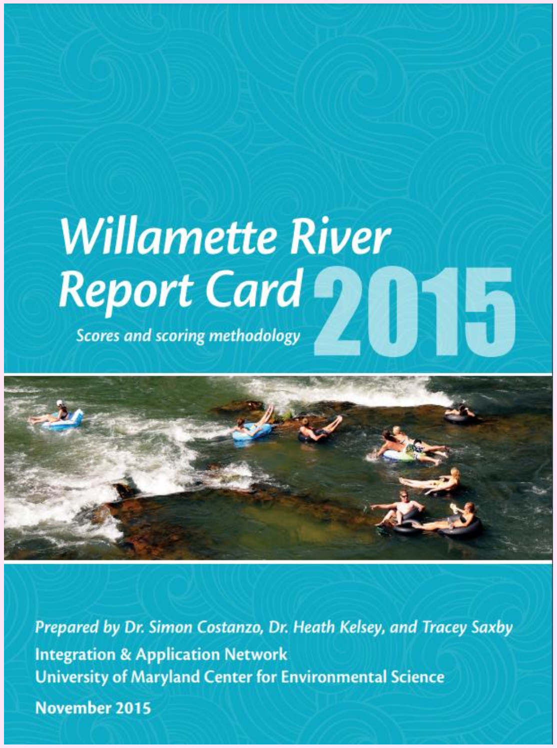
Indigenous perspectives frame all components of the basin as inter-related, and considers all interactions with the basin, whether positive or negative, to be consequential.[7]

Thus, the incorporation of indigenous knowledge systems into indicator frameworks may offer an avenue for more holistic approaches. Including Indigenous knowledge in indicator selection and development will require engagement with Indigenous scholars and shared responsibility among Indigenous communities, non-native basin residents, and external actors.[7]

CASE STUDY

Willamette River Report Card, United States (est. 2016)

The 2016 Willamette River Report Card included an indicator for culturally important fisheries for lamprey, steelhead, and Chinook fisheries. The indicator and analysis methods were co-created with representatives of the Confederated Tribes of the Grand Ronde and Confederated Tribes of the Warm Springs. The indicator was scored based on annual availability of these fisheries and catch restrictions.



Ethnographic approach

In future report cards, biocultural approaches can add a new perspective. Biocultural approaches are a more specific category of social-ecological systems approaches which focus on the localized traditions, knowledge systems, and cultural views which shape and are shaped by a basin. Moving towards a more hybrid approach that includes indicators of mindset, which may be developed through practices like interview analysis and social network mapping, can ensure that indicators are more salient not only for understanding and judging basin conditions, but also for understanding how to change those conditions. Furthermore, adoption of these approaches can foster more productive exchanges between local and external actors and create pathways for identifying the root problems of basin conditions.[12]

Risk, vulnerability, and recovery assessments

Risk in ecological systems is defined as exposure to a hazard or stressor, and risk levels can be modified by conditions of vulnerability and resilience.[47] Vulnerability describes the sensitivity of a system to stressors, and the inability of a system to persist when exposed to changing conditions.[48] Resilience, in contrast, is the capacity to absorb disruptions and adapt to changes. In the context of BRCs, a good proxy for vulnerability and resilience assessments would be the inclusion of leading indicators. Measurements of projected changes and future stressors, including climate change, development, and land cover changes, can be assessed to contextualize indicators of the basin's natural capacity.

In the Mira and Mataje River Report Card, three indicators of climate were included.[49] Remote sensing data were used to determine the number of fires. The additional two indicators included—occurrences of flood and landslides and consequences of human population—used government data[50] and a conceptual and methodological tool for the generation of National Disaster Inventories and construction of databases of damage, losses, and effects of disaster.[51]

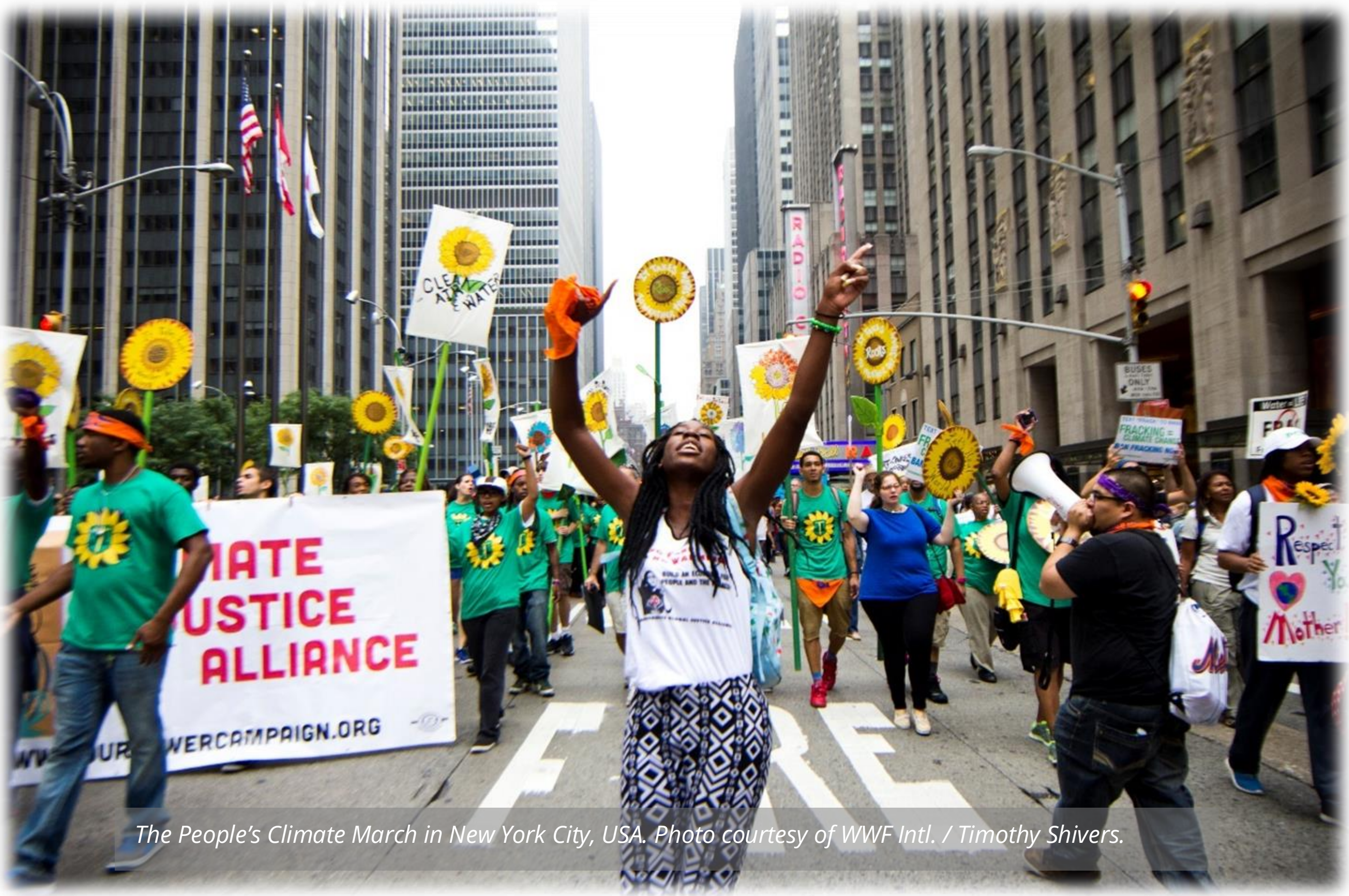
The Rio Grande Basin Report Card, which will be released in 2022, incorporates climates risks using the Resilience by Design method. This concept is based on. The concept is based on decision making under deep uncertainty and systems analysis and offers methods for planning and managing for the reliance of critical infrastructure.[52] The six steps include: (1) holding stakeholder workshops; (2) defining the water system; (3) gathering any existing data and models; (4) conducting a vulnerability assessment to validate the baseline model; (5) searching for optimal combinations; and (6) exploring the results.[52] Overall, this method adds a new dimension to the BRC process by assessing and reducing the vulnerability of communities.

Seasonal changes in physical and biological conditions can reveal a great deal about environmental variation and climate change.[47] Other possible indicators include freeze and frost dates on land and freshwater systems, and seasonal variation of ecosystem services, such as wildfire season or occurrence of flooding, as well as seasonality of migrations or mating seasons. Such indicators reflect just a few potential reactions to climate change, and they are relatively easy to monitor and measure.[47]

3D modelling is more frequently being used as a tool to measure impacts of climate change (Bai Ni Takali vessel, Fiji). Photo courtesy of Tom Vierus / WWF-US.

Environmental Justice Index

Due to the realization that social, cultural, and economic indicators must be included into BRCs to get a more holistic understanding of a basin's health, addressing environmental justice as a part of these suite of indicators. In 2021, a framework for developing the Environmental Justice Index (EJI) for the Chesapeake Bay Watershed was developed. Environmental justice requires fair treatment and meaningful involvement of all people, regardless of race, color, national origin, or income.[53] In the framework, four categories of indicators that can be incorporated into an EJI are proximity to hazards, access to green space, management and governance, and environmental financing. While some of these indicators have already been used in BRCs, the EJI can put more focus and highlight any existing inequities within a basin. The purpose of an EJI is to provide transparency and accountability to the socio-environmental dimension of BRCs.[53]



The People's Climate March in New York City, USA. Photo courtesy of WWF Intl. / Timothy Shivers.

Conclusion

Understanding the health of a freshwater basin, bay, or estuary ecosystem is challenging. These aquatic regions are the keystone of complex and interdependent social, ecological, political, and economic systems. A healthy basin, bay, or estuary is vital for countless development priorities, from conservation to cultural heritage to economic productivity, and definitions of health for each of these priorities may differ, and in some cases, come into conflict.

Balancing multiple conceptions of health in dynamic ecosystems can pose significant challenges, but the use of indicators for water resource management and the development of associated basin and ecosystem report cards has helped practitioners make management decisions across the diverse geographies of WWF and UMCES partner communities.

As demonstrated in this review, each report card iteration can reveal valuable insights about the overall health for basins, bays, and estuaries and where attention is needed to improve or maintain health. Refining indicator selection will be a continuous process, but this review and guidance document represents a strategic evaluation of progress over the past few decades.

Report cards from the past five years represent an exciting turning point as the use of indicators has expanded into more interdisciplinary assessments with the inclusion of human-focused categories. As indicator frameworks continue to expand, there is potential for more rich and varied Management and Governance, Social and Cultural, and Economy indicators.

As regions across the world continue to anticipate major changes due to climate change, globalization, economic development and more, a robust and vast set of indicators will provide invaluable tools for the empowerment of communities and their leaders across the globe.

Child and mother near a small river, looking for small animals. Photo courtesy of Michiel van den Bergh / WWF.

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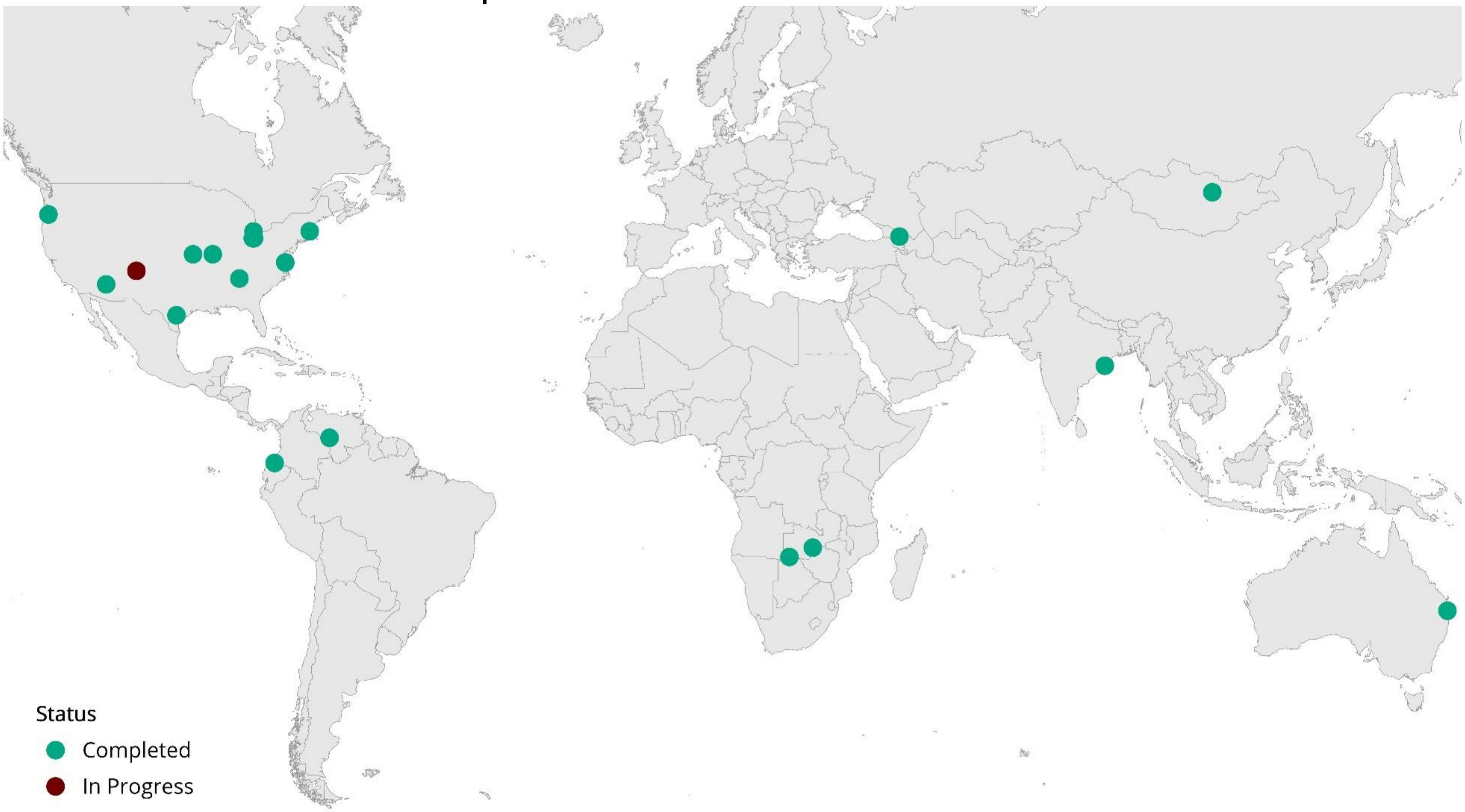
Annex

Annex 1: Locations that BRCs have been developed.



Number	Report Card	Countries	Years	Link
1	Southeast Queensland / Moreton Bay	Australia	2001-2020	https://reportcard.hlw.org.au/
2	Kura River Basin-South Caucasus Region Transboundary Report Card	Georgia, Armenia, and Azerbaijan	2009	https://ian.umces.edu/publications/south-caucasus-region-transboundary-report-card/
3	Chilika Lake Ecosystem Health Report Card	India	2012	https://ian.umces.edu/publications/2012-chilika-lake-ecosystem-health-report-card/
4	Old Woman Creek Report Card	United States	2012-2020	Pipe Creek, Ohio 44870
5	Pipe Creek Report Card	United States	2012-2020	https://erieconserves.org/your-home/watershed-report-cards/
6	Mills Creek Report Card	United States	2013-2020	https://erieconserves.org/your-home/watershed-report-cards/
7	Willamette River Report Card	United States	2015	https://ecoreportcard.org/report-cards/willamette-river/publications/
8	Mississippi River Watershed Report Card	United States	2015, 2020	https://ian.umces.edu/publications/2020-mississippi-river-watershed-report-card/
9	Orinoco River Basin Report Card	Colombia	2016	https://ian.umces.edu/publications/orinoco-river-basin-report-card-2016/
10	A Report Card for the Tennessee River Basin	United States	2017	https://ian.umces.edu/publications/tennessee-river-basin-report-card/
11	Sudbury-Assabet-Concord River Report Card	United States	2018	https://ecoreportcard.org/report-cards/sudbury-assabet-concord-rivers/publications/

12	Tuul River Basin Report Card	Mongolia	2019	https://ian.umces.edu/publications/tuul-river-basin-report-card-2019/
13	Blue River Report Card	United States	2019	https://www.heartlandconservationalliance.org/blue-river-report-card
14	Reporte de Salud de las cuencas binacionales de los ríos Mira y Mataje	Ecuador and Colombia	2019	https://www.wwf.org.co/de_interes/?uNewsID=350772
15	Chesapeake Bay and Watershed Report Card	United States	2019-2020	https://ecoreportcard.org/report-cards/chesapeake-bay/
16	Verde River Watershed Report Card	United States	2020	https://ian.umces.edu/publications/2020-verde-river-watershed-report-card/
17	San Antonio River Basin Report Card	United States	2020	https://www.sariverauthority.org/report-card-basin/2020#about-the-report-card
18	Lower Kafue Basin Report Card	Zambia	2020	https://ian.umces.edu/publications/lower-kafue-river-basin-2019-report-card/
19	Western Lake Erie 1st Report Card (Includes the basin)	United States	2020	https://ian.umces.edu/publications/western-lake-erie-1st-report-card/
20	Kwando River Basin Report Card	Angola, Namibia, Botswana, and Zambia	2022	https://ian.umces.edu/projects/kwando-river-basin-report-card/
21	Upper Rio Grande Resilient Basin Report Card	United States	In progress	https://ian.umces.edu/projects/rio-grande-resilient-basin-report-card/