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Ecosystem Goods Services – using Freshwater Health Index for

Waimanu Catchment

November 2021

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Ecosystem Goods Services – using Freshwater Health Index for **Waimanu Catchment**

November 2021

Prepared by
Conservation International

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Abbreviations

BMI	Benthic macroinvertebrates
CBD	Convention of Biological Diversity
CBO	Community Based Organization
CES	Cultural ecosystem services
CI	Conservation International
DPSIR	Driver, Pressure, State, Impact and Response
DRM	Disaster Risk Management
EBM	Ecosystem based management
ES	Ecosystem Services
FHI	Freshwater Health Index
FNDWS	Fiji National Drinking Water Quality Standard
HSO	Human Security Objectives
IWRM	Integrated Water Resources Management
MEA	Millennium Ecosystem Assessment
MLMR	Ministry of Lands and Mineral Resources
MRD	Mineral Resources Department
NBSAP	National Biodiversity Strategy and Action Plan
NES	National Environment Strategy
NGO	Non-Government Organization
NRC	National Resource Council
R2R	Ridge to Reef
SOPAC	South Pacific Applied Geoscience Commission
SPC	The Pacific Community
TEEB	The Economics of Ecosystem and Biodiversity
WAF	Water Authority of Fiji

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Vuniniudrovu villagers planting vetiver grass to control soil erosion along the Waimanu river.

Executive Summary

Ecosystem goods and service concepts can offer a valuable approach for linking human and nature, supporting arguments for the conservation and restoration of natural ecosystems. Ecosystem goods and services is often considered through the lens of provisioning, regulating and cultural aspects.

Ecosystem Goods and Services is considered in this assessment through the lens of DPSIR is outlined in the Rapid Resource Assessment (CI 2021b) and further unpacked in the National Pilot Project Area Diagnostic Report – Waimanu Catchment (CI 2021a). Information gathered in these reports are used to inform the ecosystem goods services assessment using the Freshwater Health Index.

The FHI is based on a framework that accounts for the interactions between the ecosystem, the services it provides to people, and the water governance and management systems in place in a basin. The Freshwater Health Index (FHI) tool measures ecosystem health by making clear connections between freshwater ecosystems and the benefits they provide to people. It is intended to help track freshwater health over time through an iterative process between scientists, end-users, and other stakeholders so that the result is salient, credible, and useful.

Risk assessment in alignment with the SPC R2R criteria indicates environmental issues by way of priority includes (1) the use of rivers and village sites as dump sites for waste material and effluent discharge; (2) incursion of agricultural practices into the catchment area; (3) growing number of infrastructure development in the lower Waimanu Catchment; (4) growing population in the Waimanu catchment and (5) lack of biodiversity information to ensure informed decisions.

Risk assessment under the FHI framework places ecosystem services to be more important when compared to governance & stakeholder. Under ecosystem services, provisioning services is of priority compared to regulating and cultural services. Sub-indicators under provisioning shows that water supply reliability is by far the most important environmental issue in Waimanu Catchment. Sub-indicators under cultural aspect indicate the need to establish protected areas as the most important environment issue. Under governance and stakeholder, enabling environment is deemed most important while sub-indicators (by way of priority) such as Engagement in decision making process; Strategic planning & Adaptive management; Monitoring & learning mechanism; as well as Information Access are of high priority.

Results from the two tools outlined above indicate synergies and provides the foundation for recommending the development of Integrated Waimanu Catchment Management Plan and involvement of local communities to fully engage in the decision-making process.

Introduction

Ecosystem goods and service concepts can offer a valuable approach for linking human and nature, supporting arguments for the conservation and restoration of natural ecosystems. Ecosystem goods and services is often considered through the lens of provisioning, regulating and cultural aspects. The concept links human wellbeing to the complex interaction of ecosystem functions capturing attention of policy makers and natural resource managers aspiring to improve management while maximizing social, environmental, and economic benefits. Using the lens of goods and services to assess what ecosystems can provide to maximize benefits for human wellbeing enables better appreciation of the intrinsic relationships of ecosystem services - nutrient cycling, soil formation, primary production, and the processes of ecosystem services through provision, regulating and cultural aspects. Natural resource assessment commonly considers key ecosystem services and identify the drivers, pressure, state, impact as well as response (DPSIR) mechanism that will reduce the pressure while improving management (Haines-Young and Potschin, 2010). Considering DPSIR alone simplifies the complex interaction of negative interaction and responses that exists between different activities, economic and social mechanisms (Rounsevell et al., 2010). DPSIR framework is often used to understand influencing factors that affect ecosystem goods and services.

Ecosystem Goods and Services is considered in this assessment through the lens of DPSIR as outlined in the National Pilot Project Area Diagnostic Report – Waimanu Catchment (Conservation International 2021a) and integrating the outcomes with the Freshwater Health Index as a tool to assess perceptions on ecosystem vitality, ecosystem services and governance. Valuation of potential impacts on the above would thus provide opportunities to assess trade-off and select the most suitable response strategy. Integrating ecosystem services and impact on human wellbeing with DPSIR ensures a more holistic approach (Haines-Young and Potschin 2010, Kelble et al. 2013).

A range of assessments for ecosystem services are recognized including the Millennium Ecosystem Assessment (MEA, 2005), the Economics of Ecosystem and Biodiversity (TEEB, 2010) which are carried out at national level. Other assessments analyse ecosystem services by typology of ecosystems (Maes. et al. 2016), Brauman et al. (2007) used the concept of "hydrologic ecosystem services" where each hydrological service is characterized by attributes of quantity, quality, location, and timing to define the benefits people accrue from terrestrial ecosystems.

The current evaluation applied a combination of the SPC R2R criteria through prioritization of environmental issues/problem to inform hierarchy of environmental issues while at the same time applying rapid assessment of the Freshwater Health Index of Waimanu Catchment. Due to time constraints and limitation of COVID-19 restriction, the two tools are used to inform priority issues that will safeguard ecosystem goods and services. A virtual workshop and survey were undertaken by the team to capture participants' perception about ecosystem services, governance & stakeholders in the Waimanu Catchment. A small pool of respondents was captured and although may not be scientifically representative, it provides an indication of the state of Freshwater Health Index in the Waimanu Catchment.

Risk analysis identified key problems that must be addressed to reduce environmental risks. The 'Criteria for prioritizing environmental problems' adopted from SPC Ridge to Reef Island Diagnostic Analysis framework is used to highlight environmental issues within the Waimanu catchment. Environmental issues assessed through the lens of geographical and temporal scale, anticipated future risk, networking and relationship with other environmental problems, benefits, progress in addressing problems and urgency in finding solutions. The main environmental concerns for the Waimanu catchment are: (1) incursion of agricultural practices into the catchment area & the use of river and village sites as dump sites for waste materials and effluent discharge (2) increasing number of infrastructure development in the lower Waimanu catchment; (3) growing population; (4) growing number of infrastructure development in the lower Waimanu catchment (Begg et.al 2021; Singh 2017); Nainoca (1998); and (5) lack of biodiversity information (CI,2021(a).

Using the Freshwater Health Index as a decision hierarchy to quantify priorities between ecosystem services and governance indicates consensus that ecosystem services are of top priority followed by governance and stakeholders. Assessment of ecosystem vitality was not carried out due to limited quantitative information, but qualitative observations are noted in the discussion. The responses indicate an emphasis on provisioning which indicated the perceived importance of ecosystem outputs from freshwater systems - providing benefits towards

human wellbeing. Although water supply and biomass consumption are often considered as stand-alone factors, they are heavily dependent on each other as is evident in the assessment. In Waimanu Catchment, the need for water supply reliability ranked higher than biomass for consumption. At the same time, regulating sediment is more important than water quality, flood mitigation and disease regulation. Under cultural considerations, conservation area is deemed much more important than water related recreation.

Key recommendations of the Freshwater Health Index pertain to the need to protect the headwaters of Waimanu catchment; involvement of iTaukei communities to self-govern natural resources at their bequest through setting up agreed standards for the management of solid, grey, and black water waste. Recognising the potential impact of education and awareness, to encourage the development of citizen science to connect local communities to Water Authority of Fiji and the Ministry of Environment on regular water quality checks. At the same time, the empowerment of existing bodies such as the Yaubula Management Committee which are established at village level by the Ministry of iTaukei Affairs under the endorsement of the Ministry of Environment. These committees provide grassroots support to the Natural Resource Council appointed by the National Environment Council. The adoption of the Village By-Law would provide alignment to Section 16 of the Environment Management Act 2005 and further support the decisions/standards set up by local communities.

Background

Ecosystems pertain to the complex and dynamic habitat of plants, animals and microorganisms in their natural and nonliving environment interacting in a functional unit. The definition of ecosystem services advocated in this assessment is aligned to integrated water resource management which points to the benefits people obtain from ecosystems including provisioning services, regulating services, cultural services and supporting services.

The Waimanu catchment hosts a network of critical river system draining large amounts of freshwater into the Rewa River. It is a sub-catchment of the greater Rewa catchment that is the main water source of the broader south-eastern corridor, with a dependent population of 244,000 people (UN Habitat, 2012). The Waimanu catchment receives freshwater from the upper Wainibuku, Wainimala and Waibau rivers, within the Nausori-Naitasiri corridor. It is an important water source.

Provisioning services such as food, water, timber, and fibre are important for the livelihoods of communities that are directly and indirectly dependent on such ecosystem services. Regulating services affecting climate, floods, disease, waste, and water quality is equally as important as cultural and supporting services of the ecosystem. Cultural services in Waimanu catchment provide recreational, aesthetic, and spiritual benefits to mixed ethnicity that live in or are dependent on the services provided.

The Millennium Ecosystem Assessment (MEA, 2005) aimed to answer key questions linking ecosystem services to human wellbeing - such as the impact of fulfilling human needs on ecosystems and their services, what has caused these changes and how such change affects human well-being? The assessment concluded strong links between the supporting function of ecosystem services to human wellbeing, noting the strong influence of socio-economic factors between provisioning and basic material for good life. Applying the concept to the Naitasiri highlands, technology and ease of communication have resulted in increased agriculture production (CI, 2020). Begg et. al (2021) argued that vulnerability assessments in the Pacific Island context should consider the connection between people's actions and ecosystems through landscape approach since upstream land use practices largely influence flood vulnerabilities downstream.

The TEEB study (Kumar, 2010) aimed to get a better understanding of the dynamics of governance and management of ecosystems and ecosystem services (ten Brink et al., 2011).

In comparison, the MEA 2005, considers ecosystem goods and services from the lens of the benefits people obtain from the ecosystem while TEEB, 2010 considers it as the direct and indirect contributions of ecosystems to human wellbeing. Nevertheless, both studies consider biophysical assessment, social assessment, and economic assessment where each lens of the assessment provides a better understanding of benefits (to human wellbeing) of ecosystem regulating, cultural and provisioning services and vice-versa; anthropogenic impact on ecosystem services. Other, studies have considered ecosystem services as contribution to ecosystem structure and function to support human wellbeing (Burkhard, et al., 2012).

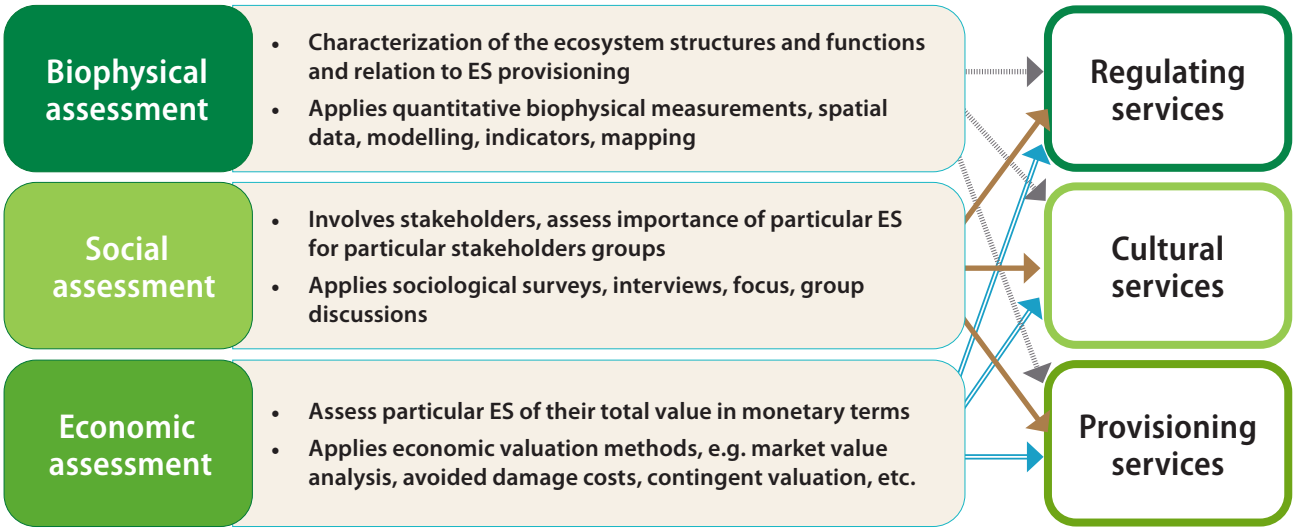

Figure 1: Component of ecosystem services

Ecosystem services is generally understood to be the interaction between people and nature, as presented by Haines-Young and Potschin, 2010; Potschin Young et.al, 2017; Burkhard and Maes (Eds.), 2017 as a cascading model. The model describes the interactions between ecosystem at one end and the human well-being at another (Fig. 2). The ecosystem within the cascading model is characterized by its biophysical structures and processes. **Biophysical structure** refers to habitat types, while **processes** refer to dynamic interactions forming the ecological system (e.g., primary production). The **ecosystem functions** are the characteristics of the ecosystem that allows the habitat to deliver ecosystem service (e.g., ability of the forest to release water absorbed in the soil slowly). The elements and features, that backup ecosystem capacity to deliver services, are sometimes called 'supporting' or 'intermediate' services, while the **'final' ecosystem service** is the produce that can harvest (e.g., Freshwater eel, timber, etc.) or gain from ecosystem (e.g., flood protection, clean water, beautiful landscape etc.). Benefits such as health and safety are derived from the ecosystem and directly contribute to human wellbeing as the "final services". Given that values are often assigned to agreed definition of benefits, they are also referred as 'goods' and 'products. The **value** can be expressed in many ways including monetary as well as non-monetary indicators based on moral, aesthetic, or other qualitative criteria.

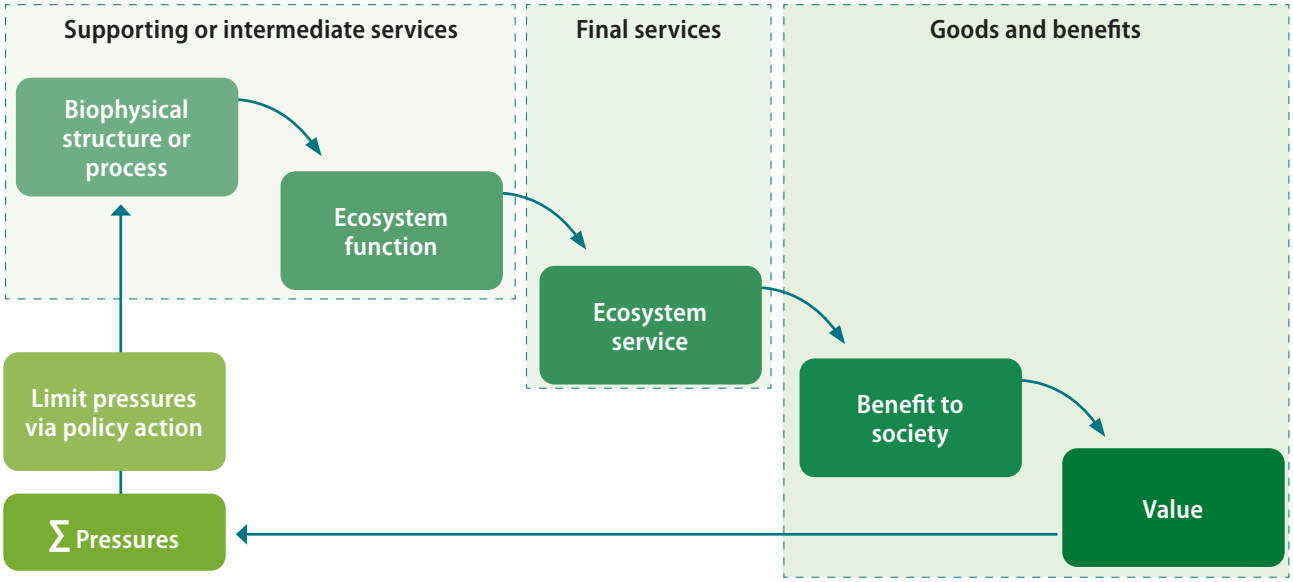

Figure 2: Cascading model (source: Potschin and Haines-Young, 2016)

Valuation of Water related ecosystem services

Assessment of ecosystem services aims to highlight the importance of ecosystems to people and society who depend on healthy ecosystems. Valuation studies provide information on the economic value which individuals and society place on environmental assets. The overall contribution of ecosystem to social and economic wellbeing are taken into consideration based on the biophysical assessment to understand how and why economic actors use ecosystem as they do while assessing the relative impact of alternative actions. Such assessment helps decision makers to compare the wide range of services provided by natural habitats and ecosystems using a common metric (Maes et al., 2016). Economic production function and economic valuation function contributes to ecosystem values which impacts human action and wellbeing (Figure 3).

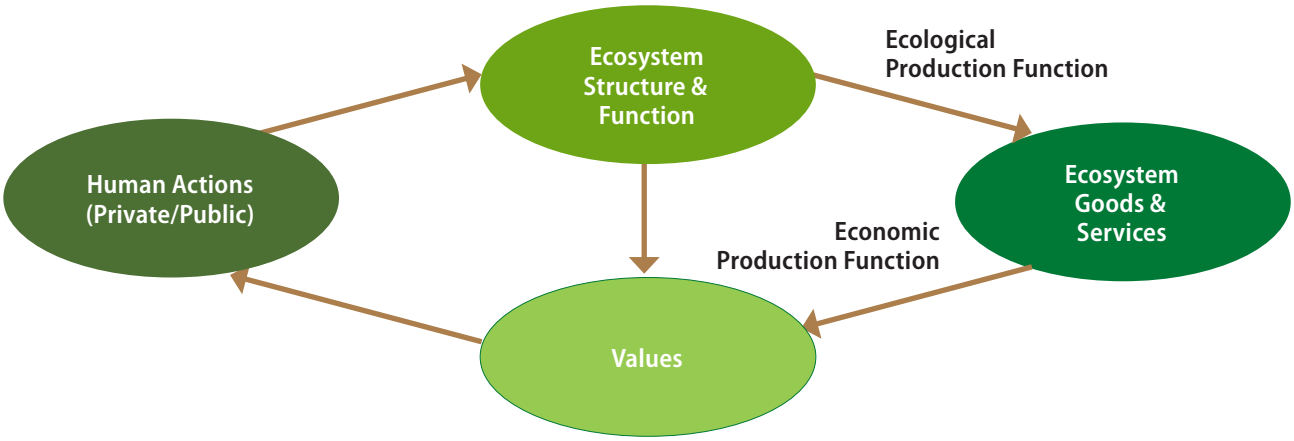

Figure 3: Conceptual Framework for ecosystem valuation (Source: NRC 2005)

Valuation of ecosystem services use a range of methods focusing on biophysical, social, and economic parameters which are complementary while assessing specific information that is important to decision makers. Estimates of ecosystem benefits are helpful to policy makers when (1) assessing the allocation of public spending on conservation, considering initiatives on preservation or restoration; (2) considering public values, encouraging public participation and support to environmental initiatives; (3) comparing benefits of different projects; (4) prioritize conservation or restoration projects and (5) maximize the environmental benefits per dollar spent. Further, economic benefits of government spending are important to justify however, rationalising expenditures and quantifying spending on ecosystem services are often challenging to secure (Dixon 2001).

Environmental initiatives may result in a wide range of benefits to the three pillars of society – social, economic, and environmental benefits. Quantification and enumeration of such benefits may be difficult where monetary values are difficult or impossible to quantify. The Total Economic Valuation approach consider use and non-use values (Crowards, 1997). Use values are simpler to define as it includes direct use (structural values), indirect use (functional values) and options values. Non-use values are considered under the lens of bequest and existence values. Currency (e.g., dollars) are useful measures of economic value to indicate the level of willingness to pay as a reflection of how much people are willing to give up for alternative goods and services that are available.

When estimating economic values, the goods and services quantified do not necessarily mean that it will be bought and sold in markets, however an estimate of the purchasing power that people are willing to give up or would need to be paid to give up the use of such resources. Often ecosystem values cannot be reflected in economic terms such as the process of photosynthesis or the protection function of root systems to reduce sedimentation and improve the quality of freshwater systems. Non-monetary benefits are often represented by indicators which are based on ranking or prioritization of the expected benefits of environmental investments.

Although this assessment is unable to make any valuation of ecosystem goods services given the limitations in the timeline of the assignment as well as COVID restrictions, attempts would first assess the extent of ecosystem services to determine the condition, quantum and quality of ecosystem services supplied which would inform the use of ecosystem services, values, and benefits.

Frameworks to assess ecosystem services and state of the environment

Ecosystem based management (EBM) applies a holistic approach that accounts for the complexity and integration of many interrelated factors including anthropogenic influences. It recognises the complex interaction of humans and ecosystems to understand the dependency of humanity on ecosystem services and the impact of human activities on ecosystem services. EBM assumes that no matter how indifferent humans are to ecosystem services, wellbeing attributes of communities can be measured through indicators such as health, safety, economic security, food security, effective governance, education, social cohesion, and environmental use (Kelble et. al 2013). Kelble et.al (2013) integrated the Driver, Pressure, State, Impact and Response (DPSIR) conceptual model with natural negative/positive human interaction to link ecosystem-based management and the DPSIR (EBM-DPSER) model. Such a model incorporates both positive and negative changes in ecosystem services.

Rapport and Singh (2006) noted the limitation of the Pressure-State-Response (PSR) model in that it ignores the dynamic process and interaction between the humans and the environment, nor does it consider an assessment of environmental trends or determination of overall viability of human impact on the environment and human wellbeing. Indicators of stress and the state of the environment (structure and function) as well as social responses to policy interventions would further enhance the "State of the Environment Reporting" (Rapport and Singh, 2006). Weber (2010) suggested the Eco-Health based framework for State of the Environment Reporting based on the DPSIR model where the "S" is the central point. The "State (S)" of the ecosystem in the broad sense of "socio-ecological system" integrates quantitative and qualitative measures as outlined in Figure 4. Quantitative measures of surface length, volume, mass, or energy coupled with the qualitative measures of vitality, organisation, resilience, dependency, and disease prevalence are measured through multicriteria assessment and expressed as quantity weighted by quality coefficient.

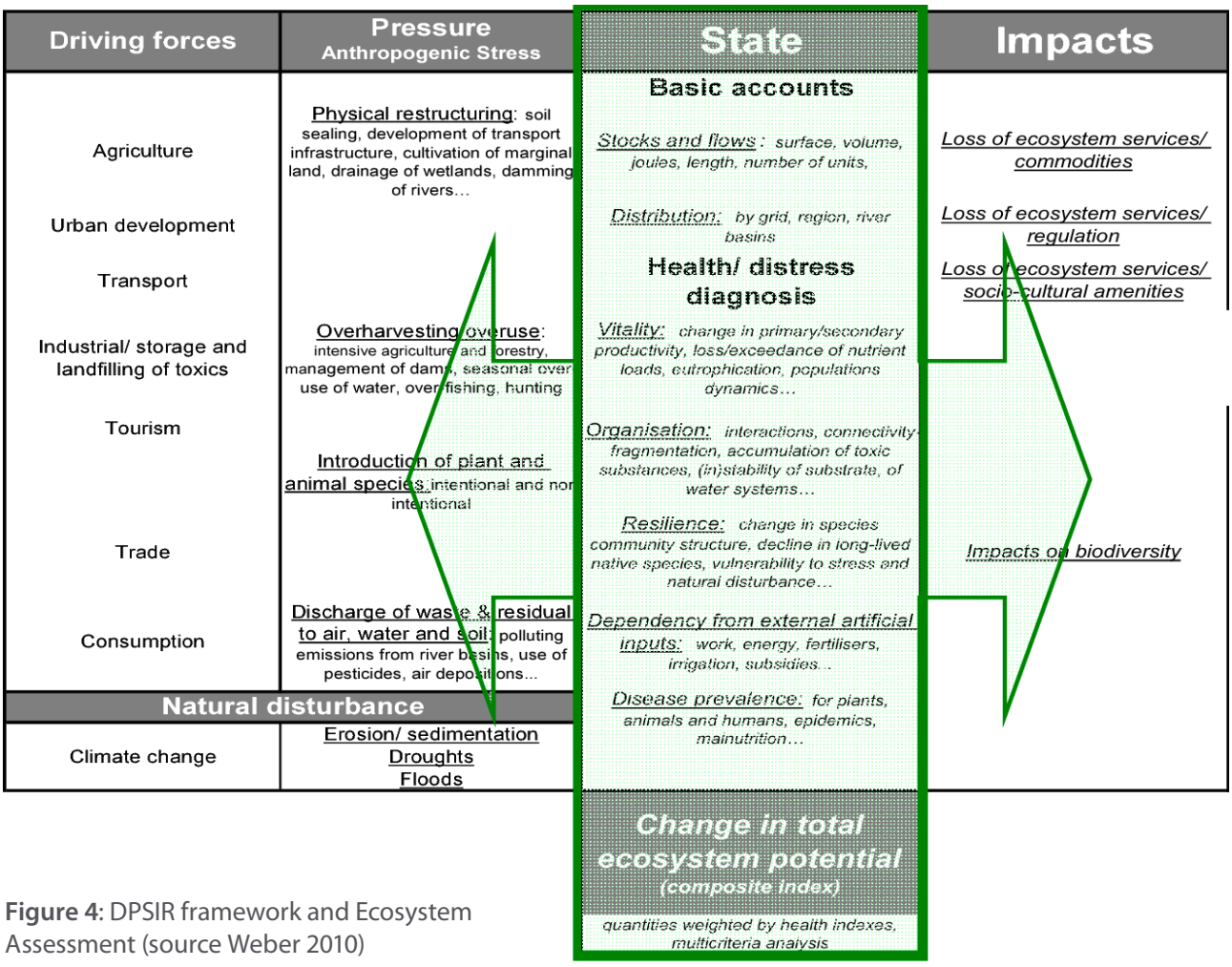

Figure 4: DPSIR framework and Ecosystem Assessment (source Weber 2010)

In managing common pool resources the prevailing assumption and treatment have aligned with either one of the three most influential economic models, driving policy assumptions and management regime. Ostrom (2009) argues that Hardin (1968) tragedy of the commons, the prisoners' dilemma game and Olson (1989 logic of collective action provides the fundamental theory of collective action and self-determination. In all cases resource is finite. In Hardin's models, lack of communication and awareness will lead to resource degradation which is reversed if the collective action of the common resource pool is driven by the availability of good relevant information to all stakeholders. Ostrom (2009) noted evidence of the ability of some resource owners for self-determination and governance aimed at sustainable practices through agreed local rules and regulations. The assumption of individual self-interest is implicit in driving overexploitation of resources resulting in adverse government policies which may only accelerate resource destruction (Ostrom 1990).

Indicators for Basin (Water catchment) Health

Quantitative and qualitative information to assess the status and health of ecosystem services are often represented by indicators. In the context of watershed or basin management, indicators have been used to organize relevant water resource information, track progress of key variables over time and ensure compliance with standards, such as water quality, ecosystem health as well as economic performance of water utilities (Bertule et.al., 2017).

Key data such as habitat health, water quality, water quantity, perceived perceptions of policy makers and local communities are analysed to project a meaningful trend of information that builds the narrative through using consistent and widely accepted indicators to help bridge the gap between science, policy, and decision makers. Such understanding is critical to align practices and develop appropriate policies that affect water resources planning and management.

Conservation International and partners developed the Freshwater Health Index as an opensource avenue to support the ecological management of freshwater systems (Shaad and Alt, 2020). The Freshwater Health Index measures the overall health of watersheds through interaction with local stakeholder and providing the avenue for dialogue that will enable participants to evaluate scenarios, understand trade off, discuss and prioritize interventions and communicate the health of freshwater systems. The scale and scope of the assessment are aimed at the whole water catchment drainage basin, engaging with most relevant stakeholders and decision makers but can also be applied at sub catchment scale to meet socio-political, economic, and ecological spaces aligned with data availability and information needs. A user manual of the Freshwater Health Index can be accessed here (CI 2017c).

The FHI aims to transparently assess trade-offs in the driver, response state and impact in a transparent manner (Figure 13). FHI provides a tool that can diagnose how social, hydrological, and ecological systems interact to provide critical ecosystem services. The FHI is a web-based tool that measures system health by making clear connections between freshwater ecosystems, the benefits they provide to people and the governance system in place (Vollmer et al. 2018). There are three main components to the freshwater health index including (1) ecosystem vitality; (2) ecosystem services and (3) governance and stakeholder.

The conceptual model outlined in Figure 5 outlines social ecological systems consisting of Governance and Stakeholders, Ecosystem vitality and Ecosystem Services. It is assumed that stakeholders will agree to set rules within governance and market systems and voluntarily respond to them. In following the rules, stakeholders modify ecosystems through land-use change or conservation efforts to exploit or manage freshwater ecosystems. At the same time, by developing infrastructure and technology to access water-based ecosystem services stakeholders ensure modifications to ecosystems and water withdrawals that continues to deliver ecosystem services to beneficiaries in the long term. Where there are competing water needs, tradeoffs are made and may necessitate adjustment to governance mechanisms that can trigger changes in markets. At the same time external biophysical conditions (droughts, long spells of rain, climate change) also influence socio economic systems.

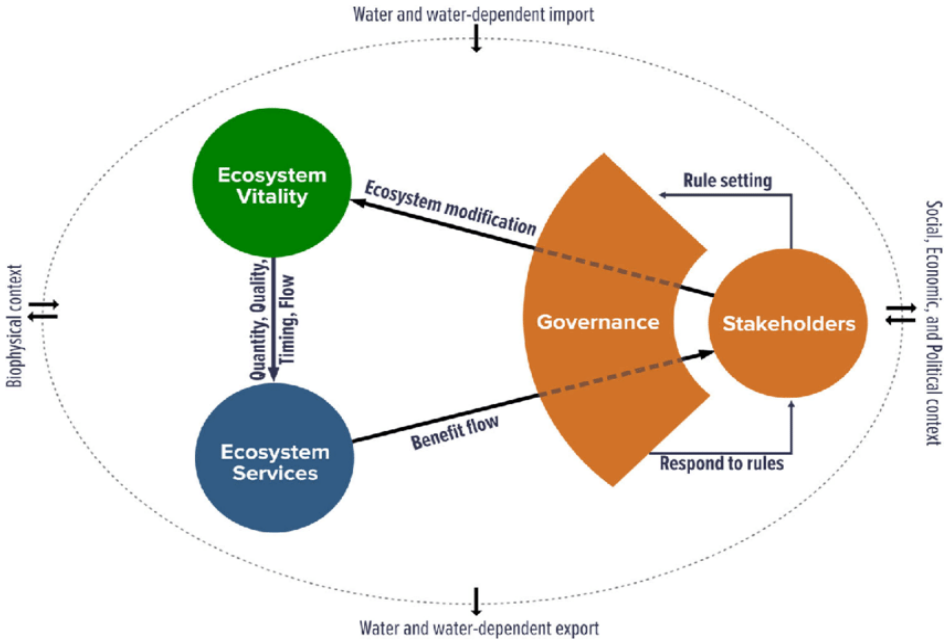

Figure 5: Conceptual Framework for Freshwater Health Index

Each of these components is assessed with a suite of measurable indicators that are aggregated into an index. The Freshwater Health Index (FHI) synthesizes a range of indicators to provide simplified and better understanding of the interface between habitat protection, ecosystem services and human development (Vollmer et.al. 2018). For this work, the FHI is discussed in the same lens as the Regional Guideline for implementing the (modified) R2R Science to Policy Strategic Framework (SPC, 2021). A comparison of the index used under each model is listed in Table 1.

Table 1: Comparison of Indicators under R2R and FHI

Freshwater Health Index		SPC R2R Indicators
Governance & Stakeholder	Enabling Environment	Legislation
	Stakeholder Engagement	Traditional Governance Coordinating Mechanism Stakeholder participation NGO & CBO Activity Knowledge & training
	Vision & Adaptive Governance	Management Plan
	Effectiveness	Risk Management
Ecosystem Services	Provisioning	Demographics Human Pressures on habitat Exploitation of living resources
	Regulation & Support	Pollutants & Introduction
	Cultural	Coastal Protection
Ecosystem vitality	Water Quantity	Habitat Quality
	Water Quality	Water Quality Habitat Quality
	Basin conditions	Abundance Shoreline stabilisation
	Biodiversity	Diversity Biodiversity Hotspots (Coastal and catchment) Species Health

Ecosystem Goods Services in Waimanu Catchment

The following section discusses application of the indicators (see Table 1) under the two frameworks discussed above. The two frameworks are further enlisted to highlight alignment. Discussion focuses on the three key indicators of the Freshwater Health Index. Data deficiency in critical areas such as Ecosystem Vitality or Environmental issues have resulted in generalisation of observations with suggestions on future applications.

Governance and Stakeholder Indicators

Enabling Environment /Legislation

Water Resources Management

SOPAC (2017) presented the status of Integrated Water Resources Management (IWRM) in Fiji noting that responsibility for water being spread among different organizations including public and private at national and local levels. Despite the completion and recommendations outlined in the diagnostic assessment of IWRM for Fiji (SOPAC 2017), there is no legislation pertaining to managing and licensing of freshwater abstraction in Fiji. Fiji's legislation with regards to water remains fragmented and outdated.

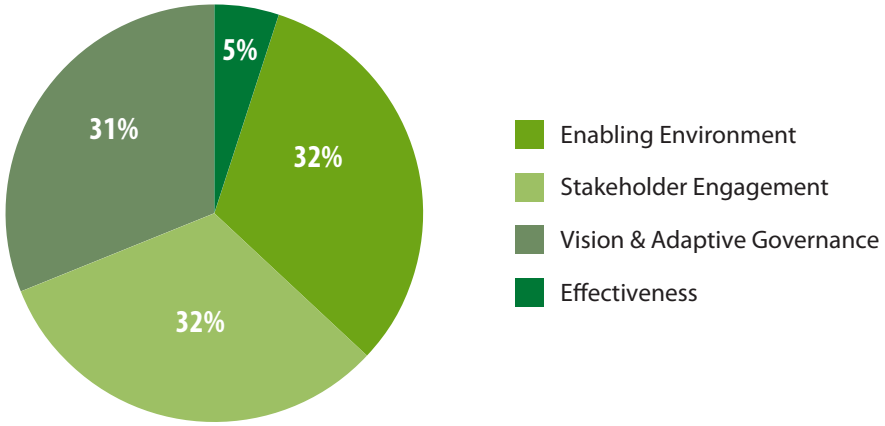

Figure 6: Freshwater Health Index – priority for Governance & Stakeholder

Rights to Resource Use

Overall, rights to adequate water are guaranteed under section 35, 36, Part 2, of Fiji's 2013 Constitution, towards progressive realization of the right of every person to have clean and safe water in adequate quantities. Water and management of water are mentioned under several guiding policies laws and regulations which are better understood through the interlinked lens of integrated water resource management. To this end, the wandering and transcendent nature of water and rights to water has been widely defined as a right to use or to enjoy the flowing water in a stream and it may emerge from a person's ownership of land on the banks of the stream (riparian ownership) or from a person's actual use of the stream. Ownership of land under rivers and streams is clearly defined and vests on the State as per Fiji's Rivers and Streams Act, [Chap 136], sections 2 and 5.

Water Authority of Fiji Act 2007 set up the Water Authority of Fiji (WAF) as a commercial statutory authority responsible for delivering water and wastewater services to an estimated 152,261 metered customers and to reach the whole population in Fiji. WAF is actively involved in the Waimanu Catchment through extraction of water provisioning to the greater Suva population. WAF is also active in supporting community consultation and the development of specific management plans to support water uptake for current and future generation.

Incentives & Regulations

Fiji's 5Yr & 20Yr National Development Plan aims to formulate and implement a national water resource management and sanitation policy that will govern planning of water resource development while advocating integrated approach through bringing WAF and the Department of Water and Sewage to develop mechanism for detail water resource monitoring in collaboration with other relevant agencies. Moving forward it may be appropriate to support community awareness of water conservation practices, civic responsibility on use of water resources, protection of traditional water sources as well as promotion of a blend of traditional and modern water conservation practices. Clear incentives and regulations will need to be formulated to support citizen uptake and implementation of government policies and management plan at catchment level.

Stakeholder Engagement/Traditional Governance/Stakeholder Participation

Information Access

In addition to formal and traditional communication mechanisms such as District Councils, Provincial Councils, Village and Community Meetings informal social media is becoming a common platform for information dissemination. The Fijian Government's mandate as highlighted in the 5 Year and 20 Year National Development Plan (Govt. Fiji 2017) is to provide universal access to information and competitive telecommunication services delivered on a secure platform. According to the Acting Permanent Secretary for Communications and Director-General Digital Government Transformation, Cybersecurity and Communications, 95% of all Fijian have access to internet connectivity (Krishant, 2020).

Engagement in Decision-making Processes

Formal governance system places Waimanu Catchment under the charge of the Commissioner Central who heads Government Rural intervention across 19 Districts in 5 Provinces. The province includes Naitasiri, Rewa, Namosi, Serua and Tailevu. Land under the Waimanu Catchment falls under the Provinces of Naitasiri, Rewa and Namosi which are subdivided into five districts, including Veivatuloa, Namosi, Waidina, Suva, Vuna and Naitasiri.

At the Provincial level, the District of Naitasiri is the Chiefly traditional leader of Naitasiri Province. The Chiefly village is the village of Navuso (outside the Waimanu Catchment) with the Chiefly title of Matanikutu na Turaga na Qaranivalu. Vuniniudrovu being part of Naitasiri District and Waimanu Catchment is listed as the fourth out of twelve village in the leadership hierarchy. Waitolu village, also part of the Naitasiri Village does not fall within the catchment area but host landowners who are direct stakeholders of Waimanu Catchment. Vuna District is the second Chiefly District under the title of Roko Tui Vuna na Vunivalu. The village of Sawani is the Chiefly village of Vuna District. Other villages in Vuna district include Colo-i-Suva and Navatuvula. Each district, village, and clan have a place in society which dictates their contribution to decision making process.

iTaukei governance structure is linked to the national governance through the Provincial Council and the District Administrator. Provincial Councils and District Administrators are under the Commissioner Central Office in the Ministry of Rural and Maritime Development. Similarly, religious, and other governance structures in Waimanu Catchment would fall under the Provincial Administrator who reports to the Commissioner Central.

The Village By-Law was proposed in 2016 under the iTaukei Affairs Act Regulation 25 which aims to ensure Fijian protocol is followed in Fijian villages and that such decisions are respected and observed. The law proposes to empower traditional chiefs or leaders in the community context and facilitates closer collaboration between community leaders and Government while reviving traditional customs, protocols, and culture that Fiji is known for. The law further enforces hygiene, peaceful coexistence, and interaction within community members. Most importantly, the village by-law establishes village councils and committees in alignment to the Village Council Regulation 1966.

Vision and Adaptive Governance/Coordinating Mechanism/Monitoring Evaluation

Strategic Planning & Adaptive Management

Governance and stakeholder indicators considered under the lens of current legal environment are viewed through the lens of water resource management, rights and resource use, incentives and regulations/financial capacity, technical capacity, strategic planning and adaptive governance, monitoring, enforcement compliance, distribution of benefits, and water related conflicts. Analysis of these indicators is outlined in Annex 6 and discussed herein.

From the analysis informed at indicators level (SPC, 2021), management plans, implementation of the plans and monitoring of the same are important considerations. While there is no approved Management Plan for Waimanu Catchment, the Water Authority of Fiji is in the process of consolidating the Waimanu Catchment Management of which CI had privy to site as part of the technical review process.

Ecosystem Vitality (Environment Indicators)

Water Quantity

Deviation from Natural Flow

Infrastructure development in the Waimanu Catchment has focused on the lower reached of Waimanu River. No major alternation to the natural flow of waterbody is observed. With exception of gravel extraction, there is no real threat to deviation from natural flow.

Groundwater Storage Depletion

Hydrogeological studies have been carried out in Fiji since 1967 by the Mineral Resources Department (MRD) in response to the rapidly increasing demand from the public to use groundwater.

Groundwater is a valuable resource stored in a natural reservoir via underground aquifer. The ground acts as a natural filter to these contaminants so groundwater is relatively pure, but care must still be taken not to pollute aquifers. Hand-dug wells are constructed in areas where groundwater is at shallow depths which can be contaminated easily. To minimize potential risk of contamination, the public are advised to locate pit latrines and animal drinking troughs at least 30 meters away from wells. Given that Waimanu Catchment falls in an area with high precipitation, ground water extraction is not common. However, in the drier parts of Fiji such as the Western Division on Viti Levu, over two hundred private boreholes have been drilled for domestic and village water supplies. In low-lying areas wells are often dug by hand and lined with concrete blocks, rings, or oil-drums. Wells made deeper as prolonged dry spells set in to find water. The boreholes in the Western Division on Viti Levu exploit the fissured aquifers of the Ba Volcanic Group and, to a lesser extent, the Wainimala Group of rocks (MLMR, 2015).

Water Quality

It is important to understand the effect of surrounding environment on the quality of water in the catchment area. According to literature, there are three main sources of threat to the water quality of the catchment, namely the agricultural activities, quarry effluents, and the low standards of septic tanks and livestock management in the area. While farming and agricultural fields are a common occurrence, especially in the lower catchment, it poses great risk of contaminating the river by stirring up sediments and animal faeces thus contaminating the water quality of the catchment. Agricultural chemicals and quarry effluents too are equally common contaminant sources that have been known to pollute river systems and so lowering the quality of water received from the catchment into treatment plants. Additionally, the low standards of septic tanks and livestock management in communities and settlement as well as other aggregate group is another concerning threat affecting quality of river water. The water quality index is an indicator of the water quality of the catchment that measures suspended solids, total nitrogen, total phosphorous and other quality parameters.

The Fiji National Drinking Water Quality Standard (FNDWS) is a set of minimum water quality requirement for drinking water. It is applicable for all sources of drinking water in both urban and rural areas, public or private water supply regardless of its source including groundwater, surface water, rainwater, desalinated water, packaged/bottled water, and ice intended for human consumption. The minimum priority parameters required under standard conditions provide specific guideline on priority parameters, bacterial, chemical, organic, and physical/chemical constituents is listed in Appendix 1.

Basin Condition (Habitat quality)

The riverbanks of the Waimanu catchment are mostly degraded with eroded banks. The relative erodibility of the Waimanu Catchment is estimated to be medium in comparison to the greater Rewa Catchment which is ranked at higher erodibility. The upper reaches of Waimanu Catchment are undisturbed with no recorded modification however, the mid and lower catchment have high risk to flood exposure. A sawmill is situated between Sawani and Vuniniudrovu village (see Figure xx). Wood wastes such as sawdust, log barks, veneer waste, and wood shavings from the timber sawmill are piled along the riverbank and deposited into the river system during heavy precipitation and flood events. At the same time, gravel extraction and quarry are located at downstream from Navatuvula village and beside Navuso village. These activities have the potential to influence bank modification and flow connectivity.

Begg et.al (2021) assessed exposure to flood risk as a function of the proximity of the village to the Waimanu River, the intensity of rainfall and frequency of intense floods. The assessment notes that Navatuvula village is located outside of flood plains while Sawani, Vuniniudrovu and Navuso village are situated directly in the flood plains and hazard zones. Begg et.al. (2021) ranked Vuniniudrovu to have the highest flood risk as it is immediately next to the Waimanu River, followed by Sawani and Navuso while Navatuvula is rated with the lowest risk being elevated above the Waimanu river.

Land use activities are common downstream from Navatuvula village along Sawani and Vuniniudrovu. Vegetation and landcover around Sawani, Vuniniudrovu and Navuso are mostly grassland rather than riparian forests (Begg et.al 2021) which are prominent in the upper reaches of Waimanu Catchment.

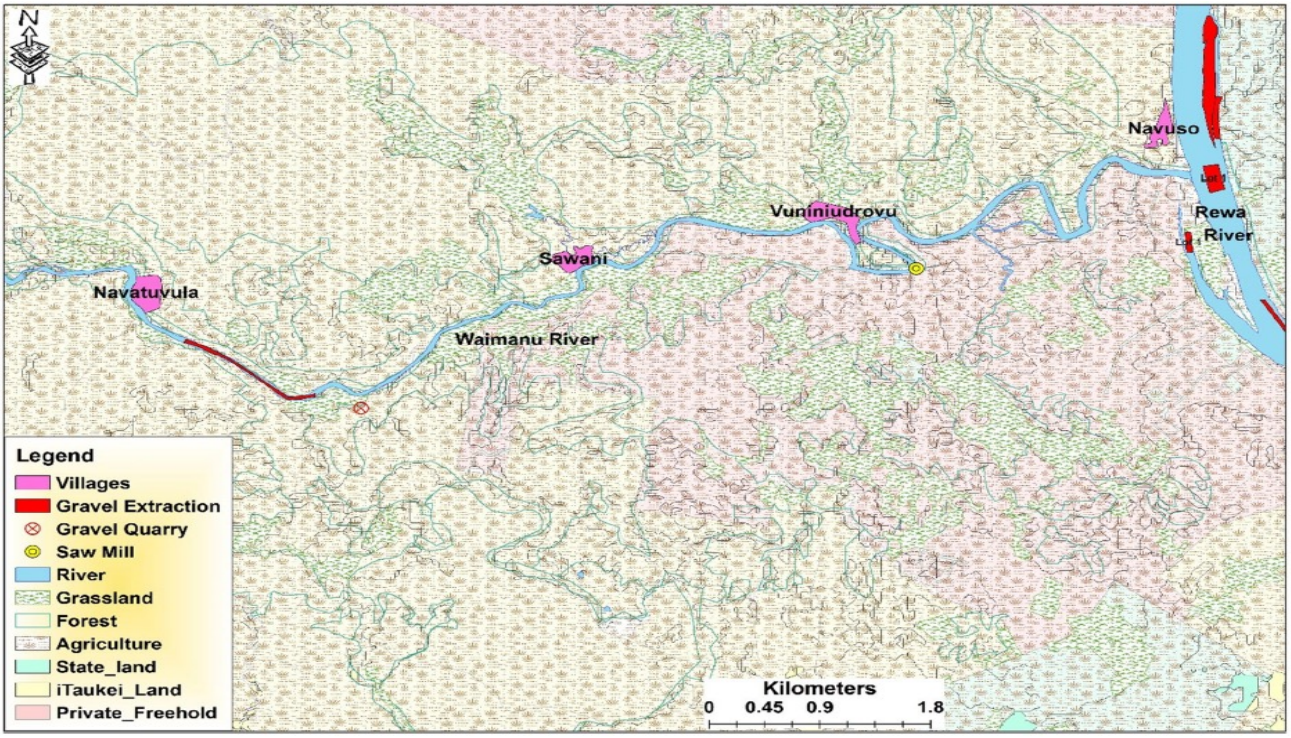

Figure 7: Close view of communities in Waimanu Catchment (mid and lower catchment as adapted from Begg et.al 2021)

Biodiversity

Although there has not been any biodiversity study dedicated solely to assessing the Waimanu catchment, biodiversity survey from surrounding areas indicates potential continuity of the forests and ecosystem habitats in Waimanu to surrounding areas. There are thus strong suggestions to include the upper reaches of Waimanu Catchment as an extension of Key Biodiversity Area in the Sovi Basin Conservation Area, Wainavadu, Savura-Vago and ColoiSuva Forest Park. Important Bird Area in the Savura-Vago and surrounding areas noted the presence of globally threatened species having a restricted range including the long-legged warbler, Friendly Ground-dove, Black-faced Shrike bill, Pink-billed Parrotfinch and Masked Shining parrot. Three species of eels are found in Fiji (Copeland, 2016) and a longitudinal pattern of distribution has been observed such that is most likely that Anguilla obscura (Figure 6) will be found in the lower-reaches of the Waimanu catchment while A. marmorata (Figure 6) will be found in the mid-reaches and the more cryptic and rarer of the three A. megastoma found in the headwaters of Waimanu catchment (CI 2021a).

Figure 8: Species of eel likely found in Waimanu River (adapted from CI(a) 2021)

Alien and invasive species such as the Red-vented Bulbul and Mynah are believed to follow access road into the Waivaka catchment prospecting site (Olson, 2010). African Tulip (*Spathodea campanulata*) is prevalent in the Waimanu Catchment (Brown and Daigneault 2014). The Nile Tilapia O. niloticus has been able to establish feral populations in the mid to upper reaches of the Sovi catchment and believed to be present in the Waimanu River system (CI 2021b).

Ecosystem Services (Socio-economic Indicators)

Ecosystem services refers to the various benefits that people receive from nature. This can also be considered through the lens of socio-economic indicators. Freshwater ecosystem services include water for drinking and crops, fisheries, protection from floods and other hazards, and recreational opportunities such as fishing or kayaking. Ecosystem Services is considered by measuring indicators related to provisioning, regulation and support, and culture and aesthetics.

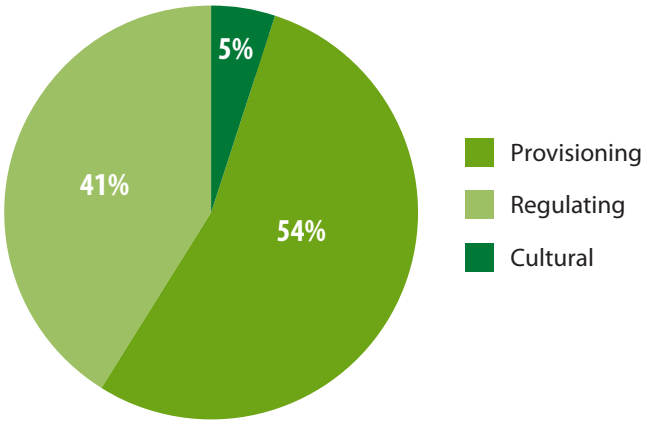

Figure 9: Freshwater Health Index – priority for Ecosystem Services in Waimanu Catchment

Provisioning/ Demographics/Exploitation of living resources

The Waimanu catchment is a critical catchment in Fiji whose location and integrity are critical to conserving and maintaining to ensure a continuous supply of good and clean water to the greater Suva area. Fiji's State of the Environment report in 2013 specified that the Waila water treatment plant, through the Water Authority of Fiji (WAF), treats close to 100 mega litres of raw water from the Waimanu river each day, serving a significant portion of population along the Suva-Nausori and Rewa delta.

Accordingly, there is a total of 244,000 (UNHSP, 2012) people living in the greater Suva area that receive water from the Waimanu pump, which according to Raj (2004), draws on average 36,000m^3 per day, while the Waila pump station pumps, 90, 000m^3 per day. The water quality of Waimanu river system is monitored monthly by the National Water Quality Laboratory.

Freshwater Benthic Macroinvertebrate (BMI) species (Figure 8: a-e) are import protein source and contribute to food security of the local riverine communities. These BMI species include (i) freshwater clam (*Batissa violacea*)/ Kai with a local market value of (price as per year 2020) $5/heap, (ii) freshwater prawns (*Macrobrachium* spp.) with a local market value of (prices as per year 2020) $20-25/heap and (iii) freshwater gastropods harvested for household consumption (Figure 8: f-g). Water affinity plants such as water cress (Nasturtium officinale) with a local market value of $2-3/bundle and Ota (*Diplazium esculentum*) $2-3/bundle has been regarded as one of the Fijian common delicacies and are grown alongside rivers and waterways in parts of Fiji including Waimanu as they require moist soil (Rashni pers. comms.13/10/21).

Regulation & Support/Human Pressure on habitats/ Exploitation of living resources

Sediment Regulation

The steep terrain of Waimanu Catchment contributes to landslide and erosion. Soil and sediment load in local river system sourced from gravel extraction and agriculture are high during heavy rainfall events (Begg et.al. 2021), increasing the water turbidity. Furthermore, agricultural activities on steep areas further aggravates erosion and sediment loads in the river system (Singh, 2017). At the same time, turbidity in Vuniniudrovu and Navuso are exacerbated by waste from the sawmill which is located at the riverbank with high potential to damage downstream waterways.

Begg et al (2021) computed indices of flood risk for four communities of Navatuvula, Sawani, Vuniniudrovu and Navuso using rating between 1-5 where 1 is very low to 5 depicting – very high risk. The indices use the Sustainable Livelihoods Framework, and the Disaster Risk Management (DRM) Framework where vulnerability to climate change considers the frequency and intensity of potential hazards such as floods (Ochoa and Cardona 2017). Begg et.al (2021) defines livelihood assets to comprise what a community possesses, including natural resources, infrastructure and services, financial resources, skills, and activities to achieve Human Security Objectives (HSOs).

Figure 10: Freshwater benthic macroinvertebrates (BMI) (Adopted from CI 2021(a))

The seven HSOs include community health, ecosystem health, security of the community, food security, water security, income security, and energy security. The indices assessed by Begg et.al (2021) is listed in Table x where score between 1-3 means the village will need assistance to readdress flood risk factors. In terms of livelihood, Sawani, Vuniniudrovu and Navuso are at higher risks, but all four communities are at risk under ecosystem and community health.

Table 2: Indices of livelihood assets and human security objectives – Villages in Waimanu Catchment (adopted from Begg et.al. 2021)

	Navatuvula	Sawani	Vuniniudrovu	Navuso
Livelihood assets:				
Natural resources	3.7	2.1	2.0	2.6
Infrastructure and services	3.0	2.7	2.4	2.6
Financial resources	3.0	2.7	2.7	3.0
Human skills	3.0	3.1	3.1	3.1
Institutions and governance	3.4	3.1	3.1	3.1
Human Security Objectives:				
Ecosystem health	2.8	1.8	1.8	2.0
Community health	2.8	2.6	2.4	2.6
Security of place	3.0	2.2	2.0	2.8
Food security	3.4	3.0	3.0	3.2
Water security	3.8	3.2	3.0	3.0
Energy security	3.8	3.8	3.8	3.6
Income security	3.0	2.8	2.8	3.0

Water security is not an issue across the communities while income security is noted to be at risk in Sawani and Vuniniudrovu which directly correlates to the low scores in livelihood assets of these villages. It is also noted that Sawani and Vuniniudrovu have the lowest indices for ecosystem health due to exposure to land use change comprising of gravel extraction, poor agricultural practices, deforestation and improper waste disposal from timber sawmill and household which compromise water quality and socio-economic benefits. Further, Sawani and Vuniniudrovu are noted to have limited access to natural resources. Without an intact ecosystem to regulate climate, soil, water, and air quality (Smith et.al. 2013; Crossman et.al. 2019); livelihood assets are further reduced by low-income security, and human security objectives are subsequently compromised (Esquivel, 2020).

Cultural/Coastal Protection

Cultural ecosystem services (CES) include aesthetic, artistic, educational, spiritual and/or scientific values of ecosystems. CES is often described as 'intangible' and complex, reflecting diverse people-nature interactions that are embedded in dynamic social-ecological systems (Pert et.al. 2010). CES has largely concentrated on more tangible aspects, such as tourism and recreation. Chowdhury and Behera (2021) observed that people in West Bengal, India, obtain a variety of non-material benefits from traditional water bodies which include artistic inspiration, cultural heritage, social relationship, and various services relating to religious, spiritual, aesthetic, recreational and environmental aspects. It is further noted that the use of these cultural ecosystem services by households vary significantly with their cultural practices, socio-economic and demographic characteristics. Contemplation of traditional knowledge could help build resilience to the impacts of climate change including risks from flooding by strengthening the adaptive capacity of local communities (Begg et.al. 2021; Weir et al. 2017; Weir and Pittock 2017).

Fiji's major instruments for conservation and environment are the National Environment Strategy (NES) and the National Biodiversity Strategy and Action Plan 2010 (NBSAP), which outlines the implementation of commitments under CBD. The NES and NBSAP have been endorsed by Cabinet and set the framework for conservation of biological diversity in Fiji's forests. According to NBSAP, conservation and sustainable management of Fiji's natural forests is the single most important means of conserving the vast majority of Fiji's endemic fauna and flora. It provides further directives for the establishment of a comprehensive and representative system of forest reserves and conservation areas and emphasizes the role of resource owners and local communities in conservation and sustainable management of natural forest.

Result of Freshwater Health Index – Waimanu Catchment

Unfortunately, this evaluation is condensed and carried out in a rapid assessment of the Freshwater Health Index of Waimanu Catchment due to time and COVID-19 limitations. A virtual workshop and survey were undertaken by the team to introduce the concept of the Freshwater Health Index and invite participants to respond to online survey. Presentation used at the workshop is outlined in Appendix 2. The survey questions focused on ecosystem services and Governance & stakeholders. The list of questions used in the questionnaire is outlined in Appendix 3. A small pool of respondents was captured hence the results discussed herein are non-conclusive but provide an insight into the state of ecosystems and human interaction with the Waimanu Catchment.

Priority issues using risk assessment

Risk analysis of environmental issues identified key problems as well as critical goals that can then be developed to respond and address problems. The 'Criteria for prioritizing environmental problems' adopted from SPC Ridge to Reef Island Diagnostic Analysis framework is used to highlight environmental issues within the Waimanu catchment. Environmental issues are considered through criteria of geographical and temporal scale, anticipated future risk, networking and relationship with other environmental problems, benefits, progress in addressing problems and urgency in finding solutions. The main environmental concerns for the Waimanu catchment are: (1) incursion of agricultural practices into the catchment area & the use of river and village sites as dump sites for waste materials and effluent discharge (2) increasing number of infrastructure development in the lower Waimanu catchment; (3) growing population; (4) growing number of infrastructure development in the lower Waimanu catchment (Begg et.al 2021; Singh 2017); Nainoca (1998)); and (5) lack of biodiversity information (CI,2021(a)).

Applying SPC Ridge to Reef Island Diagnostic Analysis (SPC. n.d) framework to Waimanu catchment indicates key threats and areas of top adaptive priority. These would include (1) Incursion of agricultural practice into catchment areas and the use of river and (2) addressing the use of village site as dump sites for waste materials as well as the prominent occurrence of effluent discharge under the criteria of whole of island and relationship with other environmental problems as outlined in Table 3.

Table 3: Criteria and Prioritizing environmental problems based on SPC R2R criteria

Weighting: 1.no importance 2. Low importance 3. Moderate importance 4. High importance					
	Environmental issues				
Criteria	Incursion of agricultural practices into the catchment area	Growing number of infrastructure development in the lower Waimanu catchment	Lack of biodiversity information	Growing population	Use of river and village sites as dump sites for waste materials and effluent discharge
Whole-of-island nature of a problem – geographical and temporal scale.	4	4	4	4	4
Future risk of the problem – (in 10 years)	4	4	3	3	4
Relationship with other environmental problems	4	4	4	4	4

Weighting: 1.no importance 2. Low importance 3. Moderate importance 4. High importance					
	Environmental issues				
Expected multiple benefits that might be achieved by addressing a problem.	4	3	3	4	4
Progress in addressing this problem at the national level	4	3	2	4	4
Urgency of addressing this problem	4	3	2	4	4

Adopted from CI 2021a

Develop priority systems and plans for actions and interventions

Using the Freshwater Health Index as a decision hierarchy to quantify priorities between ecosystem services and governance indicates consensus that ecosystem services are of top priority followed by governance and stakeholders. Assessment of ecosystem vitality was not carried out due to limited quantitative information, but qualitative observations are noted in the discussion. Within the context of ecosystem services, provisioning (social-economic) is considered of higher priority than regulating and cultural aspect.

Ecosystem Services focuses on the benefits delivered to stakeholders across a range of sectors with indicators measuring provisioning, regulation, and support as well as cultural values of freshwater system. The responses indicate an emphasis on provisioning which measures outputs from freshwater ecosystems that providing benefits towards human wellbeing. Although water supply and biomass consumption are often considered as stand-alone factors, they are combined based on their heavy reliance on each other.

Table 4: Decision Hierarchy for the Freshwater Health Index Framework-Waimanu Catchment

Level 1		Level 2		Level 3	
Ecosystem services	0.375	Provisioning	0.538	Water supply reliability Biomass for consumption	0.700 0.300
		Regulating	0.408	Sediment regulation Water quality regulation Flood mitigation Disease regulation	0.356 0.319 0.277 0.047
		Culture	0.054	Conservation area Water related recreation	0.807 0.193
Governance & stakeholder	0.333	Enabling env.	0.323	Water resource management Rights to resource use Incentives and regulations Financial capacity Technical capacity	0.277 0.292 0.216 0.081 0.134
		Stakeholder engagement	0.317	Information access Engagement in decision making process	0.417 0.583
		Vision & adaptive governance	0.311	Strategic planning & adaptive management Monitoring & learning mechanisms	0.500 0.500
		Effectiveness	0.050	Enforcement & compliance Distribution of benefits Water related conflicts	0.402 0.435 0.163

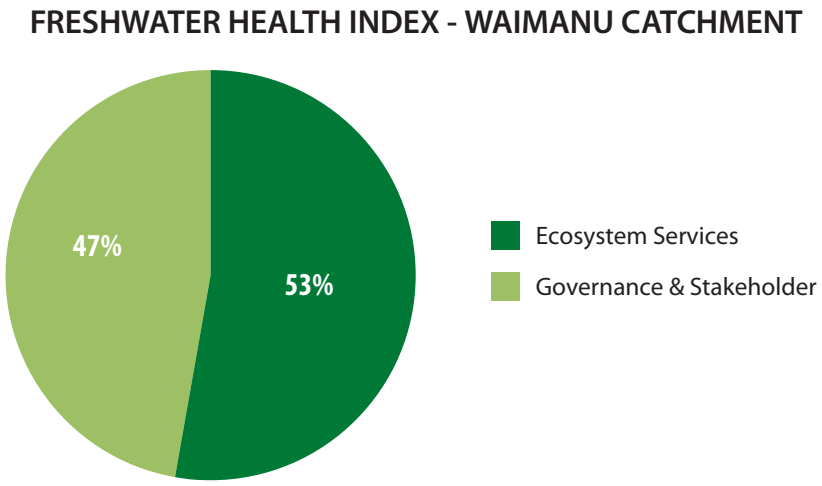

Figure 11: Ecosystem Services Index indicates high priority for Ecosystem Services in Waimanu Catchment

In Waimanu Catchment, the need for water supply reliability ranked higher than biomass for consumption. At the same time, regulating sediment is more important than water quality, flood mitigation and disease regulation. Under cultural considerations, the conservation area is deemed much more important than water-related recreation.

Assessment of governance and stakeholder system directly relates to the governance of freshwater ecosystem. Four key indicators that are assessed include enabling environment, vision and adaptive government, stakeholder engagement and effectiveness. Enabling environment considers constraints and opportunities of policies, laws, regulations, market mechanisms as well as social norms in governing and managing water resources. Stakeholder engagement considers access to information that supports decision making. It also measures whether stakeholders have a voice within the cycle of policy, planning and decision making. Vision and adaptive governance assess the level of engagement stakeholders engage within the planning and monitoring of progress towards social and environmental objectives while the last indicator measures the degree to which laws are upheld.

Under the Governance and Stakeholder Indicators, enabling environment is slightly more important than stakeholder engagement which is rendered more important than vision and effectiveness. Under enabling environment, rights to resource use are considered of highest priority followed by water resource management, incentives, and regulations. Financial and technical capacity are deemed of low priority.

Conclusion

Considered through the lens of provisioning, regulating and cultural aspects, ecosystem goods and service offers valuable approach that links human and nature. The concept enables better understanding of the links between human wellbeing to the complex interaction of ecosystem functions capturing attention of resource managers and policy makers aspiring to improve natural resource management.

Using the Freshwater Health Index as a decision hierarchy to quantify priorities between ecosystem services, ecosystem vitality and governance & stakeholders shows that ecosystem service is of top priority followed by governance & stakeholders. Limited quantitative data hindered full assessment of ecosystem vitality but allowed qualitative assessment of the current ecosystem conditions in Waimanu Catchment. Indices under the Freshwater Health Index shows that ecosystem services are deemed to be of high priority when compared to governance and ecosystem vitality.

Risk assessment in alignment with the SPC R2R criteria indicates environmental issues by way of priority includes (1) the use of rivers and village sites as dump sites for waste material and effluent discharge; (2) incursion of agricultural practices into the catchment area; (3) growing number of infrastructure development in the lower Waimanu Catchment; (4) growing population in the Waimanu catchment and (5) lack of biodiversity information to ensure informed decisions.

Risk assessment under the FHI framework places ecosystem services to be more important when compared to governance & stakeholder. Under ecosystem services, provisioning services is of priority compared to regulating and cultural services. Sub-indicators under provisioning shows that water supply reliability is by far the most important environmental issue in Waimanu Catchment. Sub-indicators under cultural aspect indicate the need to establish protected areas as the most important environment issue. Under governance and stakeholder, enabling environment is deemed most important while sub-indicators (by way of priority) such as Engagement in decision making process; Strategic planning & Adaptive management; Monitoring & learning mechanism; as well as Information Access are of high priority.

Results from the two tools outlined above indicate synergies and provides the foundation for recommendation of the Integrated Waimanu Catchment Management Plan.

Recommendations

The following recommendations aim at improving ecosystem goods and services in the Waimanu Catchment. Each recommendation is addressed as an opportunity that is linked back to the priority issues identified through the tools used in this assessment (see Table 5).

Table 5: Comparison of priority using different tools

Priority under SPC R2R criteria (see Table 2)	Priority under FHI (see Table 3)
The use of rivers and village sites as dump sites for waste material and effluent discharge	Ecosystem services
Incursion of agricultural practices into the catchment area	Engagement in decision making process
Growing number of infrastructure development in the lower Waimanu Catchment	Strategic planning & Adaptive management
Growing population in the Waimanu catchment	Monitoring & learning mechanism
Lack of biodiversity information to ensure informed decisions	Information Access

Priority under SPC R2R criteria (see Table 2)	Priority under FHI (see Table 3)	Opportunity for action
The use of rivers and village sites as dump sites for waste material and effluent discharge	Ecosystem services	Reassess the Freshwater Health Index based on further research and modelling to provide better understanding on the interactions of important contributing variables that sustain ecosystem goods and services in the long term and linking the same to local community wellbeing. Develop community based standard operating procedures or agreed standards for waste management with clear monitoring framework implemented via community science and participation as well as being adopted by all communities along the Waimanu River.
Incursion of agricultural practices into the catchment area	Engagement in decision making process	Establish priority conservation site for the provision and regulation of ecosystem services such as clean water. Increase and improve communication channels between communities and national/local authorities.
Growing number of infrastructure development in the lower Waimanu Catchment	Strategic planning & Adaptive management	Develop Integrated Waimanu Catchment Management Plan at District levels that fees to Provincial Management Plans Align village plans/ Village By-Law / standards to clear development plans built around minimum standard requirements while aligning monitoring, evaluation and reporting to existing governance structures such as the Natural Resources Council (NRC) appointed under the National Environment Council and support the work of the Yaubula Management Committee.
Growing population in the Waimanu catchment	Monitoring & learning mechanism	Develop citizen science and neighbourhood watch on environmental safeguards that will allow active participation of local communities in collaboration with relevant line agencies
Lack of biodiversity information to ensure informed decisions	Information Access	Undertake biodiversity assessment of Waimanu Catchment to enable full appreciation of species habitats supporting ecosystem services in Waimanu Catchment. Increase and strengthen community education, awareness, and participation especially on water rights issues and implications on customary land to incentivise community ownership, participation, and activities in the management of the Waimanu Catchment.

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Appendices

Appendix 1 – Parameters for Fiji National Drinking Water Quality Standard (FNDWS)

Table A-1: Minimum Priority requirements for small water supplies

Parameter[a]	Maximum Value
pH	6.5-8.5
Colour	5 TCU
Turbidity	5 NTU
Residual Chlorine[b]	0.2-0.5 mg/L
Total Dissolved Solids (TDS)	500 mg/L
Conductivity	1000 µS/cm
Thermotolerant Coliforms	0 per 100 mL
E. Coli	0 per 100 mL
Total coliforms	0 per 100 mL

[a] Additional parameters can be monitored but these are the minimum requirements.

[b] Only if chlorine is applied to the water system

Table A-2: Bacteriological quality for drinking water

Parameter	Maximum Value
Thermotolerant (Fecal) Coliforms	0 per 100 mL
E. coli	0 per 100 mL
Total coliforms	0 per 100 mL

Table A-3: Chemical constituents of health significance in "drinking water"

Parameter	Maximum Value[a] mg/L (ppm)
Antimony	0.02
Arsenic	0.01
Barium	0.7
Boron	0.5
Cadmium	0.003
Chromium	0.05
Cyanide	0.07
Fluoride	1
Lead	0.01
Mercury	0.001
Molybdenum	0.07
Nickel	0.02
Nitrate as NO_3^-	50
Nitrite as NO_2^-	*3*
Selenium	0.01

Table A-4: Organic constituents of health significance to drinking water

Parameter[a]	Maximum Value[b] mg/L (ppm)
Benzene	0.01
Disinfection by-product	
Total Trihalomethanes	0.25
Pesticides	
2,4, D[+]	0.03
Chlorpyrifos	0.03
Dicamba	0.1
Diuron	0.1
Glyphosate	0.5
MCPA[++]	0.002
Malathion	0.2
Paraquat	0.03

[a]Routine monitoring for organic constituents (Table 4) is not required unless there is a potential for contamination of water supplies.
[b]For very low concentration, laboratory results are reported in µg/L or ppb. Note the conversion: 1 mg/L (ppm) = 1000 µg/L (ppb)
[+] 2,4-dichlorophenoxyacetic acid
[++] 4-(2-Methyl-4-chlorophenoxy)acetic acid

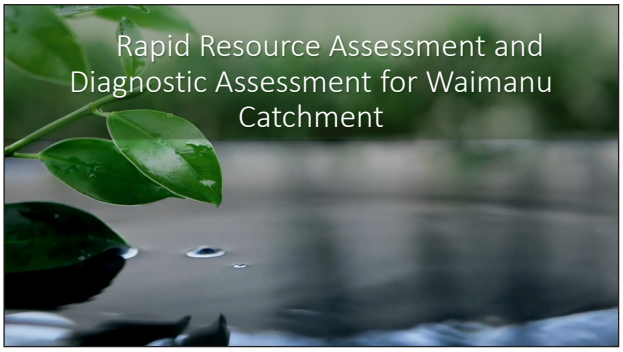
Table A-5: Physical and chemical quality: aesthetic quality

Parameter	Maximum Value
Odor	Acceptable
Taste	Acceptable
Color	5 TCU
Turbidity	5 NTU
Residual chlorine	0.2-0.5 mg/L
pH	6.5 – 8.5 (no unit)
Conductivity	1000 µS/cm
Aluminium	0.2 mg/L
Ammonia	1.5 mg/L
Chloride	250 mg/L
Copper	1.0 mg/L
Hardness	200 mg/L
Iron	0.3 mg/L
Manganese	0.1 mg/L
Sodium	200 mg/L
Sulphate	250 mg/L
Total dissolved solids	500 mg/L
Zinc	3 mg/L

Results of the Freshwater Health Index (documented in a separate report) indicates a decision hierarchy prioritizing ecosystem services where the cultural aspect is perceived to be more important to ensure support for the conservation and protection of forest areas in the Waimanu Catchment. Provisioning services is the second most important priority where Water Supply Reliability is perceived more important than biomass (freshwater species) for consumption. Although regulating is low in priority, sediment and flood regulation are too on priority list of issues that need to be addressed to ensure availability of freshwater for human wellbeing.

Indicator/s	Input data in brief	Calculation parameters
Flow deviation	Discharge time-series for regulated and unregulated conditions for outlet and other locations in the basin.	–
Groundwater Storage	Total basin area and area impacted by over-extraction of groundwater.	–
Water quality	Monitored time series data for water quality gauges.	Selection of water quality parameters and the associated threshold
Land cover naturalness	Spatial data on land cover for the basin.	Weights (or degree of naturalness) associated with each land cover type
Channel modification	Spatial data on land cover for the basin.	Buffer zone considered along water body and weights associated with each cover type
Connectivity	Vector river network and location of dams (and other instream structures obstructing flow)	'Passability' of each instream structure. Defined as the probability that an aquatic species will successfully cross the obstruction
Species of concern	List of freshwater-associated native species in the basin, associated 'Red list' code and (optional) population estimates	–
Invasive species	List of freshwater-associated invasive species in the basin and (optional) population estimates	–
Provisioning and regulating services	Supply data of these services over the basin	Criteria for 'non-compliance' based on demand
Recreation services	Evaluated outside the toolbox through surveys and economic analysis	–
Conservation areas	Map of protected area	Target protection area or length (of water body) in a basin
Governance	Output from survey of basin stakeholders	–

Appendix 2 – Workshop Slides



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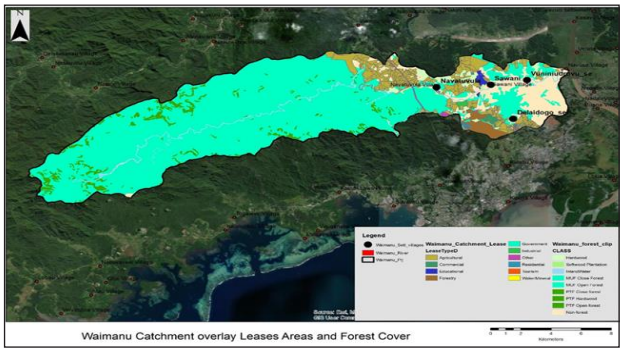

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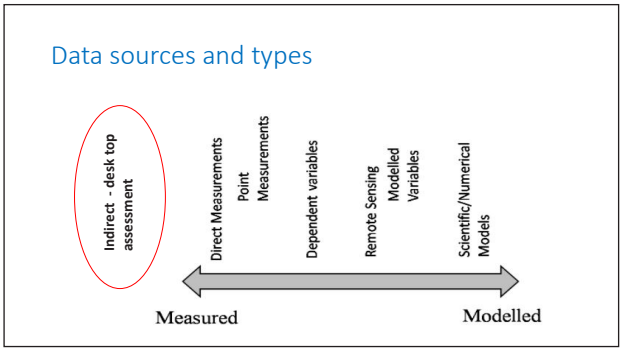

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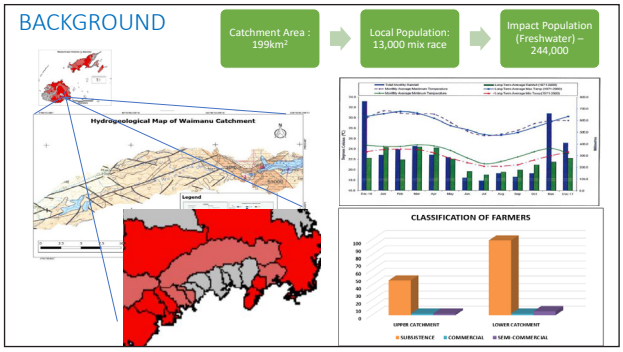
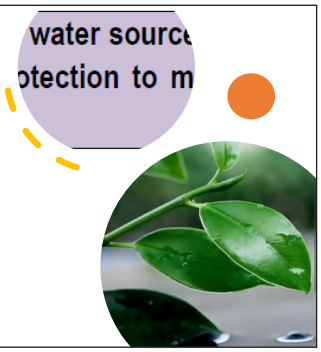


6

Waimanu River is the main drinking water source for eastern Viti Levu and almost half of Fiji's population. It is therefore crucial for protection to maintain health of the watershed and reduce costs of treatment



Source: Fiji Government. 2014. Fifth National Report to UNCBD. https://www.cbd.int/doc/world/fj/fj-nr-05-en.pdf

7

8

Why another monitoring tool?

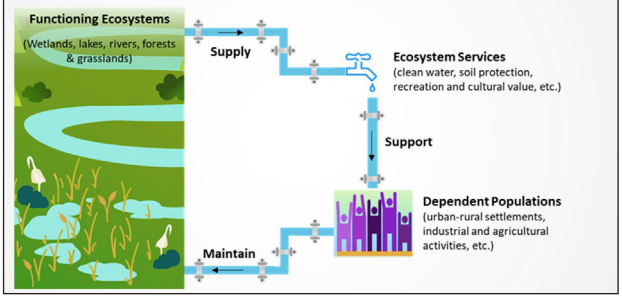
Thousands of unique indicators and hundreds of unique indices for assessing freshwater systems already exist.

Applications range from ecological assessments of streams, to water "vulnerability" at national scale, to global corporate water risk assessments.

But no approaches linked ecological integrity (health) to ecosystem service delivery, or adequately combined social with ecological indicators.

9

A SOCIAL-ECOLOGICAL SYSTEM



10

Approach To assessment

11

Ecosystem Vitality

- **Water quality** – 3 sources of threat –
  1. physical – turbidity
  2. Microbiological – low standard of septic tanks, livestock
  3. Chemical – agricultural chemicals, industry effluents
- **Water quantity** – 2 water intakes from Waimanu River
  - Tamavua – capacity for 60 ML/day running at 55ML/day
  - Waila – capacity for 100ML/day running at 95 ML/day

Indicator

Water Quality Index
- Suspended Solids
- Total Nitrogens
- Total Phosphorus
- Other Quality Parameters of Concern

Deviation from natural flow regime
Groundwater storage depletion

12

Ecosystem Vitality	Indicator
• **Drainage Basin Condition** – ▪ Medium Erosion potential (steep terrain prone to landslide) ▪ Currently - Minimal bank modification ▪ Land cover naturalness – intact in the upper catchment, excess modification at lower catchment	Basin Condition ➢ Bank modification ➢ Flow Connectivity ➢ Land Cover Naturalness
• **Biodiversity** ▪ Threats to species (endemic/cultural species) ▪ Invasive species – level of threat from invasive	Biodiversity ➢ Species of concern ➢ Invasive

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Ecosystem Services	Indicator
• **Provisioning**– • Recorded low water level during drought • Freshwater clam production at national level – 1,300mt/yr at FJD$1m/yr – source of protein • Ministry of Fisheries record drop in production over last 10yr and smaller size	Provisioning ➢ Water Supply Reliability relative to demand ➢ Biomass for consumption
• **Regulation** – • Heavy sedimentation all year round • Increase concentration of trace elements • Contamination (copper) in freshwater clam (kai with high concentration of copper – Waidina River in Waimanu Catchment)	Regulation and Support ➢ Sediment Regulation ➢ Water Quality Regulation ➢ Flood Regulation ➢ Disease Regulation

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Ecosystem Services	Indicator
• **Cultural** • Cultural heritage sites • Strong cultural links with forest and forest species	**Cultural** Conservation Sites Cultural heritage sites
• **Recreation** • Societal value – local enjoyment • Tourism - untapped	**Recreation** Aesthetic Recreational values

15

Governance & Stakeholders	Indicator
• **Enabling Environment** – • Fiji Constitution 2013 (section 36) • Rivers and Streams Act [Cap 136] • WAF Promulgation 2007 • WAF has no legislative powers and no specific mandate to manage watersheds • Consistent Water quality is a huge challenge – land and water nexus	**Enabling Environment** ➢ Water Resource Management ➢ Rights to Resource Use ➢ Incentives and Regulations Financial Capacity ➢ Technical Capacity
• **Stakeholder Engagement** – • Limited research on ecosystem/habitats • Limited engagement with local communities to appreciate local impact on water quality	**Stakeholder Engagement** ➢ Information Access and Knowledge ➢ Engagement in Decision Making Process

16

Governance & Stakeholders	Indicator
• **Vision and Adaptive Governance**– • WAF committed to Strategic Planning at catchment level – Drinking Water Catchment Management • Ongoing monitoring by WAF but results not publically shared • Functional National Water Quality Laboratory at WAF	**Vision & Adaptive Governance** ➢ Strategic Planning and Adaptive Governance ➢ Monitoring and Learning Mechanism
• **Effectiveness**– • Low compliance due to low penalties – need better control of landuse in catchment areas • Opportunity for WAF to collaborate closely with regulatory authorities	**Effectiveness** ➢ Enforcement & Compliance ➢ Distribution of Benefits from Ecosystem Services ➢ Water Related Conflict

17

Question & Answer

18

Freshwater Health

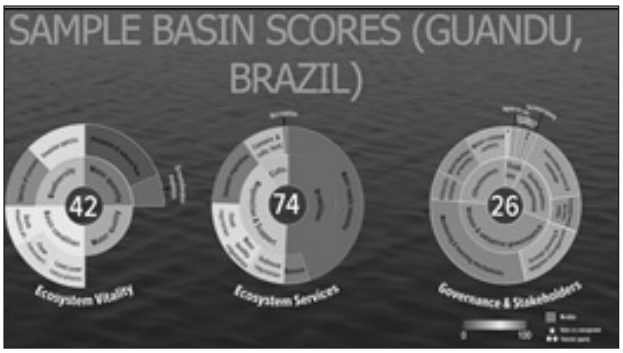
- **Catchment General Check up**
- **Integrates ecosystem goods and services (env. & social) pillars**

19

Freshwater Health Index - indicators

ECOSYSTEM VITALITY	ECOSYSTEM SERVICES	GOVERNANCE & STAKEHOLDERS
Water Quantity Deviation from Natural Flow Groundwater Storage Depletion **Water Quality** Suspended Solids Total Nitrogen Total Phosphorus Other Quality Parameters of Concern **Basin Condition** Bank modification Flow Connectivity Land Cover Naturalness **Biodiversity** Species of Concern Invasive & Nuisance Species	**Provisioning** Water supply Reliability Biomass for Consumption **Regulation & Support** Sediment Regulation Water Quality Regulation Flood Regulation Disease Regulation **Cultural** Conservation Areas Recreation	**Enabling Environment** Water Resources Management Rights to Resource Use Incentives & Regulations Financial Capacity Technical Capacity **Stakeholder Engagement** Information Access Engagement in Decision-making Processes **Vision & Adaptive Governance** Strategic Planning & Adaptive Management Monitoring & Learning Mechanisms **Effectiveness** Enforcement & Compliance Distribution of Benefits Water-related Conflict

20



21

Freshwater health index

- Standardized way to get multiple stakeholders on the same page with regards to water resource management

More information available at www.freshwaterhealthindex.org

22

Freshwater Index Survey

https://webtools.freshwaterhealthindex.org/en/wt/start.php?

- Session code: 667872
- Country enter: Fiji WC
- Sector – select
- I am not a robot ☺

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Appendix 3 – Questionnaire for Freshwater Health Index

Framework for Basin Management (1 of 12)

Integrated water resources management is a guiding framework for coordinating both development and management of all resources within a basin, to maximize welfare without compromising ecological sustainability. In some cases a single agency, such as a river basin authority, is responsible for coordinating and overseeing these functions; the questions below focus on the specific functions as managed within your jurisdiction (e.g. transnational, national or provincial) regardless of whether they are all carried out by the same agency.

Based on your own knowledge of the current situation, please evaluate the degree to which the following functions are being fulfilled throughout the basin. Provide a rating between 1 and 5 following the criteria below. Please skip any items which you do not feel qualified to answer.

Rating	Criteria
1	Function is almost never satisfactory (without conflicts among stakeholder groups)
2	Function is rarely satisfactory
3	Function is sometimes (~50%) satisfactory
4	Function is often satisfactory
5	Function is almost always satisfactory

A) **Policies and actions to advance water resource development and management are coordinated.**
For example, but not limited to, if there is river basin organization or commission, how effective is it in coordinating the different agencies, levels of government (e.g., national, provincial, local), and private interests when establishing integrated development plans for the basin?

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

B) **Infrastructure such as dams, reservoirs, and treatment plants are centrally managed or coordinated.**
Examples include, but are not limited to: dam operators communicating the timing and volume of reservoir releases, or assessing cumulative impacts of dams.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

C) **Financial resources are mobilized to support water resource development and management needs.**
Examples include, but are not limited to: cost-sharing for common projects, or collecting user fees/taxes.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

D) **Ecosystems conservation priorities are developed and actions implemented.**
Examples include, but are not limited to: protecting forested watersheds, maintaining wetland/river connectivity, or developing an aquatic species biodiversity action plan.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Rules for resource use (2 of 12)

Clear and enforceable rules are recognized as a requirement for the efficient use of scarce resources, and as a means of resolving conflicts. These rules encompass various uses and users of water, and can be both formal (i.e., legislated by a government body) or informal rules administered by communities.

Based on your own knowledge of the current situation, please evaluate the quality and stakeholders' understanding of rules concerning the use of various resources. Provide a rating between 1 and 5 following the criteria below. Please skip any items which you do not feel qualified to answer.

Rating	Criteria
1	Rules are very poorly articulated and/or understood or do not exist
2	Rules are poorly articulated and/or understood
3	Rules are acceptably articulated and/or understood
4	Rules are well articulated and/or understood
5	Rules are very well articulated and/or understood

A) **Quality and clarity of rules for allocating water among different sectors (e.g., municipal, industrial, agricultural)**
Examples include, but are not limited to: prioritizing water according to use, or limits on the timing and amount of water that can be withdrawn.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

B) **Quality and clarity of rules for allocating water among administrative jurisdictions (e.g., cities, provinces, countries)**
Examples include, but are not limited to: determining withdrawals between provinces, or setting minimum flow requirements for rivers that cross administrative boundaries.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

C) **Quality and clarity of rules for groundwater abstraction**
Examples include, but are not limited to: guidelines regarding the depth of wells, or amount of water that can be withdrawn within a certain time period.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

D) **Quality and clarity of rules for wastewater handling and water pollution**
Examples include, but are not limited to: guidelines regarding the discharge of wastewater (e.g. pollutant concentrations, volume, temperature, time of release) into water bodies.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Incentives and regulations (3 of 12)

Various management tools, from conventional regulations to market-based instruments can be applied within a governance system. Having a variety of tools offers opportunities to increase the efficiency of interventions (e.g., cost per unit outcome) or lead to a more equitable distribution of benefits.

Based on your own knowledge of the current situation, please evaluate the development of the following management tools. Provide a rating between 1and 5 following the criteria below. Please skip any items which you do not feel qualified to answer.

Rating	Criteria
1	Instrument does not exist or is in earliest stage of discussion
2	Instrument is under development, e.g. guidelines have been circulated
3	Instrument has been developed and is being piloted, but guidelines are subject to refinement
4	Instrument is fully developed, but use is not yet standardized
5	Instrument is fully developed and a standard practice

A) **Environmental and social impact assessments for all major water projects, regardless of funding source, are carried out prior to decisions being taken**
Examples include, but are not limited to: environmental impact assessment (EIA) that is submitted to a government body for evaluation.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

B) **Existence of financial incentives for environmental stewardship**
Examples include, but are not limited to: mechanisms for providing payments for watershed services provided by upstream stakeholders (e.g., farmers, forest managers, local governments).

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

C) **Existence of market-based exchange schemes**
Examples include, but are not limited to: tradeable water rights, wetland mitigation banking, or pollutant trading.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

D) **Existence of honorary recognition programs**
Examples include, but are not limited to: publishing lists of industries with good environmental performance, or awards for local governments practicing good water stewardship.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

E) **Existence of land use zoning policy**
Examples include, but are not limited to: requirements for riparian buffers, floodplain development, or forested catchment zones.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Technical capacity (4 of 12)

Lack of local capacity is often cited as an impediment to a variety of issues in resource management. Here we are referring to people employed in areas of water resource management, service delivery, monitoring and enforcement, and related research, but excluding international consultants.

Based on your own knowledge of the current situation, please evaluate the quality of human resources in water resource development and management in the basin. Provide a rating between 1 and 5 following the criteria below. Please skip any items which you do not feel qualified to answer.

Rating	Criteria
1	Level is very unsatisfactory
2	Level is unsatisfactory
3	Level is satisfactory
4	Level is very satisfactory
5	Level is extremely satisfactory

A) Number of staff (including local consultants) to fulfill necessary functions
Examples include, but are not limited to: backlogs (work waiting to be done) in a particular agency, or open positions remaining vacant due to lack of candidates.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

B) Staff have sufficient expertise to fulfill necessary functions
Examples include, but are not limited to: hydrologists to evaluate a proposed dam, or fisheries ecologists to assess fish stocks.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

C) Opportunities for professional training and certification
Examples include, but are not limited to: financial support or time allocated for continuing education courses related to improving technical skills.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Financial capacity (5 of 12)

Water resource development and management is often under-financed, particularly for services that do not generate revenue, such as ecosystem protection. Although financial capacity can be measured directly as a function of existing allocations relative to estimated budget needs, qualitative information is also useful in providing insights and identifying priorities.

Based on your own knowledge of the current situation, please evaluate the quality of human resources in water resource development and management in the basin. Provide a rating between 1 and 5 following the criteria below. Please skip any items which you do not feel qualified to answer.

Rating	Criteria
1	Level is very unsatisfactory
2	Level is unsatisfactory
3	Level is satisfactory
4	Level is very satisfactory
5	Level is extremely satisfactory

A) Level of investment in water supply development
Examples include, but are not limited to: financial resources for building and maintaining reservoirs or irrigation systems.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

B) Level of investment in service delivery systems
Examples include, but are not limited to: financial resources for building and maintaining water distribution networks (i.e. piped supply) or household wells.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

C) Level of investment in wastewater handling and treatment
Examples include, but are not limited to: financial resources for building and maintaining community toilets, or treatment systems to process waste water.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

D) Level of investment in ecosystem conservation and rehabilitation
Examples include, but are not limited to: financial resources for protecting wetlands to mitigate flood risk, remediating impaired streams, or rehabilitating fish stocks.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

E) Level of investment in monitoring and enforcement
Examples include, but are not limited to: financial resources for evaluating EIAs, collecting environmental data, inspecting facilities, and enforcing regulations.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Information and knowledge (6 of 12)

Sound water governance requires information on a range of topics and from many sources. Even in cases where data and information are abundant, if they are not made accessible (across agencies, with citizens, etc.) then they are less likely to aid in wise decision making.

Based on your own knowledge of the current situation, please evaluate the accessibility of information (including data on water quantity and quality, planning documents, and financial information), along with its quality of coverage and transparency (ability to be traced to the source). Provide a rating between 1 and 5 following the criteria below. Please skip any items which you do not feel qualified to answer.

Rating	Criteria
1	Almost never satisfactory
2	Rarely satisfactory
3	Sometimes (~50%) satisfactory
4	Often satisfactory
5	Almost always satisfactory

A) **Information is accessible to interested stakeholders**
Examples include, but are not limited to: reports made freely available through a website, or data available upon request to the agency with the information.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

B) **Information meets expected quality standards, in terms of frequency, level of detail, and subjects of interest to stakeholders**
Examples include, but are not limited to: time series data on streamflow, water levels, or water quality for specific locations within the basin.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

C) **Information is transparently sourced**
Examples include, but are not limited to: methods used to collect data are documented, or authors (source) of these data are clearly identified.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

D) **All available, sound and relevant information is routinely applied in decision-making**
Examples include, but are not limited to: modifying an infrastructure project based on EIA results, or adjusting fisheries management guidelines based on fish catch data.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Engagement in decision-making processes (7 of 12)

Stakeholder engagement encompasses the process by which any person or group with an interest in a water-related topic can be involved in decision-making and implementation. It is associated with improved information transfer, better targeted and more equitable plans and policies, improved transparency and accountability, and reduced conflict.

Based on your own knowledge of the current situation, please evaluate the degree to which all stakeholders have a voice within the cycle of policy and planning for water resources development and management. Provide a rating between 1 and 5 following the criteria below. Please skip any items which you do not feel qualified to answer.

Rating	Criteria
1	Process as described almost never, or never occurs
2	Process as described rarely occurs
3	Process as described sometimes (~50%) occurs
4	Process as described often occurs
5	Process as described almost always, or always occurs

A) **All relevant stakeholders have been identified and notified when considering major decisions**
Examples include, but are not limited to: mapping and notifying stakeholders affected by a proposed water supply infrastructure project (e.g. construction of a water supply dam).

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

B) **Stakeholders are able to provide comments prior to major decisions being taken**
Examples include, but are not limited to: consultation meetings or an information gathering period where stakeholders may provide input regarding a policy or project.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

C) **Decisions are responsive to stakeholders' participation**
Examples include, but are not limited to: processes for reaching joint agreements among a group of stakeholders prior to approval of a major policy or project, or projects being revised subsequent to stakeholder feedback.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Enforcement and compliance (8 of 12)

In many societies, there is a gap between laws and their actual enforcement, reflecting either insufficient capacity or a lack of accountability. Enforcement and compliance can be ensured through fines, incentives, or social pressure, but weak enforcement leads to poor management and a lack of confidence in the system.

Based on your own knowledge of the current situation, please evaluate how well existing regulations and agreements are enforced for the following areas throughout the basin. Provide a rating between 1 and 5 following the criteria below. Please skip any items which you do not feel qualified to answer.

Rating	Criteria
1	Enforcement is very poor or no guidelines (formal or informal) exist
2	Enforcement is poor
3	Enforcement is acceptable
4	Enforcement is good
5	Enforcement is very good

A) Surface water abstraction guidelines are enforced
Examples include, but are not limited to: industries restricted from withdrawing more than a specified amount of surface water, or farmers sanctioned for withdrawals during the dry season.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

B) Groundwater abstraction guidelines are enforced
Examples include, but are not limited to: farmers or industries restricted from pumping more than a specified amount of groundwater.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

C) Flow requirement guidelines are enforced
Examples include, but are not limited to: dam operators meeting the expectations of downstream water users, to meet environmental flows, human water needs, and/or flood protection.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

D) Water quality guidelines are enforced
Examples include, but are not limited to: industries and communities complying with requirements related to pollutant discharges, or non-negotiable fines are levied on violators.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

E) Land use guidelines are enforced
Examples include, but are not limited to: environmentally sensitive zones (e.g., catchment forests and wetlands) being protected from development or degradation.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Distribution of benefits from ecosystem services (9 of 12)

*Equity is an important issue in water resource management, most closely associated with access to safe water and sanitation. Here we extend the concept to include all benefits from ecosystem services in the basin (**water and sanitation, fisheries, flood mitigation, water quality maintenance, disease regulation, and cultural services**).*

Based on your own knowledge of the current situation, please evaluate quality of outcomes, in terms of their share of benefits from water resources, for the following stakeholder groups (groupings may overlap). Provide a rating between 1 and 5 following the criteria below. Please skip any items which you do not feel qualified to answer.

Rating	Criteria
1	Their share of benefits is almost never adequate
2	Their share of benefits is rarely adequate
3	Their share of benefits is sometimes (~50%) adequate
4	Their share of benefits is often adequate
5	Their share of benefits is almost always adequate

A) **Economically vulnerable populations benefit from ecosystem services**
Examples include, but are not limited to: poor households' access to improved water supply sources at a reasonable cost, protection from inland flood risks, or rural compared to urban populations' benefits.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

B) **Indigenous people benefit from ecosystem services**
Examples include, but are not limited to: exercising customary rights related to water, including for consumptive as well as cultural uses, or maintaining traditional fisheries.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

C) **Women and girls benefit from ecosystem services**
Examples include, but are not limited to: amount of time collecting water for households, or provision of toilets for females.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

D) **Resource-dependent communities benefit from ecosystem services**
Examples include, but are not limited to: fishermen and smallholder farmers' incomes compared to other economic sectors.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Water-related conflict (10 of 12)

Tensions among stakeholders are expected when there is competition for scarce resources such as water. An effective governance system should prevent tensions from escalating into conflicts, here defined as a difference that prevents agreement, and therefore delays or undermines a decision taken with the basin.

Based on your own knowledge of the current situation, please evaluate the frequency of conflicts occurring over the past three years regarding water-related issues. Provide a rating between 1 and 5 following the criteria below. Please skip any items which you do not feel qualified to answer.

Rating	Criteria
1	Conflicts almost always occur
2	Conflicts often occur
3	Conflicts sometimes occur
4	Conflicts rarely occur
5	Conflicts almost never occur

A) **Frequency of conflict due to overlapping jurisdictions (e.g., between national governments in transboundary systems, provincial and national government, or between agencies)**
Examples include, but are not limited to: disputes between the local environmental bureau and a national ministry about authority within a floodplain, or between agencies in managing agricultural pollution.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

B) **Frequency of conflict about water rights allocation**
Examples include, but are not limited to: disputes about how water is allocated between two municipalities, or between agricultural and industrial users.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

C) **Frequency of conflict about access**
Examples include, but are not limited to: disputes about having access to safe water and sanitation, or the costs of such access.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

D) **Frequency of conflict regarding the siting of infrastructure**
Examples include, but are not limited to: disputes about reservoir development and resettlement plans for residents and land owners, or downstream impacts to fisheries or water users.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

E) **Frequency of conflict over water quality and other downstream negative impacts**
Examples include, but are not limited to: disputes between upstream and downstream stakeholders about dry season flows or pollution concentrations.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Monitoring mechanisms (11 of 12)

Policy and planning decisions about water resources management are ideally based on sound data and information, which must be collected on a regular basis. Monitoring entails costs and so data collection should be based on needs and assessed relative to resource constraints, where a comparatively wealthy basin might invest in higher spatial and temporal coverage of information.

Based on your own knowledge of the current situation, please evaluate the degree to which different types of data are being collected, analyzed, and used to inform decisions in the basin. Provide a rating between 1 and 5 following the criteria below. Please skip any items which you do not feel qualified to answer.

Rating	Criteria
1	Data are very poorly monitored, or not monitored at all
2	Data are poorly monitored
3	Data are acceptably monitored
4	Data are well monitored
5	Data are very well monitored

A) Overall standard of water quantity monitoring
Examples include, but are not limited to: streamflow being regularly measured, estimated, or modeled in the basin

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

B) Overall standard of water quality monitoring
Examples include, but are not limited to: water quality samples taken from water bodies and measured, or water quality being modeled based on data related to discharge of pollutants.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

C) Overall standard of biological and ecological monitoring
Examples include, but are not limited to: surveillance undertaken to assess aquatic species (e.g., harvested, threatened, invasive) populations or communities (e.g. macroinvertebrates).

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

D) Overall standard of monitoring access to, and use of, water
Examples include, but are not limited to: household surveys administered to estimate the coverage of access to improved water and sanitation sources, or estimates of farmers' groundwater extraction.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

Comprehensive planning and adaptive management (12 of 12)

Comprehensive planning is the process of developing goals and objectives concerning water quantity and quality, surface and groundwater use, land use change, river basin ecology, and multiple stakeholders' needs. Adaptive management refers to the ability to handle changes, unintended consequences, or surprises to the water resource system through updating planning and processes using new information

Based on your own knowledge of the current situation, please evaluate the degree to which ***comprehensive*** *planning at the basin (or sub-basin) scale is taking place. Provide a rating between 1 and 5 following the criteria below. Please skip any items which you do not feel qualified to answer.*

Rating	Criteria
1	Process is almost never comprehensive, or does not occur at all
2	Process is rarely comprehensive
3	Process is sometimes (~50%) comprehensive
4	Process is often comprehensive
5	Process is almost always comprehensive

A) **A shared vision is established and used to set objectives and guide future development**
Examples include, but are not limited to: goals for improvement are jointly established by multiple stakeholders, or a process is in place for developing local water plans that inform higher-level (provincial or national) plans.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

B) **The existence and use of strategic planning mechanisms**
Examples include, but are not limited to: basin-specific spatial plans or management plans that guide investments and policy, or climate change adaptation plans.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5

C) **The existence and use of an adaptive management framework**
Examples include, but are not limited to: updating plans to reflect new knowledge or changing economic development priorities, or to address issues such as climate change.

☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5