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This report produced by Griffith University for the Secretariat of the Pacific Regional Environment Programme (SPREP). It is one of four reports prepared as part of the Solomon Islands Ecosystems and Socio-economic Resilience Analysis and Mapping (ESRAM) to assess and prioritise climate change-related ecosystem-based adaptations for four study areas in Guadalcanal, Rennell, Malaita, and Temotu Province.

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1 Purpose of this report

An Ecosystem and Socio-economic Resilience Analysis and Mapping (ESRAM) process is to generate a robust planning baseline to inform the identification of ecosystem-based adaptation (EbA) options for strengthening the socio-ecological resilience of communities to the impacts of climate change and other direct anthropogenic impacts. The purpose of this report is to provide a comprehensive view of desktop- and field-based research activities that contribute towards ESRAMs for communities on **Wairaha Catchment, Malaita Province, Solomon Islands**.

As such this report provides a:

1. an overview of approaches and methods for data needs identification and data collection;
2. synthesis of data and lines of evidence for Wairaha Catchment, Malaita Province, including climate risks, ecosystem mapping, ecosystem service valuation, and field data;
3. high level project priorities
4. detailed assessment of high level project priorities; and
5. implementation considerations

This report comprises Phases 2, 3, and 4 of our overall ESRAM approach (Figure 1)

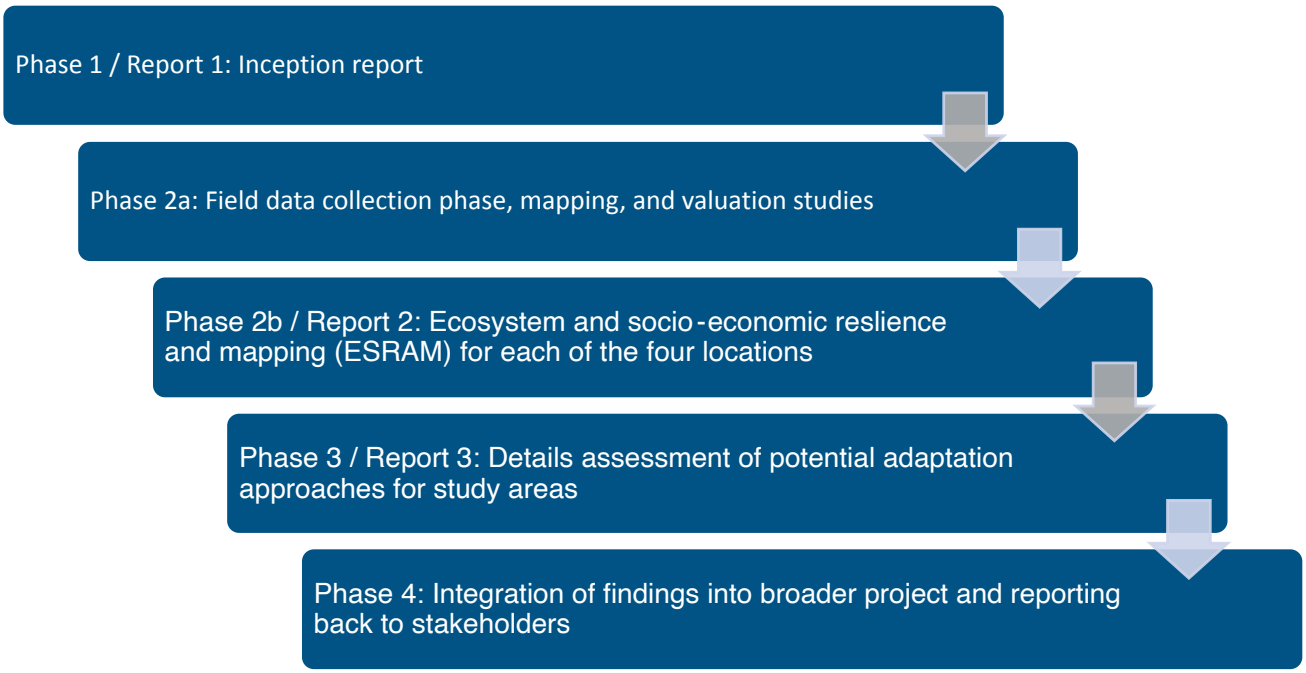

Figure 1: Locating current report

Adaptation options development

The project's methodology for developing high level EbA options draws upon six lines of evidence (Figure 2). These lines of inquiry take a sectoral approach, examining climate and socio-economic risks across (i) agriculture, (ii) water supply and sanitation, (iii) forestry, (iv) fisheries and marine conservation, and (v) infrastructure, society, and economy.

Figure 2: Lines of inquiry informing ecosystem-based adaptations

LINE OF ENQUIRY	EVIDENCE PROVIDED
Literature review (Sections 2 and 3)	• Determinants of effective ecosystem-based adaptation
Climate risk data (Section 4)	• Current climate change related risks (at regional scale only) • Future climate risks
Ecosystem service mapping & valuation (Section 5)	• Land cover extent and location of different habitats • Economic valuation of ecosystem services
Government consultations (Section 6)	• Meetings with government ministries
Individual Q method survey (Section 7 and 9)	• Q-methodology survey based on a series of statements encompassing livelihoods, conservation, climate risks, natural resource management, waste, sanitation, and health
Go-along survey (Section 8)	• Community assets • Current community projects

2 Background

2.1 Risks and adaptations

Pacific Small Island Developing States have a long history of resilience and adaptation to environmental variability (Barnett, 2011), yet their rural communities face a range of chronic threats to the sustainable management of their natural resources. These threats are exacerbated by a rapidly warming climate and new climate-related risks, such as increased incidence of extreme weather events, and sea level rise (Kossin et al., 2020; Pachauri et al., 2014). The increasing pressures on their natural resources from population growth (in most instances), tourism development (in some instances), falling agricultural productivity, and over-harvested fisheries are being magnified and compounded by climate-related impacts, including more severe tropical cyclones, ocean acidification, coral bleaching, droughts, increasing coastal inundation, and erosion (Faivre et al., 2022; Fleming, 2007; Mackey et al., 2017).

Most of the region's population's food is produced on a small scale, household basis or harvested from the sea (Anderson et al., 2013; SPREP & BMT WBM, 2017). In more remote areas, virtually all food consumed is grown by households. This food is grown in household gardens that are tended to by members of the household. Often, gardens are part of a complex agroforestry system of shifting cultivation that includes fallow periods and forest regrowth. Household livelihoods and human well-being are therefore directly related to ecosystem service delivery (the benefits people receive from nature), which is affected by climate change impacts, which, in turn risk food insecurity, malnutrition and the capacity to respond to severe weather events (Carpenter et al., 2006; MEA, 2003; Savage et al., 2019).

In addition, in the Solomon Islands, non-climate change related risks, such as seismic and volcanic activity, further increase sudden-onset disruptions in ecosystem service delivery. Social changes, economic development, and demographic pressures also play their part. The population of Solomon Islands is growing and on the move (Solomon Islands Government, 2019).

These threats not only present risk to communities. Biodiversity is also under growing pressure from the interplay between climate change risks and human impacts from their growing footprint (population X consumption X technology). The species and ecosystems of inland and coastal areas are under particular pressure due to the concentrations of human settlement and infrastructure they support. In response, governments are acting to adapt to climate change so that people avoid or minimise the harm from a rapidly changing climate. Care needs to be taken to ensure the kinds of adaptation actions being taken do not cause even more loss and degradation of natural environments. For example, in response to rising sea levels and storm surges, governments can seek to replace natural coastal ecosystems, such as mangrove forests with sea walls, which might protect coastal assets but has ecosystem impacts in terms of biodiversity regeneration and carbon sequestration (Mackey & Ware, 2018). Another example of a perverse climate change action is where natural forests, which provide significant ecosystem services, are being cleared to develop commercial agriculture to generate cash incomes, which impacts the wider community's capacity to sustain itself through the harvesting of its natural resources.

The key to dealing with climate change without compounding pressures on natural systems is to take an ecosystem-based approach. Functioning ecosystems provide a range of overlapping benefits to communities – often referred to conceptually as a 'basket of benefits' (Morgan et al., 2021). The ecosystem approach is a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way. By allowing natural ecosystem processes to unfold, preventing further damaging land uses, and restoring degraded habitats, the full mitigation and adaptation benefits of healthy ecosystems can be realised. Natural ecosystems sequester carbon dioxide from the atmosphere and securely store carbon in trees and soil.

Ecosystem-based adaptation (EbA) to climate change describes a potentially fruitful class of climate change adaptation interventions. EbA is the deployment of biodiversity and ecosystem services to help communities adapt to the adverse effects of climate change – it is not simply habitat conservation for its own sake (Andrade et al., 2011; FEBA, 2018; Munang et al., 2013; Nalau & Becken, 2018; Nalau et al., 2018). An EbA approach to adaptation is the key to helping species adapt to a rapidly changing climate, maintaining the resilience of ecosystems, and providing critical ecosystem services to local communities including climate change adaptation benefits. Removing other stressors from habitats such as industrialisation, unsustainable use, invasives and pollution, results in healthier ecosystems that are naturally more resilient to climate impacts and can provide a more reliable supply of services and benefits. A detailed description of our full understanding of EbA approaches in Appendix A.

Supporting the conservation and high integrity functioning of habitats and ecosystem is therefore vital for the continuation of efforts to improve livelihoods of the people of the Pacific.

Strategies to manage climate change impacts provide a significant opportunity for communities in Solomon Islands to simultaneously deal with climate change-induced risks and progress towards the 2030 Agenda for Sustainable Development and the goals set out in the Convention on Biological Diversity.

2.2 EREPA project

This ESRAM supports a broader program of work being undertaken by the Solomon Islands government: the 'Ensuring Resilient Ecosystems and Representative Protected Areas in the Solomon Islands' (EREPA) project. This project is a GEF6-funded project, being implemented by the IUCN Oceania Regional Office in partnership with the Solomon Islands Ministry of Environment, Climate Change, Disaster Management and Meteorology (MECDM) and SPREP.

EREPA's goal is "to establish a network of effective protected areas that will support healthy, productive, and restored landscapes in Guadalcanal, Malaita, Rennell-Bellona and Temotu provinces". The project aims to reduce the degradation of terrestrial ecosystems, while also multiplying social, economic, and environmental co-benefits by identifying project interventions that will lead to improved community livelihoods through the diversification of income-generating sources, increased direct economic value and benefits from natural resources, and increased resilience to the effects associated with climate change.

At the national level, baseline information gathered on natural resources and other variables as well as capacity building will contribute to sound and efficient decision making in the Solomon Islands. The project will contribute to addressing terrestrial biodiversity loss and ecosystem decline through the improved management of natural resources, and the creation of protected and conserved areas within four key biodiversity areas in the four provinces (see Figure 3).

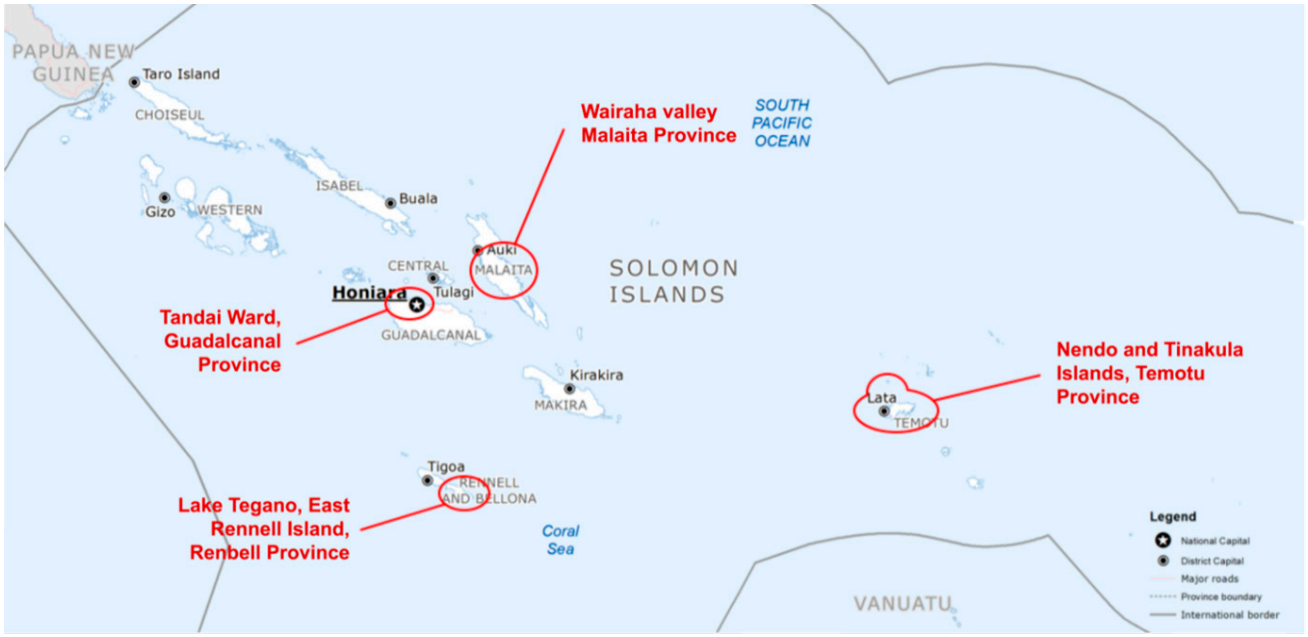

Figure 3: Location of EREPA project sites

2.3 Gender and social inclusion

Climate change-related risks are not equally shared by everyone in Pacific communities. In addition, the benefits of EbA are not automatically shared equitably and the aspirations of different members of the community are commonly divergent. Women, particularly poorer, rural women, experience greater vulnerability to climate change impacts than men, due to complex, intersectional drivers, including semi-formal community power dynamics, socially and culturally constructed discourse on the role of women in the family and society, and formal risks of land alienation and access to economic resources (Bendlin, 2014; Djoudi & Brockhaus, 2011).

An overview of considerations associated with gender and social inclusion is in Appendix B.

3 Wairaha Catchment, Malaita Province study area background

The Wairaha River is a very significant catchment draining southwards from the heavily forested Malaita highlands (Figure 4). The interior of Malaita Province is generally rugged and mountainous. The mountains are flanked by hills and narrow coastal terraces, interspersed with swamps. There are only a few tracts of flat land that are readily accessible and relatively unused. Rainfall is high everywhere: more than 3000 mm per year on the western and northern sides of Malaita, rising to an estimated 6000 mm in the centre of the island.

The region's agricultural systems are typical of Melanesia and the wider Pacific, with a shifting system of secondary forest clearance, cultivation, and abandonment for a fallow period of regrowth. Trees and other wild plants are exploited for food, building materials, and kastom medicines and species, particularly coconut, are used in plantations. The majority of households likely achieve their nutritional needs within the parameters of what they need but even though households have adequate access to food, there is a significant need to improve their nutritional needs, even if they consume the average amount of the required food groups (Bird et al., 2023). Raising pigs is a traditional practice in Malaita. They are used for traditional practices, including payment as compensation, bride price, gifts and feasts (Allen et al., 2006).

Generally, cash income levels are low for the rural people of Malaita (Solomon Islands Government, 2009, 2019). The main sources are copra, cocoa and fresh food marketed locally or in Honiara (Allen et al., 2006). However, for many people, the only way to find sufficient income to pay fees for high school children is for the husband or the entire family to migrate elsewhere for wage employment, or to sell produce or services in Honiara. Like most Melanesians who invoke concepts of kastom, on becoming Christianised (and partly Westernised), they reflect on practices that may be lost or abandoned (Keesing, 1982).

There is satellite image evidence of significant logging in the Wairaha catchment and its tributaries (Figure 5) and in very close proximity to the main water courses. A number of small timber mills have operated in the province, but there is no available estimate of their number, or of the amount being milled (Allen et al., 2006).

Furthermore, farmers are aware of adaptation measures to reduce the risk of crop failure. However, the absence of scientific information on climate change and agricultural resilience has increased the vulnerability to extreme climate-related events harming food security and nutrition. Climate change will undoubtedly intensify, resulting in a global and local drop in crop production, thus compromising livelihoods in the future (Bird et al., 2022).

Figure 4: Malaita Province showing areas of data collection in the community of Paunanu'u, in the Wairaha Catchment

Figure 5: Evidence of significant logging activity in the Wairaha catchment

Figure 6: Logging activity in close proximity to water course

4 Climate impacts on Malaita Province

As developing tropical island nation, the Solomon Islands has particular vulnerabilities to the current and future impacts of climate change. As climate change projects are not downscaled to the level of individual islands of the Solomons, much of the climate risk assessment is of a general nature and is Appendix D. Specific risks to Malaita are noted here.

As the majority of Malaita is mountainous, risks from sea level rise are limited to households situated right on the shorefront. However, given the exceptionally high rainfall already through Malaita, and increased risks from more extreme weather and logging in the Wairaha catchment, river flooding may well put some floodplain communities and gardens at risk.

Tropical cyclones have historically impacted the Solomon Islands and its exclusive economic zone at a rate of around 21 cyclones per decade, with around a quarter categorises as Category 3 and above (World Bank Group, 2021). Cyclones frequency is influenced by the ENSO cycle. Figure 7 show recent tracks of tropical cyclones across the four areas of interest between 1982 and 2022 (BOM, 2023). Malaita Island has experienced some regional cyclone activity.

The general projection is for a decrease in cyclone formation frequency through to 2100 by between 6%–35%. However, there is also evidence that the intensity of cyclones may increase. Any uncertainty is based on the future of ENSO cycles, which is not very well understood (BOM & CSIRO, 2014).

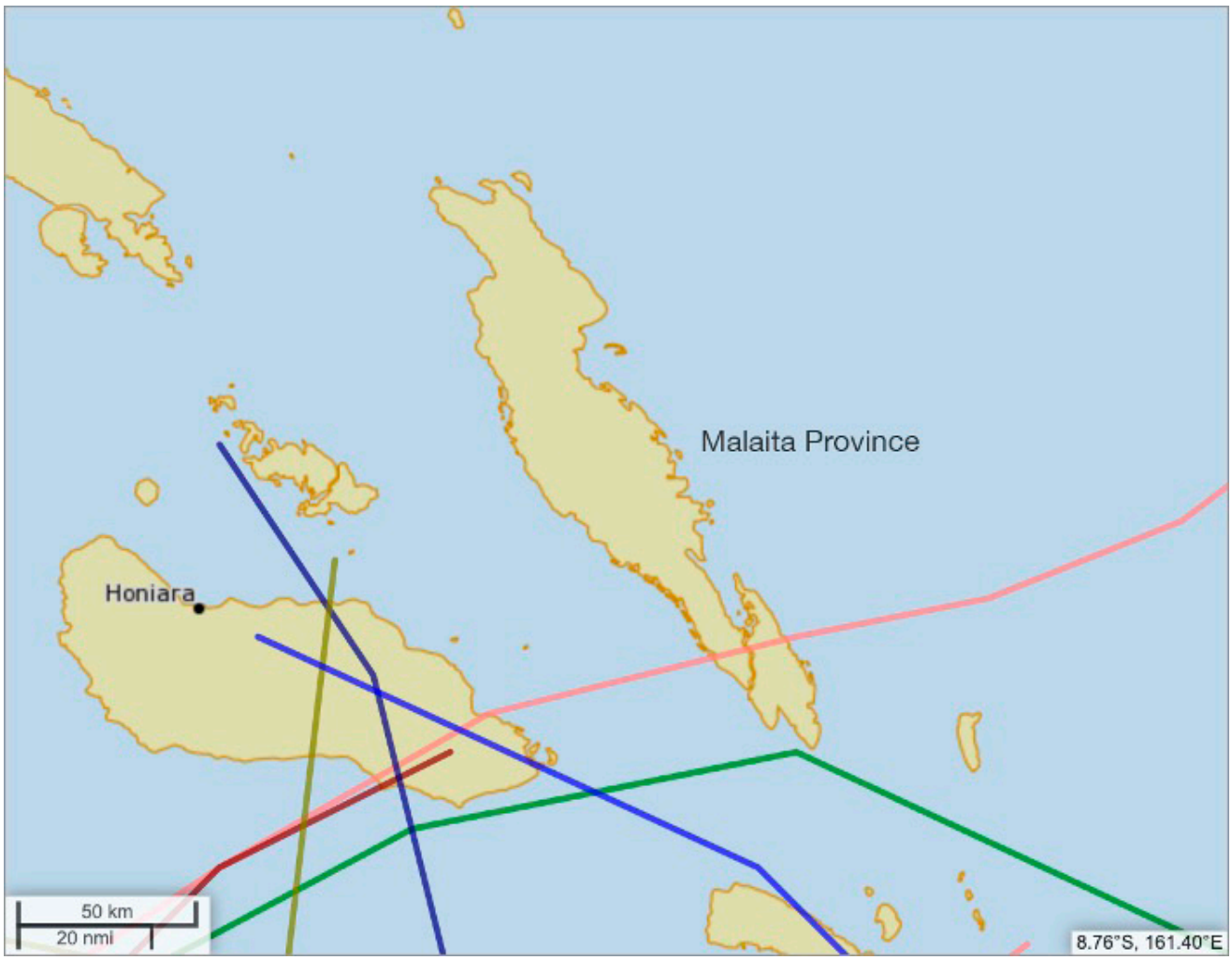

Figure 7: Cyclone tracks across Malaita Province between 1982-2022 (BOM, 2023)

5 Ecosystem mapping and economic valuation

Our approach and methods for ecosystem mapping and economic valuation of ecosystem services is in Appendix D. This section details the results of these methods for the Wairaha River catchment in Malaita.

Box 1: The use and misuse of economic valuation of ecosystem services

The use of economic valuation of ecosystem services in monetary units needs to be undertaken with an understanding of the nuance of what is trying to be achieved – particularly to avoid its *misuse*. Valuation has a series of interlinked purposes (Buckwell & Morgan, 2022):

Decision-making: by assigning monetary values to ecosystem services, policymakers, governments, and businesses can better understand the trade-offs involved in land-use decisions, resource management, and environmental policies. This information helps decision-makers prioritize conservation efforts and sustainable development projects.

This can directly feed into **social cost-benefit analysis** - economic valuation allows for the comparison of the social and environmental costs and benefits associated with different land-use options or environmental management strategies. It helps identify the most cost-effective approaches for achieving environmental goals or maximising societal welfare.

Measuring non-market environmental benefits - Traditional economic indicators often fail to account for the environmental benefits provided by ecosystems. Valuing ecosystem services in monetary terms allows these benefits to be integrated into economic decision-making processes, leading to more sustainable outcomes.

Raising awareness or political support - Expressing the value of ecosystem services in monetary terms can help raise awareness among the public, businesses, and policymakers about the importance of preserving natural capital and biodiversity by enabling comparisons of benefits provided by different forms of capital. It highlights the economic significance of ecosystems and the potential costs of their degradation or loss.

Facilitating market-based mechanisms - Economic valuation can support the development of market-based instruments such as payments for ecosystem services programs, where beneficiaries compensate providers for the maintenance or enhancement of specific ecosystem services. These mechanisms create financial incentives for conservation and sustainable management practices.

In a concrete example, the ecosystem service value of a forest can be assessed in terms of its contribution towards the value of commercially logged timber by taking a very narrow view of its economic value – its direct commercial use. Alternatively, the ecosystem service value of forest can be assessed using a wider range of values (particularly indirect use and non-use values) from a wider range of ecosystem services, for example, including its economic contribution towards climate stability, freshwater regulation, and erosion control. This has been dubbed the 'basket of benefits' approach (Morgan et al., 2021).

Economic valuation of ecosystem services in monetary terms is *not* about 'packaging up' nature for sale to the highest

5.1 Ecosystem mapping

Our approach and methods for ecosystem mapping and economic valuation of ecosystem services is in Appendix D. This section details the results of these methods for the Malaita Key Biodiversity Area (KBA) (Figures 8 and 9). For the purposes of this study, the total ecosystem services values are calculated for the whole KBA.

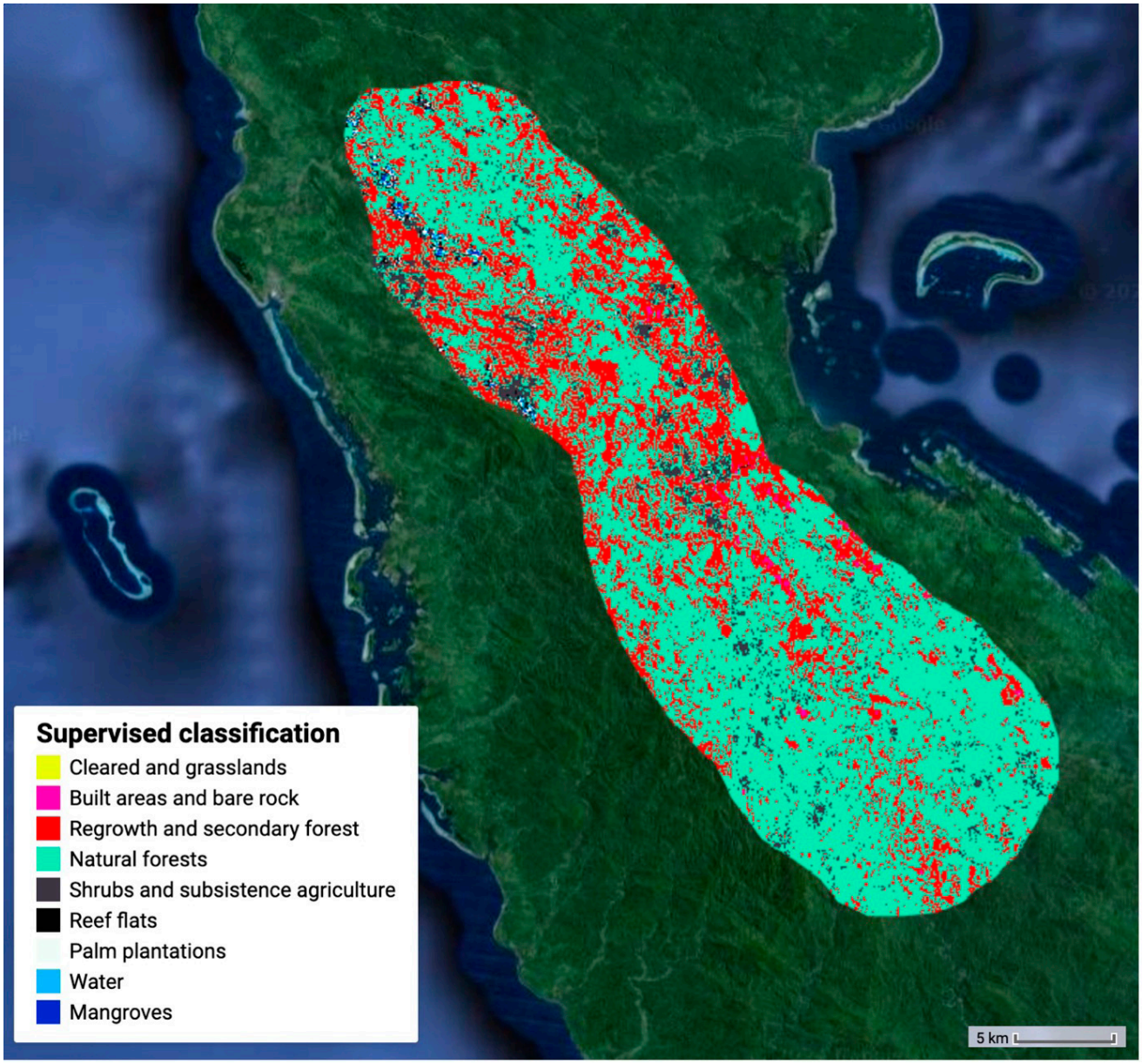

Figure 8: Supervised land cover and land use map for Malaita Highlands.

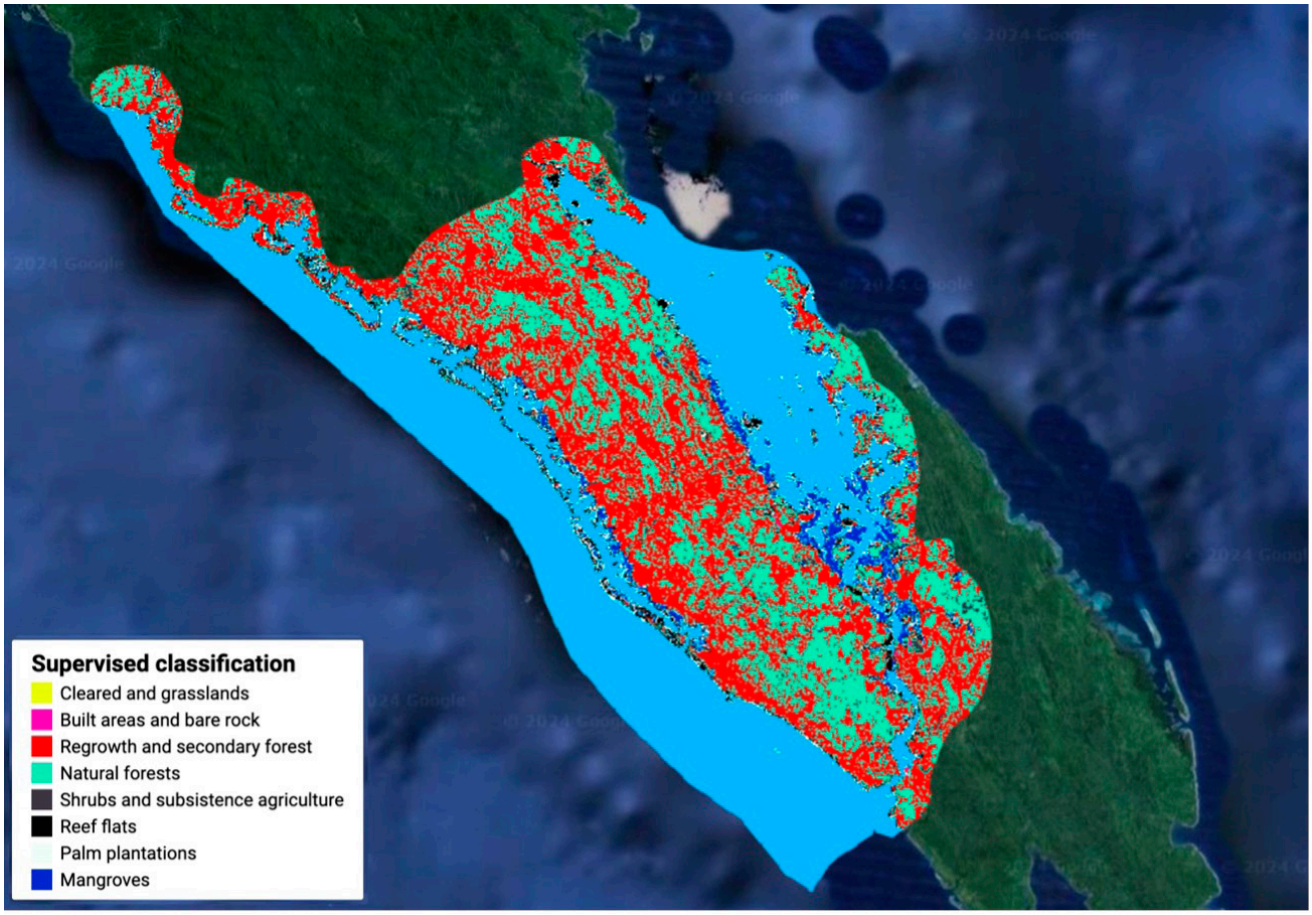

Figure 9: Supervised land cover and land use map for Southern Malaita.

5.2 Ecosystem service valuation

Tables 1, 2, and 3 report the total ecosystem service values ascertained from the mapping process (Section 5.1) for the Malaita KBAs – in the central highlands and the southern sector of the island. This value is calculated by multiplying the ecosystem service value from Table A1 of Appendix D by the total area of the particular ecosystem type (a combination of land cover and land uses). There are very significant areas of primary and secondary forests on around southern Malaita Island, representing sufficient opportunities for the fulfilment of the conservation objectives of the EREPA project. Much of the primary forest is located in the central highlands. There is also highly significant mangrove extent, with around 69% of the 427 km of the coastline having mangrove frontage. The mangrove extent has lost 105 Ha since 1996 (Global Mangrove Watch, 2024).

Table 1: Supervised land cover and land use mapping extents and total landscape ecosystem service values (2022 US$ yr-1) for Malaita Highlands Key Biodiversity Area

Land cover	Extent (Ha)	Ecosystem services valuation coefficient	Total ecosystem service valuation
Built areas and bare rock	596	0	0
Cleared grasslands	221	657	145,266
Mangroves	0	5,910	0
Primary forests	26,123	2,339	61,101,486
Secondary forests	27,323	2,339	63,908,310
Palm plantations	26	61	1,570
Coral reef and reef flats	23	895	20,666
Subsistence agriculture	3,678	8,108	29,818,873
Freshwater water bodies	11	2,014	21,207
Total			**155,017,**

Table 2: Supervised land cover and land use mapping extents and total landscape ecosystem service values (2022 US$ yr-1) for Malaita Highlands and Southern Malaita Key Biodiversity Area.

Land cover	Extent (Ha)	Ecosystem services valuation coefficient	Total ecosystem service valuation
Built areas and bare rock	726	0	0
Cleared grasslands	659	657	433,075
Mangroves	6,719	5,910	39,709,290
Primary forests	38,361	2,339	89,727,151
Secondary forests	62,465	2,339	146,106,033
Palm plantations	168	61	10,252
Coral reef and reef flats	1,410	895	1,261,726
Subsistence agriculture	6,634	8,108	53,791,958
Freshwater water bodies	91	2,014	182,327
Total			**315,004,360**

Table 3: Supervised land cover and land use mapping extents and total landscape ecosystem service values (2022 US$ yr-1) for Malaita Highlands and Southern Malaita Key Biodiversity Area.

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Total			**315,004,360**

Government engagement

The project team undertook a number of meetings with Solomon Island government ministries and activities in support of preparation for the field work. These are detailed in Appendix E.

7 Q-methodology findings

Q methodology (hereafter Q) is both a quantitative and qualitative research technique based on the statistical analysis of people's subjectivity (Brown et al., 1999; Stephenson, 1953). Q leans into discursive/contextual methods of knowledge generation that uphold both personal realities and shared experiences of the world suited to complex socio-ecological systems such as communities in the Pacific (Buckwell et al., 2024; Buckwell et al., 2023).

Q is a type of factor analysis that finds correlations amongst consistent groups of respondents who share similar views of the world. These correlations reflect coherent mindsets, which are analogous to the structure of a discourse, with views formed from both external influences (acting on people) and also emergent of collective heuristics (people and power structures actively shaping people) (Dryzek, 1994, 1997).

This section details our findings from our Q study from the Malaita study area. For details on our methodological approach, see Appendix F.

We sampled in community of Paunanu'u at a bend in the Wairaha River at -9.2173, 161.0049. We collected sorts from 40 respondents: 23 men and 17 women (Table 2).

Table 4: Respondents to Q methodology survey

Community	Men	Women	Total
Paunanu'u	21	12	33
Oteote	1	0	1
Not listed	1	5	6
Total	**23**	**17**	**40**

7.1 Factor extraction

We extracted 3 factors using the method described in Appendix F (Horst Centroid). Table 3 reports factor correlations (1 is a perfect correlation). 19 respondents fitted Factor 1, 9 in Factor 2, and 7 respondents fitted Factor 3. Five respondents did not fit either factor or were confounding (fitted into both factors)[1].

Table 3 reports the likeness of factors extracted from our Q. Factor 1 was most like Factor 2 and Factor 2 was most like Factor 3. In comparison to the three other study areas, this represents a lot greater variation.

Table 5: Factor correlations

	Factor 1	Factor 2	Factor 3
Factor 1	1	0.4357	0.2475
Factor 2	0.2475	1	0.4171
Factor 3	0.2475	04171	1

Scores and rankings in Q methodology

Factors can be assessed using a range of metrics from their composite sorts, including z-scores, rankings, and column placements. Table 6 reports the full results for each factor.

The z-score is a standardized measure of the relationship between a statement and a factor, calculated by subtracting the mean score of all statements from the score of the individual statement and then dividing by the standard deviation of all scores. The z-score can, therefore, be interpreted as the number of standard deviations that a statement is above or below the mean. Average ranking is a less informative measure than the z-score, as it does not take into account the distribution of the scores and is overly influenced by outliers.

For example, Factor 1's highest ranked statement (S22) has a z-score of 2.71, demonstrating a very high salience with this factor, whist Factor's highest ranked statement (S26) has a z-score of 1.84, demonstrating the strength of salience of this statement, despite being ranked highest, was somewhat less.

The rank score represents the placement of that statement in the composite sort for that factor, which is also in Figures 10, 11, and 12.

Syntax conventions

To justify our conclusions on factor descriptions we draw upon the statement rankings. Through the next sections, we use the following syntax conventions. When referring to a statement we use both the statement number (denoted by S) and a shorthand description of the statement to aid the reader in following our logic. To demonstrate the strength of salience of that statement, we will use the z-score (positive is positively salience, negative is negative). Where one factor has placed a statement that is very significantly differently to than another ($p < 0.01$) (this being an important aspect of factor description) we denote this with two asterisks (**) and an arrow, ▼ for lower than and ▲ for higher than. (Where only two factors are revealed, many statements can be very

1 It is assumed in Q that these respondents did not fully understand the task, completed the task with insufficient accuracy, or could not express fully coherent viewpoints.

significantly differently placed.) Where we are referring to statement ranks, or z-scores of both factors, we list only the numbers and this should be read to mean 'respectively'.

Table 6: Factor z-scores and rankings for sampled Malaita communities

Ref	Statement	Factor 1		Factor 2		Factor 3	
		Z-score	Rank	Z-score	Rank	Z-score	Rank
1	My garden is producing less food than it was before.	0.38	11	-0.93	29	-1.24	33
2	It is important to get more livestock, such as cattle, pigs, & chickens into the village, to provide food.	-0.56	27	0.3	14	2.06	1
3	There are more weather-related natural disasters happing now, like cyclones & heavy rain.	-0.53	26	-0.34	23	-1.05	30
4	Our water sources are drying-up more frequently than before.	-0.28	21	-0.18	20	-0.65	26
5	The changing weather makes it too warm & dry, & sometimes too wet, to grow our usual crops.	0.06	16	-0.52	25	-0.25	19
6	We have enough toilet, washing & cleaning facilities for all the people in the village.	2.89	1	-0.78	28	-1.4	35
7	I am confident I would feel safe in the next natural disaster.	-0.38	24	-0.47	24	-1.12	31
8	Our community needs a better place to throw away rubbish, like bottles, cans, & plastic.	1.02	8	1.37	4	1.89	2
9	I get enough good, reliable drinking water within my community.	-0.46	25	0.37	13	-0.29	20
10	I would like better ways to cook food, so I don't have to use firewood from the forest.	-0.61	28	-1.04	31	0.47	12
11	If more tourists visited, or came on a cruise ship, I worry that there would not be enough food, water, & waste facilities to cope with them.	0.19	13	-0.03	17	1.05	7
12	It is important to pass down customary knowledge of dances, songs & ceremonies to my children and grandchildren.	1.42	2	0.77	9	0.92	8
13	We should do more to prevent our special places from falling into disrepair.	0.73	9	0.39	12	0.35	14
14	Neighbouring communities encroach on our customary land & marine resources, without permission.	0.11	14	-0.33	22	-1.46	36
15	Land reclamation for development destroys reefs & the marine resources.	-0.33	22	-1.68	35	-0.35	21
16	There are less traditional medicinal plants growing than there used to be.	0.09	15	-0.08	19	-1.25	34
17	Customary knowledge of resource use & the land is being forgotten.	-0.23	20	-0.63	27	-0.4	22
18	If I could borrow a small amount of money, I would be able to invest in a small business.	-0.75	30	-0.05	18	0.38	13
19	I would like to earn a bit more cash by selling food I grow, of fish that I catch.	-0.08	19	1	6	0.72	9
20	Tourism offers many good opportunities for small businesses in my area.	0.24	12	1.09	5	-0.89	28
21	I worry that young people don't want to stay in the village, as there are more opportunities in main towns & Honiara.	-0.93	32	-0.28	21	-0.24	18
22	Improving the roads into the community will enable new business opportunities.	1.2	3	1.84	3	1.53	4
23	I would be able to spend more time in my community if there was a more equal share of housework between men and women.	-0.01	17	0.15	16	0.67	10
24	I feel safe in my home & in my community.	-0.77	31	0.23	15	-1.22	32
25	I feel that I have enough influence on decisions that affect my community.	-0.71	29	0.87	7	-1.01	29

Ref	Statement	Factor 1		Factor 2		Factor 3	
		Z-score	Rank	Z-score	Rank	Z-score	Rank
26	Conservation of forests & reefs will be most successful when people feel secure and prosperous.	0.71	10	2	2	1.59	3
27	Enforcing protected area rules in my community will be easy.	-0.36	23	0.5	11	-0.67	27
28	Marine protected areas will be good for encouraging tourism.	1.06	5	0.86	8	0.16	15
29	Reducing use of forest resources through conservation will be good for the community.	1.06	6	2.02	1	0.09	16
30	We need to protect our forests better, as they are being removed to make way for food gardens.	1.1	4	-0.56	26	1.3	6
31	Industrial discharges & sediment causes pollution in our lakes, rivers, and ocean.	-1.09	34	-1.14	32	0.66	11
32	Lack of proper grazing management pollutes waterways & the coastal reefs.	-0.01	18	-1.75	36	-0.16	17
33	Our forests, freshwater & marine resources are important to kastom. It's important we can hand them down to our children & grand children in good condition.	1.04	7	0.77	10	1.34	5
34	I would like to catch fish further out to sea, to reduce pressure on local fisheries.	-0.94	33	-1.61	34	-0.44	23
35	Mining & forestry offer benefits that make-up for the environmental damage they cause.	-1.5	35	-0.96	30	-0.44	24
36	The benefits from logging & mining are shared fairly across all the people in the community.	-2.79	36	-1.15	33	-0.63	25

7.2 Factor interpretation

7.2.1 Factor 1: Forest conservation, more business focussed,

Factor 1 had an exceptional large spread of z-scores indicating that there was a very strong agreement between the statements ranked 1st (S6, having enough water) and 36th (S36, benefits of logging and mining shared fairly). This factor was the only factor in all study areas that ranked S6 as the most salient issue (z-score of 2.89▲**) and 17 of 19 respondents in Factor 1 ranked this statement in +5 position. Given the location of the study site (on the banks of the Wairaha River) this might not be surprising, though Factor 3 had some concern over general water (S6) indicating that access to water (perhaps away from the river) is not universal. However, this factor felt it did not get enough good quality drinking water (S9 was scored at –0.46).

Statements that supported conservation were all positively scored but with less strength than many other factors in the study sites. Kastom-related statements were scored higher by this factor than others, but not strongly so. Only S12 (passing on ceremonial knowledge) was scored highly, at 1.42 (ranked 2nd). Two social issues showed salience with this Factor. S21 (concern over young people leaving the village) was scored at -0.93▼** and S24 (feeling safe in the community) was scored at –0.77.

Factor 1 was very strongly opposed to mining and logging: S36 (mining and logging benefits will be shared fairly) scored at -2.79▼** (which is exceptionally low compared to similar Q studies) and S35 (logging and mining has net benefits) was scored at -1.5▼**.

This factor was evenly split between men and women (Section 7.4).

The composite, or 'ideal', sort for Factor 1 is Figure 10.

7.2.2 Factor 2: Conservation, business, and tourism focus

Factor 2 had a very strong conservation, business, and tourism focus: S29 (conservation good for the community) was scored at 2.02▲**, S26 (prosperity leads conservation) was scored at 2.00, S22 (improving roads is good for business) was scored at 1.84, S20 (tourism offers business opportunities) was scored at 1.09p▲**, and S19 (earning

cash through sales of goods) was scored at 1.00. Also strongly ranked was support for marine conservation (S28 was scored at 0.86). Access to banking services (S18) was scored neutrally.

To execute any future plans, this factor also scored S25 (having influence over the community) highly at 0.87. This factor was all men, explaining perhaps why S24 (feeling safe in the community) was scored significantly higher than other factors (at 0.87▲**). Interestingly Factor 2 ranked the two logging and mining statements negatively but not strongly so. S36 (benefits from logging and mining fairly shared) was scored at -1.15 and S35 (logging and mining has net benefits) was scored at -0.96.

There was no concern from this factor over pollution. S32 (concern over pollution in waterways from livestock) was lowest, and S15 (modifications to land spoils marine environment) and S31 (industry causes water pollution) were ranked with little concern. Notwithstanding, local concerns over waste management were present (S8 was ranked 4th). Kastom-related statements were neutrally scored but on the basis there was no concern kastom knowledge was being lost (regardless of whether it is or isn't actually being lost): S17 was scored lowly at -0.63▼**.

This factor was composed entirely of men (Section 7.4)

The composite ('ideal') sort for Factor 2 is Figure 11.

7.2.3 Factor 3: Concerns over food, waste, and services

Factor 3 was most concerned with bringing more livestock into the community (S2 was ranked 1st and scored at 2.06 ▲**) (note that the community asset inventory at Table 12 shows very little livestock) and waste management, which was ranked 2nd at 1.89. This factor was also very concerned about the growing non-biodegradable waste (S8 was scored at 1.89 and ranked 2nd) and the lack of road infrastructure (S22 was scored at 1.53. Statements of concern over water were, on average, scored with a reasonable level of concern when compared to other factors, with particular concern over having enough general water (S6), which was ranked 35th and scored at -1.4. Fitting the patterns of all factors across all study areas, the desire for conservation (S26, S33, S30, S28, and S29) was still positive, albeit with less strength than other factors.

Factor 3 was the only factor (and the only factor across all study areas) that ranked the two statements thaat showed a positive association with logging and mining (S35 and S36) in a more neutral rank (both at -1, scored at -0.44 and -0.63). For all the factors in all of the study areas, this was the most sympathetic factor towards extractive industries. Perhaps related, this factor did not associate much importance to tourism (which is confirmed in the go-along survey) – S20 was scored at -0.89. Four statements positively associated with kastom were scored lowly (S12, S13, S16, and S17), as were statements positively relating to property rights (S14, neighbouring tribes trespass and S27 enforcing protected areas will be easy were scored at -1.46 (bottom ranked) and -0.67).

This factor was slightly weighted towards women (Section 7.4).

The composite ('ideal') sort for Factor 3 is Figure 12.

7.3 Consensus and disagreement

Consensus statements are those shared by factors within a single score of each other (represented by the z-score variance). They are relevant as they can represent potential starting points for community engagement and project development, particularly where the issue is highly or lowly salient (represented by the z-score mean).

Table 7 reports the five statements with the greatest consensus between the factors. It also reports the strength of salience (in this instance, the ranking). S17 (customary knowledge is being forgotten) had the highest level of agreement but a relatively neutral salience (only Factor 2, all men, showed a negative sentiment). The second consensus statement was also related to customary practice (S13; protecting special places from disrepair) and had a of salience, suggesting that across all factors kastom remains an important aspect of the community. The third consensus statement (S4, water sources are drying up) was neutrally ranked, as was the fifth consensus statement about the impacts of climate change (S4). S33 (handing down natural resources to future generations) showed a high degree salience across the factors.

Table 7: Consensus statements

Ref	Statement	F1	F2	F3	Variance
17	Customary knowledge of resource use & the land is being forgotten.	0	-2	-1	0.027

13	We should do more to prevent our special places from falling into disrepair.	2	1	1	0.029
4	Our water sources are drying-up more frequently than before.	0	0	-1	0.041
33	Our forests, freshwater & marine resources are important to kastom. It's important we can hand them down to our children & grand children in good condition.	2	2	3	0.054
5	The changing weather makes it too warm & dry, & sometimes too wet, to grow our usual crops.	0	-1	0	0.056

Table 8 reports the five statements of greatest contention. S6 (enough water in the community) showed an exceptionally high degree of disagreement, with Factor 1 ranking this top and Factor 3 ranking this second lowest. This is clearly indicative of access to water in the community being highly dependent on household level vulnerabilities, rather than a region-wide concern. The second most contentious statement was S2 (getting more livestock in the village) with Factor 3 ranking this as the most important issue and the other factors ranking this neutrally. Again, this points to household level differences rather than any region-wide shortage. The benefits of logging and mining being fairly shared (S36) was third most contentious, with Factors 1 and 2 ranking this statement lowly and Factor 3 being more sanguine. The same pattern stands for S31 (industrial pollution) meaning that whilst Factors 1 and 2 were strongly disapproving of mining they also weren't concerned about pollution whereas Factor 3 was less concerned about logging and mining and took a neutral stance on pollution. Lastly, S30 (forest is being cut for food gardens) was only of concern for Factors 1 and 3.

Table 8: Disagreement statements

Ref	Statement	F1	F2	F3	Variance
6	We have enough toilet, washing & cleaning facilities for all the people in the village.	5	-2	-4	3.588
2	It is important to get more livestock, such as cattle, pigs, & chickens into the village, to provide food.	-2	1	5	1.188
36	The benefits from logging & mining are shared fairly across all the people in the community.	-5	-3	-1	0.846
31	Industrial discharges & sediment causes pollution in our lakes, rivers, and ocean.	-4	-3	1	0.698
30	We need to protect our forests better, as they are being removed to make way for food gardens.	3	-1	3	0.698

7.4 Demographic alignment

Basic demographic information was collected from each respondent. Specifically, we collected data on the respondents' community, gender, age, and their occupation. Whilst this is not a core occupation of Q studies and in most instances, statistically significant correlations won't be found, it nevertheless can provide some additional insight into the propensity for different demographic attributes to correspond to each factor (see Section 5.1 in Buckwell, Fleming, Muurmans, et al., 2020).

Table 9 reports the demographic breakdown based on gender. Whilst Factor 1 was fairly even split, no women fitted Factor 2 (conservation and tourism focussed) and Factor 3 was very predominantly women.

Table 9: Factor alignment with gender

	F1	F2	F3	No factor
Men	10	9	2	2
Women	9	0	5	3

Table 10 reports factor alignment with age group – this was fairly evenly spread. There was a bias of the youngest age group (18-30) not aligning with any factor.

Table 10: Factor alignment with age group

	F1	F2	F3	No factor
18-30	5	2	2	5
31-60	12	6	4	0
Over 60	2	1	1	0

Table 11 reports factor alignment with declared occupation. There was no particular alignment between any occupation and any of the factors. (Note than many respondents belonged to more than one occupational category.)

Table 11: Factor alignment with occupation

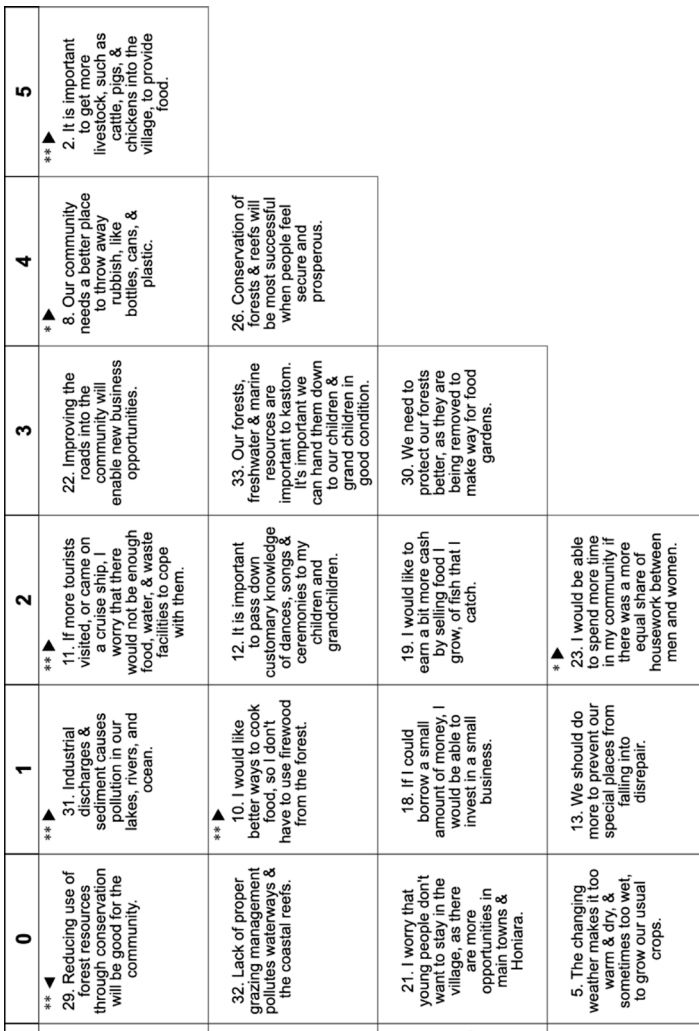
	F1	F2	F3	No factor
Farming	16	5	6	1
Fishing	5	1	1	1
Health /government / education	1	2	2	0
Business	0	1	1	0
Conservation	5	2	1	2
Other	1	1	1	1

Figure 10: Composite sort for Factor 1

-5	-4	-3	-2	-1	0	1	2	3	4	5
** ◀ 36. The benefits from logging & mining are shared fairly across all the people in the community.	31. Industrial discharges & sediment causes pollution in our lakes, rivers, and ocean.	* 24. I feel safe in my home & in my community.	** ◀ 2. It is important to get more livestock, such as cattle, pigs, & chickens into the village, to provide food.	15. Land reclamation for development destroys reefs & the marine resources.	5. The changing weather makes it too warm & dry, & sometimes too wet, to grow our usual crops.	** ▶ 1. My garden is producing less food than it was before.	33. Our forests, freshwater & marine resources are important to kastom. It's important we can hand them down to our children & grand children in good condition.	30. We need to protect our forests better, as they are being removed to make way for food gardens.	* ▶ 12. It is important to pass down customary knowledge of dances, songs & ceremonies to my children and grandchildren.	** ▶ 6. We have enough toilet, washing & cleaning facilities for all the people in the village.
	** ◀ 35. Mining & forestry offer benefits that make-up for the environmental damage they cause.	** ◀ 21. I worry that young people don't want to stay in the village, as there are more opportunities in main towns & Honiara.	* 10. I would like better ways to cook food, so I don't have to use firewood from the forest.	27. Enforcing protected area rules in my community will be easy.	23. I would be able to spend more time in my community if there was a more equal share of housework between men and women.	** 20. Tourism offers many good opportunities for small businesses in my area.	8. Our community needs a better place to throw away rubbish, like bottles, cans, & plastic.	28. Marine protected areas will be good for encouraging tourism.	22. Improving the roads into the community will enable new business opportunities.	
		* 34. I would like to catch fish further out to sea, to reduce pressure on local fisheries.	25. I feel that I have enough influence on decisions that affect my community.	7. I am confident I would feel safe in the next natural disaster.	32. Lack of proper grazing management pollutes waterways & the coastal reefs.	11. If more tourists visited, or came on a cruise ship, I worry that there would not be enough food, water, & waste facilities to cope with them.	13. We should do more to prevent our special places from falling into disrepair.	** 29. Reducing use of forest resources through conservation will be good for the community.		
			** ◀ 18. If I could borrow a small amount of money, I would be able to invest in a small business.	9. I get enough good, reliable drinking water within my community.	** ◀ 19. I would like to earn a bit more cash by selling food I grow, of fish that I catch.	* ▶ 14. Neighbouring communities encroach on our customary land & marine resources, without permission.	** ◀ 26. Conservation of forests & reefs will be most successful when people feel secure and prosperous.			
				3. There are more weather-related natural disasters happing now, like cyclones & heavy rain.	17. Customary knowledge of resource use & the land is being forgotten.	16. There are less traditional medicinal plants growing than there used to be.				
					4. Our water sources are drying-up more frequently than before.					

Figure 11: Composite sort for Factor 2

Figure 12: Composite sort for Factor 3



7.5 Summary

Looking at all Factor scores together (the ranked mean of the z-scores) , we get a picture of overall concerns of the respondents from our Malaita study site (Table 12). Altogether, across the factors, improving infrastructure to improve business opportunities was the most important issue (S22). The region where we collected the samples is relatively remote and access to Auki (the Provincial capital) is practically limited to boat transport. Waste is seen as an increasing problem (S8 was ranked 3rd).

Statements supportive of forest and marine conservation were all ranked relatively highly.

None of the factors were overly concerned with climate change impacts on the weather – S3 was ranked 30th and S5 was ranked at 19th, nor had particular concerns about the productivity of their food gardens (S1 was ranked 29th).

Table 12: Overall statement z-scores and rank

Ref	Statement	Z-score	Rank
22	Improving the roads into the community will enable new business opportunities.	1.52	1
26	Conservation of forests & reefs will be most successful when people feel secure and prosperous.	1.43	2
8	Our community needs a better place to throw away rubbish, like bottles, cans, & plastic.	1.43	3
29	Reducing use of forest resources through conservation will be good for the community.	1.06	4
33	Our forests, freshwater & marine resources are important to kastom. It's important we can hand them down to our children & grand children in good condition.	1.05	5
12	It is important to pass down customary knowledge of dances, songs & ceremonies to my children and grandchildren.	1.04	6
28	Marine protected areas will be good for encouraging tourism.	0.69	7
30	We need to protect our forests better, as they are being removed to make way for food gardens.	0.61	8
2	It is important to get more livestock, such as cattle, pigs, & chickens into the village, to provide food.	0.60	9
19	I would like to earn a bit more cash by selling food I grow, or fish that I catch.	0.55	10
13	We should do more to prevent our special places from falling into disrepair.	0.49	11
11	If more tourists visited, or came on a cruise ship, I worry that there would not be enough food, water, & waste facilities to cope with them.	0.40	12
23	I would be able to spend more time in my community if there was a more equal share of housework between men and women.	0.27	13
6	We have enough toilet, washing & cleaning facilities for all the people in the village.	0.24	14
20	Tourism offers many good opportunities for small businesses in my area.	0.15	15
9	I get enough good, reliable drinking water within my community.	-0.13	16
18	If I could borrow a small amount of money, I would be able to invest in a small business.	-0.14	17
27	Enforcing protected area rules in my community will be easy.	-0.18	18
5	The changing weather makes it too warm & dry, & sometimes too wet, to grow our usual crops.	-0.24	19
25	I feel that I have enough influence on decisions that affect my community.	-0.28	20
4	Our water sources are drying-up more frequently than before.	-0.37	21
10	I would like better ways to cook food, so I don't have to use firewood from the forest.	-0.39	22
16	There are less traditional medicinal plants growing than there used to be.	-0.41	23
17	Customary knowledge of resource use & the land is being forgotten.	-0.42	24
21	I worry that young people don't want to stay in the village, as there are more opportunities in main towns & Honiara.	-0.48	25
31	Industrial discharges & sediment causes pollution in our lakes, rivers, and ocean.	-0.52	26

Ref	Statement	Z-score	Rank
14	Neighbouring communities encroach on our customary land & marine resources, without permission.	-0.56	27
24	I feel safe in my home & in my community.	-0.59	28
1	My garden is producing less food than it was before.	-0.60	29
3	There are more weather-related natural disasters happing now, like cyclones & heavy rain.	-0.64	30
32	Lack of proper grazing management pollutes waterways & the coastal reefs.	-0.64	30
7	I am confident I would feel safe in the next natural disaster.	-0.66	32
15	Land reclamation for development destroys reefs & the marine resources.	-0.79	33
35	Mining & forestry offer benefits that make-up for the environmental damage they cause.	-0.97	34
34	I would like to catch fish further out to sea, to reduce pressure on local fisheries.	-1.00	35
36	The benefits from logging & mining are shared fairly across all the people in the community.	-1.52	36

8 Go along survey findings

For background on the benefits and methods for carrying out go-along surveys, see Appendix G. Paunanu'u lies in a bend of the Wairaha River at -9.2165, 161.0023 (see Figure 4) and the reported questionnaire answers for communities members is reported in Table 13 and the community asset inventory is reported in Table 14.

Table 13: Paunanu'u go along survey findings

Category	Notes
Community demographics	• 34 households • 207 people • People do come and go through marriage and work
Community hazards	• Extreme weather is causing river flooding • Fish stocks are OK; used only for human food • Earthquakes occur but none have been destructive
Exposures & vulnerability	• Some dwellings are exposed to river flooding • At the coast sea level rise is being experienced
Water resources, sanitation, and waste	• Few households have water taps supplied by pipes form the river • There are no private water tanks but there is one at the Kindy (early learning centre) • Piping system from river is subject to failure, which can impact supply • No proper waste facilities
Power sources	• Household stand-alone solar power • Firewood for cooking
Conservation efforts	• Conservation efforts are going well; others are still in place
Gardens and farming	• [No data]
Tourism	• Tourism is still a long way off and can only be considered once sanitation is improved
Pollution	• No air pollution; forests are well protected
Disaster management	• [No data]

Table 14: Community asset inventory for Nangu

Item	Quantity / notes	Item	Quantity / notes
Schools	1 kindy; 1 primary school	Police posts	0
Churches	2	Aid posts	0
Poultry / hatchery	0	Womens' Centres	0
Cattle farms	0	Community Halls	0
Piggeries	0 (only a few family pigs)	Banks	0
Other plantations	0 (coconut for local consumption only)	Money transfers	0
Tilapia ponds	0	Post offices	0
Docks	0	Market houses	0
Shops	0	Air strips	0
Cooperatives	0	Phone network	Adequate (1 carrier)
Boats	2		

9 Joint Q analysis

We subjected all the composite factors from all the study areas (dubbed secondary factor analysis) to determine an overall picture of the dominant factors from each study (Guadalcanal, Rennell, Malaita, and Temotu Provinces). Each composite factor (n=10) was subject to the same treatment as detailed in Appendix F . The results are reported in Table 15. Only one factor explained sufficient variance.

This factor confirmed the scepticism about logging and mining that was present in most of the factors in the study areas: S35 (logging and mining brings net benefits) and S36 (benefits from logging and mining are fairly shared) were ranked 36th and 35th by a significant margin of z-score. As a result of an absence of the significant logging and mining activities currently taking place in the study areas, they were also little concern for pollution in the waterways. At the other end, conservation-based and resource management-based statements (S26, S33, S29, S28, and S30) took up 5 of the 6 most important issues. Concerns over lack of road infrastructure and business opportunities was ranked second. Tourism opportunities (S20) was ranked moderately positively at 9th with a z-score of 0.6.

Overall, these results and the outputs from the Q and the go-along survey for Malaita support the goals of the EREPA project but nevertheless underline the importance of infrastructure provision and the requirement for livelihoods to be supported in conservation activities.

Table 15: Factor extraction from secondary analysis

Ref	Statement	Z-score	Rank
26	Conservation of forests & reefs will be most successful when people feel secure and prosperous.	1.99	1
22	Improving the roads into the community will enable new business opportunities.	1.6	2
33	Our forests, freshwater & marine resources are important to kastom. It's important we can hand them down to our children & grand children in good condition.	1.55	3
29	Reducing use of forest resources through conservation will be good for the community.	1.32	4
28	Marine protected areas will be good for encouraging tourism.	1.31	5
30	We need to protect our forests better, as they are being removed to make way for food gardens.	1.3	6
12	It is important to pass down customary knowledge of dances, songs & ceremonies to my children and grandchildren.	1.26	7
8	Our community needs a better place to throw away rubbish, like bottles, cans, & plastic.	0.94	8
20	Tourism offers many good opportunities for small businesses in my area.	0.8	9
13	We should do more to prevent our special places from falling into disrepair.	0.79	10
19	I would like to earn a bit more cash by selling food I grow, of fish that I catch.	0.55	11
27	Enforcing protected area rules in my community will be easy.	0.33	12
9	I get enough good, reliable drinking water within my community.	0.18	13
2	It is important to get more livestock, such as cattle, pigs, & chickens into the village, to provide food.	0.13	14
18	If I could borrow a small amount of money, I would be able to invest in a small business.	0.1	15
23	I would be able to spend more time in my community if there was a more equal share of housework between men and women.	0.02	16
6	We have enough toilet, washing & cleaning facilities for all the people in the village.	0.02	17
24	I feel safe in my home & in my community.	-0.06	18
16	There are less traditional medicinal plants growing than there used to be.	-0.1	19
25	I feel that I have enough influence on decisions that affect my community.	-0.21	20
1	My garden is producing less food than it was before.	-0.27	21
11	If more tourists visited, or came on a cruise ship, I worry that there would not be enough food, water, & waste facilities to cope with them.	-0.28	22

Ref	Statement	Z-score	Rank
3	There are more weather-related natural disasters happing now, like cyclones & heavy rain.	-0.43	23
5	The changing weather makes it too warm & dry, & sometimes too wet, to grow our usual crops.	-0.46	24
7	I am confident I would feel safe in the next natural disaster.	-0.54	25
4	Our water sources are drying-up more frequently than before.	-0.55	26
17	Customary knowledge of resource use & the land is being forgotten.	-0.59	27
14	Neighbouring communities encroach on our customary land & marine resources, without permission.	-0.6	28
21	I worry that young people don't want to stay in the village, as there are more opportunities in main towns & Honiara.	-0.68	29
10	I would like better ways to cook food, so I don't have to use firewood from the forest.	-0.79	30
34	I would like to catch fish further out to sea, to reduce pressure on local fisheries.	-0.99	31
32	Lack of proper grazing management pollutes waterways & the coastal reefs.	-1.01	32
15	Land reclamation for development destroys reefs & the marine resources.	-1.16	33
31	Industrial discharges & sediment causes pollution in our lakes, rivers, and ocean.	-1.31	34
36	The benefits from logging & mining are shared fairly across all the people in the community.	-1.98	35
35	Mining & forestry offer benefits that make-up for the environmental damage they cause.	-2.19	36

10 Adaptation priorities

In making high level adaptation recommendations we draw on our position of taking an EbA approach and seeing adaptations along a spectrum (see Appendix A and specifically Figures A1 and A2). Therefore, our recommendations do not specifically draw solely on pure 'nature-based solutions' (Hermelingmeier & Nicholas, 2017; IUCN, 2020) but instead lean in to the FEBA qualification criteria, including:

- reduces social and environmental vulnerabilities;
- generates societal benefits in the context of climate change;
- restores, maintains, or improves the health of ecosystems;
- is supported by policies at multiple levels; and
- supports equitable governance and enhances capabilities.

(FEBA, 2018)

10.1 Priority area 1: REDD+ and payments for ecosystem services

Given the evidence of logging in the Wairaha catchment and the desire for greater conservation catchment forest conservation projects remain a priority. Factors 1 and 2 also showed a desire to pursue livelihood development through income generating activities. This suggests that conservation efforts need to be linked to opportunities to further develop local incomes in alternative ways to extractive activities. This broadly supports the intent of the EREPA project as a basis for further exploration of projects that financially support conservation.

Payment for ecosystem services (PES) schemes are one of a suite of policy mechanisms put forward to support forest conservation and to provide for more equitable social and economic outcomes. First considered in the 1990s, PES schemes now generate between US $36 and 42 billion in global annual transactions (Pagiola, 2008; Salzman et al., 2018). PES compensate communities for pursuing sustainable forest management practices, such as protected area status, which generate positive externalities through ecosystem services (Engel et al., 2008) in lieu of extractive uses, such as logging, mining, and land-use change to agricultural uses (Morgan et al., 2021).

PES implementation is diverse and non-prescriptive but has been increasingly used to reduce carbon emissions through REDD (Reduced Emissions from Deforestation and Degradation)—a global initiative to provide compensation for communities to support sustainable management of forests (UN-REDD, 2016). REDD+ uses performance-based contracts, based on agreed activities, which support forest livelihoods and retention and/or sequestration of forest carbon (Angelsen, 2009). Later, the addition of '+' (to make REDD+) flagged the inclusion of conservation, sustainable management of forests, and enhancement of forest carbon stocks to focus the scheme more on equity rather than strict resource allocative efficiency (Pagiola et al., 2005). The capital for most nascent REDD+ programs has been provided by international multilateral development funds. Once a REDD+ program is operating benefit transfer can take multiple forms (Garcia et al., 2021).

Compensation can be made in cash or in kind; for example, for schools and medical facilities, or as funding to health and education services, and to individuals, households, or community organisations.

10.2 Priority area 2: Agricultural extension and agro-forestry

One of the higher return policy interventions for improving rural well-being and resilience is stimulating innovation in the sectors from which the rural poor derive their livelihoods (Weber, 2012, p. 84). Nearly all households undertake some form of subsistence food production and animal husbandry. A robust, resilient, evolving, and forewarned farming system is imperative to the communities of Malaita for:

- River flooding puts the low-laying gardens at considerable risk.
- Local food security during change climates and through natural disasters, ensuring the community has a reliable supply of a variety of foods but also systems in place to recover quickly or store reserves if harvesting is interrupted.
- Nutrition: Local agriculture can help to improve nutrition by providing access to a variety of nutritious foods, such as fruits, vegetables, and meats.
- Economic development: Agriculture can be a major economic driver. A robust farming system can help to create jobs, generate income, and boost exports. Experimentation in new, export-orientated niche products (coffee, cocoa) can generate income but come

at a risk to producing farmers, in terms of marketing investments and forgone effort towards foods that directly support their own and their community's livelihoods.

- Agro-forestry: Sustainable land-management through expansion of agro-forestry systems can increase the overall yield of the land by combining the production of crops, including tree crops, and forest plants on the same land. At a local level, maintaining ground cover and providing shade, reduces moisture-loss and protects soil from sunlight, and provides for a structure that enables some food plants to grow more efficiently. Agroforestry systems, featuring perennial crops can also be more efficient by demanding less maintenance than annual plants and maintaining crop diversity insures against crop diseases and pests.

Adoption of modified gardening techniques is likely to face many of the same barriers, which have been documented elsewhere, such as aversion to taking new risks, due to the potential for shocks causing crop failure and loss of livelihood, lack of new inputs and education, and conformity affects (Clifton & Wharton, 1971; Dercon & Christiaensen, 2011).

10.3 Residual risks

Understanding the distributional impacts of the proposed projects is essential to understanding the impact of a project, not just its outputs and outcomes (Asian Development Bank, 2007). No quantitative poverty impact analysis (PIS) has been undertaken to disaggregate which stakeholder groups would likely benefit most from the projects. It cannot be explicitly stated the projects, as proposed, are explicitly pro-poor. However, a number of demographic attributes suggest that we can make at least a qualified judgement that the demonstration plots project, in particular, can benefit indiscriminately and would have positive distributional impacts. The Solomon Island's rural communities remain relatively homogenous and tribally based. Tribal affiliation provides entitlements to shelter and customary rights to farming land and forest and marine resources; hence there is no land-owning class that overtly benefits from improved productivity.

Nevertheless, this optimism needs to be tempered by the understanding poorer farmers often benefit less from extension programmes due to their propensity to farm smaller plots, be more risk averse, and be less likely to engage in such programmes. Provided outreach associated with the programme is carefully designed – perhaps even specifically targeting households that are typically hard to reach, or individuals who are marginalized – the impact on poverty reduction should be high. Notwithstanding, a more detailed, quantified PIA, would provide a valuable adjunct to this report.

11 Detailed project assessment

The section further develops the high-level recommendations from Section 9 to make a more detailed assessment of the priority projects and to help informing the potential timing of project implementation.

11.1 Assessment methods

Assessment of options can take a range of approaches, depending on the relative priority given to the considerations at-hand. For example, if priority is for return on investment, cost benefit analysis of financial costs and benefits is paramount. Conversely, if there are outstanding uncertainties in both financial costs and benefits and economic costs and benefits (e.g. social costs and benefits) then this lends to other forms of assessment. If there are broader considerations than just the financial and economic, then hybrid approaches should be considered.

Cost benefit analysis

Cost benefit analysis (CBA) is a systematic approach used to evaluate the potential gains and losses of a decision, project, or action. It involves quantifying both the financial and non-financial advantages and disadvantages, allowing for comparison and informed decision-making. By weighing the costs against the anticipated benefits, this analysis provides a framework for determining whether a course of action is worthwhile. It aids in maximizing value and efficiency by identifying options that yield the greatest net positive outcome and helping individuals, businesses, and governments allocate resources effectively while considering the broader impact of their choices.

For example, Buckwell et al. (2020) used CBA to assess the return on investment from a range of EbA projects on the island of Tanna. Specifically, this was a social CBA, which used ecosystem service valuation estimates and modelled biophysical changes to determine a dollar value for the value of projects from a whole of society perspective.

Multi-criteria assessment

Multi-criteria assessment (MCA) is a decision-making approach that evaluates various alternatives using multiple criteria or factors. It considers diverse dimensions such as economic, environmental, social, and technical aspects to provide both a holistic and pragmatic view. By assigning weights to criteria, it quantifies their relative importance, aiding in comparing options objectively. This method helps stakeholders make informed choices by systematically analysing trade-offs and synergies among different criteria, fostering well-rounded and balanced decision outcomes.

Hybrid approach

Given the range of implementation considerations, we propose to take a hybrid approach to potential EbA assessment, combining elements of CBA with MCA, a broader assessment methodology, where we include a NPV estimate of a project's value (based on cost-benefit analysis) as one of the weighted criteria in a broader MCA process.

Thus, we have settled upon a 'hybrid' approach, where an economic assessment of a project is placed in the content of broader stakeholder concerns.

11.2 Hybrid assessment

Our hybrid approach included significant elements of MCA. The methodology is detailed below. Our process also allowed for stakeholder engagement and consultation with representatives from the Solomon Islands government and from SPREP at a workshop in Honiara.

1. We identified five broader social, economic, and environmental objectives for the Wairaha catchment project area: (1) secure a climate resilient landscape; (2) improve water and food security; (3) improve livelihoods and economic development capabilities; (4) financial viability; and (5) supports good governance.
2. We weighted the five objectives to total 100.
3. Within each objective, we further defined between three to five criteria and sub-weighted these criteria, creating an overall weighting for each criterion for the MCA (see Table 18).
4. To help guide the scoring of each criterion we generated an indicator phrase/question and a set of phrases pointing to a score between -5 (where not achieving an indicator was likely detrimental) and 10 (indicating complete achievement of the outcome is likely if the indicator was fully met). This scoring guide was slightly different for each criterion and is reported in Appendix H. Total costs for project implementation are in Appendix H, with the exception of agricultural extension and agro-forestry costs, which are more

specific to each case study site. For Tandai Ward, this is reported in Table 16. In this case, costs over $1 million represent an MCA score of 1.

Table 16: Total costs of implementation of agro-forestry project, nursery, and community ranger program

Item	Quantity	Total cost over 5 years (US$)
Demonstration farms for gardens and agro-forestry, staffing, logistics, and equipment	4	$1,070,788
Nursery and poultry hatchery	2	$720,131
Community rangers	12	$748,714
Total costs		**$2,539,632**

5. In conjunction with the project team, representatives from the Solomon Islands government and from SPREP went through the scoring exercise, line-by-line. Full scoring for Wairaha Catchment are reported in Table 17.
6. The following sensitivity analyses were carried out and results are reported in Table 19.
   a) We adjusted Objective 4 (financial viability) to 0 and adjusted each other objective upwards as defined in Table 17.
   b) We doubled Objective 4 (financial viability) to 34 adjust each other objectives downwards as defined in Table 17.

Objective 4 was targeted for sensitivity analysis as this is where the main uncertainties lay. The two analyses effective gave this objective a zero weighting and an approximate doubling in weighting.

Table 17: Sensitivity test weighting adjustments

Objective	Baseline score	Sensitivity test 1	Sensitivity test 2
1	23	28	19
2	17	21	13
3	17	21	13
4	18	0	34
5	25	30	21

Table 18: Multi-criteria assessment for the Wairaha catchment project area

		Program	REDD+ readiness / PES		Agricultural extension program	
		Rank	2		1	
		Total score	560		625	
Objective	**Criteria**	**Weight**	**Score**	**Weighted score**	**Score**	**Weighted score**
Secure a climate resilient landscape	Appropriate scale of management	8.40	10	92	0	0
	Prioritises biodiversity and ecosystem services within management area	4.20	10	46	2	9.2
	Protects a diverse range of habitats	2.10	10	23	0	0
	Risk costs of no action	6.30	5	34.5	10	69
Increase food and water security	Will increase the productivity of subsistence gardening system within the current footprint	7.65	3	22.95	10	76.5
	Ensures the ongoing capacity to harvest protein	4.25	3	12.75	10	42.5

		Program	REDD+ readiness / PES		Agricultural extension program	
		Rank	2		1	
		Total score	560		625	
Objective	**Criteria**	**Weight**	**Score**	**Weighted score**	**Score**	**Weighted score**
	Increases the availability of drinking water in a changing climate	4.25	10	3	3	12.75
	Increases capacity of community to purchase food	0.85	3	2.55	5	4.25
Improve livelihoods & economic development capabilities	Create opportunities for cooperatives and associations	6.65	10	59.5	10	59.5
	Economic development opportunities are available to all and do not exclude certain demographics	6.65	5	29.75	5	29.75
	Number of beneficiaries	5.7	5	25.5	5	25.5
Financial viability	Estimated cost of implementation	5.61	1	5.61	1	5.61
	Availability of cost benefit analysis data	5.61	1	5.94	10	59.4
	Timescale of social benefits	5.78	3	18.36	5	30.6
Supports good governance	Level of co-management (government, communities, private sector)	2.6	5	12.5	10	25
	Compatible with policy and legal frameworks of Solomon Islands government	7.8	5	37.5	10	75
	Consideration of GEDSI	7.8	5	37.5	5	37.5
	Incorporates local indigenous and traditional knowledge	5.2	5	25	10	50
	Long term capacity to ensure sustainable governance	2.6	5	12.5	5	12.5

11.3 Sensitivity analysis

Our two sensitivity analyses our reported in Table 19. Both sensitivity analyses revealed no change to the ranked recommended projects suggesting the MCA was a robust process to uncertainties over funding.

Table 19: Sensitivity analysis for multi-criteria assessment for Malaita Province project area

Scenario		REDD+ readiness / PES	Agricultural extension program
Baseline scenario	**Rank**	**2**	**1**
	Total score	560	625
Scenario 1 (funding costs at 0)	**Rank**	**2**	**1**
	Total score	580	645
Scenario 2 (funding costs doubled)	**Rank**	**2**	**1**
	Total score	545	606

12 ESRAM outcomes and implementation

The vulnerability of social and ecological systems due to intensifying human activities, both locally and in extended supply chains as access to wider markets, in sectors such as agriculture and fishing (and potentially, in the future, logging and mining) is increasing across Malaita Province, particularly as transport networks to Guadalcanal improve. In addition, climate change and continuing carbon emissions are likely to increase this vulnerability, as weather patterns warm and potentially alter rainfall and forest moisture patters, meaning adaptive capacity, for which Pacific nations are notably renowned, needs to also increase.

This section describes the expected outcomes and implementation considerations from pursuing each of the priority projects.

12.1 Resilient farming systems

One of the higher return policy interventions for improving rural well-being and resilience is stimulating innovation in the sectors from which the rural poor derive their livelihoods, such as food production from household gardens and agro-forestry. (Weber, 2012, p. 84). Nearly all households undertake some form of subsistence food production, agro-forestry, and animal husbandry.

Poultry management

Some baseline studies have been completed (for example see Jansen et al., 2009). In this study, most surveyed farmers thought chickens were easy to care for, provide food for the family and was a good cash income enterprise. Some farmers were interested in keeping local chickens but found it difficult to obtain the birds.

There are organisations in the Solomon Islands and in the Pacific already devoted to improved management of poultry, including Russell Parker's Kai Kokorako Perma-Poultry and the Happy Chickens Project from the Kyeema Foundation in Fiji .

Knowledge system retention

Knowledge retention and innovation are important considerations. As populations have become more mobile and economies more diverse, many young people are no longer involved in agriculture and traditional knowledge may not get passed on. Hundreds of years of carefully accumulated knowledge and the naturally adaptive character of Pacific food production system risks being lost. In addition, new knowledge and new crops and varieties from outside assistance are important. This can be achieved through recruitment of agricultural extension officers to run education programs, including the use of demonstration farms – to 'teach by showing and doing'. As farmers make decisions based on uncertain benefits and uncertain costs, demonstration farms can provide a level of assurance to support individual farmers' innovation, reducing exposure to risk of failure, hunger, loss of income or indebtedness. Demonstration farms can improve the confidence of farmers in taking up new techniques by seeing the evidence themselves.

Coordination

Agricultural extension, particularly in more rural areas, which includes Tandai Ward are best administered, or at least coordinated through subnational agencies, rather than central government. This way, delivery of advisory services can be more responsive to the needs of communities and has been shown to be delivered at lower costs. Capacity, financial resources, skills, and coordination issues commonly constrain the ability to realise economic. One specific way to address this is to build networks between semi-formalised groups and decentralised local government institutions, where the role of extension agents is equally about facilitation and knowledge and network brokering as it is information provision. This 'pluralistic model' should also seek to engage private sector partners (The University of the Sunshine Coast, 2016).

12.2 Robust forest conservation that supports livelihoods

A robust forest and forest community managed conservation network is vital for the on-going resilience of all aspects of Solomon Island communities. Establishment through formal processes, such as that promoted through the EREPA project increases the robustness and longevity of this network. The role of forest assets to the well-being of Solomon Islanders is recognized in the Protected Areas Act 2010. In addition to the inclusion of more forest under active management for harvest, there are significant benefits from retaining primary forest adjacent to subsistence gardens and integrated with agro-forestry. Forests provide fuel-wood and non-wood forest products, improve soil stability and fertility, and subsistence garden forest cover provides shade and microclimatic buffering from extreme weather events

(Harrison et al., 2016).

If the extent and connectivity of remnant primary forests cross critical thresholds, these benefits will diminish, and further downward pressure is placed on subsistence garden productivity. Assisting communities with the protection of forest areas as an EbA, implemented through protected area status can thus reduce the risk of climate change impacts.

REDD+ schemes remain novel, sometimes costly, institutionally complex and demand-led (Porras et al., 2013; Wunder, 2006), which can limit participation due to high transaction costs, the requirement for settled land tenure, and the fact that opportunities tend not motivated by communities themselves. Successful REDD+ projects require an understanding of the specific proximate drivers of deforestation and are also exceptionally challenging to implement in the context of weak institutions (Clements et al., 2010), such as in the Solomon Islands. Further, schemes can lack governance standards and legitimacy by failing to reflect stakeholder's perspectives and priorities (Rosendal & Schei, 2014), particularly those of local communities (Wallbott et al., 2019). Therefore, they demand a high degree of co-design to reflect community expectations and ensure livelihood opportunities align with donor demands for enhancement of carbon stocks (Bush et al., 2019).

Resource mobilisation

Forest conservation will be best achieved through exploration of mechanisms to valourize forest conservation. Thus, the contemporary drive towards protected area status is most likely to be both supported and effective only if it is linked to alternative, non-extractive, or limited-extraction livelihood opportunities, including non-timber forest products (e.g. honey production, which is already present) (Pandey et al., 2016), eco-tourism (Munch-Petersen, 2011), agro-ecological tourism (Addinsall et al., 2017), voluntary PES approaches, where a greater basket of forest benefits are demonstrated and values captured (Engel et al., 2008; Morgan et al., 2022), or the global REDD+ mechanism designed to reverse forest loss in service of preserving carbon stocks in developing countries (Atmadja et al., 2022; Venter & Koh, 2012). The latter is paid passing attention in the Solomon Islands' National Development Strategy: 2016-2035, but the document recognises the country may only be prepared for 'readiness activities' (Solomon Islands Government, 2016, p. 45).

Readiness status

REDD+ readiness refers to the efforts undertaken to develop the capacities needed to demonstrate and implement REDD+, and meet UNFCCC REDD+ requirements. REDD+ readiness support is provided to developing countries through bilateral and multilateral initiatives, including the UN-REDD Programme. Readiness activities include both financial and technical support on REDD+ related areas of work including governance, stakeholder engagement, developing a REDD+ national strategy/action plan, designing a safeguards information system, and developing a forest emission reference level and a national forest monitoring system.

For more information see the REDD+ Factsheet: https://www.un-redd.org/sites/default/files/2021-10/Fact%20Sheet%201-%20About%20REDD3.pdf

In 2011 the status of readiness for REDD+ implementation for the Solomon Islands was considered low (UN & Solomon Islands Government, 2011). This has begun to be address though the REDD+ Readiness Roadmap 2014-2020 (Solomon Islands Government, 2014). The roadmap recognised that developing capacity in the following areas is paramount:

- Policies and programmes that promote REDD+ activities and provide guidance for government, landowner, NGO, community groups and private sector action;
- REDD+ safeguards; and
- Verifying emission reductions

Responsibility for REDD+ readiness lies with two government agencies, the Ministry of Environment, Climate Change, Disaster Management and Meteorology, reflecting its mandate both for Climate Change Policy and for conservation of natural resources and sound environmental management; and the Ministry of Forestry, the line agency responsible for forest resources, which may have competing objectives for any given potential project area (see Appendix E).

PES and REDD+ and, to an extent, certified eco-tourism schemes are all contingent on highly integrous monitoring and verification processes and thus demand new capacity and skills in new technologies to be available on-the-ground, which may all still be lacking (Gabrys & Heywood, 2012).

Nevertheless, as part of the EREPA project, sites in the catchments around Malaita Province should be promoted as candidate sites for specific REDD+ pilot activities in the Solomon Islands to enable enabling ministries and staff to learn lessons and develop capacity as part of the readiness process at provincial and national level.

Potential budget limitations

Such schemes also demand infrastructure investments that support the development, marketing, and sale of such products (e.g. tourism or sustainable forest products). Both alternative livelihood development opportunities (tourism and the conservation economy) demand commitments to

infrastructure development from government, regardless of the continued support with the communities. Potentially they will remain unfulfilled due to fiscal constraints shackling the government, which natural resource extraction and export were supposed to alleviate. Greenfield development of both sectors is complex and requires a long lead time, suggesting that the immediate demands of livelihoods generation, such as food and water security remain more pressing (Buckwell et al., 2024).

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Appendix A: Ecosystem-based adaptation

Defining ecosystem-based adaptation

Climate change adaptation can be defined broadly as adjustments to social-ecological systems in response to actual or expected climatic changes that ease any adverse effects or take advantage of new opportunities (Adger et al., 2005; Betzold, 2015; IPCC, 2023). By adapting management of natural resources and socio-economic and ecological systems to climate changes, communities can reduce risks and lessen potential future damages that might otherwise occur (Leary, 1999). However, it is important to acknowledge the different vulnerability and capacity of many individuals have "to adapt to climate change and how this varies according to their age, sex, gender, education, social status, wealth and access to other strategic resources (e.g., information, finance, land, etc.)". It is also important to recognise that there is "a high degree of diversity between and within groups, making some people more vulnerable, and some more adaptable, than others" (SPC, 2015, p. 1). In addition, ecological systems also operate at different vulnerabilities according to their condition, scale, and impacts from outside the system under consideration.

EbA links habitat conservation and active, adaptive management with broader social and economic development strategies that assist communities to adapt to trends and shocks associated with climate change and, in parallel, to improve social and economic well-being. EbA interventions are not rigidly defined but can be best understood in terms of their position on a continuum from 'hard', infrastructure-based interventions to those that solely deploy ecosystems in adaptation (see examples for coastal zone presented in Figure A1). In this sense, EbAs work with nature and natural processes (even when containing some 'hard', engineered, or capacity- and institutional components) and therefore provide the support and space to assist species and ecosystems to adapt to changing conditions in ways that are beneficial to human society.

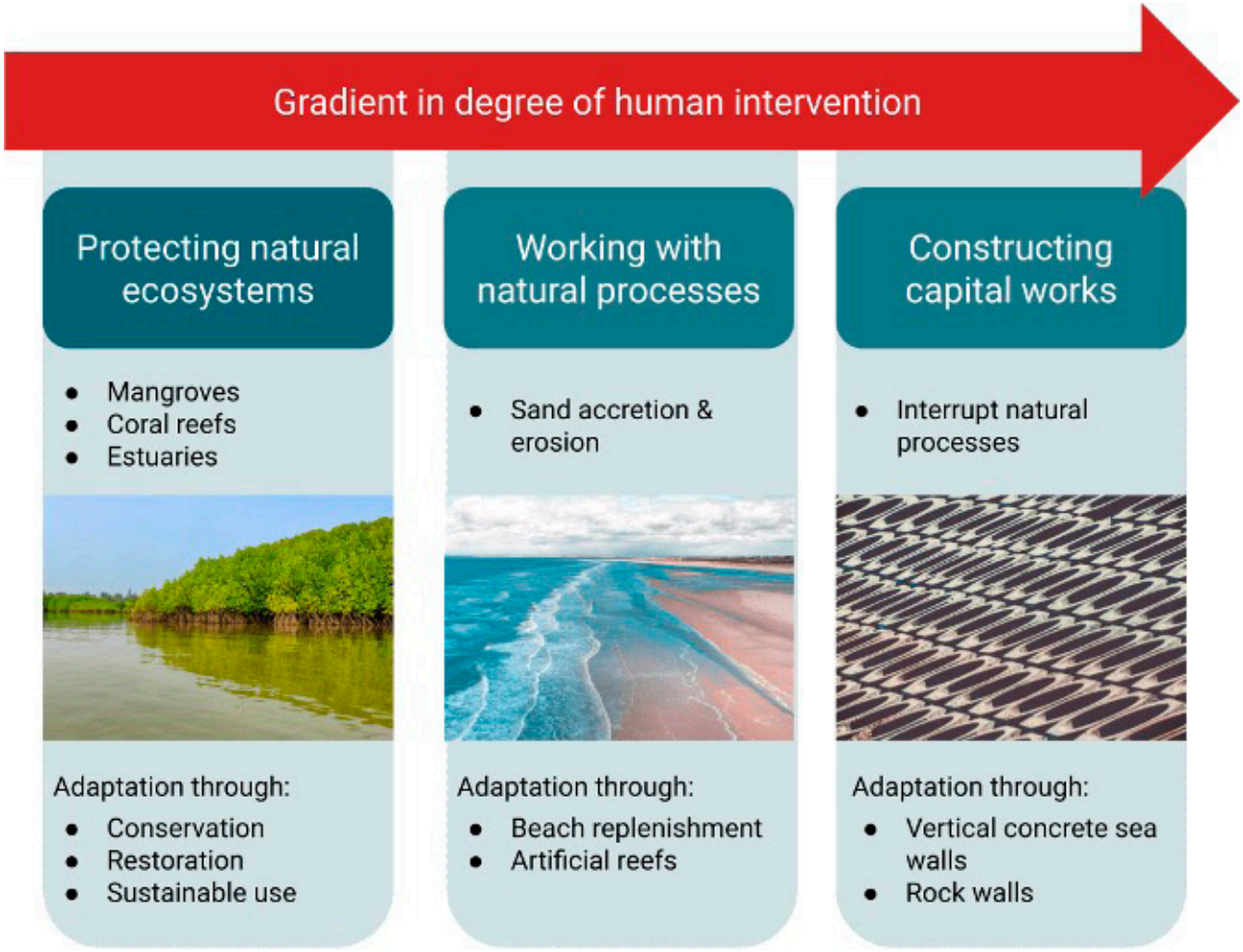

Figure A1: A spectrum of adaptation options available (example given for adaptations in the coastal zone) from interventions that maintain or build ecosystem integrity through to pure engineering solutions.

EbA is often closely tied with community-based adaptation, which is focused on a community scale and ensures that adaptation efforts are integrated with local development goals and community well-being and resilience, therefore taking a place- and sector-based approach, focussing on economic/lifestyle mainstays, such as fishing or eco-tourism (Failler et al., 2015; Hafezi et al., 2021; Nalau & Becken, 2018). In addition, EbAs can take the form of approaches that reduce pressure on natural systems to enable them function and potentially migrate (Buckwell, Ware, et al., 2020).

Therefore, EbA is an approach, rather than a prescribed set of solutions. EbA approaches need to consider different aspects of climate and environmental risk alongside other community needs.

More transformative adaptation presents even greater challenges but is also burdened with definitional ambiguity (Panda, 2018). Three key issues arise in the context of Solomon Islands

- The identification, level, distribution, and management of the costs, for example, many transformational adaptations will demand significant costs today (e.g., the transformation of subsistence agriculture to new levels of agricultural productivity) but many of the benefits will not accruing to many years into the future (Buckwell, Ware, et al., 2020).
- The definition of, the potential for, and need to avoid maladaptation (activities that add to environmental risk, such as over-extraction of natural resource inputs into intensified agriculture), especially as knowledge and risks change through time (Rickards & Howden, 2012).
- The human knowledge and capacity demands that this level of adaptation present; and the role of government in this adaptation (e.g., logistics, provision of funding, financing, research) (Bryan & Behrman, 2013; Dumaru, 2010).
- The uncertainty in our climate futures and the downscaling of climate projections to provide useful information to policy makers (Whetton et al., 2012).

Socio-ecological systems framework

EbA approaches to adaptation projects in rural Pacific communities can take a range of forms but must lay at the intersection of socio-economic development pathways, biodiversity conservation, and climate change adaptation. A socio-ecological systems approach is also required, embedding household and community wellbeing within a complex system that interacts with the range of socio-economic and ecological systems and sub-systems (Sahin et al. 2021).

For example, the expansion of animal husbandry (hens and eggs) reduces pressure on the harvesting of wild fish for protein from local reefs, which, in turn, may increase the integrity of coral reef systems, protecting future fish stocks and – in the even longer term – maintaining coastal protection through reducing wave energy through the accrual of coral cover. Other EbA approaches may also achieve the same objectives, such as increasing the capacity of a community to harvest fish protein away from local reefs in deeper water, which would demand investment in more robust watercraft, the skills, diesel supplies, and technicians to maintain the fleet, and training and financial support of a broader range of fishers, including members of socially vulnerable groups, than presently exists.

This food sub-system interacts with other sub-systems. For example, through protecting fish stocks and coral cover, and perhaps through the introduction of managed marine protected areas, the community can provide future opportunities for tourism businesses that are attracted by high integrity coral reefs and alternative and diverse livelihood opportunities. It is worth noting that tourists also generally demand higher protein diets. However, tourism businesses are only enabled though other infrastructure investments, such as access roads, communications, safe drinking water, sanitation, electricity, and pleasant accommodation options.

Conceptualising socio-ecological systems is necessarily complex and must find a balance between explicit local reflection and complexity and conceptual usefulness. In this series of studies, the team draws on two conceptualisations from studies in Vanuatu: that provided by Buckwell et al. (2020) for Port Resolution in Tanna and that by Sahin et al. (2021), which explores local, regional and country-level outcomes of EbA interventions.

Importantly, both conceptualisations determine end points as household and community well-being that supports community resilience to external shocks. In particular, the socio-ecological systems thinking informed our Q methodology statement concourse (see Appendix F), which enabled us to consider a full range of concerns, relationships, and aspiration within the communities in each of the study areas.

Criteria for qualification of ecosystem-based adaption

Figure A2 is drawn from FEBA (2018) and describes the foundational qualities and criteria that qualify interventions as EbAs. It sets a series of standards against which EbA intervention should be considered, for them to both meet the criteria for EbA but also to fulfil broad social and economic objectives.

Foundation	Qualification criteria	Standards
EbA helps people adapt to climate change	Reduces social & environmental vulnerabilities	1. Use of climate information 2. Use of local traditional knowledge 3. Adaptations take into account findings of vulnerability assessment 4. Vulnerability reduction at the appropriate scale
	Generates societal benefits in the content of climate change adaptation	1. Quantity and quality of societal benefits compared to other adaptation options 2. Timescale of societal benefits is demonstrated 3. Economic feasibility and advantages compared to other adaptation options 4. Maximising the number of beneficiaries 5. Equitable distribution of benefits
EbA makes active use of biodiversity and ecosystem services	Restores, maintains, or improves ecosystem health	1. Appropriate scale of management 2. Prioritisation of key ecosystem services within management
EbA is part of an overall adaptation strategy	Is supported by policies at multiple levels	1. Compatibility with policy and legal frameworks and policy support 2. Multi-actor and multi-sector engagement (communities, civil society, private sector)
	Supports equitable governance and enhances capacities	1. Accountability and group representation 2. Consideration of gender balance and empowerment 3. State of Indigenous and local knowledge and institutions 4. Long-term capacity to ensure sustainable governance

Figure A2: What foundational qualities and criteria qualify ecosystem-based adaptations as effective.

ESRAMs and EbA

Ecosystem and Socio-economic Resilience Analysis and Mapping (ESRAM) is a developing and evolving methodology developed for the Pacific Ecosystem-based Adaptation to Climate Change (PEBACC) project led by SPREP. It aims to build capacity for developing and implementing EbA and resilience projects within Vanuatu and the wider Pacific region. Our approach to this assignment (Figure 3) is consistent with the SPREP methodology. The objective is to generate a robust planning baseline that can inform the identification of EbA approaches and project options for strengthening the socio-ecological resilience of communities to climate change and anthropogenic environmental risks. ESRAM findings feed into a process to plan, assess, and design fully costed EbA options.

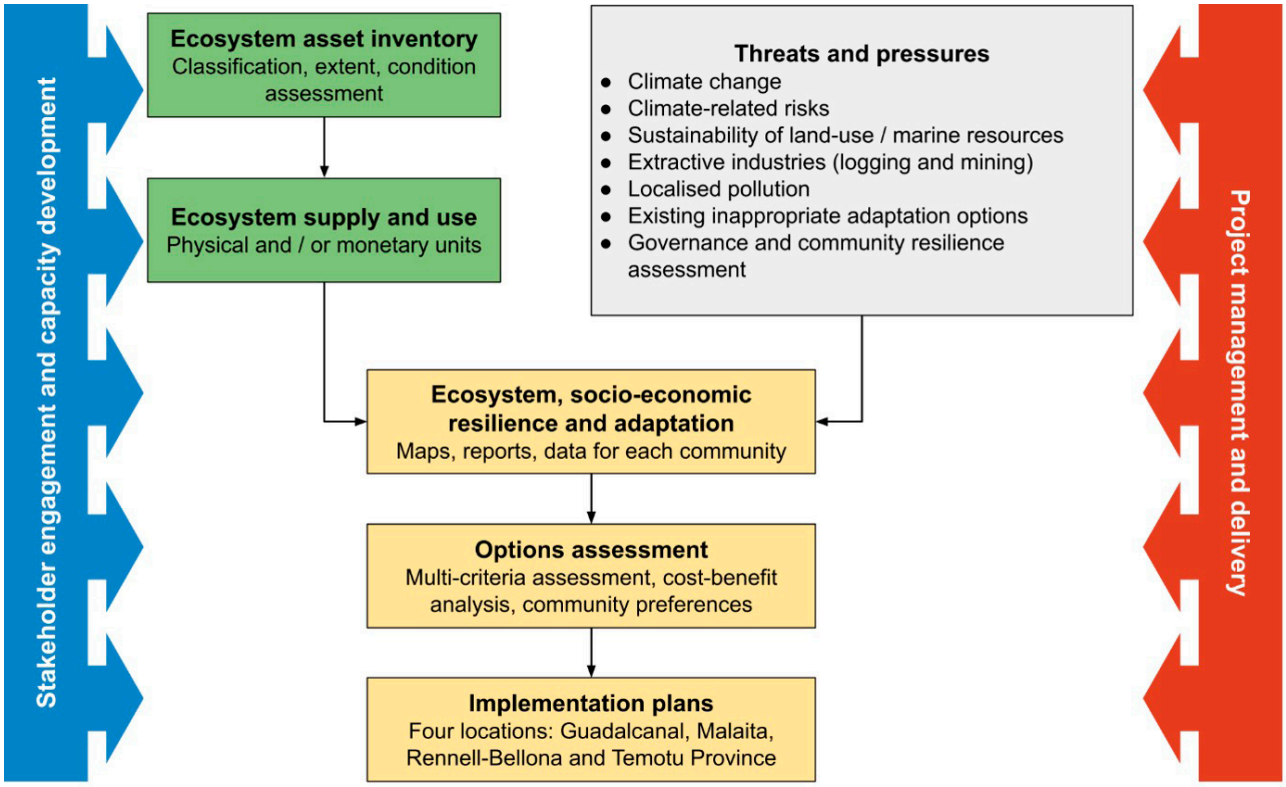

Figure A3: Our approach to the ESRAM methodology

Appendix B: Gender and social inclusion

Climate change-related risks are not equally shared by everyone in Pacific communities. In addition, the benefits of EbA are not automatically shared equitably and the aspirations of different members of the community are commonly divergent. Women, particularly poorer, rural women, experience greater vulnerability to climate change impacts than men, due to complex, intersectional drivers, including semi-formal community power dynamics, socially and culturally constructed discourse on the role of women in the family and society, and formal risks of land alienation and access to economic resources (Bendlin, 2014; Djoudi & Brockhaus, 2011). Furthermore, gender is not only a driver of different vulnerability to climate change but also should play a role in determining appropriate adaptations, as the needs and priorities of women are likely to different to men, or the community as a whole (Bryan et al., 2015). Notwithstanding, womens' roles and leadership in adaptation, in the families, in communities, and in formal representative structures, is recognised as being necessary condition for fostering resilience (Aipira et al., 2017). This is constantly demonstrated empirically, where womens' empowerment is linked to adaptation to change and improved social and economic outcomes for themselves and for communities as a whole (Bowman et al., 2009; Kassie et al., 2020).

Solomon Islands is traditionally considered a male dominated and remains a largely patriarchal society, with men occupying positions of decision making in both formal representative democratic structures (the national parliament, for example) and at local, community level, where customary application of kastom lore can disadvantage women and the rights women do have – in using kastom natural resources – can be ignored.

Gender roles and the gendered division of labour continue to be sharply demarcated in Solomon Islands. Solomon Islands is a patriarchal society—men have greater access to important resources as well as greater institutional access to power and privilege (Dyer, 2017). Notwithstanding, women are increasingly participating in the formal economic sphere in Solomon Islands and play key roles in domestic and household decision making and in local management of natural resources. Nearly 30% of all businesses and approximately 20% of small and medium-sized enterprises in Solomon Islands are operated by women (Solomon et al., 2009).

However, gender consistently explains relationships of power, access to resources, vulnerability and resilience and is therefore a key category for analysis (Anderson, 2009, p. 3) and is therefore a vital element in assessing the climate adaptation literature and in designing community-based adaptation (CBA) and climate change adaptation (CCA) projects.

Appendix C: Solomon Islands climate impacts

Overview

As tropical developing island nation, the Solomon Islands has particular vulnerabilities and exposures to the current and future impacts of climate change.

Year to year the climate of the Solomon Islands is influenced by interconnected, large-scale climate phenomenon, such as the El Niño–Southern Oscillation (ENSO), which alters inter-annual rainfall patterns, temperatures, and wave direction. However, due to its location near the equator, the Solomon Islands experiences a relatively stable climate (distribution of mean weather) with average temperatures between 24.5°C and 26.5°C year-round. Average monthly rainfall is also relatively consistent, ranging from 150–350 millimetres (mm), and usually peaking between January and March.

Notwithstanding, historical climate data point to increases in average temperature between 1962–2012 at a rate of around 0.14–0.17°C per decade. And rates of warming appear to have accelerated since about 1990, with the Berkeley Earth Dataset suggesting temperatures in 2015–2017 have reached around 0.8°C above the long term average (Climate Change Knowledge Portal, 2023; World Bank Group, 2021).

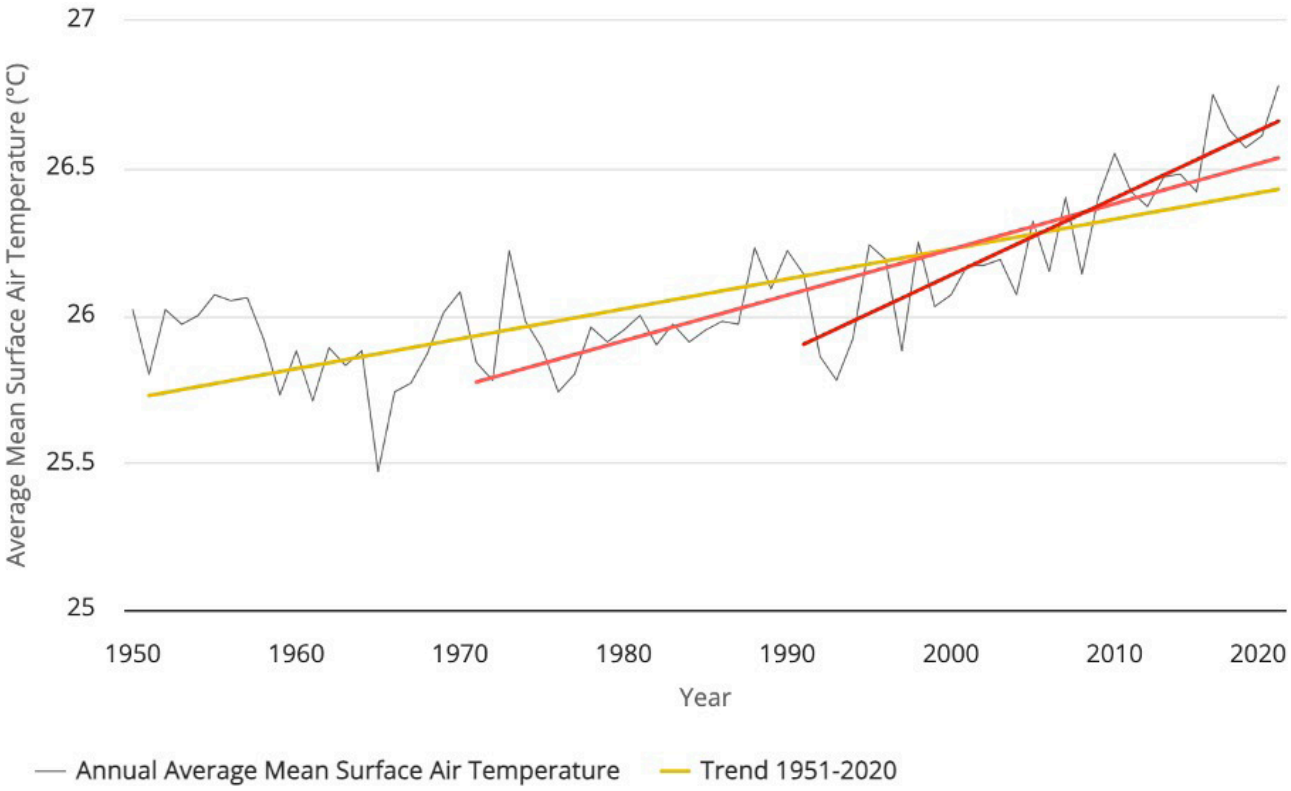

Figure A4: Solomon Islands average mean surface air temperature annual trends with significance of trend per decade for 1951-2020 showing accelerating increases (Climate Change Knowledge Portal, 2023).

Projected future climate changes

Projections for the Solomon Islands in the Representative Concentration Pathways[1,2], (RCPs) suggest that temperatures will rise between 0.7°C (0.4°C -1.2°C) in the high mitigation scenario (RCP 2.6) and 2.8°C (2°C - 4°C) in the low emissions scenario (RCP 8.5) by 2090 (Figure A5). Climate change is likely to be below the global average in the Solomon Islands with the difference reflected in the moderating effect of large amounts of nearby ocean cover. However, ocean cover is known to distort model simulations, and the current iteration of global models does not have the spatial accuracy to reliably capture climate processes over small island states, these projections should be approached with caution (World Bank Group, 2021).

There is some evidence that annual precipitation will increase slightly, however, there is uncertainty around future changes, as models disagree, particularly around the future impacts of ENSO. A warmer atmosphere is likely to lead to an increase in the frequency and intensity of extreme rainfall events.

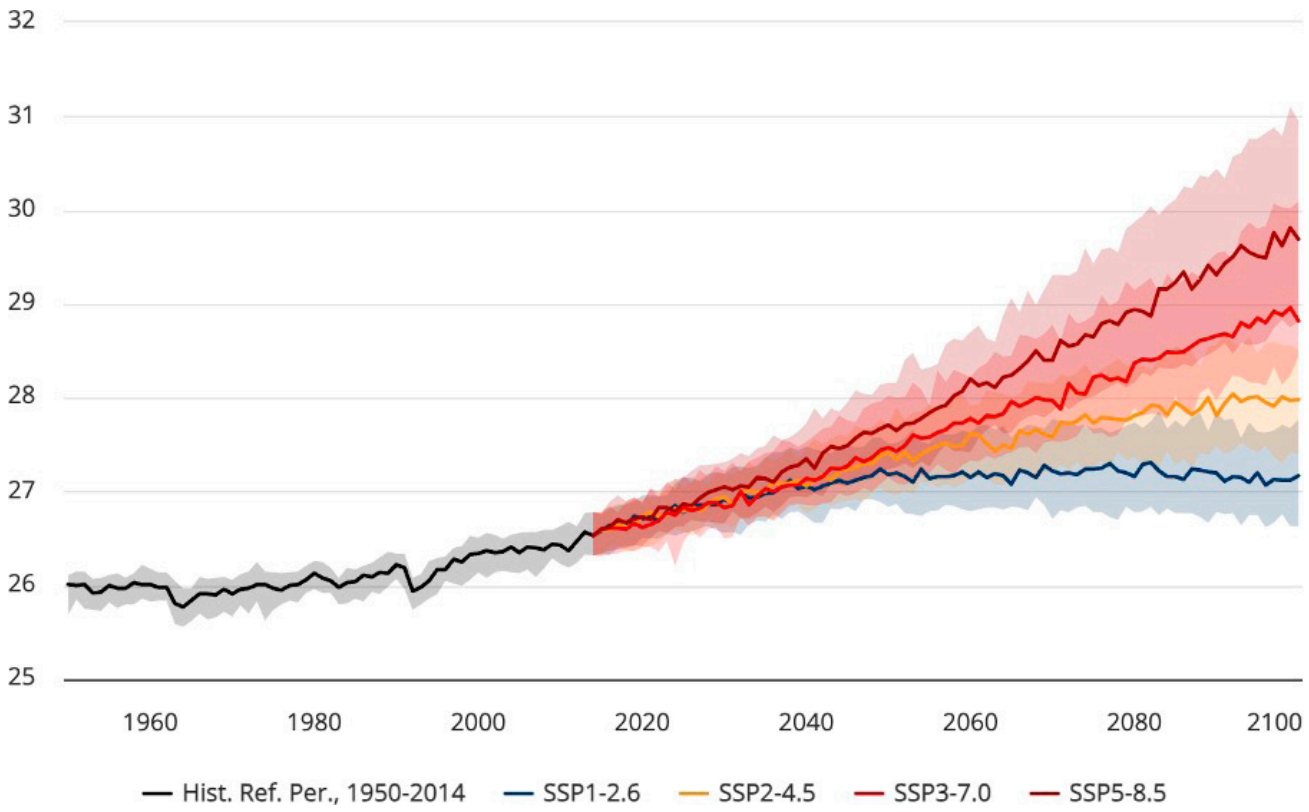

Figure A5: Solomon Islands multi-model ensemble projected mean temperature to 2100 under a range of Representative Concentration Pathways (Climate Change Knowledge Portal, 2023).

Further climate change impacts

Sea level rise

The IPCC's 6th Assessment Report (AR6) (IPCC, 2023) concludes that global sea level rise is accelerating and is projected to continue to do so in the future. The report states that sea levels have risen by about 20 cm since the late 19th century and are currently rising at a rate of about 3.6 mm per year. This rate is expected to increase to 4-9 mm per year under RCP2.6 and 10-20 mm per year under RCP8.5 by the end of the century.

1 Since the International Panel on Climate Change's (IPCC) sixth assessment report (AR6) projected future changes to climate and impacts on society are now modelled through 'Shared Socioeconomic Pathways' (SSPs). SSPs have not replaced RCPs. The two ways of looking at projected future changes both remain valid and active. However, whilst RCPs focussed on carbon dioxide concentration ('radiative forcing') pathways, SSPs are meant to provide a more comprehensive framework that includes the interactions between social, economic, and environmental factors.

2 There are four Representative Concentration Pathways: RCP2.6, RCP4.5, RCP6.0, and RCP8.5. They represent four plausible futures, based on the rate of emissions reduction achieved at the global level and are defined by their total radiative forcing (cumulative measure of GHG emissions from all sources) pathway and level by 2100.

The report also states that sea level rise will continue for centuries beyond 2100, even if greenhouse gas emissions are reduced. This is because the oceans have a large thermal inertia, meaning that they take a long time to warm up and cool down. As a result, sea levels will continue to rise even after global warming has been stabilized.

The Solomon Islands are in an area that has experienced above average rates of sea-level rise in recent decades[3]. Estimates show a rise of ~8–10 mm/year between 1993 and 2010 (World Bank Group, 2021). Note this is relative sea level rise which is a net combination of increases in sea surface levels and any uplift / recession that specific parts of tectonically active areas experience (Faivre et al., 2022). In addition, localised sea level rise is impacted by regional cyclical phenomena, in particular ENSO. Global mean sea-level rise is estimated in the range of 0.44–0.74 meters (m) by the end of the 21st century by the IPCC's Fifth Assessment Report (Pachauri et al., 2014). Such increases are a significant threat to low lying coastal areas in the Solomons.

Tropical cyclones and extreme weather

Tropical cyclones have historically impacted the Solomon Islands and its exclusive economic zone at a rate of around 21 cyclones per decade, with around a quarter categorises as Category 3 and above (World Bank Group, 2021). Cyclones frequency is influenced by the ENSO cyclone. Figures A6 and A7 to A10 (in greater detail) show recent tracks of tropical cyclones across the four areas of interest between 1982 and 2022 (BOM, 2023). East Rennell (Rennell and Bellona Province) has experienced the most intense cyclone activity, with five direct crossings and two within close vicinity. At the other end of the spectrum, Temotu Province has experienced only near misses.

The general projection is for a decrease in cyclone formation frequency through to 2100 by between 6%–35%. However, there is also evidence that the intensity of cyclones may increase. Any uncertainty is based on the future of ENSO cycles, which is not very well understood (BOM & CSIRO, 2014).

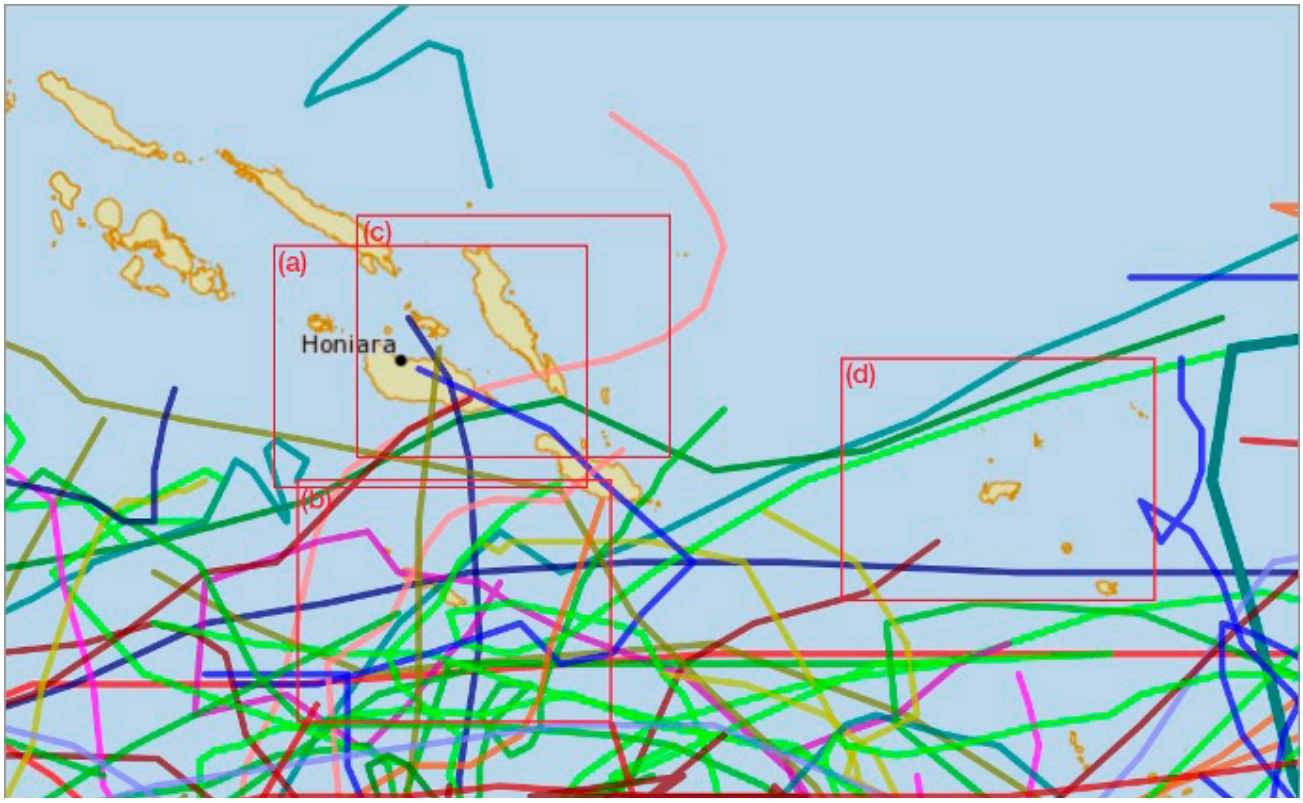

Figure A6: Tropical cyclone activity over the Solomon Islands (2002-2022). Inserts are figures below. (BOM, 2023)

3 According to the Solomon Island's Second National Communication to the UNFCCC

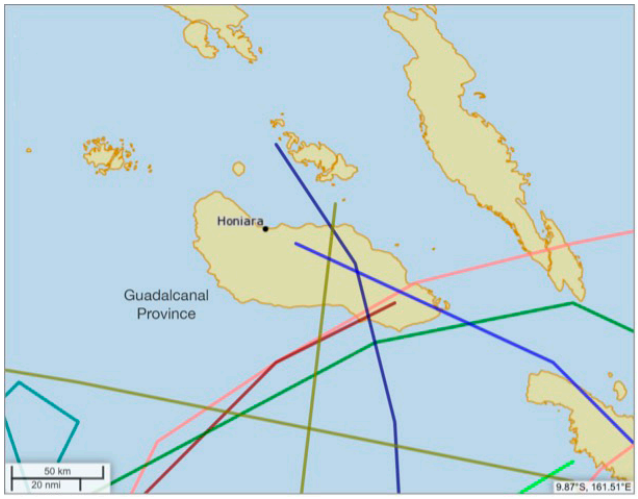

Figure A7: Tropical cyclone activity over Guadalcanal Province (2002-2022) (BOM, 2023)

Figure A8: Tropical cyclone activity over Rennell Island (2002-2022) (BOM, 2023)

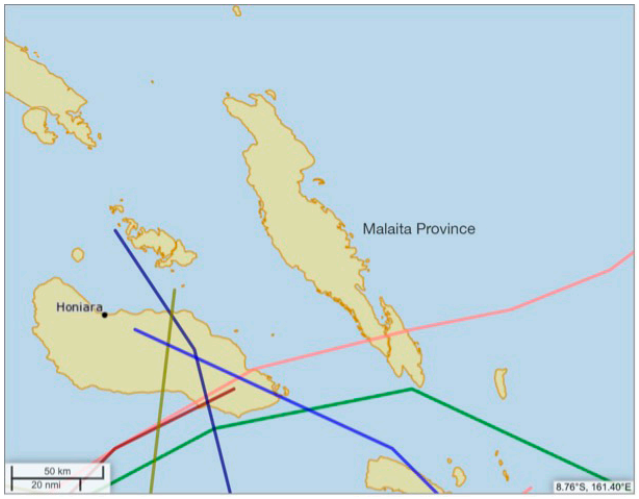

Figure A9: Tropical cyclone activity over Malaita Province (2002-2022) (BOM, 2023)

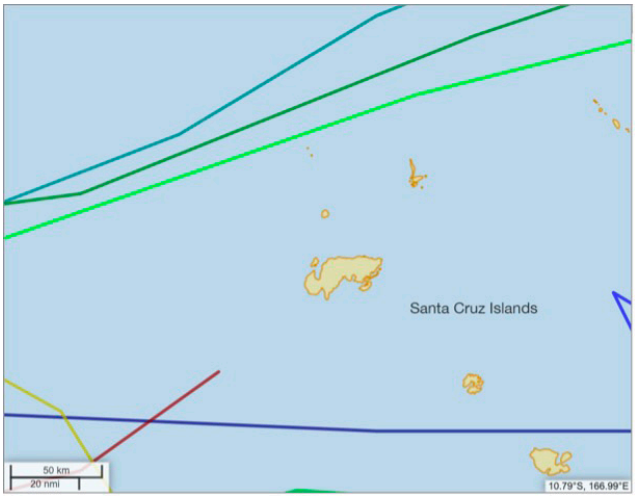

Figure A10: Tropical cyclone activity over Temotu Province (2002-2022) (BOM, 2023)

Impacts on marine environments

As a Pacific island nation, communities of the Solomon Islands, and to a great extent, all four study areas, are highly dependent on marine resources (though reliance on fish for food direct food consumption is becoming less) (Turner et al., 2007) and marine ecosystem services, such as coastal protection services offered by coral reefs. Even where fresh fish is less important for local consumption, it is still a driver of income generation and support for livelihoods through sale at major markets and into the tourism sector.

Climate change is projected to have significant impacts on marine environments. Increased frequency of coral bleaching and ocean acidification may progressively degrade reefs leading to decreased coastal protection (greater risk from extreme weather events to coastal communities) and to diminished fish catch (Duvat & Pillet, 2017; Hoegh-Guldberg et al., 2007; Pittock, 2010; Turley & Gattuso, 2012)

The production of coastal fisheries from coral reefs is expected to decline by up to 50% by the end of the century (Bell et al., 2016). Moreover, climate change is expected to increase damage to reefs from more severe physical damage to reefs, while greater sediment and nutrient runoff from heavier rainfall would damage coral reefs more frequently, particularly in study areas that have significant rivers, such as Guadalcanal and Malaita (Bell et al., 2016).

Food production impacts

Climate change will likely have significant negative impacts on agricultural output in Solomon Islands (Rosegrant et al., 2015). For example, crop yields of staples, such as taro, are projected to diminish over time due to increased heat and its impacts on soils, perhaps demanding increased inputs, such as artificial fertilisers to make up the gap. Given agriculture's significant role in both employment, GDP, and livelihoods, adverse climate change-driven impacts on the agriculture sector maintaining "business-as-usual" in the agriculture sector demands costly long-term actions. In addition to local food consumption, cash crops are also vulnerable to climate change, in particular, extreme weather events that can have significant impact on crops, such as coconut, bananas, breadfruit, and cacao (Bell et al., 2016).

Projections for growing season length out to 2100, under all RCPs, present a grim picture but is nevertheless still subject to significant social, economic, and environmental uncertainty (see Figure A11; by definition, the growing season cannot be >365.25 days).

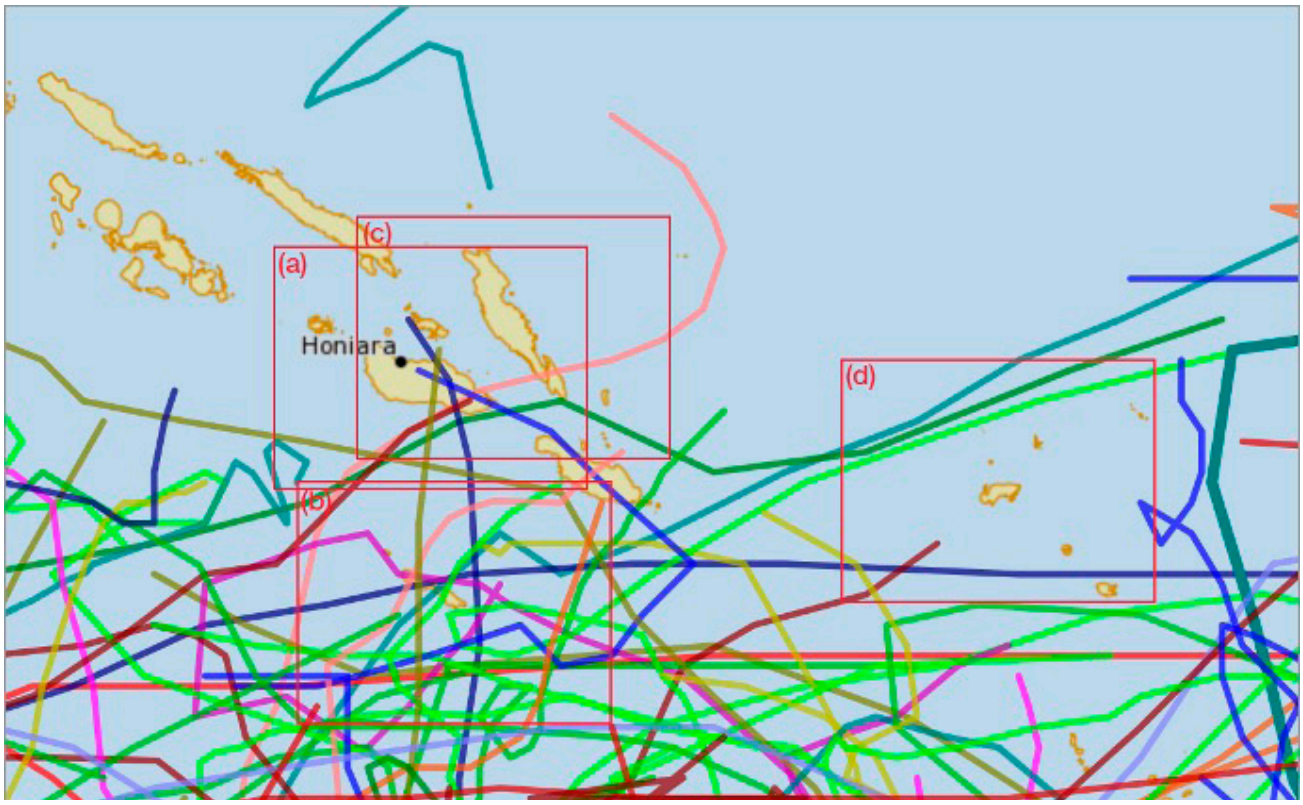

Figure A11: Solomon Islands projected growing season length from multi-model ensemble to 2100 (Climate Change Knowledge Portal, 2023).

Appendix D: Ecosystem mapping and economic valuation

Ecosystem mapping

Terrestrial ecosystems can be identified and mapped using various criteria, from a practical perspective (and in a Melanesian context) they have been defined here according to the major vegetation types that have been recognised by biodiversity and forest surveys. However, the pattern of land cover and land use remains complex and dynamic in the Solomon Islands, with transition between forest, rotational subsistence gardens, and secondary forest regrowth. Thousands of years of shifting cultivation and regrowth has left only the remotest areas and steepest terrain completely unmodified – it has been suggested that disturbed and logged forest will take more than 50 years to recover (Katovai et al., 2015; Katovai et al., 2021) Nonetheless, the Solomons Islands still contains very significant tracts of primary forest.

Whilst numerous possible classifications are available for ecosystem asset types, in preparation for the economic valuation of ecosystem services component of our study we adopted a simplified classification scheme that could be detected through the training of machine learning tools using the library of support vector machines (libsvm) classification through Google Earth Engine. Cleaned Sentinel-2 satellite imagery dating from 2020 - 2022 was used as the input dataset and trained using locally identified land classifications. Further desktop validation was performed using Maxar high resolution imagery to ensure the accuracy of the outputs.

For coral reef data we used extracted extent data from the Allen Coral Atlas (Allen Coral Atlas, 2024).

For mangrove extent and loss data we used extracted date from Global Mangrove Watch (Global Mangrove Watch, 2024).

Consistent with the UN's System of Environmental Economic Accounting Ecosystem Accounting (SEEA-EA) (UN, 2021), in our project sites we include the human-modified land-uses of 'subsistence gardens' and 'plantation forests' as ecosystem assets; as residual values, beyond human labour and capital input, are provided by nature in the delivery of the final ecosystem service (Boyd & Banzhaf, 2007).

Ecosystem valuation

The SEEA EA framework allows for the benefits from ecosystem services to be valued in economic, or monetary terms. Economic valuation provides a way of enabling common measures of value between different ecosystem goods and services with other elements of well-being traded in markets to enable trade-offs and benefits to be more effectively assessed. Not all ecosystem services lend themselves well to economic valuation for specific local cultural reasons (for example, some spiritual services).

The team used a Total Economic Valuation (TEV) framework (Figure A12) (Buckwell & Morgan, 2022). The TEV framework ensured that both obvious values (e.g., direct use values, such as the production of cash crops) and non-use values (e.g. existence values such as those surrounding unique ecosystems) were incorporated as much as practicable. This provided us with an estimate of TESV.

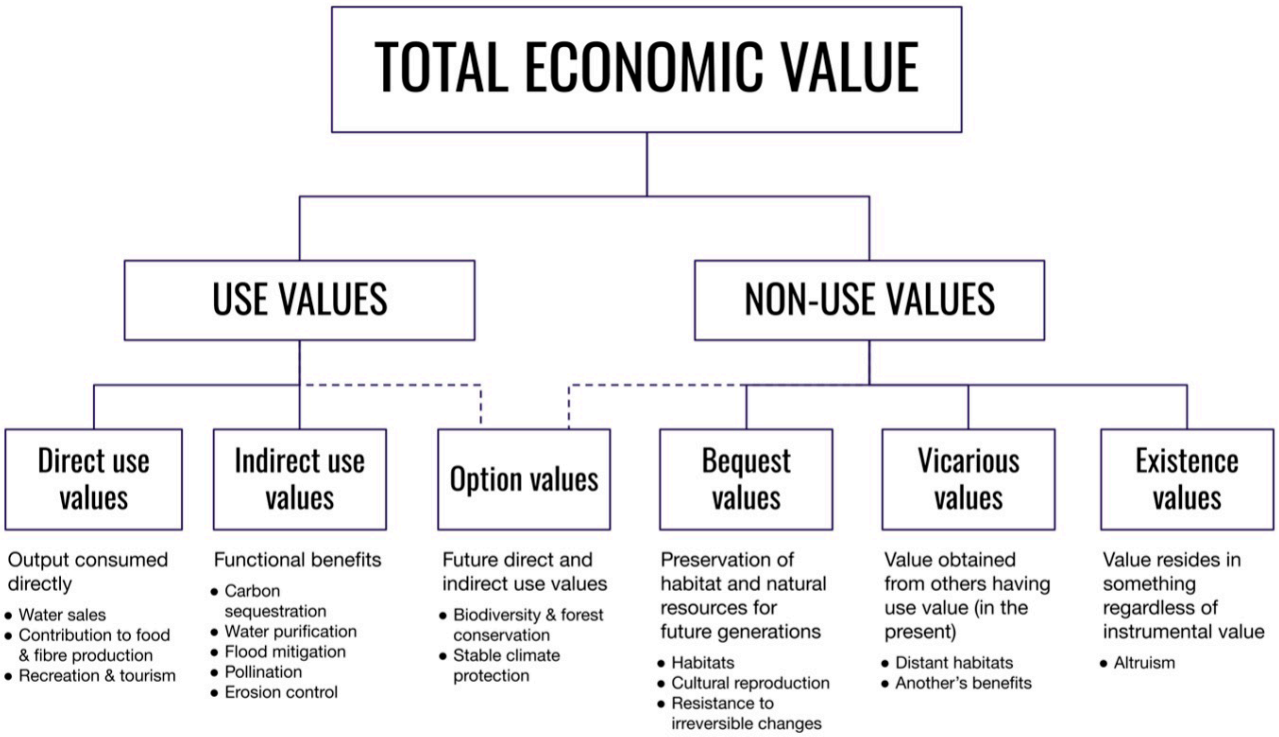

Figure A12: Total economic value framework.

Benefit transfer

When seeking to estimate the monetary benefits of ecosystem services, several possible valuation techniques can be used depending on data and resource constraints. In this project, market-based methods were used to estimate use values (food and water consumption, for example) where relevant data were available. Benefit transfer was used to estimate non-use values. Benefit transfer is a method of estimating the value of a change in an environmental good or service at a (target) site using information from an existing study (or studies) conducted at another (source) site. This approach is useful when a primary study for the target site is not possible due to time and/or budget constraints. The team drew estimates from a range of sources, including databases from Brander et al. (2024), Taye et al. (2021) and van der Ploeg & de Groot (2012) filtered in accordance with those deployed in assessing TESV for Vanuatu and Tanna by Buckwell et al. (2020). Buckwell's study could only find a single data point for the value of subsistence farming that would be appropriate for the Solomon Islands – that by Anderson (2006) for communities in Papua New Guinea – and this remains the case today.

While the authors recognised this as a potential weakness in their study, geographic and cultural similarities suggest it could be an effective substitute.

Method

Our benefit transfer for value estimates took the following hierarchy of value estimates:

1. Estimates from Pacific islands from the Ecosystem Services Valuation Database (Brander et al., 2024).
2. Estimates from appropriate value estimates (low income countries) from the TEEB Valuation Database (de Groot et al., 2012) as extracted by Buckwell et al. (2020).
3. Specific valuation from Anderson (2006) for the value of subsistence gardens (from Papua New Guinea)

Where multiple values were extracted from the datasets, the median value of all datapoints was calculated. At each step, where gaps in individual ecosystem service valuations for the range of habitat types were not filled, they were filled by the next step. In all instances, only per hectare, per year estimates were used. All valuation methods were considered. Value estimates were normalised to 2022 US dollars estimates using GDP deflator values from World Bank datasets (World Bank, 2023) and the 12 month mean exchange rates between currencies.

Value estimate coefficients

From this range of sources, the team estimated an ecosystem coefficient based on the median values from the filtered list of appropriate benefit transfer values. This is reported in Table A1.

Special note on value estimate for subsistence gardens

Of particular note is the estimate for the economic value of subsistence gardens from Anderson (2006). Anderson's study was based on several communities in Papua New Guinea (PNG) and used a market-price replacement method to provide a per hectare per year value. The estimate is based on the equivalent cost of purchasing the grown food at a local market. The basket of food on which Anderson's estimate is based (staple crops) is broadly similar to the staples grown in Vanuatu. The study accepts that the estimates provided take a narrow view of the sustenance provided from subsistence gardens and ignores additional economic value that may be attributed to "risk management concerns of food security and social security, nor the important but less tangible values of social cohesion and cultural reproduction" (Anderson, 2006, p. 141). Nevertheless, the surprisingly high value estimate provided is contrasted, perhaps provocatively so, with the customary land's relatively low prices customary land achieves when it is transacted for alternative commercial uses. Anderson's value is a per hectare value based on exchange values (economic value is based on quantity X price) and is therefore compliant with the SEEA-EA principles; nonetheless, as it contributes a significant proportion to TESV, it needs to be treated with some caution and seen as more as a potential value of subsistence gardens. The value provided by Anderson is significantly inflated from its original 2016 values due to relatively high price inflation in PNG in the subsequent years but is also moderated by a significant loss of value of the PNG Kina against the US dollar (see Table A1).

Three further values from the for the value of agro-forestry are in the TEEB database (2010) of ecosystem services:

1. A study by Predo (2003) valuing agro-forestry in the Philippines at US$ 1,695 yr-1 ha-1 in 2001 by direct marketing pricing method (US$ 2,610 yr-1 ha-1 in 2022).
2. A study by Yaron (2001) valuing agro-forestry in Cameroon at US$ 1,400 yr-1 ha-1 in 2000 by direct pricing method (US$ 2,232 yr-1 ha-1 in 2022).
3. A study by Pagiola (2004) valuing agro-forestry in Nicaragua at US$ 1,450 yr-1 ha-1 in 2004 using a payment for ecosystem service scheme as a proxy (US$ 2,174 yr-1 ha-1 in 2022).

None of these values are specific to Melanesia, so therefore we will use Anderson's value from PNG (2006).

Table A1: Ecosystem service valuation coefficients (2022 US$ per hectares per year).

Ecosystem service	Coral reef	Grasslands	Mangroves	Primary forest	Secondary forest	Plantation	Subsistence gardens	Freshwater water bodies
Provisioning								
Food	69	42	693	8	8	61	8,108	23
Water supply	0.0	150	2,206	232	232			1,494
Raw materials / energy	1.0	8	215	37	37			1
Genetic resources				7	7			
Ornamental resources				57	57			
Medicinal resources	3		3					
Regulating services								
Air quality regulation		114	236	497	497			
Climate regulation	231	338	483	140	140			65
Moderation of disturbance	204		990	52	52			
Water flow regulation				1	1			

Ecosystem service	Coral reef	Grasslands	Mangroves	Primary forest	Secondary forest	Plantation	Subsistence gardens	Freshwater water bodies
Water treatment (inc. water)	3							
Erosion prevention			102	119	119			
Soil fertility maintenance		277	224	16	16			1
Pollination				47	47			
Biological control	0.3							
Cultural services								
Aesthetic	3							
Cognitive	2							
Inspiration								
Spiritual	1							
Recreation	381	5	982	1,190	1,190			431
Existence value								

Establishing final ecosystem service value

Estimating TESV requires making judgments as to what constitutes intermediate and final ecosystem services—those that are directly "enjoyed, consumed, or used to yield human well-being" (Boyd & Banzhaf, 2007, p. 619). If both intermediate and final ecosystem service values are totalised, contributions are double counted. For example, pollination services are intermediate inputs into the final food production value provided by agriculture, forests, and plantations. Therefore, the value of pollination services is embedded in the provisioning ecosystem service value for food.

Ecosystem accounting reconciles inputs and outputs so that the value of final services is the sum of value– added through intermediate components. In general, regulating ecosystem services are intermediate services to final benefits enjoyed locally and therefore not totalled in a TESV (though nevertheless present useful information for decision-making). The exceptions to this are (a) air quality regulation (an end in itself); (b) erosion control and moderation of disturbance (b) climate regulation, which, although it provides a measure of an intermediate service (a stable climate) that contributes to local food production, for example, it also provides a final service to global society as a public good or a private good if emissions reductions are converted into a carbon permit; and (c) the moderation of disturbance functions of coral reefs and mangroves, providing coastal protection.

The final ecosystem service value coefficients used in our ecosystem service valuations for the four areas of interests is shown in Table A2.

Table A2: Summary of final ecosystem service value coefficients (2022 US$ per year per hectare).

Ecosystem service	Coral reef	Cleared grasslands	Mangroves	Primary forest	Secondary forest	Plantation forest	Subsistence gardens	Water bodies
Provisioning	73	200	3,117	341	341	61	8,108	1,518
Regulating	435	452	1,811	808	808	0	0	65
Cultural	387	5	982	1,190	1,190	0	0	431
Total value	895	657	5,910	2,339	2,339	61	8,108	2,014

Appendix E: Government engagement

The project team undertook a number of meetings with Solomon Island government ministries and activities in support of preparation for the field work.

Ministry of Fisheries

Mariculture

- Seaweed growing is for export. Mainly small scale, grown on ropes in the ocean. Needs to be cut and dried for export.
- Supply chain is quite complex, as it needs to stay dry throughout and so market access is limiting factor.
- Anecdotally, it generates a good, easy, and often supplementary livelihood for those engaged in it.

Aquaculture

- Government owned hatcheries are in operation for a new, slightly larger freshwater tilapia species in Guadalcanal and Malaita. Then distributed to small scale producers to grow in tanks around 25m x 15m.
- Feedstock for tilapia is quite diverse and includes local staples, such as coconut and cassava.
- Tilapia needs to go through quarantining processes. It is also an invasive species, having been released into the lake at Rennell and Tikopia.
- There is also a beche-de-mer hatchery. …

FAD programme

- Inshore FADS are in operation as part of a program. Inshore FADs are all community operated and managed and lay within customary marine managed areas, known as Community-based Resource Management (CBRM) areas.
- Programs have not always been accepted. Sometimes this is due to inappropriate placement (in transport lanes, there is too much wave energy, or they are too close together).
- Benefits have not yet been fully demonstrated. This assessment work is currently taking place and is part of the CBRMs.
- FAD programmes include training in the deployment, maintenance, and also training in the type of fishing that works for FADs. Ministry is looking for ways to enable the community to take ownership of the FADs.
- Offshore FADs are sometimes laid by commercial enterprises for large scale tuna catches. Community members with the requisite crafts or skill often access the offshore FADs. Offshore FADs come under the purview of provincial level government.

Regulation & general

- All provincial level government fishing ordinances are being reviewed in a World Bank funded project.
- There is regulation around allowable fishing gear and practices, such as what mesh sized nets can be used. However, there is a lot of illegal sales of small mesh nets.
- Night lighting to attract fish is also occurring.
- Some recent historical fishing has been inappropriate in its bag size, with risks that food is wasted.
- However, as infrastructure improves and markets become available, the excess fish catch can still find a market and thus over-exploitation can occur.

Ministry of Provincial Government

- Responsible for socio-economic resilience, disaster risk reduction, climate change adaptation.
- Ministry currently has seven climate change risk and resilience offices and a climate change specialist from the MECDM. Eventually, there will be nine climate change officers.
- Much of this work is coordinated through Ward Development Committees (WDC); each has a ward officer and a small budget for operations and small projects (water for schools, sea walls, community farms).
- WDC officers are not necessarily full time but do get paid for results.
- Chiefs and church elders also intervene below WDC level (e.g. land disputes).
- Ward Development Committees feed into Provincial Development Plans, which is a three-year rolling plan.
- Provincial government governance is operated through ordinances; currently, East Rennell has an ordinance for protected area status (in the World Heritage area)

Ministry of Agriculture and Livestock

- Most projects run by the Ministry are donor funded.
- It was felt the Pacific Games had drawn in funds that could been otherwise allocated to agricultural projects

Ministry of Mines and Natural Resources

- It was recognised that mining and logging operate at cross-purposes to forest conservation when it comes to pathways to economic development.
- Communities own their resources and have full rights to choose their pathway to development.
- It is recognised that buffer zones around mining and logging activities are being eroded
- It was suggested that research and community engagement that focusses on the trade-offs between resource extraction and forest conservation should also take place in areas where the choice is most stark.
- Legislation to promote logging and mining restoration (through a system of bonds) is currently sitting in Cabinet.
- Specific to West Rennell – some mines were closed due to non-compliance; some prospecting is now again taking place.

Appendix F: Q-methodology

About Q methodology

Q methodology (hereafter, Q) is both a quantitative and qualitative research technique based on the statistical analysis of people's subjectivity (Brown, 1980; Stephenson, 1953). Q leans into discursive/contextual methods of knowledge generation that uphold both personal realities and shared experiences of the world suited to SES where the more complex a problem, the greater the number of plausible and coherent perspectives there likely is, as the understanding of the nature of the complex links becomes more personalised and less subject to repeatable proofs (Buckwell, Fleming, et al., 2023). Q is a type of factor analysis that finds correlations amongst consistent groups of respondents who share similar views of the world. These correlations reflect coherent mindsets, which are analogous to the structure of a discourse, with views formed from both external influences (acting on people) and also emergent of collective heuristics (people and power structures actively shaping people) (Dryzek, 1994)

In practice, Q facilitates the placement of statements (the 'Q-set') by respondents (the 'P-set') onto a grid ranked from most salient to least salient in response to a statement of condition (Figure A13). The Q-set present is constructed from a potentially infinite concourse of perspectives, which is filtered down to a management number for study. Statistical techniques ('Varimax Rotation') reduce the often considerable variance into the fewest possible meaningful factors.

Figure A13: Respondent undertaking a Q-sort in Guadalcanal.

Our concourse was generated by taking a mixed methods approach, which included drawing prior author experiences in Melanesia, SES and Solomon Islands literature, and expert elicitation. Funding and logistical constraints limited any piloting. The concourse for this study subsequently filtered down to 36 statements, which, from experience, provides a reasonable depth and breadth of statements but is not unwieldy for respondent sorting.

Participants were asked to rank statements on a quasi-normal distribution, with fewer statements at the most positively and negatively salient columns (our sorting grid is in Figure A14). This pattern has no statistical implications but is a strategy used in Q to encourage participants to 'think harder' about what is most and least salient (Watts & Stenner, 2012).

During and after sorting, participants are asked to 'think out aloud' and explain their feelings about the statements, particularly the reasoning behind their placement of the most and least salient statements. This information, though not

part of the statistical analysis, can enable further, subjective analysis, to be undertaken by the researcher, with greater confidence.

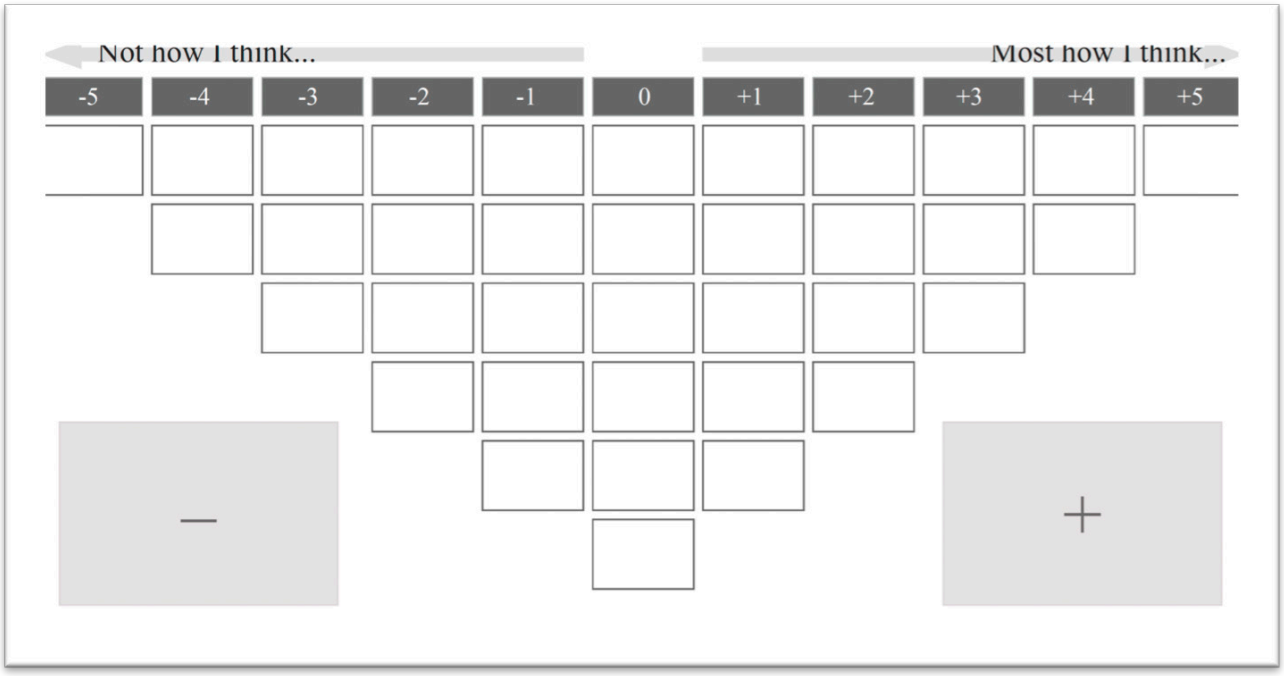

Figure A14: Sorting grid for our Q-methodology.

Figure A15: Sampling

As Q-method is not designed to garner generalisable results (e.g. 50% of men align with discourse x) therefore respondent recruitment is done through strategic sampling. It is more important that a very wide range of viewpoints of respondents are sampled, rather than trying to capture as many responses as you can from stakeholders who are likely to have similar viewpoints. Therefore, we tried to seek a diversity of respondents, including all the demographic groups, farmers, hunter-gatherers, service providers, agricultural extension officers, government policy officers.

Statistical treatment

For statistical analysis we used KADE (Banasick, 2018), which automates many of the functions of Q, unless stated. Unless otherwise stated, our correlation matrix was subject to factor analysis using Horst Centroid, allowing the application to recommend the number of factors to extract, as recommended by Brown (1980). In each case, the factors were subjected to Varimax rotation – a technique that maximises the variance shared amongst responses (Akhtar-Danesh et al., 2008). Respondents were included in each rotated factor using the autoflag feature at p-values of <0.05. Confounding sorts (respondents who load into more than one factor) and null sorts (respondents who do not load, or were flagged, into any factor) were set aside from further subjective analysis.

Composite sorts

Using the composite sorts generated by the KADE software, Q practitioners can generate common language summaries of the factor, called 'composite' or 'ideal' sorts (Figure A15). This is a hypothetical sort of a respondent who fits 100% in that factor (in reality, the threshold for placement into a factor is typically any respondent fitting more than >40%). Interpretation of the composite factor is best achieved by considering the placement of strongly negatively- and positively-salient statements (in the +/-5, +/-4, and +/-3 columns) and distinguishing statements—those where the z-score variance reaches a defined threshold (Sneegas et al., 2021).

Whilst demographic data can provide useful information to the discourse descriptions, Q is not designed to lead to statistically generalisable results but rather to provide a detailed portrayal of the full scope of perspectives of a situation within a given community (Buckwell, Fleming, Muurmans, et al., 2020).

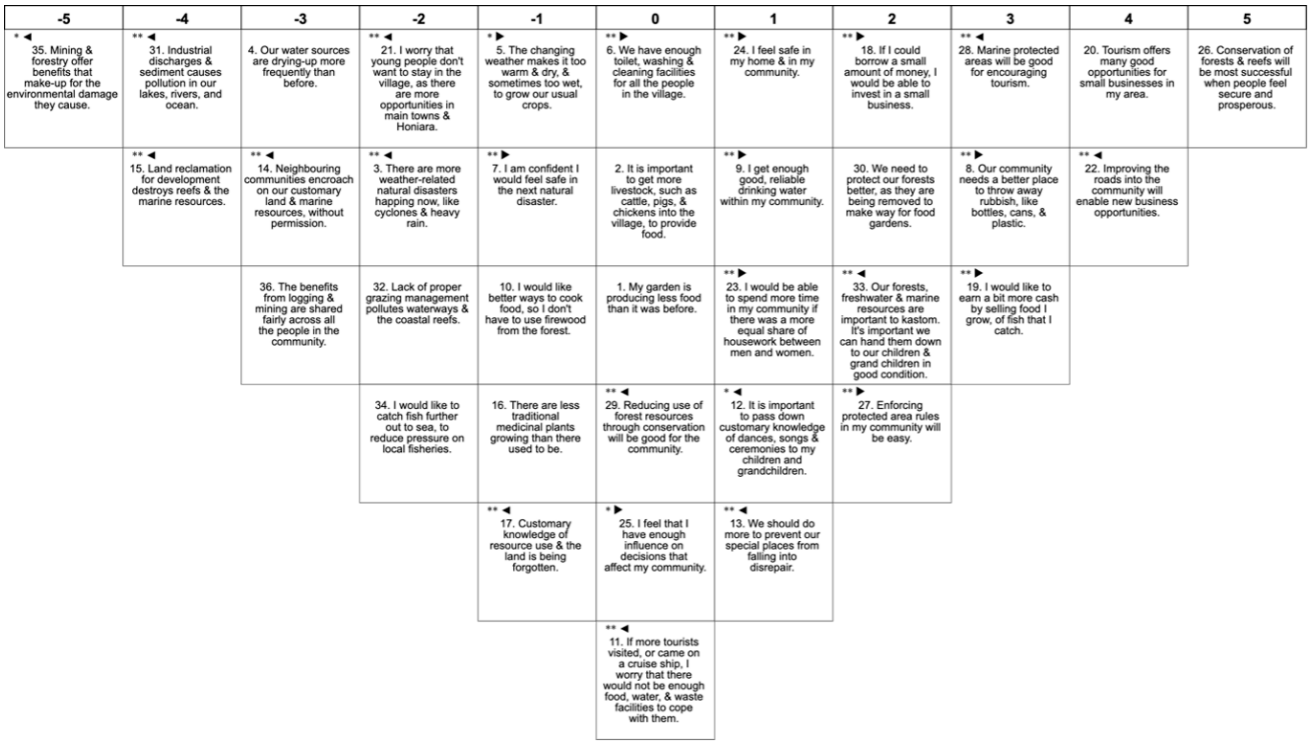

Figure A16: Example composite (or ideal) sort.

Appendix G: Go along surveys

Overall, neither quantitative nor qualitative data only will be able to capture the dimensions of community vulnerability to environmental hazards, nor elicit ideas for the community to reduce its vulnerability. Both are needed (Naudé et al., 2014). Quantitative information from household-level questionnaires will be combined with qualitative maps and diagrams from participatory community appraisal based on a community transect walk (Chakraborty et al., 2005).

Go-along surveys can supplement formal maps and data, but in cases where these do not exist, they are an excellent tool for creating a record of environmental conditions: those arising in the natural, built, and experienced environments. The walk can take 1-3 hours, but advance planning is important to identify objectives and methods. The transects are completed with members of the community with sufficient local knowledge and technical skills to identify broad, community-level issues and propose high level solutions (Ahmed & Kelman, 2018). Data will also be captured through note taking and sound recording.

Key topics of the go along survey include:

1. **Community population** – How many households are in the community / what is the estimated population?
2. **Community assets** – including Nakamals, schools, medical centres, tourism enterprises and potential tourism opportunities.
3. **Defining the boundaries of the community** – Using physical maps*, ascertain the boundaries of household gardens, community forest, communal forest and marine resources.
4. **Existing conservation areas and projects** – including a subjective assessment of the level of resourcing, management, and governance of existing CCAs.
5. **Community hazards** – What are the key hazards faced by your community; Extreme weather, fish stocks, tsunamis, volcanoes, earthquakes, droughts.
6. **Community exposures** – Are there dwellings or buildings that are particularly exposure to coastal hazards in your community?
7. **Community vulnerabilities** – Are there any people or households in your community who have reported, or are known to be more vulnerable to hazards than others; do they have anything in common?
8. **Water resources, sanitation, and water resource and sanitation vulnerabilities and risks**.

Given the number of communities that are engaged in forest conservation through the EREPA project it is not feasible to undertake transect walks in each. Therefore, our approach was to undertake a detailed study in at least one community to generate a general picture of life there as an analogue of life across each. For example, time permitted only a single transect walk in Malaita but we were able to undertake transects in all four communities involved in EREPA in Rennell.

Appendix H: Project assessment

Cost benefit analysis

Cost benefit analysis (CBA) (also called benefit cost analysis) is an assessment technique used to estimate and compare the net benefits of a project (benefits minus costs) with the base case (sometimes called 'business as usual', or BAU), which represents a continuation of current conditions under which the proposed project is not implemented (Boardman et al., 2017; Buckwell, Ware, et al., 2020). To be comparable, these benefits and costs are homogenised into economic values (in money terms). CBA also considers the timing of each of the benefits and costs and converts these into today's prices so that all impacts and benefits can be meaningfully compared, regardless of the timing of implementation or realisation. In this way, a CBA can enable a comparison of options that deliver different streams of benefits and costs over time. It does this through the concept of 'discounting' - the application of an annual rate by which future values are discounted back to present day values. Discounting is represented in the following, standard equation:

Equation A1: Calculating present value of projects

$$PV=(FV/(1+r))^t$$

The total present value (PV) is the future value (FV) i.e. the actual costs and benefits incurred in the future seen from today's perspective, thus discounted back at a specific rate (r) each year of the assessment (^t).

Specifically, a social CBA, considers costs and benefits from a whole of society perspective. In this case, it includes ecosystem service valuation estimates and modelled biophysical changes to determine a dollar value for the value of the assessment projects and a cost-benefit ratio to determine the return on investment.

CBA generates a number of metrics to guide decision making. The benefit cost ratio (BCR) can be calculated by dividing the present value benefits by the present value costs. If this value is greater than 1, from an economic perspective, the project is worthwhile. If this value is less than 1, from an economic perspective, the project is not worthwhile. The BCR can be seen as a 'social return on investment', which can often apply at any scale[4].

BCR does not provide a decision maker with information on the scale of the project — for example, a project may be worthwhile undertaking, but capital costs might be beyond the capabilities of a potential proponent. Therefore, a second method, the Net Present Value (NPV) is the sum of the present value benefits and the present value costs (as negatives). If the NVP is negative, the project is not worthwhile pursuing, at least from an economic perspective. If the NPV is positive, the project is worthwhile pursuing.

The NPV aids decision-making by helping investors compare potential returns to the cost of capital and assess the risk associated with an investment. It provides a quantitative basis for choosing between different projects or investments, aiming to maximise value and make informed financial choices.

Multi-criteria assessment

Multi-criteria assessment (MCA) is a decision-making approach that evaluates various alternatives using multiple criteria or factors. It considers diverse dimensions such as economic, environmental, social, and technical aspects to provide both a holistic and pragmatic view (Triantaphyllou, 2000). By assigning weights to criteria, it quantifies their relative importance, aiding in comparing options objectively. This method helps stakeholders make informed choices by systematically analysing trade-offs and synergies among different criteria, fostering well-rounded and balanced decision outcomes.

MCA accepts that several criteria are required to estimate effective options, especially in the context of EbA. MCA is useful because it can incorporate both quantitative and qualitative considerations and can assess across a suite of criteria. Both aspects are extremely important for EbA. The approach allows assessment of different adaptation options against multiple criteria, each of which is given a weighting (most often assigned through community engagement activities, or surveying). The overall score is obtained using the weighting and the option with the highest score is selected by stakeholders.

This method is useful when exact economic valuation data is not available or where the monetised ecosystem service

4 Many projects can have economies of scale – that is, there are falling marginal costs of a next unit of benefit. This can occur with administration costs, for example, where a given level of administrative cost can service a project of a much larger scale, in most instances costs and benefits generally rise commensurately, particularly where maintenance or regeneration costs make up a significant proportion of the cost structure. Notwithstanding, when projects research a certain scale, additional marginal costs can be incurred due to additional complexities.

costs and benefits (provisioning, regulating, cultural) are hard to quantify, or where many criteria (in addition to monetary benefit and effectiveness) need to be assessed in parallel.

Further, MCA enables greater transparency to the assessment (avoiding the 'black box effect' of CBA) and provides opportunities for feedback from the client and efficient re-assessment of options based on client preferences.

The steps we will take in our MCA will be as follows:

1. **Criteria identification:** Clearly define the problem you're trying to solve and identify the relevant criteria that need to be considered. These criteria should be measurable, relevant, and reflective of the objectives and values of the decision-maker.
2. **Criteria weighting:** Assign relative weights to each criterion to reflect their relative importance in the decision-making process. The weights are determined (mostly) subjectively through discussions, or surveys.
3. **Program evaluation:** Evaluate each alternative against each criterion. This can involve gathering data, conducting research, and quantifying how well each alternative performs with respect to each criterion.
4. **Normalisation:** Normalise the data to ensure that the criteria are measured on the same scale. This might involve converting raw scores into a standardised format, such as scores out of 100.
5. **Scorings:** Assign scores or values to each alternative for each criterion. Apply the criteria weights to the normalised scores to calculate weighted scores for each alternative-criterion combination.
6. **Aggregation:** Sum up the weighted scores for each alternative to get an overall score for each alternative. This reflects its performance across all criteria, considering their relative importance.
7. **Sensitivity analysis:** Test the robustness of the results by varying the weights of the criteria or changing the evaluation scores to see how sensitive the final rankings are to changes in these inputs.
8. **Ranking and decision:** Rank the alternatives based on their aggregated scores. The alternative with the highest score is often considered the most favourable choice. However, the decision-maker may also consider other factors, such as budget constraints or risk tolerance.
9. **Iteration:** Depending on the complexity of the decision and feedback received, you might need to iterate through the process, revisiting criteria weights or evaluating additional alternatives.

Hybrid approach

Given the range of implementation considerations, we propose to take a hybrid approach to potential EbA assessment, combining elements of CBA with MCA, a broader assessment methodology, where we include an estimate of a program's value, based on cost-benefit analyses and total as two of the weighted criteria in a broader MCA process, where this is available and considered robust.

Our MCA hybrid framework is listed in Table A3. This table includes the broad objectives (groupings) for the individual criteria, the individual criteria and statement against which the program score was assessed, the weightings, and the justification for the inclusion of the objective and criteria.

Table A4 is the scoring guide for our hybrid multi-criteria assessment.

Data sources for economic and financial criteria

Our hybrid approach included scores related to estimates of program cost benefit analysis and total project costs. These estimates are drawn from the following data sources.

- **REDD+ readiness program** – Cost estimates for a REDD+ readiness program are estimated from a current readiness program with which Griffith University is currently engaged (with Infinity Blue PNG Ltd. https://infinitybluepng.org). The total budget for the 1.5 year readiness program at a regional scale is $700,000. This is also broadly in line with a historical proposal that Griffith University put together for the Melanesian Spearhead Group.

  We assume that the REDD+ readiness program in and of itself will not generate any benefits besides enabling the implementation of a REDD+ program, therefore, our BCR estimate is drawn from a significant review paper by Rakatama et al. (2017). The authors' mean estimate for BCR for a REDD+ program is ~0.7[5]. This estimate includes the opportunity cost – the forgone value of commercial use of the forest for logging. However, on the benefits side, this estimate is acknowledged to only include direct monetary benefits (generally livelihood benefits) and does not include

5 Note the Rakatama et al.'s (2017) estimate uses the metric of dollars per tonnes of carbon dioxide equivalent ($/tCO2e). The metric makes no difference to interpretating the benefit cost ratio as the numerator and the denominator are the same unit.

non-market benefits from REDD+ programs, such as carbon sequestration and other forest ecosystem service benefits[6]. Including an estimate of only climate benefits from REDD+ programs can flip the BCR into positive territory, depending on which value of carbon is used. For example a recent review of the social costs of carbon (SCC) in Nature Climate Change by Ricke et al. (2018) estimated a median of value of US$417/ tCO2e. This would score the BCR in our MCA at the maximum of 10.

- **Agricultural extension and agro-forestry program** – Social cost benefit analysis and total project cost estimates are drawn from Buckwell et al. (2020). This study estimated an agricultural extension program generates a very positive BCR (28-74) at a standard discount rate of 10%.

  Project costs, which included requisite nursery to manage the program and a poultry hatchery was dependent on the scale of the operation. Cost are scaled to the required size of the operation based on a five year initial implementation program of demonstration farms, nurseries, poultry hatcheries, staffing, community rangers, equipment, and logistics.

- **Community-based marine protected area** – Social cost benefit analysis and total project cost estimates are drawn from Buckwell et al. (2020). This study estimated a community-based protected area generates a neutral BCR (~1) at a standard discount rate of 10%. Project costs, which included requisite community rangers to manage the program, where estimated to be ~$325,000 for a five year initial implementation program.

- **Mangrove planting / rehabilitation** – Social cost benefit analysis and total project cost estimates are drawn from a meta-analysis by Su et al. (2021) and a report by USAID (Narayan et al., 2017). Su et al. (2021) estimates that mangrove restoration projects generate a BCR of between 6.83 and 10.50 at varying discount rates suggesting a maximum MCA score of 10. Narajan at el. (2017) provides cost estimates for mangrove rehabilitation of approximately $10,000 per hectare (total over a 10 year implementation period).

- **Sanitation and water security** – Kouwenhoven & Cheatham (2006) make estimates on the costs of installation of water tanks. As a guide, installation of community-sized water tanks of 27,500 L is approximately $45,000 per unit suggesting an MCA score of 2. No BCR for water tank installation was estimated in this report. For sanitation aspects, data is drawn from Kinrade et al. (2014) and who costed installation of water efficient composting toilets and Gerber et al. (2011) who estimated avoided costs of improved sanitation in terms of hospital treatments and avoided lost wages. From this data Buckwell et al. (2023) estimated a BCR of 0.1 for composting toilets suggesting an MCA score of 0. Without specific further investigation into the number of installations required we cannot make cost estimates. All these datapoints were adjusted to be in 2023 US$.

- **Eco-tourism investment plan** – No estimates for BCR and total costs are provided.

6 Rakatama et al. (20147) attribute this to the difficulty in obtaining expertise and the unavailability of environmental and biodiversity benefits data on the right scale. However, ignoring the value of non-monetary and indirect benefits of REDD+ in the total benefit estimates effectively lowers the cost-effectiveness, or attractiveness, of REDD+ programs.

Table A3: Multi criteria assessment criteria, weightings, and justifications for criteria inclusion

Objective	Criteria	Metric	Weight	Justification
1. Secures a climate resilient landscape	Secures a climate resilient landscape		**23**	How well does the option promote a climate resilient landscape notwithstanding it not meeting the specific 20,000 hectares of protected area forest.
	Appropriate scale of management	Will this EbA option protect the requisite area of forest in EREPA project?	9.20	The option ultimately should be able to fulfil the objectives of the EREPA project.
	Prioritises biodiversity and ecosystem services within management area	Number of species protected; protects economically valuable ecosystem services ($ valuation)	4.60	The option protects a range of ecosystem and biodiversity benefits, in contrast to a narrow range, such as commercial values of timber.
	Protects a diverse range of habitats	Connectedness of representative habitats are protected	2.30	A protected area strategy should seek to protect a range of specific habitat types.
	Risk costs of no action	Social / environmental cost of not undertaking EbA action	6.90	Commonly, in a business-as-usual scenario (such as worsening climate change, or deforestation) there will be increasing social and environmental costs.
2. Improves food & water security			**17**	Food and water security remain paramount. Programmes will not be supported if the most critical needs are not first supported.
	Will increase the productivity of subsistence gardening system within the current footprint	Will this option increase calories produced per hectare per year	7.65	Most people in most communities are reliant on their allocated / owned subsistence gardens. Improvements here are essential to improving food security.
	Ensures the ongoing capacity to harvest protein	Will this option increase the quantity of protein produced / captured per year	4.25	Whilst subsistence gardens can generate the requisite nourishment and much essential nutrition, protein production, specifically, is also essential.
	Increases the availability of drinking water in a changing climate	Will this option increase in quantity of drinking water available each year	4.25	Drinking quality water can be secured in a range of ways, from nature-based solutions, such as forest conservation and catchment management, to localised engineering focussed solutions, including rainwater tanks.
	Increases capacity of community to purchase food	Will this option generate cash incomes for households?	0.85	If food security is not specifically increased an option that improved people's capacity to purchase food can help meet (at least short term) security needs through earning an income.

Objective	Criteria	Metric	Weight	Justification
3. Improves livelihoods & economic development capabilities			**17**	A programme's success is most likely if people's livelihoods are broadly supported.
	Create opportunities for cooperatives and associations	Of any enterprises that are created out of the project, what proportion will be cooperatives, or associations?	5.95	Options may bring economic development opportunities and/or new business and enterprise opportunities. Enterprises that are cooperative, rather than individualistic, in nature should be prioritised.
	Economic development opportunities are available to all and do not exclude certain demographics	What is the likely distribution of benefits (cash and livelihoods)?	5.95	The distribution of opportunities needs to be inclusive and not captured by a few individuals or classes within the community.
	Number of beneficiaries	What is the proportion of people that would materially benefit from this option?	5.1	Economic and financial benefits should benefit as many people as possible.
4. Financial viability			**18**	Proposed options will likely be externally funded; nonetheless, project costs and benefits will influence decision making. However, this is where the greatest uncertainties lay.
	Estimated cost of implementation	Total estimated financial investment required to pursue option (grant + private + government)?	5.94	Setting aside any returns on investment, options that are less costly will more likely be funded and therefore prioritised. Cost-free / no regrets options should be given the highest ranking.
	Availability of cost benefit analysis data	Cost benefit ratio (if data is available)?	5.94	Projects with the higher cost benefit ratio should be prioritised. Note this is a social cost to benefit ratio, which should include non-market social and environmental benefits.
	Timescale of social benefits	What is the timescale that benefits start to outweigh costs?	6.12	Whilst discounting in cost benefit analysis reflects this criteria, where this is missing, option consideration should also include the timescale where social benefits begin to outweigh the costs.

Objective	Criteria	Metric	Weight	Justification
5. Supports good governance			25	With good governance any option will fail in the medium and long term will fail.
	Level of co-management (government, communities, private sector)	Extent to which any project has and can maintain buy-in from multiple government stakeholders.	2.50	Buy-in from multiple levels of government stakeholders (from national to village-level decision making) will build resilience to shifting priorities, organisational change, and changes in staffing.
	Compatible with policy and legal frameworks of Solomon Islands government	Number of direct links between EbA and legal and policy frameworks; n of political decision makers engaged in process.	7.50	Options that are compatible or are supported by Solomon Islands' government policies and strategies should be prioritised.
	Consideration of GEDSI[7]	GEDSI requirements of implementation agencies.	7.50	Project requirements for GEDSI can be written into project plans, however implementation agencies require their own GEDSI requirements in order to be most effective.
	Incorporates local indigenous and traditional knowledge (ITK)	Extent to which the EbA incorporates or can incorporate ITK.	5.00	Projects that have robust methods for considering, incorporating, and adapting ITK will be most likely to be most appropriate and most successful.
	Long term capacity to ensure sustainable governance	Proportion of people directly involved in governance.	2.50	The greater number of people involved in the governance and implementation of a project the greater its chances of success.

Table A4: Scoring guide for multi-criteria assessment

Scoring guide Statement against which the score should be tested should be scored	-5	0	1	2	3	5	10
Will this EbA option protect the requisite area of forest in EREPA project		No		A small proportion	Potentially		Yes
Number of species protected; protects economically valuable ecosystem services ($ valuation)	Negative impact	No	Very low	Low	Moderate	High	Very high
Connectedness of representative habitats are protected		0	Very low	Low	Moderate	High	Very high
Social / environmental cost of not undertaking EbA action		No consequence	Very low	Low	Moderate	High	Very high
Will this option increase calories produced per hectare per year	Negative	None		Some increase possible	Probable	Very probable	Approximate doubling

7 Gender equity, diversity and social inclusion.

Scoring guide Statement against which the score should be tested should be scored	-5	0	1	2	3	5	10
Will this option increase weight of protein produced / captured per year	Negative	None		Some increase possible	Probable	Very probable	Approximate doubling
Will this option increase in quantity of drinking water available each year	Negative	None		Some increase possible	Probable	Very probable	Approximate doubling
Will this option generate cash incomes for households	Negative	None		Some increase possible	Probable	Very probable	Approximate doubling
Of the enterprises that are formed, what proportion will be cooperatives, or associations		None		Some		Most	All
What is the likely distribution of benefits (cash and livelihoods)		Very low	Weakly fair	Some evidence of fairness and transparency likely	Moderately fair and transparent	Very fair and transparent	Completely fair and transparent
What is the proportion of people that would materially benefit from this option		0	0.1	0.2	0.3	0.5	1
Total estimated financial investment required to pursue option (grant + private + government)		Not known	>$ 1 million	$250k-$ 1million	$50k-$250k	$0-$50k	$0
Cost benefit ratio (if data is available)	<1	>0.5	~1	1 to 2	2 to 3	3 to 5	>5
What is the timescale that net benefits start to outweigh costs		None	>25 years		>10 years	>5 years	Some immediately + 5 years
Extent to which any project has and can maintain buy-in from multiple government stakeholders		None			Moderate		Very high
Number of direct links between EbA and legal and policy frameworks; n of political decision makers engaged in process		None	Very low	Low	Moderately	Very high	Comprehensive
Gender requirements of implementation agencies		Not at all		To a reasonable extent	Likely to / has potential to		Completely
Extent to which the EbA incorporates or can incorporate ITK		Not at all		To a reasonable extent	Likely to / has potential to		Completely
Proportion of people directly involved in governance		Not at all		To a reasonable extent	Likely to / has potential to		Completely

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