

# RESILIENT RIVERS **BLUEPRINT**

PROTECTING OUR RIVERS FOR  
FUTURE GENERATIONS



International RiverFoundation • IW:Learn  
Healthy Land and Water • Deloitte  
University of Maryland Center for Environmental Science

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## Resilient Rivers Blueprint

Rivers are the lifeblood of civilizations and communities have formed intimate relationships with rivers for millennia. But the relationships that communities have with rivers are changing rapidly due to disturbances exacerbated by population increases and climate change. Developing resilience to disturbances is becoming a priority for river communities so we have created a novel partnership, the Resilient Rivers Blueprint, that will **create a new way of managing rivers** in a world undergoing a dramatic acceleration of change.

The considerable efforts that have been expended in developing monitoring, modeling and management capacities have been important for the protection and restoration of rivers globally. But the frequency, severity and unpredictability of disturbances has complicated the effective monitoring, modeling and management of rivers. Therefore, **a transformation in thinking** is needed to ensure that the important relationships that communities have with rivers can continue into the future.

The Resilient Rivers Blueprint differs from most other management approaches in that the focus is on protecting rivers, not just for the current generation, but for **future generations**. This long-term time horizon leads to some subtle, but crucial differences in management priorities. These changes in management priorities include a) establishing stable institutional arrangements, b) developing a systems approach, c) securing financial security and d) embracing an adaptive management framework. The Resilient Rivers Blueprint has developed a rigorous holistic assessment process to evaluate a community's resilience through a series of simple qualitative self-assessments, followed by a quantitative independent assessment.

The combination of population pressures and climate change provide **unprecedented challenges** for river managers. River management has been evolving over time and integrated river basin management has become the standard management approach. But due to the rapid rate of change that lead to an increased frequency and intensity of disturbances to rivers and

their associated communities, **a new management framework is needed**. The Resilient Rivers Blueprint addresses the need to develop management strategies that can lead to more resilient communities and rivers.

The Resilient Rivers Blueprint is **targeted** for a) river managers, b) practitioners in river related organizations, c) scientists who work with river communities and managers, d) community organizers, e) river basin organizations, and f) interested parties.

The Resilient Rivers Blueprint provides the overarching framework to enable river basins to become more resilient. **The Resilient Rivers Blueprint is not just another plan**. It sets out the vision, principles and goals to complement and add value to existing river basin planning. The Resilient Rivers Blueprint is comprised of the following components:

- River Journey
- River Personality
- River Resilience Report Card
- Resilient Rivers Hub

A **unique partnership** comprised of academic, NGO and business partners has been formed to address the critical issue of river resilience. The founding partners are the International Riverfoundation, IW:Learn, Healthy Land and Water, Deloitte, and the University of Maryland Center for Environmental Science. Each organization brings different strengths to the partnership. The International Riverfoundation serves a convening role in the Resilient Rivers Blueprint. Healthy Land and Water brings experience in incorporating science into the planning, policy and management realm. The University of Maryland Center for Environmental Science has been pioneering science communication, environmental report cards and stakeholder engagement which will inform the resilient rivers report card. Deloitte helps organizations internalize strategies for dealing with change, a critical component of the Blueprint. IW:LEARN has experience in developing learning communities that will help the Blueprint accelerate transformative changes in river management.

A short description of the relevant aspects of the founding partners follows:

**International Riverfoundation (IRF):** An international NGO that facilitates leadership, celebration and collaboration for better river management. IRF convenes an annual International Riversymposium and awards the Thiess International Riverprize in addition to smaller regional Riverprizes. IRF is building a global community of river leaders to champion the health and resilience of rivers around the world.

**IW:LEARN** (International Waters Learning Exchange and Resource Network): A global project of the Global Environment Facility (GEF) established to strengthen transboundary water management around the globe by collecting and sharing best practices, lessons learned, and innovative solutions to common problems. IW:LEARN promotes learning among project managers, country officials, implementing agencies, and other partners.

**Healthy Land and Water (HLW):** A profit for purpose, member based organisation in Southeast Queensland, Australia, dedicated to protecting and improving our natural resources and environment. HLW operates within a complex governance system, working with, and relying

upon, a variety of partners and stakeholders. HLW delivers innovative, evidence-based, solutions to environmental challenges and to inform transformational change. HLW partnerships and links to community ensure on-ground actions deliver impact. HLW navigated the River Journey, pioneering science communication and environmental report cards, which continues to support and inform decision-makers.

**Deloitte:** A multinational professional services company specializing in accounting and risk management. Deloitte services include auditing, consulting, financial advisory, risk advisory, tax and legal. Deloitte strives to make impacts that matter and has an important role in environmental stewardship.

**University of Maryland Center for Environmental Science (UMCES):** A research and educational institution working to understand and manage the world's resources. Research from the mountains to the sea and from genes to ecosystems is conducted at laboratories located on Chesapeake Bay, USA and in its headwaters. The Integration and Application Network (IAN) within UMCES was created to solve, rather than just study, environmental problems by pioneering science communication approaches, socio-environmental report cards and effective stakeholder engagement.

In addition to the founding partners, a global assemblage of **Independent Science Members** has been recruited to aid in the development of the Resilient Rivers Blueprint. These members bring an incredible wealth of academic and practical experience to the Resilient Rivers Blueprint team:

Mr. Vladimir Mamaev, Regional Technical Advisor, International Waters, United Nations Development Programme, based in Europe.

Dr. John Matthews, Coordinator and co-founder of the Alliance for Global Water Adaptation (AGWA), based in the USA.

Dr. Paul Maxwell, Research and Development Specialist at Alluvium Consulting, based in Australia.

Dr. Qinghong Pu, Assistant Director, International Engagement, Australia Department of Agriculture, Water and the Environment, based in Australia.

Dr. Niels Vlaanderen, Coordinator, International Water at the Dutch Ministry of Infrastructure and Water Management, based in Europe.

Mr. Ivan Zavadsky, Executive Secretary of the International Commission for the Protection of the Danube River, based in Europe.

# Definition of River Resilience

There are many definitions of resilience that have been developed from ecological theory, social science, and common usage in language. The use of the term resilience is widespread and commonly employed in a range of areas, including disaster response, climate adaptation, community and ecological resilience and infrastructure design, among others.

Resilience thinking starts from the belief that people and ecosystems are inextricably linked, to the point that they should be viewed as one social ecological system (SES) or as a coupled human and natural system. Resilience thinking is about increasing our knowledge on how we can strengthen our capacity and adapt and respond to stresses caused by social, economic and environmental change in the form of unexpected events and crises, but also due to rapid change (e.g., population growth, climate extremes).

Resilience has traditionally been considered to be the ability of a system to resist change and then recover from disturbances. But the pace of change has been accelerating and the almost constant disturbance regimes that rivers are facing has made resistance more difficult and sometimes even futile. So the concept of resilience needs to include adaptation to disturbances and continually learning from these experiences so that rivers and their associated communities can be transformed into a more resilient systems.

Resilience can mean many different things to different people, so we have developed a definition that stems from the resilience literature, but also attempts to be practical and aspirational. At the most simple level, river resilience can be considered the ability of a river and its associated community to be there in a recognizable form tomorrow. But even though it may still be there in a recognizable form, it will likely be different after going through a tough time.



Figure 1. Definition of River Resilience.

Our definition of river resilience, which is derived from the Stockholm Resilience Center’s definition, is the following:

**River Resilience** is the capacity of a river system and its associated communities to quickly *recover* from disturbances, *adapt* to changes

without collapsing, and to **transform** through innovation and implementation of resilience strategies.

The key verbs in this definition of river resilience are **recover**, **adapt** and **transform**. These verbs are in order of a) usage, and b) difficulty to implement. **Recover** is one of the most common words used to define resilience, and recovery is typically the first priority of a community that is responding to a disturbance (e.g., flood, drought, environmental disaster). The second verb, **adapt** is less commonly used with respect to resilience, although as climate change becomes more relevant and pervasive, adaptation has become more commonly used. The final verb, **transform**, is relatively rare in the resilience literature and represents a major shift in perspectives and requires considerable effort to achieve. Behavior change is difficult and, as a result, transformation is not common. Thus, the transformation through innovation and implementation strategies is what the Resilient Rivers Blueprint is fostering.

The key to the Resilient Rivers Blueprint is to map out a path toward river resilience, regardless of where you are on the resilient rivers journey (discussed below). There are various strategies and actions that can be employed to build river resilience. Building resilience requires taking a systems approach, making the right institutional arrangements and obtaining the needed financial support. Achieving resilience requires a flexible and cross-sectoral management approach that has an ecosystem-based foundation.

There are some resilience attributes that have been identified as being essential for building river resilience, derived from a review of resilience frameworks (e.g., Stockholm Resilience Center, Rockefeller Foundation). The following resilience attributes are 1) resistance, 2) inclusivity, 3) integration, 4) redundancy/back-up, and 5) flexibility. Each of these will be discussed below.



RESISTANCE

**Resistance** refers to the attribute of systems to withstand and adapt to threats without changing the services they provide. Examples include - critical habitat, which comprises species that are tolerant to chronic impacts or can withstand shocks up to a point; or, infrastructure (e.g. roads and bridges) that is well designed, constructed and managed to ensure that it can withstand shocks and will not fail catastrophically when design thresholds are exceeded.



INCLUSIVITY

**Inclusivity** refers to the ability to engage with broad consultation and collaboration across all stakeholders to create a sense of shared ownership or a joint vision to build resilience. Informed, engaged and well-functioning participation leads to a shared understanding and builds trust. Involving a broad range of stakeholders from diverse backgrounds can identify new perspectives, fill gaps and strengthen the links between data gathering and decision-making.



INTEGRATION

**Integration** refers to systems that bring together a range of social, economic and environmental processes and governance across a range of scales and can also catalyse additional benefits as resources are shared. For example, integrated plans enable river basin managers to address multidisciplinary issues, such as climate change, disaster risk reduction or emergency response through coordination.



**Back up** refers to systems that incorporate multiple components that can perform the same function, so that the loss of some components does not jeopardise the entire system. Examples include a diverse network of protected areas so that each will not be equally affected by an impact; or by providing multiple transport routes/supply chains so that if some are impacted it will not impact on regional transport or food supplies.



**Flexibility** encourages multiple sources of knowledge, which promotes adaptability and means that people and institutions can modify their behaviour and adopt alternative strategies in response to past experiences, changing circumstances or shocks. For example, using the experiences from a flood to implement changes to society and infrastructure to ensure better resistance to and recovery from future events.

## Resilient Rivers Journey

Rivers are complex, dynamic systems. River complexity includes their bifurcations and branching, diverse geomorphic forms (pools, riffles, meanders, bars) that produce the heterogeneous habitats essential to support the complex terrestrial and aquatic ecosystems that they support. In addition, rivers are both dramatically influenced by human actions and they, in turn, dramatically influence human actions. Rivers are dynamic, with variable flows and variable geomorphologies complicated by the effects of water management flood management and climate change. Both positive and negative feedbacks occur in river systems, further enhancing the dynamic nature of rivers.

There are various phases of human interactions with rivers, starting with the origination phase. This is followed by an exploitation phase, a mitigation phase, and then a reconciliation phase. The ultimate goal is to undergo a transformation to become a resilient river.

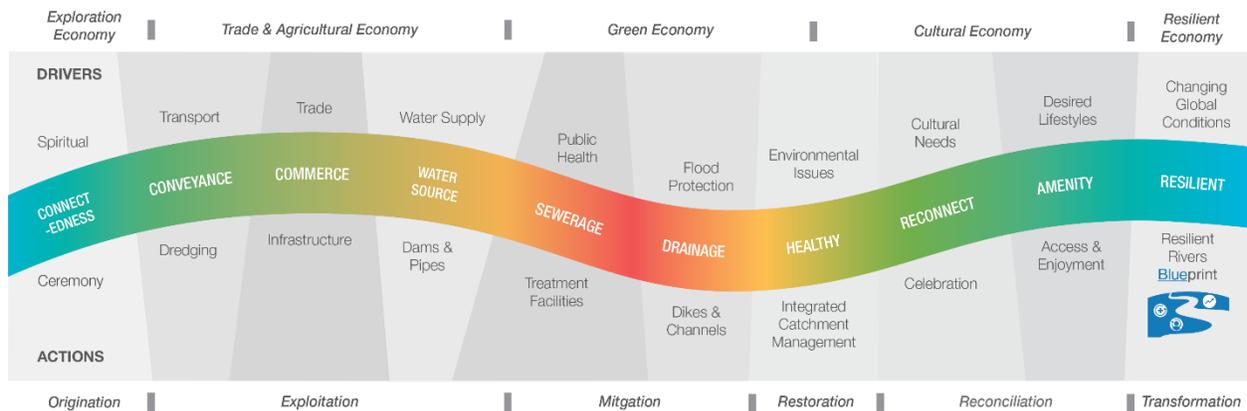


Figure 2. The Resilient Rivers journey.

### Origination phase

Origination occurs with the initiation of human contact, where people develop connectedness with rivers. Honoring past ancestors and recognizing the timeless nature of rivers is a key to the connectedness people feel with rivers. There is often a spiritual connection that people have with rivers, and this is evident in historical references to rivers beginning in ancient cultures. People often create ceremonial events associated with rivers like baptisms, weddings and funerals. Today, ecotourism is a major driver for people in modern societies to reconnect with this spiritual aspect of rivers, so an exploration economy has developed.

Since access to safe drinking water is one of the most fundamental of human needs, the first human encounter with rivers is often a result of the search for a reliable water source. Another form of early encounters with rivers is via a transportation mode since sailing ships and human powered craft (e.g., canoes, longboats) used water as the major means of transportation.

### Exploitation phase

The exploitation phase of human interactions with rivers includes three utilitarian uses of rivers as they support 1) conveyance, 2) commerce and provide 3) a water source for agriculture and drinking water. In this phase, a trading and agricultural economy are supported by the river uses.

The driver for conveyance is transport as rivers preceded roads and railroads as the major mode of transport. Beginning in the late 1800s, mechanized dredging allowed rivers to be dredged to support transportation. The driver for commerce is trade, as rivers can be used to transport goods between different locations and even serve as ports in some cases. Conveyance via rivers preceded railroads and road transport, thus early settlements were often river based. Shore-based infrastructure is created to support commerce, and often dredge and fill operations are used to enhance land creation for commercial activities. Navigational aids are also part of the needed infrastructure to support commerce.

The basic human need for freshwater supply is an important driver for using rivers as a water source. River diversions have been used since ancient times for agriculture and drinking water. Water is diverted from rivers, often using dams and weirs and pipes to transport water to the agricultural fields or municipal supplies for drinking water. The other major driver for dams is the creation of hydropower, beginning with the creation of small dams and millponds to generate power to operate various mechanical devices (e.g., sawmills, grain mills), and evolving to the development of large dams to generate electricity through turbines in the dam. Dams were also created to provide flood protection for human settlements downstream of the dams.

### **Mitigation phase might be consistent - sewage or sewerage**

The mitigation phase of human interactions with rivers includes three aspects in which people use rivers to cope with 1) sewage and 2) drainage/floods and 3) recover some ecosystem services to establish healthy waterways. A green economy has developed to support mitigation efforts, powered by innovations in sewage treatment and stormwater abatement approaches. Large public investments in sewage and stormwater controls are accompanied by a myriad of smaller investments in the private sector.

The driver for sewerage, drainage of human waste provided by sewers, is in the interest of public health. As human populations grow alongside rivers, the need to dispose of human waste becomes crucial to avoid water borne diseases like cholera. Beginning in the late 1800s, sewage treatment has become increasingly sophisticated, but rivers are still a major disposal site of treated sewage in many parts of the world.

A major driver is for flood protection from both a) high flows associated with high precipitation events and b) high water levels from storm surges that extend inland from the sea. Rivers are used as a mechanism for drainage, particularly when they are channelized with dikes or levees to separate the river from its associated flood plain. The need for dams and reservoirs is a response to droughts, so that a more reliable water supply is available. But dams and reservoirs come at a cost to ecological function. Many rivers were dammed and along with various other flood protection works (e.g., dikes, training works, dredging, channels, levees), have had the natural function of rivers and their associated floodplains dramatically altered. The separation of rivers from their natural floodplains can result in the collapse of various fisheries dependent on the river and floodplain connectivity. In addition, soil fertility of floodplain fields, often very productive agricultural land, is also linked to periodic flooding.

### **Restoration phase**

The driver for creating healthy waterways are environmental issues that occur when various substances enter the river, degrading water quality (e.g., human waste, sediments, nutrients and toxicants). While sewage treatment facilities can be used to mitigate urban runoff, in order to deal with various diffuse sources throughout river basins, integrated catchment management is needed.

## **Reconciliation phase**

Reconciliation is motivated by the deep human need to connect with nature, coined “biophilia” by E.O. Wilson (1984). The reconciliation phase of human interactions with rivers includes 1) reconnecting with rivers and 2) creating amenity. A cultural economy has developed to allow people to access rivers using ferries, bikeways and walking paths, kayak and canoe rentals, tour boats, and riverside parks, including restaurants, bars, and shops.

The driver for reconnecting with rivers is from a cultural perspective. People attempt to recreate the original and primal bond that people have with rivers. This form of human expression can be river celebrations, and/or embracing arts, sports and various recreation pursuits.

The driver for creating river amenity is the desire for river focused lifestyles. This is often manifested as a transition from communities who have structures and views that face away from the river to communities who have structures and views that face toward the river. River access that provides opportunities for people to enjoy the river enhances river amenity.

Reconciliation with respect to rivers can take many different forms. Some stream and river restoration efforts do not address the underlying water quality or riparian and watershed health issues, rather just turn the stream or river into an “elongated fountain”. These public works may provide amenities like walking tracks, cultivated gardens and views that represent an extension of the exploitation phase, rather than a true reconciliation in which the natural functions of the river are enhanced. Ideally, both the human amenities and natural functions are enhanced so that iconic species like salmon (e.g., Rhine River) or river otters (e.g., Thames River) return, in addition to providing more access and amenities to enhance the human enjoyment of the stream or river.

## **Transformation phase**

The transformation phase is the shift to resilience that is the goal of the Resilient Rivers Blueprint. A resilience economy is envisioned for this phase of the river journey. In this economy, restoring river connections to the flood plain, allowing the ‘River to Roam’, providing migration corridors for biota, and reimagining the human interactions with rivers can occur. This transformation often comes under the rubric ‘Nature Based Solutions’ in which solutions are “inspired and supported by nature”. These approaches bring diverse natural processes into solutions to environmental issues.

The drivers for this shift are the massive changes due to a) climate change impacts to rivers due to changing temperatures, precipitation patterns and storm intensity, for example, and b) population increases that lead to land use alterations, intensified agriculture, dense human development. The combination of these changes means that managing for historical and even current conditions must be replaced with managing for river resilience to recover from disturbances, adapt to changes without collapsing and transform through innovation and implementation of resilience strategies. Ultimately, it means that river communities can envision a future resilient river in a desirable state.

## River ‘Personalities’

Rivers have different ‘personalities’, reflecting their unique geology and landscape topography, geography, culture, political governance structures (transboundary, different environmental laws) and economics that shape each river and associated human communities. The word ‘personality’ as it applies to rivers refers to the characteristic set of river and river community behaviors that are exhibited from the environmental and cultural factors that affect rivers.

An emerging trend is providing rivers with the same rights as a person. For example, the Whanganui River in New Zealand was granted these rights based on the indigenous Maori people who considered the river to be an ancestor of the Whanganui iwi people. So, assigning personality traits to rivers has some precedent.

Some large rivers have multiple personalities, with different river reaches exhibiting different characteristics. For example, a large river may have sections in the upper catchment that are relatively pristine, attracting ecotourism, but the lower reaches may be highly industrialized or urbanized.

By defining different river personalities, various strengths and weaknesses can be identified which can lead to tailored recommendations for different rivers. In addition, a library of rivers with similar personality traits can be identified to facilitate exchange of ideas and lessons learned.

	HIGHLY COMPLEX	LESS COMPLEX	HIGHLY COMPLEX	LESS COMPLEX
PREDICTABLE	<b>HUP</b> <b>Working</b> Rhine	<b>LUP</b> <b>Provider</b> Pasig	<b>HCP</b> <b>Iconic</b> Ganges	<b>LCP</b> <b>Vital</b> Amazon
EPISODIC	<b>HUE</b> <b>Recurrent</b> Mississippi	<b>LUE</b> <b>Supplier</b> Hudson	<b>HCE</b> <b>Ambitious</b> Brisbane	<b>LCE</b> <b>Seminal</b> Whangawehi
	<b>UTILITARIAN</b>		<b>CULTURAL/SPIRITUAL</b>	

Figure 3. River Personality matrix

In order to categorize river personalities, a dichotomous suite of 3 characteristics were used to differentiate different river personality traits. **1) Complexity, 2) Human engagement and 3) Flows.** These personality traits were selected because they do not involve a quantitative assessment (e.g., condition status or improving vs. degrading condition). The quantitative assessment is being reserved for the river resilience report card. Instead, the effort was to select those traits that are largely independent of one another and that do not vary rapidly. Each of these traits are considered below.

- 1) Complexity:** There are many different facets of river complexity. The size of the river, its watershed (or catchment, basin) and the size of the human population associated with the river is a key element of complexity. Larger river systems and larger human populations are inherently more complex. The complexity of the governance arrangements of rivers is also important. For example, issues associated with transboundary rivers are often noted as being more complex. The number of levels of government that the management of a river and its associated communities adds to the complexity of managing the system. The diversity of issues that a river and its associated community is faced with contributes to the complexity. Most rivers are multi-use, but some have more uses than others, as depicted in the River Journey. Finally, another facet of complexity is the number and diversity of actors or institutions who interact with the river. This diversity adds to the complexity of the river system.
- 2) Human engagement:** Rivers which are used largely for the utilitarian purposes like water supply, sewage discharges, port development and flood management are contrasted with rivers used for largely cultural or spiritual uses such as amenity, healthy waterways, reconciliation with spiritual values. While multi-use rivers often serve both utilitarian and cultural needs, there exists a spectrum of the overriding value that society places on rivers.
- 3) Flow regime:** Rivers with predictable flows are distinguished from those with episodic flows that are difficult to predict. Predictable flows can result from a) rivers with their headwaters in high mountains that rely on snowpacks, b) rivers that have predictable seasonality (e.g., monsoonal climates), or c) rivers in which flows are manipulated and managed by humans (e.g., dam releases). Rivers with episodic flows that are difficult to predict include rivers with ephemeral flows and rivers in climatic regimes with highly variable precipitation (e.g., Australia).

There are eight possible combinations of the complexity, human engagement and flow regime dichotomies. Each combination is a unique river personality, described as follows:

**Working:** (HUP: Highly complex, utilitarian, predictable flows)

This river personality is one that often supports large human populations, with highly complex rivers and associated communities due to the large populations. The heavy reliance on the river

results in its utilitarian rating and the predictable flows allow for irrigation and drinking water security. These rivers are used for commerce and trade, as conduits for sewage disposal. Dams for flood management, hydropower and water supply are common. These rivers are viewed by their communities in the context of what they provide in terms of goods and services. An example of a Working River is the Rhine River in Europe. This river won the 2014 Thies International Riverprize.

**Provider:** (LUP: Less complex,utilitarian, predictable flows)

This river personality is less complex due to its relatively small size and number of organizations involved. Flows are predictable which enhances their utilitarian uses, but there is less cultural or spiritual connection with these rivers. This river personality has multiple uses, providing a versatility of human interactions. An example Provider River is the Pasig River in the Philippines which connects Laguna de Bay, maintained as a freshwater aquaculture and fishing resource, and Manila Bay, running through downtown Manila. This river won the 2018 Asia Riverprize.

**Recurrent:** (HUE: Highly complex, utilitarian, episodic flows)

This river personality has a highly complex suite of features, including large size, with multiple governance levels, issues and actors involved. These rivers support considerable and diverse uses, and the utilitarian use of these rivers is multi-faceted. These rivers are influenced by the episodic nature of the flows, but in spite of this, they are heavily utilitarian. An example Recurrent River is the Mississippi River, which is the third largest watershed in the world, with 2 countries, 31 states and numerous municipalities involved. Flows vary considerably from year to year, alternating between large floods and droughts which compromise the drinking water supplies and navigation channels.

**Supplier:** (LUE: Less complex, utilitarian, episodic flows)

This river personality is less complex due to smaller watersheds and less governance levels. These rivers are heavily utilized and have episodic flows due to the lack of major dams or high altitude headwaters. An example of a Supplier River is the Hudson River in New York, which is heavily utilized by industry, drinking water supplies, and shipping. It is managed largely through one state and federal government and has a limited number of actors and institutions involved in its management.

(HCP: Highly complex, Cultural/spiritual, Predictable flows)

This river personality is iconic in that it is highly complex, has a strong cultural or spiritual connection with predictable flows. Water availability is not taken for granted, in spite of predictable flows that often are a result of high altitude headwaters. The spiritual/cultural connection has helped the communities associated with these rivers value these rivers. As example of an Iconic River is the Ganges in South Asia, which serves as a major Hindu sacred site, and helps sustain one of the world's largest populations with its predictable flows.

**Vital:** (LCP: Less complex, Cultural/spiritual, Predictable flows)

This river personality is one that has strong cultural and spiritual connections, but is less complex. The predictable flows of these rivers have supported human populations for

millennia. An example of a Vital River is the Amazon River. It is extremely large, but the complexity is low due to the watershed being largely in one country (Brazil) with a limited number of actors and institutions involved. It has strong spiritual connections for the indigenous populations and ecotourists who visit.

**Ambitious:** (HCE: Highly complex, Cultural/spiritual, Episodic flows)

This river personality is one that highly complex as a result of the large size and multiple governance arrangements, diverse issues and actors involved. These rivers are ambitious in that they have both a utilitarian history but a reconnection to enhance the cultural and spiritual aspects. The episodic flows are a result of the lack of high altitude headwaters and incomplete damming. An example Ambitious River is the Brisbane River in Queensland, Australia. This river has irregular flooding and has a complexity of issues and governance levels.

**Seminal:** (LCE: Less complex, Cultural/Spiritual, Episodic flows)

This river personality is one with less complexity, largely due to small size. There are strong cultural and spiritual connections to these rivers. The episodic flows are a result of small watersheds with variable precipitation. An example Seminal River is the Whanganui in New Zealand, a small river highly valued by the indigenous Maori people. This river won the Australasian Riverprize in 2018.

These different river personalities are relatively fixed in terms of their major traits. 1) Complexity can evolve largely in terms of the human engagement elements, but even those are often a function of size and number of issues associated with each river. 2) Human engagement can evolve as evidenced by the River Journey, but these transitions take decades to centuries to alter, thus are relatively fixed as a river personality trait in the time frames of assessment. These human engagement transitions also require considerable investments of time and resources. 3) Flow regimes are relatively fixed in terms of climatic regimes and headwater sources, but climate change can alter these relationships (e.g., reduced snowpack, altered monsoonal regularity). In addition, the construction of dams can make flows more predictable. Both climate change and dam construction are on the time scales of decades so these aspects of river personalities are relatively fixed in terms of assessment.

## River Resilience Report Card

### Report card background

Report cards are assessment and communication products that compare ecological, social, and/or economic information against predefined goals or objectives. Similar to school report cards, river basin report cards provide performance-driven numeric grades or letters that reflect the status of a river system on a regular basis. They effectively integrate and synthesize large, and often complex, information into simple scores that can be communicated to decision makers and the general public. With expanding digital connectivity around the world, river basin report cards can reach even larger audiences and provide transparency and scientific information to help us make good decisions.

Report cards enhance research, monitoring, and management in several ways. First and foremost, the process of developing a report card facilitates interaction among people, governments, and industries who have different agendas, perspectives, and levels of awareness—often leading to a shared vision of what the future will be, and what is needed to get there. For the research community, report cards can lead to new insights through multi-disciplined data analyses that reveal patterns not immediately apparent, help design a conceptual framework to integrate scientific understanding and ecological and socio-economic values, and to scale approaches that allow for comparison in time and space.

By providing timely and relevant basin status updates, report cards have the added benefit of accelerating management and community response. For basin managers, they provide both accountability and focus by measuring the success of restoration efforts and identifying impaired regions or issues of concern that require resource attention. These elements catalyze improvements in basin health through improved public awareness, peer pressure between communities, and more informed decision makers.

Report cards can provide multiple benefits. By engaging stakeholders and providing easily understandable interpretation, they socialize science and create a shared understanding of the issues facing a river basin. They provide a concise, big-picture understanding of the condition of a basin that can lead to new insights and increase awareness of important issues. By engaging stakeholders directly in the process of creating a report card, we are provided a holistic view that helps balance competing uses and values. Ultimately, a report card is intended to catalyze management action and stakeholder engagement that leads to improvements in river basin health.

Because report cards are data-driven, geographically detailed, and transparent, they lead to shared understanding of regional or use-based differences in condition. This understanding not only increases awareness of important issues by examining differences in condition, it also allows better insights into what works and, as report cards are repeated over time, allows insights into whether interventions to raise the grade are having the intended effects.

River basin report cards provide readily accessible, synthesized, and interpreted information to a wide audience. Traditionally, scientists share their results with their colleagues through a peer review system of scientific publications. These scientific publications or journals generally have restricted access and are difficult to obtain outside of academic libraries and are difficult to understand due to the high level language used in them. But report cards provide a means of delivering accurate information in a timely manner to broad audiences in a more comprehensible language.

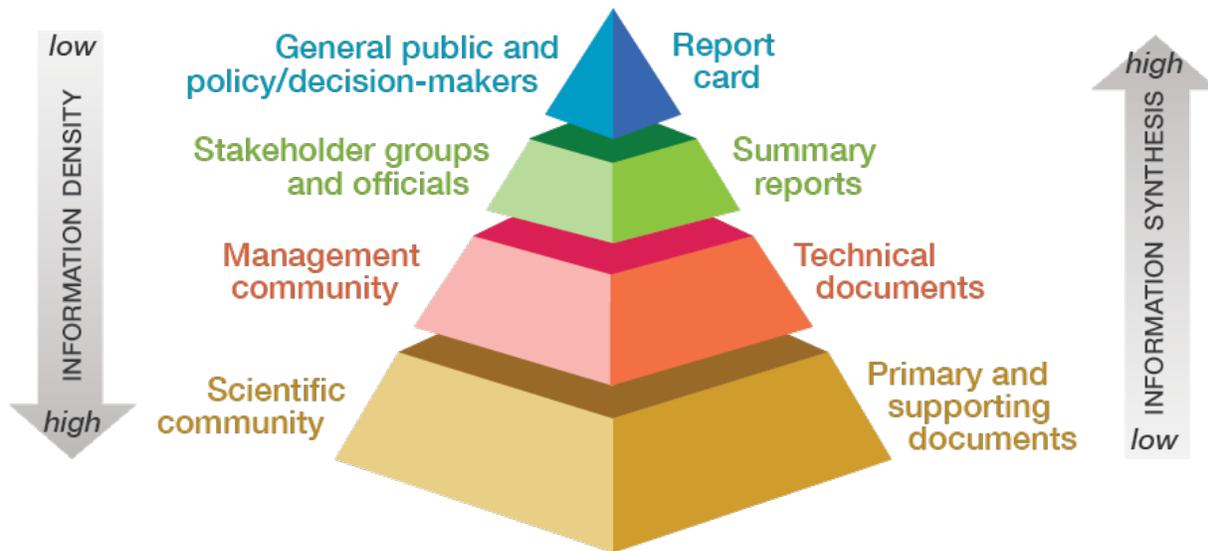


Figure 4. Different communication products based on stages of information synthesis and density.

To produce a report card, consult various stakeholders, including scientific experts, to help select indicators, determine thresholds and obtain data, as well as help with the data analysis and interpretation. In particular, scientific and technical experts are helpful in providing review of methods and results of data analysis. Your report card should include extensive consultation with managers, decision makers, and stakeholders, and communicate results to a wide audience. This distinguishes river basin report cards from scientific publications, in that consultation is open to as many relevant stakeholders as you can include. Publish results using non-technical language and in local languages, and support the results with graphic elements like maps, diagrams, figures, and photos.

Every step in creating a report card involves a diversity of stakeholders. Stakeholders are consulted to develop reporting regions, select indicators, define the period of the year to integrate measurements, and the units and measurement techniques. The report card scoring, design, layout and color palette for the final product is done in consultation with key partners.

Report cards usually receive extensive media coverage. This media coverage aids in the broad dissemination of results. Ultimately, good science addresses fairly basic questions phrased in a manner that is easily understood by a wide audience. The technologies and analyses used to answer these basic questions are often very sophisticated and difficult to explain. But they can be written in the same manner that the original question is framed. In terms of your river basin report card, the basic question is “How healthy is your basin?” This question takes many people and many measurements to answer, but the answer can be equally simple using the report card scoring approach. Employing a stakeholder-driven approach for developing report cards is a process that attempts to engage and solicit input and support from all sectors of society that depend on, or impact, river basin health.

## River resilience

Although river report cards have become well established and employed throughout the world over the past two decades, the development of a resilience report card has not been developed. The intent of the Resilient Rivers Blueprint is to build the capacity to assess, not just the condition of a river system, but also the resilience of the river system. This requires a unique set of goals, objectives, indicators and thresholds for assessment of resilience.

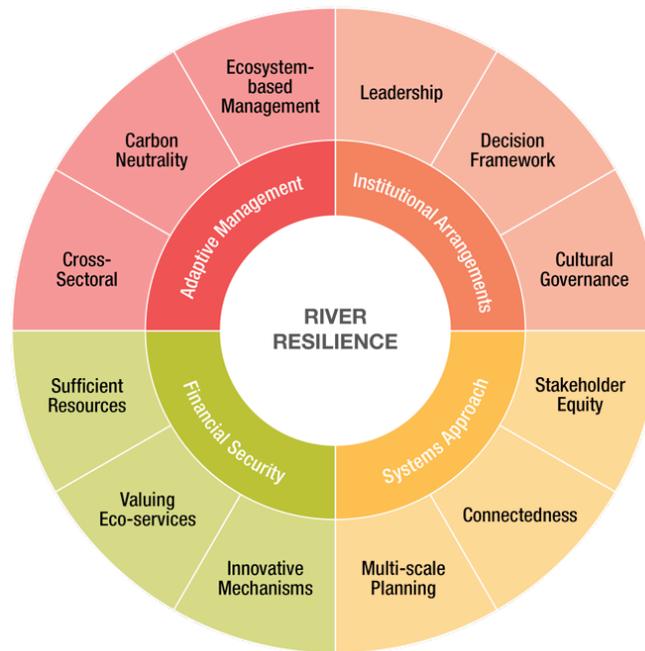


Figure 5. The River Resilience Report Card framework.

There are four major goals of river resilience that have been identified: 1) Institutional arrangements, 2) Systems approach, 3) Financial security, and 4) Adaptive management. These goals are viewed to be cumulative, in other words, the primary necessary component is 1) Institutional arrangements, which include a) leadership, b) decision frameworks and c) cultural governance. Basically, it is key to get the right people in the right organizational structure before anything else can happen. Following institutional arrangements, having a systems approach is the next critical component. In order to tackle a complex issue like resilience, a systems approach which involves a) stakeholder equity, b) connectedness, and c) multi-scale planning is needed. This component is about having the right people working together effectively at the right scale. Following the systems approach, the next critical component is financial security. Financial security is achieved through a) innovative financing mechanisms, b) valuing eco-services and c) ultimately obtaining sufficient resources. This component addresses the need for resources, but it is only obtained by having the right people working together effectively. The final component is adaptive management. Adaptive management is achieved by having a) a cross-sectoral approach, b) carbon neutrality, or even developing a net carbon sink, and c) ecosystem-based management. Effective and responsive adaptive management can only

occur after the right people, working together effectively and supported financially can address the issues through a 'learn-by-doing' adaptive management approach.

Each of the river resilience goals have 3 objectives assigned to them. These objectives represent a broad category and the actual indicators, metrics and data used to assess the indicators may vary from river basin to river basin. To be effective, river resilience report card indicators need to resonate with the local river basin practitioners and stakeholders. And since the river resilience indicators are quantitative, the necessary data needs to be available, which will vary from river basin to river basin.

A more academic approach would be to create a suite of recommended resilience indicators and thresholds that can be applied to any river basin. This way river basins could be more easily rated or compared with one another and stakeholder engagement would be much simpler. But the issue with that approach is that the relevance to the local practitioners and stakeholders would likely be lost. The indicators and thresholds need to be tailored to the local suite of values and threats and to the data available in a particular region. Stakeholders need to be involved in the co-design and co-production of an assessment for it to be meaningful to assessing river resilience in order to help chart the way to build river resilience. Having an outside academic organization provide grades or scores without full stakeholder engagement may produce academic papers, but it will not lead to social change that builds resilience.

### Report card process

A process for creating report cards has been developed through extensive experimentation and experience. This process involves three phases: Phase 1: Planning, Phase 2: Report card process and Phase 3: Raise the grade (Vargas-Nguyen, 2020). Each of these phases will be outlined below.



Figure 6. The Report Card process.

**Phase 1: Planning.** This phase involves the conceptualization of existing knowledge, particularly with regard to the culture of the river basin community and their values. Traditional environmental knowledge from indigenous groups and a diversity of river basin stakeholders is brought to bear. Identifying the key stakeholders and institutions is key, and this can be aided by stakeholder mapping and social network analyses. The design of the report card process with relevant practitioners is important in the planning phase. This includes designing the evaluation methodology up front in order to assess the effectiveness of the report card process and final product(s).

**Phase 2: Report card process.** This phase involves the co-design of the report card with stakeholders and practitioners. Developing the conceptual framework, often illustrated as conceptual diagrams, is an important first step. This is followed by the selection of indicators, which integrates data availability and robustness, balancing various different values, and built through a consensus process involving stakeholders. Determining thresholds is the next step in creating a report card. Thresholds can be derived from management guidelines, literature values or by geographic or historical conditions. Calculating scores by collecting data and comparing to thresholds is the next step. There are multiple ways of integrating seasonal and spatial data, and multiple decisions need to be made to develop a simple methodology that is transparent and can be easily replicated. The final stage of the report card process is co-production in which the practitioners and stakeholders are involved in the process of producing the final report card product.

**Phase 3: Raising the grade.** This phase aims to leverage the report card results to incentivize actions that will raise the grades. The first step is to communicate report cards results widely as possible. It is generally best to involve the highest levels of government that can be entrained into the report card release to help magnify the impact of the release. The development of systems dynamic models is an approach that is being developed to provide prioritized recommendations as to the steps needed to raise the grades. One of the ultimate goals of the report card process is to build capacity through increased social capital obtained through co-design and co-production of products that help form trusted relationships.

## Developing a river resilience blueprint and action plan

The Resilient Rivers Blueprint incorporates the River Journey, the Resilience Report Card, and the Resilient Rivers Hub. Each play a vital role in establishing the tools for building and achieving resilience in your river and community.

**River Journey** is a self-assessment tool to determine where on the spectrum of river uses and desired river aspects your river and community are situated. You will learn about other rivers and communities that are in a similar situation and we will be building a network of best practices for moving toward resilience.

**River Personality** complements River Journey as a second self-assessment tool and refer to a characteristic set of river and river community behaviors that are exhibited from the environmental and cultural factors that affect rivers. **River Personality** recognises that a river can be in several phases of the River Journey.

**Resilience Report Card** is a data integration approach to quantitatively measure key indicators to determine how well you achieving the goals and objectives and hence, building and achieving resilience. Indicators and thresholds will be developed for a variety of case studies and are river basin/catchment-specific.

**Resilient Rivers Hub** is a networking website in which self-assessment tools will be made available for the River Journey and River Personality, as well as a description of how to engage in developing a **Resilience Report Card**. In addition, the **Hub** will provide a forum for the exchange of river resilience knowledge and experience, and more importantly, link to the education platform that underpins the Resilient Rivers Blueprint- *RiverAcademy*.

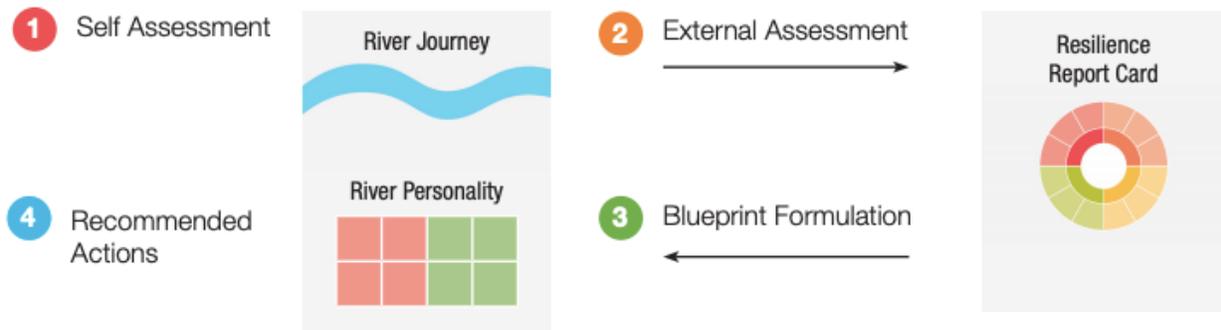


Figure 7. The Resilient Rivers Blueprint: integrating the River Journey, River Personality, Resilience Report Card to recommend actions.

The process of developing a river resilience report card is to first establish the characteristics of the river that will influence the resilience attributes. This can be achieved by selecting the phases of the River Journey that pertain to your river. In addition, selecting the River Personality will also help establish the relevant features that will influence the choice of the resilience indicators and thresholds. These qualitative self-assessments can be compared to other river systems with a growing database (Resilient Rivers Hub) as more rivers conduct the self-assessments, choosing their River Journey and River Personality. Developing cohorts of river systems with similar river journeys and river personalities will aid in networking so that river managers can learn from one another.

The three-phase river resilience assessment process will take both time (18-24 months) and resources (personnel), but it is a necessary step in developing a resilience blueprint. The blueprint lays out the issues that will require responses. Combining the blueprint with River Journey and River Personality will help create a plan of actions to enhance resilience tailored to the river basin.

## Appendix 1: River Resilience Learning Principles

1. River resilience represents a new way of thinking in terms of interacting, managing, and financing.
2. Resilience is the ability of a river and its associated community to recover, adapt and transform.
3. Geography, history, culture and economics shape each river basin and community into their distinct entities.
4. There are many different uses and values of rivers for different communities.
5. No matter the state of the river, the move toward resilience is important.
6. River resilience can be assessed through a rigorous report card process.
7. Resilience requires developing institutional arrangements through leadership, decision frameworks and cultural governance.
8. Resilience requires taking a systems approach through stakeholder equity, maintaining connectedness and undertaking multi-scale planning.
9. Resilience requires establishing financial security using innovative financing mechanisms, valuing ecosystem services and obtaining sufficient resources.
10. Resilience requires managing adaptively by employing cross sectoral approaches, becoming carbon neutral and using ecosystem-based management.

## Appendix 2: Terminology

<b>Term</b>	<b>How it is used in the document</b>
<b>Attributes</b>	Resilience <b>Attributes</b> : resistance, inclusivity, integration, redundancy/back-up, and flexibility
<b>Phases</b>	River Journey <b>Phases</b> : Origination, Exploitation, Mitigation, Restoration, Reconciliation, Transformation
<b>Traits</b>	River Personality <b>traits</b> : complexity, human engagement, flow regime
<b>Goals</b>	River Resilience Report Card <b>goals</b> : adaptive management, institutional arrangements, systems approach, financial security
<b>Objectives</b>	River Resilience Report Card objectives for each goal: <ul style="list-style-type: none"> <li>• Leadership, decision framework, cultural governance (Institutional Arrangements)</li> <li>• Stakeholder equity, connectedness, multi-scale planning (Systems Approach)</li> <li>• Sufficient resources, valuing eco-resources, innovative mechanisms (Financial Security)</li> <li>• Ecosystem-based management, carbon neutrality, cross-sectoral solutions (Adaptive Management)</li> </ul>
<b>Indicators</b>	River basin/catchment-specific Report Card <b>indicators</b> to track achievement of River Resilience Objectives
<b>Components</b>	Resilient Rivers Blueprint <b>Components</b> : River Journey, River Personality, River Resilience Report Card, Resilient Rivers Hub