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FINAL REPORT

Co-developing nutrient thresholds in submarine groundwater discharge: An integrated transdisciplinary and capacity development project towards safeguarding the future of coral reefs in the Pacific



CBA2024-03SY-Leong

2026

RIHN
Research Institute for Humanity and Nature (RIHN)
総合地球環境学研究所

RIHN LINKAGE

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 Asia-Pacific Network for Global Change Research (APN)

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1. Summary

This APN project investigated land-to-sea nutrient pathways affecting freshwater, coastal, and coral reef ecosystems in Ra Province, Fiji, with a focus on Navolau District. The project was developed in response to growing concerns in island settings that land-based pollution, in the form of agricultural runoff via groundwater discharge may be contributing to nutrient enrichment in coastal waters and coral reef environments. In Pacific Island communities, coral reefs provide essential ecosystem services, including fisheries, coastal protection, cultural value and livelihood support. However, these reef systems are increasingly threatened by climate change, land-use change and local pollution pressures.

The project adopted a ridge-to-reef approach, connecting land-based activities in villages, farms, rivers, groundwater systems, coastal zones, fringing reefs and barrier reefs. Field activities included community engagement, land-use observations, river and groundwater surveys, coastal water sampling and reef-related nutrient assessments. Surveys were conducted across land-based sites, river systems, fringing reef environments and barrier reef areas. The project also incorporated local knowledge from village communities, including observations of river conditions, flooding, waste movement, coastal changes and reef-related concerns. This helped link scientific measurements with lived community experience.

Preliminary findings indicate that land-based nutrient inputs are a significant concern in the study area. Excess nutrient concentrations were detected at barrier reef sites at levels that may threaten juvenile coral survival and reduce reef recovery potential. Fringing reef environments were found to be severely degraded and, in some areas, almost absent, potentially due to substantial sediment accumulation that may smother juvenile corals and inhibit reef regeneration. These findings highlight the urgent need for improved land-management practices and targeted interventions to reduce nutrient and sediment inputs from land to the coastal environment.

The project also identified several visible land-based pollution pathways. Rubbish dump sites were observed near rivers, and waste was found caught in trees and vegetation along higher downstream riverbanks. This suggests that flood events transport waste from riverbank dumping areas downstream toward coastal environments. Agricultural areas, particularly sugarcane farms, may also contribute nutrients through runoff, erosion and fertilizer loss. Groundwater and submarine groundwater discharge remain important hidden pathways because they can transport dissolved nutrients from land to coastal waters even outside major rainfall or flood events. However, the results indicate that rivers are the dominant pathway delivering nutrients and pollutants to the reefs in this study area, rather than SGD. Therefore, future management efforts should place greater emphasis on adaptation and resilience measures for surface-water pathways, including riverbank restoration, riparian buffer zones, improved waste management and flood-sensitive land-use planning.

The community component revealed an important management dilemma: communities generally understood which activities and substances were contributing to coral reef degradation, yet many continued to rely on the same practices because they remain central to household livelihoods and agricultural production. In particular, chemical-based farming

practices were recognized as environmentally harmful but continued to be widely used because they provide economic security and reliable income.

This highlights the limitation of awareness-based interventions alone. While communities expressed willingness to change, alternative practices must also be economically viable. The findings therefore point to the need for **economic incentive-based nature-based solutions**, where environmental restoration is linked with supplementary or alternative livelihood opportunities like filter feeder aquaculture and mariculture projects. Examples could include sea weed, sea-grape cultivation, oyster or giant-clam farming, mangrove-related livelihoods or other locally appropriate activities that reduce pressure on land and reef systems while providing tangible economic benefits to communities.

Overall, this project provides an important baseline for understanding nutrient pollution and reef vulnerability in Navolau District. It demonstrates that coral reef protection in Fiji requires integrated ridge-to-reef management that addresses both visible river-based pollution and hidden groundwater nutrient pathways, while strengthening collaboration among communities, researchers and government stakeholders in Ra Province and the wider Pacific region.

2. Objectives

The project had four main objectives:

1. Conduct capacity-development workshops on transdisciplinary approaches in hydrological projects, hydrological research surveys, citizen science training, basic equipment operation, basic modelling and simulation, and sustained networking for future collaboration in Pacific Island Countries.
2. Determine a threshold for submarine groundwater discharge nutrient excess impacting coral ecosystems by identifying and quantifying the main sources of SGD contaminants and assessing coral growth.
3. Document and synthesize lessons learned and best practices that help connect communities and stakeholders in decision-making, and co-design a customized transdisciplinary framework suited to Pacific Island Countries, considering different socio-economic environments, cultural settings, decision-making processes, and project longevity.
4. Support pathways towards integrated water resources management measures that align with ecosystem-based adaptation by recommending strategies that harness multiple ecosystem services and sustain the wellbeing of local people, based on suitable solutions practiced elsewhere.

3. Outputs, Outcomes and Impacts

Outputs	Outcomes	Impacts
Pre-engagement workshop: Conducted in Navolau District through **talanoa* (discussions) and field visits. The project objectives were not formally introduced at this stage to avoid influencing community responses, allowing participants to freely share their knowledge, experiences, and concerns about the environment and changes, natural resource usage and livelihoods. **Participants:** 26	Established an initial relationship with the community and gained insight into local culture, livelihoods, traditional knowledge, environmental concerns, and community observations. The workshop helped identify key local issues and guided how future project activities should be communicated and conducted in a culturally appropriate way.	Built trust and community ownership early in the project, helping the team design future workshops, surveys, and training around local needs, cultural protocols, and practical management priorities. This created a stronger foundation for long-term collaboration and commitment, community monitoring, and locally relevant ridge-to-reef management.
Knowledge Exchange Workshop: Conducted a community-centred capacity development and knowledge exchange workshop combining classroom learning, talanoa discussions, regional experience sharing, participatory activities, and field demonstrations. The workshop introduced key concepts on land–sea interactions, island hydrology, SGD, nutrient pollution, coral reef health, citizen science, and community-based monitoring, while also including practical activities such as participatory mapping, water-quality discussions, sampling demonstrations, and	Participants improved their understanding of how land-based activities, rivers, groundwater, nutrients, and coastal processes affect coral reef health. The workshop supported two-way learning between communities, scientists, early-career participants, and regional partners, while helping participants connect scientific concepts with local observations and practical land-to-reef management.	Strengthened local and regional capacity for ridge-to-reef monitoring and community-based reef protection. The workshop helped turn scientific knowledge into practical community action, supported stronger collaboration among communities, researchers and government stakeholders, and created a foundation for future monitoring, adaptive management, and locally grounded reef-protection planning.

community solution design for protecting the i-qoliqoli and reducing nutrient impacts on coral reefs. **Participants:** 45-61 people **Beneficiaries:** workshop participants (community, early career, local, regional and international collaborators)		
Results Sharing and Future Pathways Workshop: Conducted a follow-up results-sharing and future pathways workshop to present interim field survey and modelling findings to the community. The workshop reviewed previous project activities, allowed community questions and feedback, and supported each village group to design and refine practical actions for protecting rivers, groundwater, coastal areas, i-qoliqoli, and coral reefs. It also introduced nature-based and eco-resilience options, such as marine filter feeders and mangroves, and gathered community reflections and expectations for future support. **Participants:** 40	Community members received feedback on the survey results and connected the scientific findings with their own observations of land, rivers, flooding, waste movement, groundwater, sea grapes, fishing grounds, and reef health. The workshop shifted the discussion from awareness to practical planning, helping each village refine locally appropriate management ideas while also clarifying community priorities and future support needs.	The workshop strengthened community ownership and helped translate scientific findings into practical village- and district-level actions. It supported future planning for reef protection, river and waste management, nature-based solutions, community monitoring, and collaboration with the Ra Provincial Council and relevant government agencies.
Closing Workshop — Final Results, Recommendations and Future Collaboration: Conducted a closing workshop with Navolau	Participants received the final project results and recommendations in an accessible format and gained a clearer understanding of key land-to-	The closing workshop strengthened the link between research findings and

communities, wider coastal villages in Ra Province, and relevant government and partner organisations. The workshop presented the final findings, shared the community report and recommendations, and discussed future actions for monitoring, river and coastal management, waste management, agricultural nutrient reduction, nature-based solutions, and continued collaboration. **Participants:** 87	reef pathways, including rivers, flood transport, agricultural runoff, waste disposal, groundwater/SGD, and reef vulnerability. The workshop also enabled different stakeholder groups to discuss shared responsibilities and identify practical actions across village, district, provincial, agricultural, and coastal-management levels. Government departments in attendance (Min of i-Taukei, Min of Environment, Min of Agriculture and Waterways, Min of Fisheries, Min of Lands and Mineral Resources) Interim Project Report and Recommendation to be submitted to Ra Provincial Council The Paramount Chief of Ra Province attended and provided strong traditional leadership support for the project and its continuation within the province. This allows us to do future work in the province without local interference and also strengthens our position for getting permits from the government.	management action by sharing the final report and recommendations with communities, provincial authorities, agricultural and tourism stakeholders, and wider coastal villages across Ra Province. It supported broader awareness, ownership, coordination, policy uptake, community monitoring, improved waste and river management, sustainable farming practices, and long-term coral reef protection. The participation and endorsement of the Paramount Chief, together with representation from coastal villages across the province, strengthened relationships with traditional leadership and communities and created an important foundation for future research access, collaboration, and project development across Ra Province. Initiated discussions with Min i-Taukei Lands on potential collaboration for soil research and land-management studies.

Exposure Learning Workshop — Nature-Based Solutions for Reef Protection: Conducted an exposure learning workshop to introduce community representatives and stakeholders to ongoing coastal and marine restoration initiatives in Fiji. The workshop highlighted nature-based and livelihood-linked solutions such as oyster farming, giant clam farming, coral replanting, sea cucumber initiatives, sea-grape/nama approaches, and other coastal rehabilitation activities, allowing participants to consider which options may be suitable for their own i-qoliqoli, coastal areas, and village development priorities. **Participants:** 12 people	Participants gained practical exposure to reef restoration, filter-feeder systems, nutrient uptake, coastal management, and livelihood opportunities. The workshop showed how nature-based marine solutions can complement land-based pollution reduction and helped communities assess which options may be realistic, culturally appropriate, economically beneficial, and environmentally suitable for Navolau District. The places visited were Navutulevu MPA, Namara mariculture and Galoa Hatcheries	The exposure workshop strengthened community capacity to evaluate practical reef-protection and nutrient-management options. Learning from existing Fiji-based projects generated ideas for locally led initiatives that combine environmental restoration, food security, livelihoods, and reef-health improvement, while supporting future collaboration with government agencies, NGOs, and community groups across Ra Province. Built a strong foundation for future research, collaboration, and project development in the area.
Land and Marine Survey: Conducted land-to-reef surveys across rivers, groundwater, coastal waters, fringing reefs, and barrier reefs to establish baseline conditions. Data were collected on water quality, nutrients, land-use pressures, river conditions, reef indicators, agricultural areas, and potential pollution sources. **Beneficiaries:** workshop participants	The data improved understanding of current environmental conditions in Navolau District, including nutrient levels, pollution sources, land-to-reef pathways, river and groundwater contributions, and reef exposure. Analysis identified key concerns such as nutrient enrichment, flood transport, agricultural runoff, waste movement, and areas requiring continued monitoring.	The survey results provide a scientific baseline for project recommendations, community action, and future policy discussions. They support evidence-based decision-making on river management, waste disposal, agricultural nutrient control, coastal protection, reef monitoring, and integrated water resources management. The findings are also particularly relevant to ongoing discussions in Ra Province about transitioning away from sugarcane

		farming, especially in areas where access to functioning sugar mills has become increasingly limited. Communities have expressed interest in diversifying toward alternatives. However, until now, there has been limited local scientific evidence to support and guide this transition. The project results have provided communities and stakeholders with evidence on the environmental impacts associated with current land-use and agricultural practices, helping to strengthen the basis for considering alternative farming systems. This has laid an important foundation for initial discussions on agricultural diversification, future land-management strategies, and potential collaboration with government and regional agencies to support a more environmentally and economically sustainable transition in Ra Province.
Collaboration with Ra Province Integrated Coastal Management Review Team: Collaborated with the working group for the Ra Province Integrated Coastal Management Review (2026–2031), sharing APN findings and	The collaboration linked the APN findings with the wider Ra Province planning process, allowing scientific and community evidence to inform integrated coastal management, land-based pollution control, reef protection, and future	The collaboration strengthened the policy relevance and practical uptake of the APN project by linking Navolau District findings to the Ra Province Integrated Coastal Management Review (2026–2031). It

recommendations on nutrient pathways, river and groundwater pollution, waste management, agricultural runoff, reef vulnerability, and community-based monitoring. **Beneficiaries:** Ra Province	monitoring priorities. It also strengthened coordination among researchers, provincial stakeholders, and other coastal-management groups. Ra Coastal Review ICM 2026-2031	supported broader coastal planning, ecosystem-based adaptation, water-resource management, and coral reef protection across Ra Province.
Technical Capacity Building Training — Field, Theory & Modelling: Conducted a structured capacity-building programme for early-career government professionals and university students from Fiji and the wider Pacific region. Training began with hands-on field survey activities, followed by lectures explaining the purpose of each survey, the rationale for sample collection, and how the resulting data are used to understand hydrological and environmental processes. This was followed by online and in-person modelling sessions covering surface-water and flood modelling, GIS and remote-sensing analysis, groundwater modelling, and land-to-reef assessment. The training linked field observations, scientific theory, and modelling to improve understanding of how rainfall, flooding, vegetation, groundwater, land use, and	Students and early-career participants from different professional and academic backgrounds were exposed to the full research process—from field surveys and sample collection, to community workshops, scientific theory, data interpretation, and hands-on modelling. This strengthened their skills in hydrological modelling, spatial analysis, environmental data interpretation, and field-based water-resource assessment, while helping them connect classroom learning with real Pacific Island challenges and community needs. Participants included government professionals and students from the University of the South Pacific (USP) and Fiji National University (FNU), with representation from Fiji, Samoa, Papua New Guinea, New Caledonia, Tahiti, Federated States of Micronesia, Northern Marianas Solomon Islands, Tuvalu, Kiribati, Tonga, Vanuatu, Palau and Japan.	The activity strengthened regional capacity in water-resource management, land-to-reef monitoring, and coral reef protection. It also helped build a network of Pacific early-career professionals, strengthening connections both among themselves and with international counterparts.

coastal processes influence water resources and coral reef health. **Beneficiaries:** Early career		
Secured International Association for Hydrological Sciences (IAHS) Grant — Ridge-to-Reef Training and Regional Capacity Development: Secured IAHS grant to expand ridge-to-reef training and capacity development in Fiji and the wider Oceania region. Building on the APN project, the programme will train early-career professionals, students, government practitioners, community representatives, and regional partners in hydrology, coastal processes, reef protection, community monitoring, social hydrology, and practical water-resource management. **Beneficiaries:** Early career	The APN project created the foundation for this follow-up training by identifying local needs, strengthening partnerships, and demonstrating the value of ridge-to-reef capacity development in Ra Province. The IAHS grant will allow this training to continue beyond the APN project and reach a wider group of participants across Fiji and Oceania.	The follow-up grant strengthens the sustainability and long-term impact of the APN project by supporting continued regional training, monitoring, technical skills development, and practical ridge-to-reef management. It also helps position Ra Province and Fiji as a regional hub for integrated hydrology, community-based monitoring, and coral reef protection in Oceania.
Scientific Dissemination — International and Regional Conference Presentations: Shared APN project findings and lessons through presentations at STAR 2025, PICES 2025, JpGU 2026, IWRM 2026, IAHS-ICWRS 2026, and STAR 2026. Invited presentations were delivered at PICES 2025 and JpGU 2026. The presentations highlighted ridge-to-reef	Conference participation increased the project's regional and international visibility and created opportunities to receive expert feedback, strengthen scientific interpretation, and connect the Fiji case study with wider research on coastal ecosystems, groundwater, nutrient pollution, coral reef protection, and community-based environmental management.	These dissemination activities strengthened the scientific and policy relevance of the APN project beyond Fiji, promoted wider knowledge exchange and future collaboration, and increased recognition of Pacific Island ridge-to-reef challenges within regional and international research networks.

nutrient pathways, SGD, river and flood-related pollution, coral reef vulnerability, community monitoring, and transdisciplinary capacity development in Navolau District. **Beneficiaries: Project Future and Networking**		Initiated discussions with the University of the South Pacific (USP) Centre for Sustainable Futures on potential collaboration for the next phase of research and community development activities in Ra Province.
Exposure Tour and Japan Symposium — Learning from Regional Reef and Coastal Management: Organised an exposure tour for four community members and two government and regional collaborators to attend the LINKAGE Project Symposium in Japan. Participants will learn from coastal and reef management approaches in Japan and Indonesia, including coral reef protection, nutrient reduction, ecosystem restoration, community-based management, and nature-based solutions, while connecting with regional researchers and practitioners. **Beneficiaries:** Navolau community, government and regional collaborators.	Participants will gain first-hand exposure to coastal management, reef restoration, nutrient-control measures, and community-linked initiatives outside Fiji. The tour will help them compare these approaches with Navolau District and identify options that may be adaptable, culturally appropriate, and suitable for local i-qoliqoli and coastal-management needs.	The exposure tour will strengthen community leadership, regional learning, and ownership of reef-protection activities. Connections with Japan, Indonesia, and the LINKAGE Project network will support future collaboration, locally adapted nature-based solutions, improved coastal planning, and wider regional knowledge exchange. Maintain our relationship with the community and stakeholders and start working on future plans Following the Paramount Chief of Ra Province's support for continued research in the province, the head of the Fiji contingent and the lead responsible for community natural-resource management have initiated discussions with the Japanese research teams on future work in

		Ra Province. These discussions aim to identify priority research needs and use the project findings to support decision-making and guide the next phase of research and management activities.

4. Key facts/figures

Pre-engagement Workshop (March 2025)

(a)



(b)



(c)



(d)



(e)



(f)



Figure 1: (a) group photo; (b) prayer event; (c) group work; (d) field tour break; (e) marine reconnaissance; (f) evening bonding event

Knowledge Exchange Workshop (September 2025)

(a)



(b)



(c)



(d)



(e)



(f)



Figure 2: (a) group photo; (b) knowledge exchange discussion; (c) group work; (d) board game; (e) marine survey; (f) evening bonding event

Solutions and Implementation Workshop (March 2026)

(a)



(b)



(c)



(d)



(e)



(f)



Figure 3: (a) group photo; (b) group work; (c) group presentation; (d) field group photo with community; (e) field survey; (f) evening bonding event

Closing Workshop (September 2026)

(a)



(b)



(c)



(d)



(e)



(f)



Figure 4: (a) Event Poster; (b) Traditional Welcome to Tu Navitilevu (Paramount chief of Ra Province); (c) Prof. Yasumoto (LINKAGE Project Leader) addresses the community; (d) Chris Leong (APN Project Leader) addresses the community; (e) workshop discussion (f) Early career group photo with APN-LINKAGE team and Tu Navitilevu

Exposure Tour (September 2026)

(a)



(b)



(c)



(d)



(e)



(f)



Figure 5: (a) Navutulevu MPA; (b) Galoa Hatchery; (c) Seaweed farming; (d) shrimp farming (pond) and mud crab (background mangrove); (e) traditional sevusevu at MPA; (f) women's group photo

Citizen Science & early career field survey (September 2025; 2026)

(a)



(b)



(c)



(d)



(e)



(f)



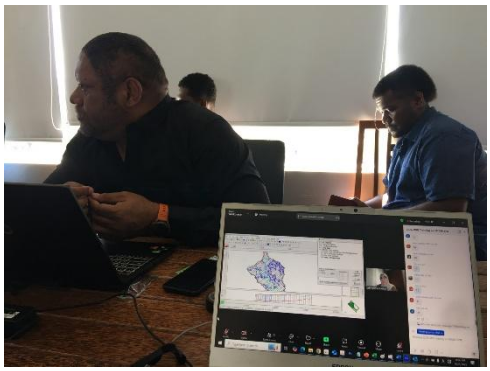
Figure 6: (a) community citizen science 2025; (b) early-career marine survey 2025; (c) team bonding exercise 2026; (d) early-career marine survey 2026; (e) early-career groundwater survey 2026; (f) early-career stream survey 2026

Early career onsite modelling workshop (2025-2026)

(a)



(b)



(c)



(d)



(e)



(f)



Figure 7: (a-b) onsite modelling workshop 2025; (c-d) modelling workshop 2026 at the mineral resources department (MRD); (e-f) modelling workshop 2026 at the Pacific Community (SPC)

Dissemination conferences

(a)



(b)



(c)



(d)



(e)



(f)



Figure 8:
(a) PICES conference 2025 (Yokohama, Japan) (Photo credits: Toya Hirokawa; taken from https://meetings.pices.int/publications/pices-press/PICES-Press-2026-Vol34No1.pdf);
(b) STAR conference 2025 (Suva, Fiji) (Photo credits: MRD);
(c) Japan Geoscience Union (JpGU) 2026 (Chiba, Japan);
(d) International Water Resources Systems (IWRS) 2026 (Canberra, Australia);
(e) Navolau district community members at the LINKAGE Symposium 2026 (Okinawa, Japan);
(f) Fiji contingent attending a workshop at the LINKAGE Symposium 2026 (Okinawa, Japan)

(a) (b)

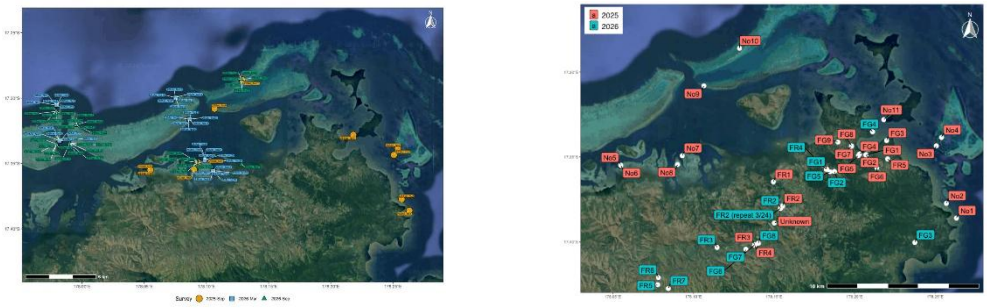


Figure 9: Map of preliminary survey points (a) marine (b) land (and few marine points)

5. Publications

Lead Author	Theme/Title	Journal	Impact Factor	Status
Chris Leong	Ridge-to-reef hydrological pathways: Linking intensive sugarcane agriculture and coral reef ecosystems in Ra Province, Fiji	Journal of Hydrology	7.3	In preparation
Chris Leong	Insights into socio-cultural drivers of environmental stress and management: A transdisciplinary ridge-to-reef study in coastal Fiji	Hydrological Sciences Journal	2.9	Under review
Chris Leong	Synthesis of a transdisciplinary ridge to reef project in coastal Fiji	APN Bulletin		In preparation
Kana Miyamoto	Assessing Rural Water Security under Shifting Rainfall Patterns and Population Growth: A Social-Ecological Systems (SES) Approach in Rakiraki, Fiji	People and Nature	5.8	In preparation
Ko Yasumoto	Spatial correspondence among exchangeable phosphate, volcanogenic sediment signatures, and coral assemblages along the Rakiraki coast, Fiji	Marine Pollution Bulletin	4.9	In preparation
Chris Leong	Ridge-to-Reef Nutrient Pathway Study in the Sugarcane Belt of Ra Province	Report	N/A	In preparation
Salanieta Kitolelei	Ra Integrated Coastal Management Plan 2.0 (2026-2031)	Report	N/A	Submitted to Working Group

6. Media reports, videos and other digital content

ITaukei Land Trust Board's Facebook Post:
https://www.facebook.com/share/p/1JEeXzFJEU/?mibextid=wwXIfr

Pacific Islands Countries and Territories (PICTs) LinkedIn Post:
https://www.linkedin.com/groups/14400089/

7. Pull quotes

"This project helped our community better understand how activities on the land, especially the use of chemical fertilizers, can affect our rivers, coastal waters and coral reefs. It has encouraged us to think more carefully about reducing chemical use, restoring the health of the land, and using nature-based approaches such as mangrove restoration, sea grapes and shellfish farming to bring back the productivity of our coastal environment."
— Mr. Josefa Uluibua, Navolau District spokesman & head of natural resources use and conservation, Fiji

"This project broadened my understanding of groundwater as an important pathway carrying land-based nutrients to coastal waters and coral reefs. It highlighted the need for science-based nutrient thresholds, stronger monitoring, better wastewater and fertilizer management, and the integration of groundwater into policy. Most importantly, lasting solutions must be co-developed with communities, landowners and government."
— Dr. Rusila Savou, Min of i-Taukei Affairs, Fiji

"This project gave me my first real experience working beyond the classroom—combining field surveys, groundwater and marine science, community engagement and modelling. It strengthened my confidence, practical skills and understanding of how land-based activities affect coastal and reef environments, while also giving me valuable professional networks that I can take back to the Solomon Islands."
— James Foli, Marine Science Graduate, Solomon Islands

8. Acknowledgements

The project team gratefully acknowledges the many communities, collaborators, institutions, government agencies, regional organizations, facilitators, researchers and funding partners who contributed to the project.

We sincerely thank the communities of Navolau District for their participation, hospitality, knowledge sharing and continued support throughout the project. We also acknowledge the Ministry of iTaukei Affairs through the Ra Provincial Council, the Ministry of Fisheries, Department of Environment, Ministry of Agriculture, and the Mineral Resources Department (MRD) for their support, technical contributions and assistance in facilitating project activities or participating in workshops.

We further acknowledge the contribution of the Pacific Community (SPC), the LINKAGE Project, workshop facilitators, invited speakers, field assistants, students, early-career professionals, and regional participants who shared their expertise and supported knowledge exchange and capacity development.

Special thanks are extended to collaborators and advisors including Dr Kastali, Prof Fiori, Dr Metherall, and other contributing researchers and facilitators who supported the scientific, technical and community components of the project.

The project also gratefully acknowledges financial and institutional support from the Asia-Pacific Network for Global Change Research (APN), the Research Institute for Humanity and Nature (RIHN)—LINKAGE Project, and the International Association of Hydrological Sciences (IAHS), including support for capacity development, conference participation and follow-up regional training activities.

The collective support of these partners was essential in strengthening community engagement, scientific research, regional capacity building and the long-term ridge-to-reef management goals of the project.

9. Appendices

1. Community Workshops
    - A-2025_March_Workshop_Program
    - A-2025_Sept_Workshop_Program
    - A-2026_March_Workshop_Program
    - A-2026_Sept_Workshop_Program
2. Community Workshops Attendances
    - B-2025_March_Attendance
    - B-2025_Sept_Attendance
    - B-2025_Sept-b_Modelling_Training_List

- B-2026_March_Attendance
- B-2026_Sept_Attendance

3. Early Career Activities and Attendance
    - C-2025_Sept_Modelling_Program
    - C-2025_Sept_Modelling_Attendance (Hybrid)
    - D-2026_Early_Career_Field_Survey_Program
    - D-2026_Sept_Modelling_Program
    - D-2026_Sept_Modelling_Attendace

Capacity Development Workshop: CBA2025-03SY-Leong

Phase 1: Pre-engagement
18-20 March 2025, Rakiraki, Fiji

INTRODUCTION

CBA2025-03SY-Leong, an Asia-Pacific Network for Global Change Research (APN)-supported project, conducting a capacity development workshop (CapDev) focused on ridge-to-reef environments in the Pacific region. Our team is an environmental research group working on small islands in the Pacific. During this visit, we will carry out basic field surveys and hold discussions with local people to better understand water, land, and coastal environments, and to build longer-term collaboration on issues important to the community.

OBJECTIVES

The objectives of this workshop are to:

a. Establish a friendly connection with the community, observe and learn and understand local culture, way of life, history, language, and religion.

b. Build a spirit of collaboration and mutual trust between community members, local partners, and the locally based project team members.

c. Conduct a basic overview survey of the community, including livelihoods, water use, key environmental features, and important community sites (e.g. villages, schools, churches, coastal areas).

d. Listen to community perspectives on environmental change, including observations, concerns, and local priorities related to land, water, and coastal areas.

e. Identify potential areas for future workshop activities, training, or research that are consistent with community interests, customs, and existing initiatives.

f. Ensure that any future project phases are co-designed, respectful of local customs and leadership structures, and supportive of community well-being and resilience.

Pre-engagement Components

Part I – Community Survey

- This will be attended by Navolau District Members from the four villages; Navolau 1, Navolau 2, Nakorokula, and Namuaiamada
- Conduct traditional ceremony with kava and have informal discussions on the objectives in a traditional approach

- Conduct surveys, in a traditional approach, "Talanoa" approach

Part II – Field Survey.
- Conduct marine survey and land survey, get the community members to participate and have a feel of the work/research/project
- Observe the way community members participate, or conduct work, gather foods etc., i.e., observe the way of life (e.g., gathering and selecting marine food) during this survey.

WORKSHOP AGENDA

TIME	ITEM	Document Reference
DAY 1, Tuesday, 18 March 2025, Nakorokula, Rakiraki, Fiji **Moderators: Chris Leong & Sainiana Hulita & Rusila Savou**		
	Morning Session	
8:30-9:15	**Registration**	
9:15-9:30 *(15 min)*	**Opening Prayers: Vakatawa Nakorokula (Pastor)**	
9:30-9:40 *(10 min)*	**Opening and Welcome remarks** - Mr. Pena Navunisinu, Village Spokeman (Nakorokula), Rakiraki, to welcome the participants and deliver a brief welcome remark - Prof. Jun Yasumoto (LINKAGE Project Leader) to deliver a short welcome note.	
9:40-10:00 *(20 min)*	**Self-introduction & Group Photo** - Participants introduce themselves (Name & Village) and their affiliations	Participants list
10:00-10:10 *(10 min)*	**Item 1: Introduction on Objectives and Structure of the Pre-engagement visit** - Dr. Chris Leong briefly introduces the workshop objectives and group settings	
10:10-10:40 *(30 min)*	**Item 2: Social Survey Questionnaire and Discussion (Dr. Miyamoto)** • Full details will be provided during the visit	Supported by Sainiana
10:40-11:00 *(20 min)*	**COFFEE BREAK**	
11:00-11:30	**Item 3: Water Survey Questionnaire and Discussion (Dr. Leong)** • Full details will be provided during the visit	
11:30-11:45 *(15 min)*	**Item 4: Ice Breaker** Participants position, clan, and traditional omens (plant and fish)	Led by Rusila

TIME	ITEM	Document Reference
11:45-12:15 *(30min)*	**Item 5: Ecological Survey Questionnaire and Discussion (Dr. Tomojiri)** • Full details will be provided during the visit	Supported by Chris
12:15-12:45 *(30 min)*	**Item 6: Groundwater Survey Questionnaire and Discussion (Prof. Yasumoto)** • Full details will be provided during the visit	Supported by Chris
12:45-13:45 *(60 min)*	**LUNCH BREAK**	
	Afternoon Session	
13:45-15:45 *(120 min)*	**Item 7: Groundwater Field Survey (Dr. Leong)** Participants and Team	Supported by Team
15:45-16:00 *(15 min)*	**Return to Nakorokula Village**	
16:00-16:15 *(15 min)*	**Item 8: Onlooking for Day 2**	
16:15-16:30	**Closing Prayers: Vakatawa Nakorokula (Pastor)**	

TIME	ITEM	Document Reference
DAY 2, Wednesday, 19 March 2025		
08:30-9:15	**Registration**	
9:15-9:30 *(15 min)*	**Opening Prayers: Vakatawa Nakorokula (Pastor)**	
9:30-15:30	**Item 9: Marine Field Survey** Participants and Team	
15:30-16:30	**Return**	

TIME		
DAY 3, Thursday, 20 March 2025		
	Post-workshop survey (AM)	
08:30-9:15	**Registration**	
9:15-9:30 *(15 min)*	**Opening Prayers: Vakatawa Nakorokula (Pastor)**	
9:30-10:00	**Item 10: Marine Survey Questionnaire and Discussion (Prof. Yasumoto)**	Supported by Chris
10:00-10:30 (20mins)	**COFFEE BREAK**	
10:30-11:15 (30mins) *(15 min)*	**Item 11: Presentation Phosphate Accumulation in Okinawa (Prof. Yasumoto) & Discussion**	
11:15-11:30 (15mins)	**Closing Thanks: Prof. Yasumoto & Dr. Chris Leong**	
11:30-11:45 (15mins)	**Closing Prayers: Vakatawa Nakorokula (Pastor)**	
11:45-12:15 (30mins)	**Traditional Ceremony**	
12:15-12:30 (15mins)	**End of Pre-engagement Visit**	

Capacity Development Workshop
22-24th September 2025, Rakiraki, Fiji

INTRODUCTION

CBA2025-03SY-Leong is an Asia-Pacific Network for Global Change Research (APN)-supported project titled "*Co-developing nutrient thresholds in submarine groundwater discharge: An integrated transdisciplinary and capacity development project towards safeguarding the future of coral reefs in the Pacific region*." At its heart, this initiative places local communities at the forefront—especially those living in small coral reef islands such as Fiji—by equipping them with the knowledge and tools to better understand the impacts of submarine groundwater discharge (SGD) on coral reef ecosystems.

Through this community-centered Capacity Development (CapDev) workshop, the project seeks to educate the science of SGD, highlight its connection to land-based practices, and explore how traditional ecological knowledge and cultural values can contribute to long-term environmental resilience. Special attention is given to the Navolau District in Rakiraki Province, where local village representatives will actively participate in learning, sharing, and co-developing solutions that align with both science and their lived realities.

Additionally, early-career professionals from diverse fields—including marine science, fisheries, civil engineering, and agriculture—will participate in the workshop to deepen their understanding of submarine groundwater discharge (SGD) and its impacts on coral reef ecosystems. As part of their learning journey, they will receive hands-on training in groundwater resource system modelling, enabling them to apply interdisciplinary tools and perspectives to address complex land–sea interactions in their respective fields.

As coral reef degradation continues to challenge the sustainability of Pacific ecosystems, this workshop provides a unique opportunity to build bridges between community knowledge, scientific research, and policy relevance. Rooted in the transdisciplinary framework of the LINKAGE Project, it addresses the urgent need for action by emphasizing inclusivity, accessibility, and respect for local governance structures.

Aligned with APN's goal of enhancing regional scientific and technical capacity, this workshop potentially stands as the first of its kind in Fiji to spotlight submarine groundwater discharge and coral reef protection through a community-first approach. It represents a step forward in ensuring that those most connected to the land and sea are also the most empowered to safeguard them.

OBJECTIVES

The objectives of this workshop are to:

a. Empower local communities as primary actors
Educate and empower local communities in Rakiraki and surrounding districts to understand the critical role of submarine groundwater discharge (SGD) in shaping coral reef health.

Emphasis will be placed on the links between land-based activities, nutrient pollution (particularly phosphorus), and reef degradation. Communities will be guided through practical sessions to design their own locally grounded solutions for reef rehabilitation and protection.

b. Enhance capacity through hands-on learning
Engage participants—especially early-career scientists from marine, agricultural, fisheries, and civil engineering backgrounds—with community members in collaborative field data collection and participatory learning. Hands-on demonstrations using simple hydrological modelling tools will provide foundational skills to interpret groundwater–reef interactions and inform solution-building.

c. Foster transdisciplinary exchange and regional networking
Create meaningful opportunities for early-career scientists, local stakeholders and government stakeholders to learn from one another, build synergies across disciplines and sectors, and establish lasting connections across provincial and national boundaries within the area.

d. Integrate local knowledge into environmental monitoring
Promote inclusive participation of communities in research activities by recognizing and leveraging traditional ecological knowledge (TEK). This participatory approach enhances the role of local residents as long-term monitoring agents of change in their coastal ecosystems.

e. Co-develop pathways for adaptive governance
Facilitate collaborative identification of actionable entry points toward adaptive governance of interconnected resources—freshwater, marine ecosystems, agriculture, and livelihoods—within the socio-ecological context of Rakiraki, Fiji.

THEME

Accumulated nutrient loads in small islands and its relationship with coral reefs

Coral reefs are considered the rainforests of the sea. They provide numerous ecosystem services such as land formation, natural wave breakers, fish breeding grounds, raw materials for pharmaceuticals, being linked with unique traditional culture, tourism, and construction materials. One of the key services is its function on provision of food and nutrition connected to serving as breeding grounds of fishes (fish productivity) but nowadays, coral reef island systems are on the frontline of global environmental issues. This is because coral reef islands are under combined local and global stresses. Hence, it underscores the importance of managing land-based activities and monitoring submarine groundwater discharge (SGD) to protect coral reef health and ensure sustainable marine ecosystems.

Recent studies on the impact of SGD on coral reefs highlight the significant role of SGD in transporting nutrients, pollutants, and trace elements from land to the marine environment. This process can lead to positive and negative outcomes for coral reef ecosystems. Excessive nutrients, particularly from agricultural runoff, can lead to eutrophication, algal blooms, and coral reef degradation. Some studies developed coastal coral reef system's measure of carrying capacity in terms of nutrient loading, i.e. nutrient budget/threshold which defines the maximum acceptable that the system can tolerate and that the natural internal mechanism can absorb/uptake.

On land, water footprint/water utilization, conditions of water resources, and water-related practices and livelihood activities in small coral reef islands are important factors to be examined and understood. Water resources are a basic necessity in island life, but islands have small recharge rate capacity due to its small land size. Small islands are also increasingly at risk with climatic variations and extremes, and due to its geographic isolation, unique characteristics and biodiversity are preserved, however, communities and ecosystems are more vulnerable to environmental and climatic changes and impacts.

Workshop Components

Given the above, we planned to conduct the CapDev into two parts:

Part I – Community sessions on concepts of island hydrology, land-sea dynamics, island system (system components), community integration, etc.; On-site primary data collection

- This will be attended by village members from Navolau 1, Navolau 2, Nakorokula, and Namuaiamada
- Representation from different sectors in Fiji will also be present, as well as a representative from Palau, Solomon Islands and Samoa
- Ideally, those who attended the first meeting/consultation in March 2025 are expected to be present
- Day 1 will include sessions, lectures and interactive workshop activities
- We will be conducting a community-based participatory mapping and timeline analysis in the afternoon of Day 1.
- On Day 2, there will demo collection and demo assessment methods, as well as NGO and government personnel detailing community research improvements and policy.

Part II – Hands-on SGD modelling demonstration using MODFLOW

MODFLOW, a widely used groundwater flow model, is crucial for predicting submarine groundwater discharge (SGD). By simulating groundwater flow patterns, MODFLOW helps estimate the rate and extent of freshwater and nutrient inputs from land to coastal waters, impacting marine ecosystems and coastal water quality.

- Mainly to be attended by government personnel (Mineral Resources Department, Min. of. Agriculture and Waterways, Water Authority of Fiji) and early-career researchers/students (both Fijian and Samoan USP students, and will be open to other Pacific nationals currently studying at USP)
- Trial data will be used to demonstrate software functions and relevant analyses

WORKSHOP AGENDA

TIME	ITEM	Document Reference
DAY 1, Monday, 22 September 2025, Nakorokula, Rakiraki, Fiji **Moderators: Christmas Uchiyama and Rusila Savou**		
	Morning Session	
8:30-9:15	**Registration**	
9:15-9:25 *(10 min)*	**Opening Prayers: Vakatawa Nakorokula**	
9:25-9:35 *(10 min)*	**Opening and Welcome remarks** - Mr. Keasi Vakalagalaga, Village Spokeman (Nakorokula), Raki raki, to welcome the participants and deliver a brief welcome remark - Dr. Chris Leong (APN Project Leader) and Prof. Jun Yasumoto (LINKAGE Project Leader) to deliver a short welcome note and open the workshop	
9:35-9:55 *(20 min)*	**Self-introduction & Group Photo** - Participants introduce themselves and their village/affiliations	Participants list
9:55-10:05 *(10 min)*	**Item 1: Introduction on Objectives and Structure of the Workshop and Group Placements** - Ms. Christmas Uchiyama briefly introduces the workshop objectives and group settings (with support of Rusila for Fijian language)	Workshop agenda
10:05-10:15 *(10 min)*	**Item 2: Introduction to Japan life and Japanese culture** - Japanese students	Led by Christmas and Rusila
10:15-10:45 *(30 min)*	**Item 3: Participatory Game (Suimaru / The Groundwater Game)** (ice breaker) Full details will be provided during the workshop	
10:45-10:55 *(10 min)*	**COFFEE BREAK**	
10:55-11:30 *(30 min)* *(5 min: Questions)*	**Item 4: Pre-engagement review (March 2025) and analysis** - Ms. Christmas Uchiyama & Dr. Chris Leong, (APN Project Leader), RIHN, Japan	PowerPoint & Talanoa

TIME	ITEM	Document Reference
11:30-11:50 *(20 min)*	**Item 5: Land-Sea Interactions and Dynamics, Hydrological Processes in Small Islands / Overview of land-ocean connection in small coral-reef island systems** - Prof. Yasumoto (LINKAGE Project Leader) & Dr. Chris Leong, (APN Project Leader), RIHN, Japan	PowerPoint & Talanoa Talanoa
11:50-12:00 *(10min)*	**Item 6: Experience Sharing (Marine Ecosystems)** - Joeli Roqouca (Diver)	
12:00-12:15 *(15 min)*	**Item 7: Overview of hydrology in Samoa** - Ms. Emarosa Romeo, Ministry of Natural Resources and Environment, Samoa	PowerPoint & Talanoa
12:15-13:00 *(45 min)*	**LUNCH BREAK**	
	Afternoon Session	
13:00-13:20 *(20 min)*	**Item 8: Aquaculture and Coastal Futures: Lessons and Warnings from Southeast Asia** - Dr. Daiki Tomojiri (freshwater ecologist)	PowerPoint
14:20-14:40 *(20 min)*	**Item 9: Quick introduction and demo on how to use TRAFFIC Indicator Tool** - Ms. Bindiya Rashni (freshwater ecologist) and Dr. Daiki Tomojiri	PowerPoint
14:40-15:40 *(60 min)*	**Item 10: Community resource mapping and participatory landscape-seascape timeline co-creation** - Christmas Uchiyama Each group, facilitated by project members, will conduct participatory mapping using a base map of their village, to identify key and important resources, assets/capitals, problems/threats/risks/barriers, etc. Coloured value point stickers will be provided corresponding to different landscape values. After mapping, timeline analysis using an illustration board/paper will also be conducted. (Demo of IPSI SEPLS indicators) **Groupings will be:** Group 1: Navolau 1 Group 2: Navolau 2 Group 3: Namuaimada Group 4: Nakorokula	No paper

TIME	ITEM	Document Reference
15:40-15:50 *(10 min)*	**BREAK**	
15:50-16:20 *(30 min)*	Each group will assign a representative who will briefly present their community map & landscape-seascape timeline (about 7 min per group)	
16:20-16:35 *(15 min)*	**Item 11: Onlooking for Day 2** (Early-Career Researchers Fieldwork, and Government & NGOs and Talanoa session on Day 2)	
16:35-16:45 *(10 min)*	**Closing Prayers: Vakatawa Nakorokula**	
16:45-16:50 *(5 min)*	**Group Photo**	

TIME	ITEM	Document Reference
DAY 2, Tuesday, 23 September 2025		
08:30-9:15 *(30 min)*	**Registration**	
9:15-9:30 *(15 min)*	**Opening Prayers: Vakatawa Nakorokula**	
9:30-9:45 *(15 min)*	**Item 12: Review of Day 1 and Expectations on Day 2**	
09:45-10:15 *(20 min)* *(10min: Questions)*	**Item 13: Learning, dialogue and collaboration toward land-water sustainability and coral reef health in Fiji - How to increase stakeholder influence on research** - Prof. Joeli Veitayaki, Strategic Adviser, Blue Prosperity Fiji	PowerPoint
10:15-10:30 *(15 min)*	**COFFEE BREAK**	
10:30-10:45 *(15 min)*	**Item 14: Introduction to the Socio-Ecological Resilience IPSI toolkit** - Ms Christmas Uchiyama (with Dr Rusila Savou)	PowerPoint
10:45-11:15 *(30 min)*	**Item 15: Answering the IPSI Indicators Survey** - Ms Christmas Uchiyama - Participants per village will answer the SEPLS Indicators	Venue

		Survey Questionnaire
11:15-11:30 **11:30-12:00** *(30 min)*	**Item 16: Early-career researchers/students introduction** (selected ECRs based in Fiji) (2-3 mins each) **Item 17: Introduction to the importance of designing a water quality monitoring programme or threshold indicator with citizen science** - Dr. Rusila Savou, Mr. Albert Whippy, Ms Christmas Uchiyama, Dr. Chris Leong, Ms. Bindiya Rashni	
12:00-13:00 *(60 min)*	**LUNCH**	
Hands-on demonstration at the field (PM)		
13:00- 13:05 *(5mins)*	**Community & Early-Career (field demonstrations)** Briefing and instructions - Rusila Savou	
13:05-16:30 *(55mins)*	**A. Field survey** A.1. Navolau river sampling and demo (Freshwater survey with Jun Yasumoto and Chris Leong) A.2 Nasogoi river sampling and demo (Freshwater survey with Bindiya Rashni and Christmas Uchiyama)	
Back at the hall	**B. Microscope observation** **C. Co-design of community-based solutions** **Design community-based solutions to help rehabilitate and protect your *i-qoliqoli* and reduce the impact of nutrient pollution on coral reefs (Group 1, 2, 3, 4 by village)**	

TIME		
DAY 3, Wednesday, 24 September 2025		
Post-workshop survey (AM)		
08:30-9:15	**Registration**	
9:15-9:30 *(15 min)*	**Opening Prayers: Vakatawa Nakorokula**	

9:30-10:30	**Expectations from the project (what was learnings/solutions/what help is needed): Groups 1,2,3,4 and presentation**	
10:30-10:40 *(10mins)*	**COFFEE BREAK**	
10:40-11:10 *(30mins)*	**Distribute post-workshop survey for post-test assessment**	
11:10-11:20 *(10mins)*	**Closing Thanks: Prof. Yasumoto & Dr. Chris Leong**	
11:20-11:30 *(10mins)*	**Closing Prayers: Vakatawa Nakorokula**	

Capacity Development Workshop
22-24th September 2025, Rakiraki, Fiji

INTRODUCTION

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Through this community-centered Capacity Development (CapDev) workshop, the project seeks to educate the science of SGD, highlight its connection to land-based practices, and explore how traditional ecological knowledge and cultural values can contribute to long-term environmental resilience. Special attention is given to the Navolau District in Rakiraki Province, where local village representatives will actively participate in learning, sharing, and co-developing solutions that align with both science and their lived realities.

Additionally, early-career professionals from diverse fields—including marine science, fisheries, civil engineering, and agriculture—will participate in the workshop to deepen their understanding of submarine groundwater discharge (SGD) and its impacts on coral reef ecosystems. As part of their learning journey, they will receive hands-on training in groundwater resource system modeling, enabling them to apply interdisciplinary tools and perspectives to address complex land–sea interactions in their respective fields.

As coral reef degradation continues to challenge the sustainability of Pacific ecosystems, this workshop provides a unique opportunity to build bridges between community knowledge, scientific research, and policy relevance. Rooted in the transdisciplinary framework of the LINKAGE Project, it addresses the urgent need for action by emphasizing inclusivity, accessibility, and respect for local governance structures.

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Engage participants—especially early-career scientists from marine, agricultural, fisheries, and civil engineering backgrounds—with community members in collaborative field data collection and participatory learning. Hands-on demonstrations using simple hydrological modelling tools will provide foundational skills to interpret groundwater–reef interactions and inform solution-building.

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Create meaningful opportunities for early-career scientists, local stakeholders and government stakeholders to learn from one another, build synergies across disciplines and sectors, and establish lasting connections across provincial and national boundaries within the area.

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Part II – Hands-on SGD modelling demonstration using MODFLOW

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- Trial data will be used to demonstrate software functions and relevant analyses

WORKSHOP AGENDA

TIME	ITEM	Document Reference
DAY 1, Monday, 22 September 2025, Nakorokula, Rakiraki, Fiji		
Moderators: Christmas Uchiyama and Rusila Savou		
	Morning Session	
8:30-9:15	**Registration**	
9:15-9:30 *(15 min)*	**Opening Prayers: Vakatawa Nakorokula**	
9:30-9:40 *(10 min)*	**Opening and Welcome remarks** - Mr. Keasi Vakalagalaga, Village Spokeman (Nakorokula), Raki raki, to welcome the participants and deliver a brief welcome remark - Dr. Chris Leong (APN Project Leader) and Prof. Jun Yasumoto (LINKAGE Project Leader) to deliver a short welcome note and open the workshop	
9:40-10:00 *(20 min)*	**Self-introduction & Group Photo** - Participants introduce themselves and their villag/affiliations	Participants list
10:00-10:10 *(10 min)*	**Item 1: Introduction on Objectives and Structure of the Workshop and Group Placements** - Ms. Christmas Uchiyama briefly introduces the workshop objectives and group settings (with support of Rusila for Fijian language)	Workshop agenda
10:10-10:40 *(30 min)*	**Item 2: Participatory Game (Suimaru / The Groundwater Game)** (ice breaker) Full details will be provided during the workshop	Led by Christmas and Rusila
10:40-10:55 *(15 min)*	**COFFEE BREAK**	
11:00-11:30 *(20 min) (10min: Questions)*	**Item 4: Pre-engagement review (March 2025) and analysis** - Ms. Christmas Uchiyama & Dr. Chris Leong, (APN Project Leader), RIHN, Japan	PowerPoint & Talanoa
11:30-11:45 *(15 min)*	**Item 3: Lecture on Land-Sea Interactions and Dynamics, Hydrological Processes in Small Islands / Overview of land-ocean connection in small coral-reef island systems** - Prof. Yasumoto (LINKAGE Project Leader) & Dr. Chris Leong, (APN Project Leader), RIHN, Japan	PowerPoint & Talanoa
11:45-12:00 *(15min)*	**Item 5: Experience Sharing (Marine Ecosystems)**	

TIME	ITEM	Document Reference
	- Joeli Roqouca (Diver) & Elina (Seagrapes)	
12:00-12:30 *(20 min)* *(10min: Questions)*	**Item 6: Understanding social factors related to water resource management in Rakiraki using social-ecological system (SES) framework** - Kana Miyamoto and Sainiana Hulita	PowerPoint & Talanoa
12:30-13:20 *(50 min)*	**LUNCH BREAK**	
	Afternoon Session	
13:30-14:00 *(20 min)* *(10min: Questions)*	**Item 7: Aquaculture and Coastal Futures: Lessons and Warnings from Southeast Asia** - Dr. Daiki Tomojiri (freshwater ecologist)	PowerPoint
14:00-14:30 *(20 min)* *(10min: Questions)*	**Item 8: Quick introduction and demo on how to use TRAFFIC Indicator Tool** - Ms. Bindiya Rashni (freshwater ecologist) and Dr. Daiki Tomojiri	
14:30-14:40 *(10 min)*	**BREAK**	
14:40-15:40 *(60 min)*	**Item 9: Community resource mapping and participatory landscape-seascape timeline co-creation** - Christmas Uchiyama Each group, facilitated by project members, will conduct participatory mapping using a base map of their village, to identify key and important resources, assets/capitals, problems/threats/risks/barriers, etc. Coloured value point stickers will be provided corresponding to different landscape values. After mapping, timeline analysis using an illustration board/paper will also be conducted. (Demo of IPSI SEPLS indicators) **Groupings will be:** Group 1: Navolau 1 Group 2: Navolau 2 Group 3: Namuaimada Group 4: Nakorokula	No paper
15:40-16:00 *(20 min)*	Each group will assign a representative who will briefly present their community map and landscape-seascape timeline (5min per group)	
16:00-16:15 *(15 min)*	**Item 10: Onlooking for Day 2 (Government & NGOs and Talanoa session)**	

TIME	ITEM	Document Reference
16:15-16:30	**Closing Prayers: Vakatawa Nakorokula**	

TIME	ITEM	Document Reference
DAY 2, Tuesday, 23 September 2025		
08:30-9:15 *(30 min)*	**Registration**	
9:15-9:30 *(15 min)*	**Opening Prayers: Vakatawa Nakorokula**	
9:30-9:45 *(15 min)*	**Review of Day 1 and Expectations on Day 2**	
09:45-10:15 *(20 min)* *(10min: Questions)*	**Item 11: Learning, dialogue and collaboration toward land-water sustainability and coral reef health in Fiji - How to increase stakeholder influence on research** - Prof. Joeli Veitayaki, Strategic Adviser, Blue Prosperity Fiji	Field
10:15-10:30 *(15 min)*	**COFFEE BREAK**	
10:30-11:00 *(20 min)* *(10min: Questions)*	**Item 12: Guardians of our ocean: Women, Wisdom & Community in Fiji's Marine Protection** - Maloni Siga, ADRA Fiji	Field
11:00-11:30 *(20 min)* *(10min: Questions)*	**Item 13: Bridging Policy and People: Pathways to Community-Government Collaboration on Environmental Issues** - Andrew Coriakula, Head of Unit – Ocean, Ministry of Environment and Climate Change	Venue
11:30-12:00 *(20 min)* *(10min: Questions)*	**Item 14: Introduction to the importance of designing a water quality monitoring programme or threshold indicator with citizen science** - Dr. Rusila Savou, Mr. Albert Whippy, Dr. Chris Leong	
12:00-13:00 *(60 min)*	**LUNCH**	
	Hands-on demonstration at the field (PM)	
13:00- 14:00 *(60mins)*	**<u>Community & Early-Career (field demonstrations)</u>** **Seawater and sea sediment collection** **Groundwater sampling (downstream)** **Labelling and storing of trial samples; Recording of what data have been collected, date and place of collection, etc.** **SOP procedures in field research**	

14:00- 16:00 *(60mins)*	**<u>Community:</u>** **14:00- 15:00** **Design community-based solutions to help rehabilitate and protect your *i-qoliqoli* and reduce the impact of nutrient (phosphorus) pollution on coral reefs: Groups 1,2,3,4 and 20min presentation.** **15:00- 16:00: Talanoa Session**	**<u>Early-Career</u>** **14:00-16:00** **This would be an opportunity for collection in an upstream/ headwater area (spring in Namuaimada, specifically) and also to go to a midstream point to conduct macroinvertebrates demo survey in one river there (with Bindiya): Traffic Indicators** **Addition (time permits): Collection of tree ring cores (with Christmas) (just for demo to early career participants).**	

TIME		
DAY 3, Wednesday, 24 September 2025		
	Post-workshop survey (AM)	
08:30-9:15	**Registration**	
9:15-9:30 *(15 min)*	**Opening Prayers: Vakatawa Nakorokula**	
9:30-10:30	**Expectations from the project (what was learnings/solutions/what help is needed): Groups 1,2,3,4 and presentation**	
10:30-10:50 *(20mins)*	**COFFEE BREAK**	
10:50-12:00 *(70mins)*	**Distribute post-workshop survey for post-test assessment**	
12:00-12:15 *(15mins)*	**Closing Thanks: Prof. Yasumoto & Dr. Chris Leong**	
12:15-12:30 *(15mins)*	**Closing Prayers: Vakatawa Nakorokula**	

Capacity Development Workshop
23 March 2026, Rakiraki, Fiji

INTRODUCTION

CBA2025-03SY-Leong is an Asia-Pacific Network for Global Change Research (APN)-supported project titled "*Co-developing nutrient thresholds in submarine groundwater discharge: An integrated transdisciplinary and capacity development project towards safeguarding the future of coral reefs in the Pacific region*." At its heart, this initiative places local communities at the forefront—especially those living in small coral reef islands such as Fiji—by equipping them with the knowledge and tools to better understand the impacts of submarine groundwater discharge (SGD) on coral reef ecosystems.

Through this community-centered Capacity Development (CapDev) workshop, the project seeks to educate the science of SGD, highlight its connection to land-based practices, and explore how traditional ecological knowledge and cultural values can contribute to long-term environmental resilience. Special attention is given to the Navolau District in Rakiraki Province, where local village representatives will actively participate in learning, sharing, and co-developing solutions that align with both science and their lived realities.

Additionally, early-career professionals from diverse fields—including marine science, fisheries, civil engineering, and agriculture—will participate in the workshop to deepen their understanding of submarine groundwater discharge (SGD) and its impacts on coral reef ecosystems. As part of their learning journey, they will receive hands-on training in groundwater resource system modeling, enabling them to apply interdisciplinary tools and perspectives to address complex land–sea interactions in their respective fields.

As coral reef degradation continues to challenge the sustainability of Pacific ecosystems, this workshop provides a unique opportunity to build bridges between community knowledge, scientific research, and policy relevance. Rooted in the transdisciplinary framework of the LINKAGE Project, it addresses the urgent need for action by emphasizing inclusivity, accessibility, and respect for local governance structures.

Aligned with APN's goal of enhancing regional scientific and technical capacity, this workshop potentially stands as the first of its kind in Fiji to spotlight submarine groundwater discharge and coral reef protection through a community-first approach. It represents a step forward in ensuring that those most connected to the land and sea are also the most empowered to safeguard them.

OBJECTIVES

The objectives of this workshop are to:

a. Empower local communities as primary actors
Educate and empower local communities in Rakiraki and surrounding districts to understand the critical role of submarine groundwater discharge (SGD) in shaping coral reef health.

Emphasis will be placed on the links between land-based activities, nutrient pollution (particularly phosphorus), and reef degradation. Communities will be guided through practical sessions to design their own locally grounded solutions for reef rehabilitation and protection.

b. Enhance capacity through hands-on learning
Engage participants—especially early-career scientists from marine, agricultural, fisheries, and civil engineering backgrounds—with community members in collaborative field data collection and participatory learning. Hands-on demonstrations using simple hydrological modelling tools will provide foundational skills to interpret groundwater–reef interactions and inform solution-building.

c. Foster transdisciplinary exchange and regional networking
Create meaningful opportunities for early-career scientists, local stakeholders and government stakeholders to learn from one another, build synergies across disciplines and sectors, and establish lasting connections across provincial and national boundaries within the area.

d. Integrate local knowledge into environmental monitoring
Promote inclusive participation of communities in research activities by recognizing and leveraging traditional ecological knowledge (TEK). This participatory approach enhances the role of local residents as long-term monitoring agents of change in their coastal ecosystems.

e. Co-develop pathways for adaptive governance
Facilitate collaborative identification of actionable entry points toward adaptive governance of interconnected resources—freshwater, marine ecosystems, agriculture, and livelihoods—within the socio-ecological context of Rakiraki, Fiji.

THEME

Accumulated nutrient loads in small islands and its relationship with coral reefs

Coral reefs are considered the rainforests of the sea. They provide numerous ecosystem services such as land formation, natural wave breakers, fish breeding grounds, raw materials for pharmaceuticals, being linked with unique traditional culture, tourism, and construction materials. One of the key services is its function on provision of food and nutrition connected to serving as breeding grounds of fishes (fish productivity) but nowadays, coral reef island systems are on the frontline of global environmental issues. This is because coral reef islands are under combined local and global stresses. Hence, it underscores the importance of managing land-based activities and monitoring submarine groundwater discharge (SGD) to protect coral reef health and ensure sustainable marine ecosystems.

Recent studies on the impact of SGD on coral reefs highlight the significant role of SGD in transporting nutrients, pollutants, and trace elements from land to the marine environment. This process can lead to positive and negative outcomes for coral reef ecosystems. Excessive nutrients, particularly from agricultural runoff, can lead to eutrophication, algal blooms, and coral reef degradation. Some studies developed coastal coral reef system's measure of carrying capacity in terms of nutrient loading, i.e. nutrient budget/threshold which defines the maximum acceptable that the system can tolerate and that the natural internal mechanism can absorb/uptake.

On land, water footprint/water utilization, conditions of water resources, and water-related practices and livelihood activities in small coral reef islands are important factors to be examined and understood. Water resources are a basic necessity in island life, but islands have small recharge rate capacity due to its small land size. Small islands are also increasingly at risk with climatic variations and extremes, and due to its geographic isolation, unique characteristics and biodiversity are preserved, however, communities and ecosystems are more vulnerable to environmental and climatic changes and impacts.

WORKSHOP AGENDA

TIME	ITEM	Document Reference
DAY 1, Monday, 23 March 2026, Nakorokula, Rakiraki, Fiji		
Moderator: Chris Leong		
	Morning Session	
8:30-9:15	**Registration**	
9:15-9:30 *(15 min)*	**Opening Prayers: Vakatawa Nakorokula**	
9:30-9:40 *(10 min)*	**Opening and Welcome remarks** - Mr. Keasi Vakalagalaga, Spokesman (Nakorokula), Rakiraki, to welcome the participants and deliver a brief welcome remark - Prof. Jun Yasumoto (LINKAGE Project Leader) to deliver a short welcome note	
9:40-10:00 *(20 min)*	**Self-introduction & Group Photo** - Participants introduce themselves and their village/affiliations	Participants list
10:00-10:10 *(10 min)*	**Item 1: Introduction on Objectives and Structure of the Workshop and Group Placements** - Mr. Chris Leong briefly introduces the workshop objectives and group settings	Workshop agenda
10:10-10:40 *(10 min)* *(10 min)* *(10 min)* **10:40-10:55** *(15 min)*	**Item 2: Review** Overview of previous visit (Chris Leong) Presentation of Results (Ko Yasumoto/Alice Yamazaki/ Daiki Tomojiri) Community Questions **COFFEE BREAK**	PowerPoint & Talanoa
11:00-12:00 *(40 min) (20min: Questions) 5mins presentation per village*	**Item 3: Community Solution Design (Individual Village)** - Mr. Chris Leong	Group Work & Talanoa
12:00-12:10 *(10 min)*	**BREAK**	
12:10-12:30 *(20 min)*	**Item 4: Lessons from Elsewhere: Eco-Resilience (Marine Filter Feeders, Mangroves etc.)** - Mr. Chris Leong	PowerPoint

TIME	ITEM	Document Reference
12:30-13:30 *(60 min)*	**LUNCH BREAK**	
	Afternoon Session	
13:30-14:10 *(20 min) 5mins presentation per village*	**Item 5: Community Solution Re-Design (Individual Village)** - Mr. Chris Leong	Group Work & Talanoa
14:10-15:00 *(50 min)*	**Item 6: Questionnaires (Chris Leong)**	Group Work & Talanoa
15:00-15:10	**Closing: Mr. Chris Leong**	
15:10-15:30	**Closing Prayers: Vakatawa Nakorokula**	

Capacity Development Closing Workshop
23 September 2026, Nakorokula Village, Ra Province, Fiji

SUMMARY

CBA2025-03SY-Leong is an Asia-Pacific Network for Global Change Research (APN)-supported project titled “Co-developing nutrient thresholds in submarine groundwater discharge: An integrated transdisciplinary and capacity development project towards safeguarding the future of coral reefs in the Pacific region.”

This event is the closing workshop for the APN project. Its main objectives are to deliver the final project results, discuss practical solutions, and identify opportunities for future collaboration with communities, traditional leaders, government departments, local councils, sector representatives, and partner organisations.

The project was originally designed to improve understanding of submarine groundwater discharge (SGD), which is groundwater that flows into the sea and can transport nutrients to coral reef ecosystems. However, the Fiji field results showed that reef impacts in the wider Rakiraki area are linked to multiple connected pathways, including rivers, flood-related surface-water movement, groundwater, estuaries, coastal waters, and land-use activities. The closing workshop will therefore present the main findings in a clear and practical way, with emphasis on how nutrients and pollutants move from land to sea and what this means for reef protection, fisheries, water resources, and community livelihoods.

The workshop will bring together representatives from Navolau District, wider coastal villages in Ra Province, the Ra Provincial Council, traditional leadership, Ra Town Council, the Sugar Cane Farmers Association, tourism representatives, relevant government ministries, and project partners. It will provide a space to share results, discuss community concerns, and jointly identify realistic actions for river protection, floodplain and coastal-zone management, waste reduction, agricultural nutrient control, reef monitoring, and nature-based solutions.

As coral reef degradation continues to affect Pacific coastal communities, this closing workshop provides an important opportunity to connect scientific findings with local knowledge, traditional governance, and practical management needs. Rooted in a transdisciplinary and community-centred approach, the workshop aims not only to report what the project has found, but also to support future collaboration for safeguarding the land, rivers, groundwater, coastal waters, and coral reefs of Ra Province.

AGENDA

TIME	ITEM	Approach
DAY: Wednesday, 23 September 2026, Nakorokula Village, Navolau District, Ra Province, Fiji **Moderator: Dr. Rusila Savou; Mr. Albert Whippy**		
Morning Session		
8:00-8:45 (45min)	**Registration**	
8:45-9:20 *(35 min)*	**Traditional Protocol Ceremony:** Ratu Emori Bolobolo (Tu Navitilevu)	
9:20-9:30 *(10 min)*	**Opening and Welcome Remarks to Nakorokula** - Mr. Keasi Vakalagalaga, Spokesman (Nakorokula Village) to deliver a brief welcome remark	
9:30-9:45 *(15 min)*	**Opening Prayers:** Vakatawa Nakorokula	
9:45-9:55 *(10 min)*	**Welcome Note to APN Closing Workshop:** - Prof. Jun Yasumoto (LINKAGE Project Leader)	
9:55-10:15 *(20 min)*	**MORNING TEA**	
10:15-10:45 *(30 min)*	**Item 1a: Presentation on Marine Field Survey Results (Prof. Ko Yasumoto)** - Nutrient distribution and impacts on coral reefs in Ra coastal waters	Talanoa
	Item 1b: Discussion	
10:45-11:15 *(30 min)*	**Item 2a: Presentation on Land Survey and Results (Chris Leong)** - Hydrological modelling of groundwater flows from mountain to coastal regions	Talanoa
	Item 2b: Discussion	

TIME	ITEM	Approach
11:15-11:30 *(15 min)*	**Item 3: Presentation on Overall Summary (Prof. Jun Yasumoto)** - Comparison with overseas case studies, recommendations, and future work and collaborations	Talanoa
11:30-12:00 *(30 min)*	**General Discussion**	Talanoa
12:00-12:05 *(5 min)*	**Closing Remarks** - Prof. Jun Yasumoto	
12:05-12:20 *(15 min)*	**Closing Prayers:** Vakatawa Nakorokula	
12:20-12:40 *(20 min)*	**i-Tatau Ceremony**	
12:40-	**LUNCH BREAK (and Kava)**	

Modelling Workshop
25 September 2025, Suva, Fiji

AGENDA

TIME	ITEM	Approach
DAY: Thursday, 25 September 2025 [Mineral Resources Department, Mead Road, Suva] **Moderator: Christmas Uchiyama (RIHN-Japan)**		
9:00-9:05 *(5 min)*	**Welcome Note to MRD:** Mr. Aklesh Kumar (Snr. Technical Officer)	
9:05-9:10 *(5 min)*	**Welcome to APN Modelling Workshop:** Prof. Awnesh Singh (USP)	
9:10-9:15 *(5 min)*	Overview of Program	
9:15-10:00 *(45 min)*	Concepts of hydrology modelling and applications - by Prof. Jun Yasumoto and Dr. Chris Leong (RIHN)	PowerPoint & Software
10:00-10:15 *(15 min)*	MORNING TEA	
10:15-11:45 *(90min)*	Practical Demonstration of MODFLOW GUI - Tools and Model Construction - Case Study: Mitidja Aquifer, Algeria - by Dr. Fatima Kastali	PowerPoint & Software
11:45-12:00 *(15min)*	DISCUSSION	
12:00-12:10 *(10min)*	Closing & Future Work	

IAHS Field Survey
20-22 September 2026, Ra Province, Fiji

AGENDA

TIME	ITEM	Approach
DAY: Sunday, 20 September 2026 [USP Marine Lower Campus Gate]		
13:45	Pick up at USP Marine Lower Campus Gate & Briefing	
14:00-15:15 *(75min)*	Suva-Korovou Town	
15:15-15:30 *(15 min)*	**Break: Korovou Town**	
15:30-17:15 *(105 min)*	Arrive Nakorokula Village	
17:15-17:30 *(15 min)*	Traditional Ceremony	
17:30-19:30 *(120 min)*	Move to Host Family	
19:30-20:00 *(30 min)*	Briefing & Meet Japanese Team	
20:00	Rest	

TIME	ITEM	Approach
DAY: Monday, 21 September 2026 [MARINE SURVEY] **Target:** • **Sediment Samples: Phosphate; Nitrogen; eDNA** • **Coral Transect** • **Submarine groundwater (Pore Water)**		
8:15am	Briefing and Move to Malake Landing	
9:00-12:00 (3 hours)	Morning Marine Survey	
12:00-13:00 (60 min)	**LUNCH BREAK (On Boat)**	
13:00-16:00 (3 hours)	Afternoon Marine Survey	
16:00-17:00 (60 min)	Move back to Host Family	
19:30-20:00 *(30 min)*	Briefing	
20:00	Rest	

TIME	ITEM	Approach
DAY: Tuesday, 22 September 2026 [LAND SURVEY] **Target:** • **Water Quality: Phosphate; Nitrogen; eDNA** • **Groundwater Wells Heads and Well Measurements** • **River Stage & Velocity** • **GNSS**		
8:30am	Briefing and Move to Sites	
9:00-12:00 (3 hours)	Morning Land Survey	
12:00-13:00 (60 min)	**LUNCH BREAK (Rakiraki Town)**	
13:00-16:00 (3 hours)	Afternoon Land Survey	
16:00-17:00 (60 min)	Move back to Host Family	
19:30-20:00 *(30 min)*	Briefing	
20:00	Rest	

Modelling Workshop
24-25 September 2026, Suva, Fiji

AGENDA

TIME	ITEM	Approach
DAY: Thursday, 24 September 2026 [Mineral Resources Department, Mead Road, Suva] **Moderator: Chris Leong (RIHN-Japan)**		
7:30-8:00 (30 min)	Registration to International Association of Hydrological Sciences (IAHS)	
8:00-8:05 *(5 min)*	**Welcome Note to MRD:** Mr. Aklesh Kumar (Snr. Technical Officer)	
8:05-8:10 *(5 min)*	Overview of Program	
8:10-8:20 *(10 min)*	**Welcome: President IAHS:** Prof. Salvatore Grimaldi	
8:20-8:30 *(10 min)*	**Welcome: President of the Pacific Islands Countries and Territories (PICTs-IAHS) Working Group** Ms. Pearl Winchester/ Dr. Nick Metherall	
8:30-8:35 *(5 min)*	**Introducing demonstrators** - Prof. Aldo Fiori (Roma Tre University) - Dr. Kastali Fatima (Water Engineering and Environment Laboratory, Algeria)	
8:35-10:00 *(1hr 25min)*	Groundwater Modelling Lecture (Modflow6): Prof. Aldo Fiori	PowerPoint & Software
10:00-10:20 *(20 min)*	MORNING TEA	
10:20-12:00 *(100 min)*	Modelling Demonstration: Dr. Kastali Fatima (Part 1)	PowerPoint & Software

TIME	ITEM	Approach
12:00-13:00	**LUNCH BREAK**	
13:00-13:30 *(20 min)* **Questions** (10min)	**Phosphorus Lecture (Prof. Ko Yasumoto)**	PowerPoint
13:30-14:00 *(20 min)* **Questions** (10min)	**Nitrogen Lecture (Prof. Takahiro Hosono)**	PowerPoint
14:00-14:30 *(20 min)* **Questions** (10min)	**e-DNA Lecture (Dr. Daiki Kadotani)**	PowerPoint
14:30-15:00 *(15 min)*	**AFTERNOON TEA**	
15:00-15:20 *(10 min)* **Questions** (10min)	**Coral Transect Lecture (Ms. Lucia Kusolo)**	
15:20-15:50 *(30 min)*	Research Topic Examples: Japanese University Students	PowerPoint
15:50-16:00 *(10 min)*	**End: Future Works**	

TIME	ITEM	Approach
DAY: Friday, 25 September 2026 [The Pacific Community (SPC), Suva] **Moderator: Dr. Nick Metherall (SPC-Fiji)**		
Morning Session		
8:00-8:20 (20 min)	**Registration to International Association of Hydrological Sciences (IAHS) & SPC**	
8:20-8:25 (5 min)	Opening Prayer	
8:25-8:30 (5 min)	Opening Remarks	
8:30-10:30 (120mins)	Groundwater Modelling Demonstration (Modflow6): Prof. Aldo Fiori	software
10:30-11:00 *(30 min)*	**MORNING TEA**	
11:00-11:30 (30 min)	Introduction to scope: Overview presentation of content	
11:30-12:00 (30 min)	Setting up DE Pacific / EO-GPT accounts	
12:00-13:00 (60 min)	Activities: machine learning classification of coral reefs	
13:00-14:00	**LUNCH BREAK**	
14:00-16:00 (120 min)	Activities: machine learning classification of coral reefs	
16:00-16:30 (30 min)	Discussion	
16:30	CLOSING	