Managing multifunctional landscapes: local insights from a Pacific Island Country context

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Abstract: Across Pacific Island Countries, projects and policies are incorporating objectives related to managing landscape multifunctionality to sustain flows of multiple, valued ecosystem services. Strategies to manage natural resources are often not effective, or do not have intended outcomes, if they do not account for local contexts and the varied needs and constraints of stakeholders who rely upon natural resources for their livelihoods. Through fieldwork in Ba, Fiji, local insights were generated concerning the institutional, geographic, and socio-economic factors which determine and challenge i) different stakeholders' ability to access landscape resources, and ii) stakeholders' capacities to benefit from ecosystem services. The following insights were generated from this research which are important for guiding management of landscape multifunctionality. In Ba hierarchical governance systems present barriers to effective management of landscape multifunctionality, and projects or policies with aims to manage landscapes should establish context appropriate multi-scale governance. Such governance systems should facilitate communication and interaction between different stakeholders, build upon community knowledge, and support communities as key actors in landscape management. Consideration of the spatial footprint of landscape resources, stakeholders' different physical and financial capacities, and the institutional structures that mediate access to resources should be central to landscape management and planning. Various climatic stressors affect flows of ecosystem services from the Ba landscape and people's capacity to access landscape resources; therefore, it is important that management of landscapes also builds resilience to climate stressors.

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1. Introduction

The functioning of societies and economies depends upon the flow of services from landscapes and their constituent ecosystems (Biggs et al., 2015; Carpenter et al., 2009; MEA, 2005). However, mismanagement of environmental resources has negative impacts on ecosystems and their capacity to supply valued services (Foley et al., 2011). Awareness of these negative impacts, and concerns about whether ecosystems will continue to provide the array of services that society desires, has led to a shift in focus towards managing landscape multifunctionality as opposed to production-orientated management that seeks to maximise single objectives such as crop yield or profit (O'Farrell and Anderson, 2010; Sayer et al., 2013).

A multifunctional view considers landscapes as 'spatial human-ecological systems that deliver a wide range of functions that can be valued by humans because of economic, sociocultural, and ecological reasons' (Termorshuizen and Opdam (2009); p. 1041). O'Farrell and Anderson (2010) define multifunctional landscapes as 'landscapes created and managed to integrate human production and landscape use into the ecological fabric of a landscape maintaining critical ecosystem function, service flows, and biodiversity retention' (p. 59). Multifunctional landscapes have also been associated with increased climate resilience and mitigation of climate change (Harvey et al., 2014; Scherr et al., 2012) and conservation and biodiversity preservation (Scherr and McNeely, 2008).

The benefits of managing and protecting multifunctional landscapes are applicable to a range of contexts spanning developing and developed countries. Pacific Island Countries represent one region where ecosystem service flows are under threat yet the benefits of preserving landscapes that deliver multiple services would be invaluable. Across Pacific Island Countries livelihoods are supported by a myriad of ecosystem services including food and income from fishing, crops and fruit trees, timber, and livestock (Dacks et al., 2018; Lisson et al., 2016; Taylor et al., 2016; Vunisea, 2016); energy from hydropower and forests (firewood) (Department of Energy, 2013); cultural attachment to the land (Neef et al., 2018); natural hazard regulation and sediment control from forests (Atkinson et al., 2016; Daigneault et al., 2016); and income from tourists attracted to leisure opportunities and landscape aesthetics. In this paper, a multifunctional landscape refers to both seascapes and terrestrial landscapes recognising the interconnection between coastal and terrestrial socio-ecological systems. Across the Pacific, flows of ecosystem services are under threat due to degradation and mismanagement of natural resources (Sisifia et al., 2016; Wairiu, 2017). There are examples of how landscape (mis)management decisions reduce multifunctionality, which, in turn, has adverse societal impacts; for example, deforestation reducing natural hazard regulation services with subsequent amplified flood impacts in northern Fiji (Daigneault et al., 2016).

In recognising the societal benefits that are provided by ecosystem service flows, government policy and development projects in Pacific Island Countries are increasingly incorporating objectives to manage and enhance landscape multifunctionality. For example, the GEF funded Pacific Ridge to Reef project, operational in 14 Pacific Island Countries, aims to enhance 'ecosystem goods and services (provisioning, regulating, supporting and cultural) through integrated approaches to land, water, forest, biodiversity and coastal resource management that contribute to poverty reduction, sustainable livelihoods and climate resilience' (Pacific R2R - Ridge to Reef, 2018). The Secretariat of the Pacific Regional Environment Programme (SPREP) is implementing the Pacific Ecosystems-based Adaptation to Climate Change Project in Fiji, Vanuatu, and Solomon Islands (SPREP, 2018). The *Fiji 2020 Agricultural Sector Policy Agenda* recognises the importance of a diversified agricultural system and also outlines the importance of agroforestry while Fiji's *National Climate Change Policy* acknowledges traditional crop diversity as a source of resilience (Government of the Republic of Fiji, 2012). Diverse agricultural and cropping systems have been associated with increased climate resilience, resilience of ecosystem service flows, improved ecosystem functioning, and increased benefits to livelihoods (Di Falco et al., 2010; Di Falco and Chavas, 2008; Sibhatu et al., 2015; Thornton and Herrero, 2015)[1].

Landscape multifunctionality has become prominent in guiding policy used to manage landscapes (Sayer et al., 2013). However, the literature evaluating what enables and inhibits managing landscape multifunctionality in different contexts remains relatively limited (Sayer et al., 2016) echoing the earlier concerns of Carpenter et al. (2009) about the limited evaluation of projects that focus on managing ecosystems for human well-being. This paucity of evaluation is particularly evident in the Pacific Island Countries. In a pan-tropical review of landscape approaches Reed et al. (2017) found only six peer-reviewed studies providing reliable data to evaluate the effect of landscape management on environmental or societal outcomes. Other studies focused on Africa, Latin America and the Caribbean, and South Asia have identified broad patterns in how integrated landscape projects are applied (Estrada-Carmona et al., 2014; Milder et al., 2014; Zanzanaini et al., 2017). However, their focus was not on generating local insights into factors that shape how landscape resources are accessed or determine the ability of stakeholders to benefit from ecosystem services.

Local insights into the institutional, geographic, and socio-economic factors which determine access to landscape resources are important for understanding how society benefits from ecosystem services (Carpenter et al., 2009; Dawson and Martin, 2015; Malmborg et al., 2018; Potschin and Haines-Young, 2013), and, thus, for guiding initiatives seeking to manage landscape multifunctionality. There is a history of failure in natural resource management projects which overlook local heterogeneity in society-environment interactions and the institutional arrangements

[1] We refer the reader to Table 5 which outlines several examples of how landscape users in Ba, Fiji, utilise farm and landscape diversity to respond to climatic stressors.

governing these interactions (Leach et al., 1999; Reed et al., 2009). Context specific interactions between people, their local environment, and broader institutional, economic, and environmental changes shape the trajectory of socio-ecological system functioning and service supply (Enfors, 2013). Successful management of landscapes, that deliver multiple ecosystem services to stakeholders, appears contingent on a granular level understanding of a landscape's constituent socio-ecological systems. Such a contextual understanding will be particularly important in Pacific Island Countries due to the local heterogeneity within socio-ecological systems and the diversity and complexity of arrangements governing access to resources (Sisifia et al., 2016).

Given the importance of local understanding to guide effective management of multifunctional landscapes (Carpenter et al., 2009; Potschin and Haines-Young, 2013), this paper draws upon participatory fieldwork in Northern Viti Levu, Fiji (Fig. 1), generating detailed information on how people interact with the landscape to utilise flows of ecosystem services to support livelihoods. The following questions were addressed through this fieldwork: i) What ecosystem services do people derive from the landscape to support their livelihoods, and what pressures influence the availability of these services?, ii) how do people access landscape resources, and what are the barriers to access?, and iii) how do community members obtain information to guide decision making for landscape management? Through addressing these questions we identify and synthesise key concepts derived from a community perspective that can guide initiatives attempting to manage landscape multifunctionality.

2. Methods and study site

2.1 Study Site: Ba River Catchment

The Ba River in Northern Viti Levu, Fiji, courses through a catchment of mixed land use marked by both commercial and subsistence agriculture (Fig. 1). Ba province has 247,708 residents as identified by the 2017 Census (Fiji Bureau of Statistics, 2018). The population consists of indigenous Fijians (*iTaukei* Fijians) and people of Indian heritage. The average climate for the Ba landscape is depicted in Fig. 2. The catchment frequently experiences climatic hazards including floods in 2012 (Brown et al., 2014; Daigneault et al., 2016), Tropical Cyclone Winston in 2016 (DFAT, 2017), several recent tropical storms, episodes of drought, and intra-seasonal climatic variability that can bring periods of warm temperatures.

Fieldwork was conducted primarily with indigenous (*iTaukei)* Fijians within the settlements of Etatoko and Koronubu-Vunibaka and in the village of Nawaqarua; all three communities are situated in close proximity to households of Fijians of Indian heritage and lie within the mid to lower reaches of the Ba River catchment (Fig. 1). Study communities were selected based on existing relationships and recommendations from the Ba Provincial Conservation Office concerning our research needs, the current situation in the communities, and potential benefits of the research to communities and local stakeholders.

Typically, within indigenous Fijian communities the *yavusa* is the largest and most inclusive social grouping. Households within a *yavusa* are sub-divided into land-owning units (*mataqali),* and mataqali are sub-divided into groups of families termed *itokatoka* (Fig. 3; please see Walter (1978), Sano (2008), and Lasaqa (1984) for a more detailed discussion of Fijian social groupings). A village chief or *yavusa* leader presides over the *mataqali* in a village. Registered indigenous Fijian villages also have a *turaga-ni-koro* (headman) who interacts with the local formal government structures (Sano, 2008). In settlements that are not registered villages, an appointed advisor plays a similar role to the *turaga-ni-koro*.

Nawaqarua is flanked by the Ba River on the east with croplands and mangrove forests bordering the northern and western sides of the village. Etatoko is approximately six kilometres inland from Nawaqarua. As a result of river bank erosion and severe flooding in 2012, the Etatoko community relocated from its riverine location at Wavuwavu. At the time of fieldwork, Etatoko was not formally registered as a village. Nawaqarua is a registered village and both Nawaqarua and Etatoko are linked to the larger village of Votua through *yavusa* and *mataqali* affliation, and share the same *yavusa* leaders. Koronubu is an *iTaukei* settlement approximately 17 km south-east of the Ba River mouth; we conducted fieldwork in the community of Vunibaka within Koronubu (Koronubu-Vunibaka) which is part of *mataqali* Namacuku from Nasolo and Nailaga villages.

2.2 Data Collection

In each community we undertook a range of Participatory Rural Appraisal (PRA) activities: participatory mapping, transect walks, focus group discussions, and revisit interviews (Table 1). Fieldwork activities collected detailed information on how people interact with the landscape to utilise flows of ecosystem services to support livelihoods. From this information we identified challenges that landscape users experienced when managing landscape resources.

The field activities employed in this research have been used in other rural landscapes to capture how people utilise ecosystem service flows (Malmborg et al., 2018; Sinare et al., 2016). PRA techniques, such as the ones used in this research, emphasise the value of local knowledge and the importance of participants' perspectives (Chambers, 1994). These data generation approaches are suited to capturing information from multiple perspectives, at multiple scales, and integrating socio-economic, biophysical, and climate information (Mwongera et al., 2017). This is important in landscapes such as Ba where there are multiple landscape users and a diversity of landscape resources. Through adopting a methodological pluralism we i) were able to build a more nuanced analysis of human-environment interactions (Rasmussen et al., 2016), and ii) triangulate recurrent themes emerging from data generation using information collected in different fieldwork activities (Schreckenberg et al., 2016). A detailed description of our fieldwork activities is presented in Table 1.

All PRA activities were undertaken separately with male and female community members given that they utilise the landscape in different ways. This allowed for further analytical insights through comparison of experiences. The transect walks and participatory mapping exercises were used to elucidate spatial patterns of landscape users' interactions with landscape resources, which ecosystem services they benefit from, and challenges faced in accessing landscape resources and benefiting from ecosystem service flows. High-resolution satellite imagery was used as a visual aid for the participatory mapping. There were between five and ten participants at each mapping session and one session held with male and female landscape users per community. The route for transect walks were identified to capture the main features discussed in the participatory mapping; the transect walk was led by members of the community with additional community members engaged at various points during the walk. Data were collected on a tablet using the mappt app (https://www.mappt.com.au/) with photos, notes, and a GPS location stored as a .kml file.

Following the participatory mapping and transect walks focus group sessions were held to allow for open and in-depth discussion of key issues related to accessing landscape resources, sourcing information, and learning processes that inform landscape decision making. Large paper sheets with prompting questions written on them were placed in the centre of the discussion, and when necessary, were used to encourage flow of conversation and to keep the topics consistent across communities. These prompting questions were initially developed following discussions with senior community members when arranging the fieldwork. Following preliminary data analysis, we revisited the communities to clarify outstanding issues and validate initial themes that emerged from the data related to availability of ecosystem services, access to landscape resources, and access to and use of information.

All fieldwork activities were undertaken by research assistants fluent in the local language and versed in local customs. A female research assistant conducted all PRA activities with female community members. At the end of each PRA activity the field team debriefed, compared notes for consistency, and identified further points for clarification. All information from the PRA activities were collated in a database for further analysis; this included notes from the transect walks, notes and quotes from focus group discussions, annotations from participatory maps, and open responses to questions posed in the revisit interviews. Information was entered as individual text fragments (e.g. notes associated with a location and photo collected during the transect walk) with associated metadata indicating community, fieldwork activity, and gender of participants. Arrangements for all PRA activities were made through contact with senior community members and followed local cultural practices.

Table 1. Overview of participatory rural appraisal (PRA) methods.

	Participatory Mapping	Focus Group Discussions	Transect Walks	Revisit Interviews
Purpose	• Elucidate what landscape resources community members use to sustain their livelihoods • Identify what factors enable or constrain access to resources	• Understand decision making process regarding use of landscape resources • Identify where community members source information to guide decision making • Identify barriers to accessing information • Discussion on access and utilisation of climate information	• Capture landscape resources the community identified as important to their livelihoods • Capture individual perspectives to complement aggregated community perspectives • Use landscape resource units as prompts and stimulants for discussion	• Conducted after first round of analysis of information collected in participatory mapping (PM), focus group discussions, and transect walks • Clarification of outstanding issues • Validation of key themes
Method	• 'Hands-on mapping' (Corbett, 2009) with community members assisted by local research assistant • Landscape resources sketch-mapped on paper with fine spatial resolution satellite imagery used as a tool for orientation • Discussion regarding use, challenges with availability, barriers to access, and	• Open discussion informed by the outcomes of the preceding PM activity facilitated by local research assistants • Discussion prompts developed to aid facilitators and ensure the discussion remained focused • Discussion prompts were updated after each focus group session to allow further exploration of issues	• The initial route for the transect walk was discussed following the PM activity • Photographs and notes collected at each landscape resource unit using mobile Geographic Information Systems (GIS) mapping app Mappt on tablets • High-spatial resolution imagery from Google Maps used as an ancillary	• Structured discussion with community leader and other community members • Local research assistant asked a set of open, pre-specified questions

	climate impacts and response for mapped resources	that arose in previous sessions	support for the transect walk and discussions	
Participants	• Between five and 10 participants • Separate mapping sessions for male and female participants	• Same participants as for participatory mapping	• Transect walk conducted separately with female and male community members • One or two community members acted as guides through the walk • Discussions at each landscape resource unit with the resource user and guides	• Community leader (in Koronubu-Vunibaka the male community elder was not present due to cultural commitments so the revisit interview was conducted with a senior female community member) • Three to four other community members were present

2.4 Data Analysis

The data from the PRA activities were analysed using qualitative data analysis techniques (Gibbs, 2008). Initially the text fragments from the different fieldwork activities were organised into categories related to availability of ecosystem services, accessing landscape resources, and accessing and using information. Text fragments were also assigned codes related to a particular landscape resource (e.g. *mangroves, fields near homes*), the participants who provided the data (e.g. female transect walks), and the research activity (e.g. participatory mapping). This was to facilitate easy sorting and re-organising of the data for analysis. Subsequently, for each research question, a process of iterative thematic coding was undertaken to identify key explanatory themes in the data. These themes were refined through re-evaluation of the existing data and review of ancillary information including policy documents and interviews undertaken with secondary stakeholders (e.g. staff working at the national level in Government, development agencies, and the private sector). This process ensured our findings were grounded in the original data and served as pseudo-validation of the key themes we identified. The key themes for each research question are presented in the *results* section alongside examples from the data.

The coding was primarily undertaken by one researcher; however, an initial section of the data was jointly coded by two researchers to develop a coherent coding process. Subsequently, at regular stages in the coding process, random subsets of the data were extracted and re-coded by a second researcher to ensure consistency. This multiple-coding strategy (Barbour, 2001) was important to ensure reliability in code assignment, that code labels were appropriate, and that key patterns and themes were not overlooked.

3. Results

3.1 Availability of ecosystem services

A summary of how the landscape is utilised by the community members is presented in Table 2. It was typical for households to directly benefit from multiple streams of ecosystem services and to generate income through the sale of produce derived from the landscape. Many households also generated income through remittances or through household members working in a range of non-natural resource related professions.

Table 2. Profiles of the three communities in Ba Catchment where fieldwork was conducted (accurate at the time of fieldwork).

	Nawaqarua	Etatoko	Koronubu-Vunibaka
Community Governance	• *Turaga-ni-koro* • *Yavusa* leaders based in another village	• *Turaga-ni-koro* based in Votua village • *Yavusa* leaders based in another village • Decisions at the settlement made by community elder but he is subservient to community leaders in Votua	• *Turaga-ni-koro* based in Nasolo village • *Yavusa* leaders based in Nasolo village (near Ba Town and $17 (FJD) carrier ride away) • Koronubu has an advisor to represent the entire settlement
Village Profile	• 56 households • All households have piped water (but difficulties in paying water bills) • 20 households do not have electricity • Good mobile phone signal • Not all households have a TV • One computer • Internet access through mobile phone data	• 16 households • No households have piped water but all households have access to water from a borewell (solar operated pump) • No households have mains electricity • Seven households use solar power and nine households use kerosene lanterns or battery lamps • Good mobile phone signal • One TV (household has a 1000 kw solar panel)	• 16 households • 14 households have piped water • No households have mains electricity • Two households use kerosene lanterns, two households use diesel generators, the rest use solar panels and battery lamps • Irregular mobile phone signal • Two households have a television
Landscape Resources and Services	• Fishing in the ocean and reefs • Fishing in Ba river • Collect crabs from mangroves • Collect freshwater mussels from Ba river • Farming vegetables in plots near homestead • Cassava and root crops in	• Fishing in the Ba river and small creeks • Farming root crops, vegetables, and fruit trees at Wavuwavu • Extraction of firewood from Wavuwavu • Farming root crops (mainly cassava), vegetables, and fruit trees at Etatoko	• Fishing in the Ba river and small creeks • Farming root crops, vegetables, and fruit trees in plots surrounding settlement • Farming vegetables and fruit trees in plots near homestead

	fields surrounding the village • Fruit trees • Firewood from mangroves	• Farming vegetables and fruit trees in plots near homestead	
Livelihood activities	• Farming is predominantly for subsistence • Fish and other marine life sold to generate cash for household needs • Some community members work in Ba town in skilled and un-skilled employment • Wage labour work on sugarcane fields	• Farming is predominantly for subsistence • Fishing predominantly for subsistence • Farm and fish produce sold as necessary to generate cash for household needs • Some community members work in Ba town in skilled and un-skilled employment • Wage labour work on sugarcane fields	• Farming is predominantly for subsistence • Fishing predominantly for subsistence • Farm produce sold as necessary to generate cash for household needs • Some community members work in town in skilled and un-skilled employment • Wage labour work on sugarcane fields

There were some commonalities in the spatial patterns and socially differentiated nature of resource use across the communities. For example, women often had a greater responsibility for cultivating vegetables in plots close to the homestead. However, there was diversity in landscape resource use between and within communities. One clear distinction was the predominance of fishing and marine life extraction from mangroves and fishing grounds in Nawaqarua compared to the predominance of subsistence farming in Koronubu-Vunibaka. Within communities, households operated plots of land with varied quality and exposures to climatic stressors and undertook a range of activities within the landscape. For example, in Koronubu-Vunibaka households with paper mulberry (*Broussonetia papyrifera*) trees were able to sell bark for making masi cloth and benefit from this income stream. Similarly, in Etatoko women with pandanus trees were able to weave mats and generate income for the household; this extra income was apparent in greater levels of household assets.

The results also revealed that community members faced multiple challenges in benefiting from ecosystem service flows from landscape resources (Table 3). Some of the challenges listed in Table 3 are symptomatic of a lack of wealth and assets; for example, a lack of boat access for fishing, tools for farming, or reliance on solar power in lieu of mains electricity during inclement weather. Other challenges were related to activities occurring in distant locations but with local impacts such as the release of chemicals from sugar mills upstream reducing downstream fish stocks, flood debris from upstream washed onto downstream fields, or upstream deforestation amplifying flood impacts downstream. The geographic relationship between people and resources in the landscape created challenges; for example, women from Nawaqarua reported that it was time consuming to walk to mangroves to collect crabs. Climatic variation and natural hazards affected flows of ecosystem services and people's capacity to utilise landscape resources (Table 3). The institutional arrangements that govern people's interaction with the landscape also presented indirect challenges to utilising landscape-derived resources (Table 3); for example, limited capacity to monitor fishing grounds in Nawaqarua was reported as a contributory factor to declining fish stocks.

Table 3. Challenges to the availability of ecosystem services in the Ba landscape for female ♀ and male ♂ landscape users; farmers (fa), fishers (fi), gleaners (g), and community members (cm)

Landscape Resource	Landscape Users	Challenge	Example(s)
Fields (away from home)	♂ fa	climatic variation	small creeks flood fields in heavy rains; warmer temperatures impact crops
		theft	people stealing crops forcing farmer to change planting location
		low wages	farmers that cannot afford to go fishing get lower wages for clearing sugarcane fields
		natural hazards	flooding of sugarcane fields reduces demand for labour and subsequent income; flooding of fields; flood debris, weeds, and invasive trees washed onto fields; cyclone damage to crops
		lack of assets	lack tools and seeds for farming
		erosion	river bank erosion washing away fields
		land quality	local variations in land quality / fertility; saline land close to the coast which cannot be cultivated
	♀ fa	erosion	river bank erosion washing away fields
		land quality	land close to the road is not fertile with thin layer of soil before soft stones - soil closer to river is more fertile; concern that other farmers grazing cattle will impact land quality
Fields (near home/kitchen garden)	♂ fa	natural hazards	flooding of fields; cyclone damage
		pests	insects eating vegetables
		land quality	limited fertile land and stones in soil make it hard to farm some areas during drought
		lack of assets	lack tools and seeds for farming
		climatic variation	drought; warm temperatures impact crops
	♀ fa	land quality	not planting vegetables because of sandy soil
		lack of assets	lack of tools to make masi from paper mulberry tree; taps / piped water required for irrigation during dry spells
		climatic variation	drought; warm temperatures impact crops
		theft	theft of vegetables
		climate change	weather is more unpredictable and crops that used to grow well do not anymore; elderly farmers perceive more flooding
		natural hazards	strong winds / heavy rain push over paper mulberry trees; flooding of fields; cyclone damage
Ocean	♂ fi	decline in stocks	declining fish stocks in fishing grounds; lots of fishing vessels have licenses to fish on community fishing grounds lowering stocks
		dynamite fishing	dynamite fishing kills all the fish including young fish
		lack of assets	limited availability of boats for fishing
		natural hazards	floodwater and storms prevent fishing; floodwater can reduce fish catch in fishing grounds
		price of fuel	price of fuel for fishing boats is expensive
River	♀ g	decline in stocks	decline in freshwater mussel stocks in Ba River
		time constraints	time constraints to collect freshwater mussels as a single parent

		natural hazards	cyclone washed away freshwater mussels; strong currents and floodwater make collecting mussels dangerous
	♂$_{fi}$	sugarcane processing chemical release	chemicals released from the sugarcane mill into Ba river reduce fish catch
	♀$_{fi}$	natural hazards / erosion	debris from upstream and bank erosion making areas which used to be good for fishing too shallow
Mangrove	♀$_{g}$	time constraints	time constraints to collect crabs as a single parent
		natural hazards	during heavy rain cannot collect mud crabs or sell them at markets; cyclones damage mangroves
		climatic variation	continuous rain can make collecting crabs difficult
		proximity	long walk from homes to collect crabs
		overharvesting marine life	more women collecting crabs resulting in smaller crab catches
	♂$_{cm}$	dredging	loss of mangrove trees due to dumping of dredging spoils; kills habitat for marine life
Other locations	♂$_{fa}$	climate change	perceived change in tree species due to climate change
	♂$_{cm}$	proximity to firewood	limited firewood near homes
		climatic variation / natural hazards	solar power does not work in bad weather
	♀$_{cm}$	wild animals killing livestock	mongoose killing chickens near home
		climatic variation / natural hazards	solar power does not work in bad weather

3.2 Access to landscape resources

Access to landscape resources is important for undertaking activities that generate ecosystem services. In Fiji, land access is typically governed by three types of land ownership or leases: native (*iTaukei*) land, crown land, and freehold land (Department of Town and Country Planning, 2017). Native land is owned by *iTaukei* villages and access to this land is determined by *mataqali* affiliation or through leases administered by the iTaukai Land Boards Trust (TLTB) on behalf of the traditional land owners. In this research, sugarcane plantations surround all three communities on land typically leased from the *iTaukei* landowners. Reefs near the coastal villages are designated as village fishing grounds; the village at Nawaqarua has access to the traditional fishing grounds of Votua.

People faced a range of challenges to accessing landscape resources; these are listed in Table 4 under categories of institutional, capacity (e.g. related to finance, assets, and infrastructure), and geographic factors. The spatial arrangement of resources within the landscape affects different groups' ability to capture ecosystem services; for example, women in Nawaqarua highlighted the burden of long walks to collect crabs from mangroves and strong river currents challenging collection of freshwater mussels (Table 4). A lack of financial capacity, assets, or infrastructure can restrict access to landscape resources; for example, money to purchase a spot on boats was required to access offshore fishing grounds. In Etatoko, farmers lacked tools to clear trees and debris washed onto their fields during floods; this resulted in reduced access to land for farming. Physical capacity, as well as financial capacity, intersected with the spatial location of landscape resources to influence resource accessibility; elderly farmers reported that it was challenging to cultivate plots far from their home (Table 4).

A range of institutional factors influence resource access; in particular, the nature of land ownership and leasing of *iTaukei* land is important in determining land access. The reality of this arrangement presented several challenges to community members seeking to utilise landscape resources to support livelihoods. There was an instance where the TLTB had renewed leases on *iTaukei* land without undertaking prior consultation with the land owners in Koronubu-Vunibaka. The land owners did not want to renew the lease and wished to cultivate the land themselves. The experience of Etatoko's inhabitant's relocation illustrates how the land tenure arrangements can impede flexibility in accessing and managing landscape resources. The community at Etatoko relocated their settlement to the current site from a riverine location that suffered bank erosion and frequent flooding. However, this move was to land traditionally owned by a different *mataqali* and brought the community into conflict with the village leadership (Table 4). Institutional arrangements within communities, that are often informal, also challenge people's ability to access landscape resources (Table 4). For example, elderly village members restricted the expansion of one farmer's area of cultivation due to envy over his productivity even though space was available. There were also cases where there was limited regulation of access to landscape resources. Community members highlighted concerns over limited regulation of mangrove use, limited regulation of use of fishing grounds, and in the process of provision of licenses for fishing (Table 4).

Table 4. Challenges faced by community members in Etatoko, Nawaqarua, and Koronubi-Vunibaka in accessing different landscape resources.

Factor	Challenge
Institutional	• Male head of household decides where to plant • Conflict over land ownership when moving settlement (Etatoko) • No control over fishing license approvals • Difficulties in having land access formalised in writing • Community 'elders' preventing farmers from expanding area under cultivation – envy over productivity of some farmers • Community leaders are not strict in regulating village fishing grounds • No regulation of firewood collection from mangroves • Communities not engaged in the process of leasing their traditional land by government organisations
Capacity (e.g. financial, physical,	• Cannot work plots away from homestead due to old age • Debris from flooding covers fields – community members do not have tools to remove it

infrastructure)	• Burn weeds to clear land if ‘weedicide’ is too expensive • Limited availability and cost of boats for fishing • Cost of fuel for boats for fishing
Geographic	• Cannot work plots away from homestead due to old age • Flooding makes it risky to collect harvests • Flooding causes shift in planting location • Firewood not close to settlements • Long walk for women to mangroves to collect crabs • Strong currents when collecting freshwater mussels • Settlement location far from traditional village where village meetings are held – time and cost to travel to village • Long walk for labouring activities on sugarcane plantations

3.3 Information and decision-making

3.3.1 Stakeholder interaction across landscape levels

Communities interacted with the local government via the *turaga-ni-koro* or through advisors (in settlements). Both Etatoko and Koronubu-Vunibaka settlements were located away from their traditional villages where the *turaga-ni-koro* is based. Community members in Koronubu-Vunibaka emphasised the financial costs of travelling to their traditional village to engage with the *turaga-ni-koro,* the *yavusa* leaders, and for village duties. In Nawaqarua, village meetings were held every month and the *turaga-ni-koro* discussed village issues at Provincial level meetings.

Typically, community members reported that local agricultural officials[2] only came to villages after natural disasters or to provide seeds; engagement with agricultural officers was often not associated with flows of information. Farmers in Etatoko reported that they did not hear back when they sought assistance from the local agricultural office, and often they do not know when seeds are available at the agricultural office. The *turaga-ni-koro* in Nawaqarua and Votua were able to call agricultural officers if they needed information or assistance. However, female farmers in Nawaqarua reported that if the agricultural officer did interact with the *turaga-ni-koro* they were not aware of what was discussed and were reluctant to approach agricultural officials as they perceived them only to engage with men[3]. It was also noted that registered farmers (with larger farms) and farmers who are more commercially orientated received more assistance from agricultural officials.

[2] When using the term ‘local government officials’ we refer to employees of government departments or ministries operating at levels above the village or community (i.e. District or Province) but below the National level. There are government offices located at the Province level (Lautoka) and at the District level (Ba) which provide a range of rural development and administrative functions. This includes the Ministry of Agriculture, which through its extension division has technical officers at the District.

[3] One female farmer reported that an agricultural extension officer had given her seeds for beans; however, the seeds were not replaced the following season.

The challenges community members faced in interacting with other landscape stakeholders reflects the predominantly hierarchical governance structure within Ba. This structure does not reflect the local heterogeneity in the landscape and means local government officials struggle to support the diversity of landscape users. For example, the modes of government engagement with communities, via interaction with an advisor or *turaga-ni-koro* do not account for the geographic dispersion of communities within a village unit (e.g. Koronubu-Vunibaka and Etatoko are dislocated from their traditional villages). Further, there were concerns that when community-level issues were raised at the Provincial-level by the *turaga-ni-koro* they 'fall on deaf ears'. Agricultural extension officers are a main point of contact with the Ministry of Agriculture yet the little community interaction with agricultural officials is through predominantly male-only channels. Further, agricultural officials were perceived, by community members, to have a predominant focus towards larger, more commercial farms. These examples highlight the limitation of using an individual, within a hierarchical governance structure, as a conduit for information between heterogeneous groups. The community-level perception of the agricultural officials' focus and support does not reflect the reality of landscape use and functioning. For example, women are key landscape users and cultivate a diversity of crops and there are many diverse small-scale farms operated by indigenous Fijians.

Provision of information about the importance of protecting fisheries from staff of the University of the South Pacific (USP) and the Department of Fisheries incentivised the *yavusa* leaders in Votua to initiate a Marine Protected Area on the village's traditional fishing grounds. The staff from USP used videos and discussions to highlight the importance of protecting fishing grounds and warned about the consequences of continued fishing. This illustrates how provision of information to communities can incentivise action to manage landscape (seascape) resources. However, this appeared to be an isolated case rather than common practice in Ba. The norm is for limited sharing of information from stakeholders in the landscape above the hierarchical level of the community.

3.3.2 Intra-community stakeholder interaction

Knowledge of how to utilise landscape resources is held within communities and generated through past experiences. For example, in Etatoko, based upon a long history of cultivation at Wavuwavu, farmers knew which crops were suited to different seasons. Farmers planted vegetables at the end of the cyclone season in March and village elders had instructed farmers to plant duruka (*Saccharum edule)* on flood prone land. Similarly, community members in Nawaqarua were able to predict the weather 'by looking at the skies', and elders use the stars to navigate when fishing. Elderly women in Nawaqarua teach younger women how to collect crabs from the mangroves. The relocation of the community from Wavuwavu to Etatoko exemplifies the impacts associated with loss of community knowledge. When the community moved to Etatoko they did not know which plots were fertile and what spatial configuration of crops would best support livelihoods and buffer climatic stressors.

Community members expressed a preference for sharing information regarding landscape use through intra-community, informal, face-to-face interaction. For example, female community members in Nawaqarua mentioned how informal conversation often initiated sharing of vegetable seeds. In Koronubu-Vunibaka, not all households owned a radio, but households with a radio passed on weather forecasts.

In contrast to the informal information exchange between community members that facilitated effective landscape management community members reported some challenges when engaging with the formal community-level governance system. This included accessing information about landscape management that would affect ecosystem service provision; for example, community members in Nawaqarua and Votua felt they were not fully informed about the potential effects of mining operations that are now active in the Ba River delta. A village committee in Votua was managing the mining compensation funds; the community members in Nawaqarua were concerned that no-one from their village was represented on this committee. In addition, a lack of assets inhibits community access to information about landscape resources; for example, the communities at Nawaqarua and Votua reported that they do not have enough boats to monitor their fishing grounds. The formal community-level governance system, at times, did not function in response to community-level concerns about landscape management or needs. The *yavusa* leaders approved licenses and permission for people, who were not members of the community, to extract fish and coral from fishing grounds without community agreement.

3.3.3. Information exchange via technology

Community members received weather forecasts via the radio. If the forecast predicted heavy rain or flooding they would attempt to harvest crops. However, it was mentioned that forecasts came too late to allow farmers to fully prepare. Most community members had access to mobile phones and were receptive to idea of seasonal weather forecasts via text messages. Some women in Nawaqarua subscribed to a weather forecast through their mobile phone provider, and if heavy rain was forecast they would not go swimming to collect freshwater mussels due to currents. In Etatoko and Koronubu-Vunibaka community members mentioned challenges to accessing information via mobile phones due to a lack of electricity and poor reception in bad weather. It was frequently reported that younger community members had a greater capacity to use mobile phones to access information. In all communities, the cost of mobile phone credit was mentioned as being prohibitive.

4. Discussion

Sayer et al. (2013) and Kusters et al. (2017) emphasise that platforms which facilitate communication between stakeholders across spatial levels are important for effective landscape management; Reed et al. (2009) make a similar point in the broader context of sustainable natural resource management. Limited access to information has been shown to inhibit community-level environmental management in Pacific Island Countries (Nunn et al., 2014). Our findings corroborate these assertions; for example, the multi-stakeholder arrangements that enabled communication between community members, academics, and government officials led to a restriction on fishing in Votua and Nawaqarua (*section 3.3.1*). Experiences from other landscapes also found that removing barriers to stakeholder communication enables change in ecosystem management (Tompkins and Adger, 2004). However, in Ba, the norm is for limited communication between stakeholders across hierarchical levels, with this barrier particularly apparent between communities and other landscape stakeholders. Thus, initiatives in the South Pacific with a focus on landscape multifunctionality should prioritise developing platforms that facilitate cross-level communication between stakeholders.

Natural hazards and climatic variation negatively affect flows of ecosystem services (Table 3) and restrict access to landscape resources (Table 4). Thus, successful management of landscapes requires awareness of climatic risk and consideration of landscape design that increases the resilience of ecosystem service flows. Landscape users in Ba exploit the multifunctional nature of the landscape to respond to climatic stressors and stabilise flows of ecosystem services (Table 5). This implies that effective management of landscape multifunctionality can simultaneously increase the climate resilience of ecosystem service flows while meeting other development objectives pursued in rural landscapes (Biggs et al., 2015; Mwongera et al., 2017; Scherr et al., 2012). The myriad ways community members utilise the landscapes in response to change reflects a rich community knowledge base. This knowledge is an asset for informing effective response to environmental challenges within Pacific landscapes (Janif et al., 2016; McMillen et al., 2014). Strategies for landscape management under changing climates and dynamic environments in the Pacific could complement and build upon this knowledge. This is another example of why removing barriers to communication across-levels and between stakeholders is important for managing landscape multifunctionality.

Table 5. Examples of use of landscape use in response to climatic stressors. Coping refers to short-term and reactive responses to variation in weather or 'unexpected' climatic events and adapting refers to more permanent responses to trends in climate or efforts to permanently reduce sensitivity to weather variation.

Coping	Both	Adapting
• Replant crops (often cassava) affected by drought • Cover exposed roots of crops after floods (chili, pandanus trees) • Moving crops away from exposed land[2] • Crop choice due to weather warning[3] • Collect mud crabs during bad weather as men cannot go out fishing with boats • Diversify livelihood activities (e.g. sell crabs to buy food as income from cassava as decreased)	• Hosepipes to water plants close to settlement[4] • Deliberate crop diversity[5]	• Digging a well (for irrigation) • Dig drainage besides fields • Moving flood prone vegetables to drier land[5] • Vegetables planted under trees to protect them from weather • Plant crops at different time-steps to increase chance of some crops surviving inclement weather • Plant different crops in different seasons • Female farmers think planting more trees would help them cope with rising temperatures (in Nawaqarua) and flooding (in Koronubu-Vunibaka) • Settlement relocation (Etatoko)

[2]Farmers in Etatoko moved banana trees from land adjacent to rivers that were at risk of flooding closer to their settlement on higher ground.
[3]Farmer planted watermelon but heard a cyclone warning so harvested watermelon to plant cassava (Etatoko).
[4]Male farmers /elders in the focus group in Etatoko reported that watering plants from the homestead is new to them and they have started planting closer to the home during the dry season as a result of warmer temperatures recently.
[5] Farmers in Koronubu-Vunibaka planting both cassava and breadfruit. The breadfruit is a source of food in case of flooding (coping), but this is something they learnt to do from their elders (indicating learning and a more permanent farming strategy - adapting).
[6]This constitutes an adaptation as the farmer in question (in Etatoko) had planted the vegetables near a creek by his property when he moved there, but after damage due to heavy rain and flooding he has decided to shift where he cultivates vegetable crops.

The spatial arrangement of landscape resources, stakeholders' locations within the landscape relative to these resources, and the various institutional footprints create local variability in people's access to landscape resources and ability to benefit from ecosystem service flows. The spatial arrangement of landscape resources and people's landscape activities can also contribute to climate resilience. In part, this is due to different locations having different exposure to climatic variables, and different flows of ecosystem services having varied sensitivities to climatic shocks and stressors. The institutions governing land tenure can prevent movement within landscapes as an adaptation response to the spatial variability in climate exposure; this was illustrated by the challenges faced in relocating the community to Etatoko from Wavuwavu. Socio-demographic factors also impede certain groups' capacity to use the landscape (Table 4); for example, old age preventing farmers cultivating fields far from their homestead. Ensuring land tenure, and other institutional and socio-demographic factors, do not impede flexibility in landscape management in response to climate stressors will be important in Fiji and Pacific Island Countries given the density of coastal populations and their acute climate exposure (Lough et al., 2016; Nunn, 2009). These examples emphasise the importance of integrated spatial planning within multifunctional landscapes, and, in particular, place-based planning that is cognisant of where stakeholders interact with the landscape and their differing capacities and institutional barriers to doing so.

A predominantly hierarchical landscape governance structure prevails within Ba resulting in resources for landscape management being misaligned with actual landscape heterogeneity or failing to support the range landscape users (*see section 3.3.1*). For example, activities that occur in distant locations within the landscape impact communities locally, and local-level governance systems have little capacity to exert influence on these activities. In landscapes comprising complex multi-scale socio-ecological systems, such as Ba, multi-scale governance systems allow for aligning management resources at appropriate scales (Biggs et al., 2012). In a global review of landscape approaches Reed et al. (2017) found multi-scale governance systems were associated with successful management outcomes but noted that top-down governance structures are commonplace. Effective multi-scale governance might facilitate addressing other challenges to managing landscapes that were identified in Ba. For example, multi-scale governance structures are associated with broader participation in governance and management processes which, in turn, might enable cross-level communication and the incorporation of local and place-based knowledge into landscape governance (Biggs et al., 2012).

Communities are key groups in multi-scale governance systems; thus, cognizance of community capacity to undertake landscape management is important. In contexts outside Pacific Island Countries where rural communities have been effectively integrated into multi-scale governance structures community-level adaptive capacity has been leveraged (Osbahr et al., 2008). However, there are also documented examples of where community capacity to successfully manage natural resources is limited (Blaikie, 2006; Dougill et al., 2012; Dyer et al., 2014) including in Pacific Island Countries (Jupiter et al., 2017; Nunn et al., 2014). In Ba, various factors challenged community-level management of landscape resources including: a lack of assets situated at the community-level for utilising or monitoring landscape resources, community members' immediate needs for ecosystem services being at odds with goals of long-term landscape sustainability, and local-level governance systems not responding to community-level concerns regarding landscape management. These factors, observed in Ba, resonate with factors that Jupiter et al. (2017) suggest contribute to successful community-led management of locally marine managed areas in Fiji. Thus, policies and projects seeking to promote landscape multifunctionality should be aware of varied groups and their capacity to effect landscape management. Multi-scale governance systems should function to support and enhance community capacity to manage landscape multifunctionality.

5. Conclusions

Challenges that stakeholders faced in managing, or deriving the benefits from, landscapes in Ba, Fiji, were identified following participatory fieldwork. Numerous landscape resources and ecosystem services support livelihoods in Ba. The landscape resources utilised, and ecosystem services valued, varies across and within communities which highlights i) complex socio-environmental interactions within the landscape, and ii) managing landscape multifunctionality is important to ensure that the diverse needs for ecosystem services of different stakeholder groups are met. The functioning of formal and informal institutions, geographic proximity to landscape resources, and physical or financial capacity shape people's ability to access landscape resources. A hierarchical governance structure prevails within Ba which is misaligned with actual landscape heterogeneity and often fails to support the diverse needs of landscape users. There was limited interaction between stakeholders across spatial levels; however, when platforms that facilitated community interaction with other stakeholders were initiated changes in landscape management ensued. Limits to community-level landscape management were observed across multiple dimensions, and, at times, community-level governance systems did not operate in accordance with community needs or goals of landscape sustainability.

As managing landscape multifunctionality becomes a more prominent goal in Pacific Island Countries awareness of the following factors will be important. Initiatives should be aware of the barriers to managing landscape multifunctionality through hierarchical governance systems and aim to establish context appropriate multi-scale governance. Such systems should facilitate communication and interaction between different stakeholders, build upon community knowledge for managing landscapes, and support communities as key actors in landscape management. Consideration of the spatial footprint of landscape resources, different landscape stakeholders' capacities, and institutions that mediate access to landscape resources should be central to managing multifunctional landscapes. Pacific Island Countries are exposed to numerous stressors which affect flows of ecosystem services from landscapes; thus, management of landscape multifunctionality should also build resilience to climate stressors.

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Fig. 1 Land cover map of the Ba Catchment. The land cover data were obtained from the Ministry of Agriculture, Fiji.

Fig. 2 Average monthly precipitation and minimum and maximum temperatures (climate data from Worldclim).

Fig. 3 Schematic of indigenous Fijian social groupings adapted from Walter (1978), Sano (2008) and Lasaqa (1984).

Figure

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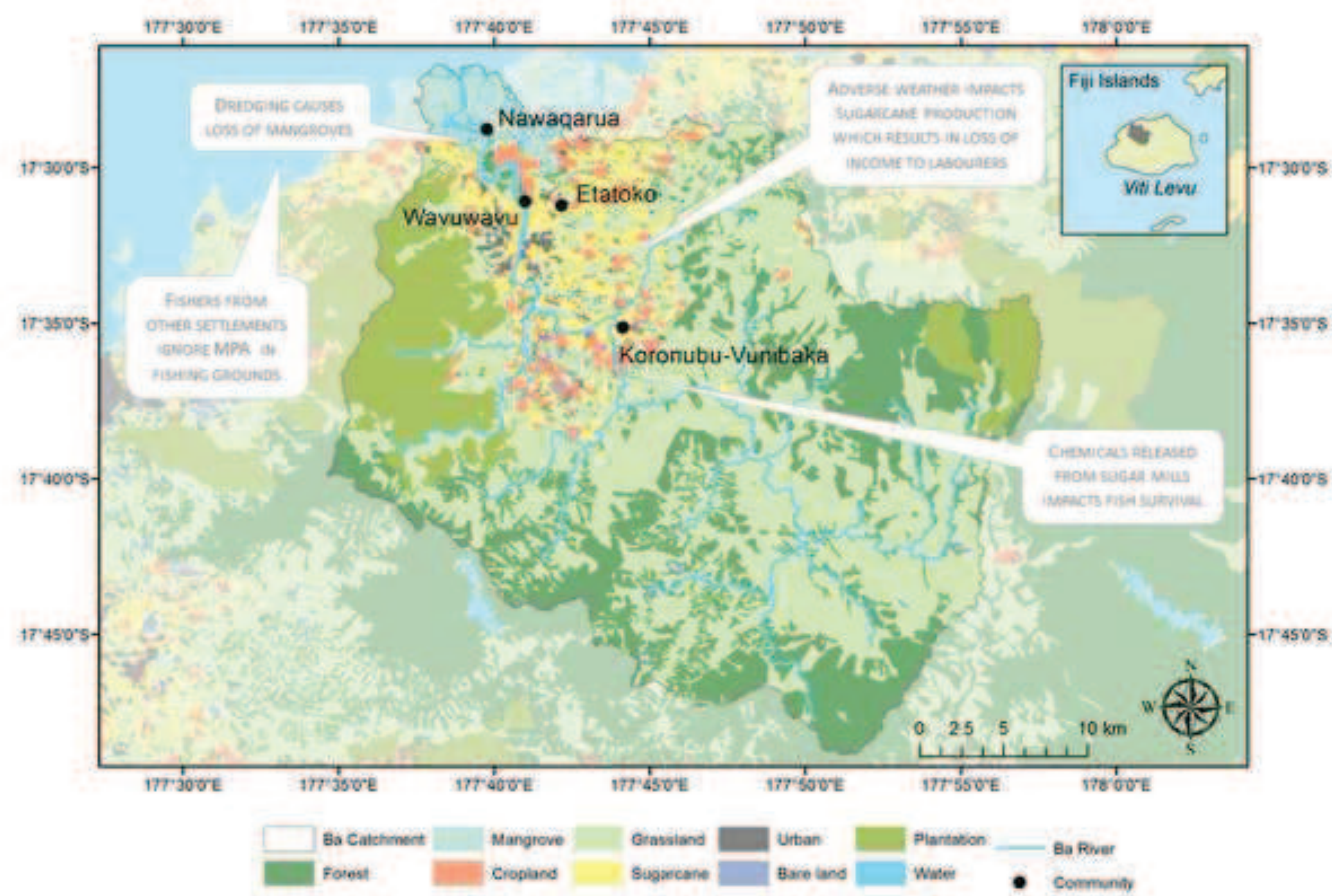

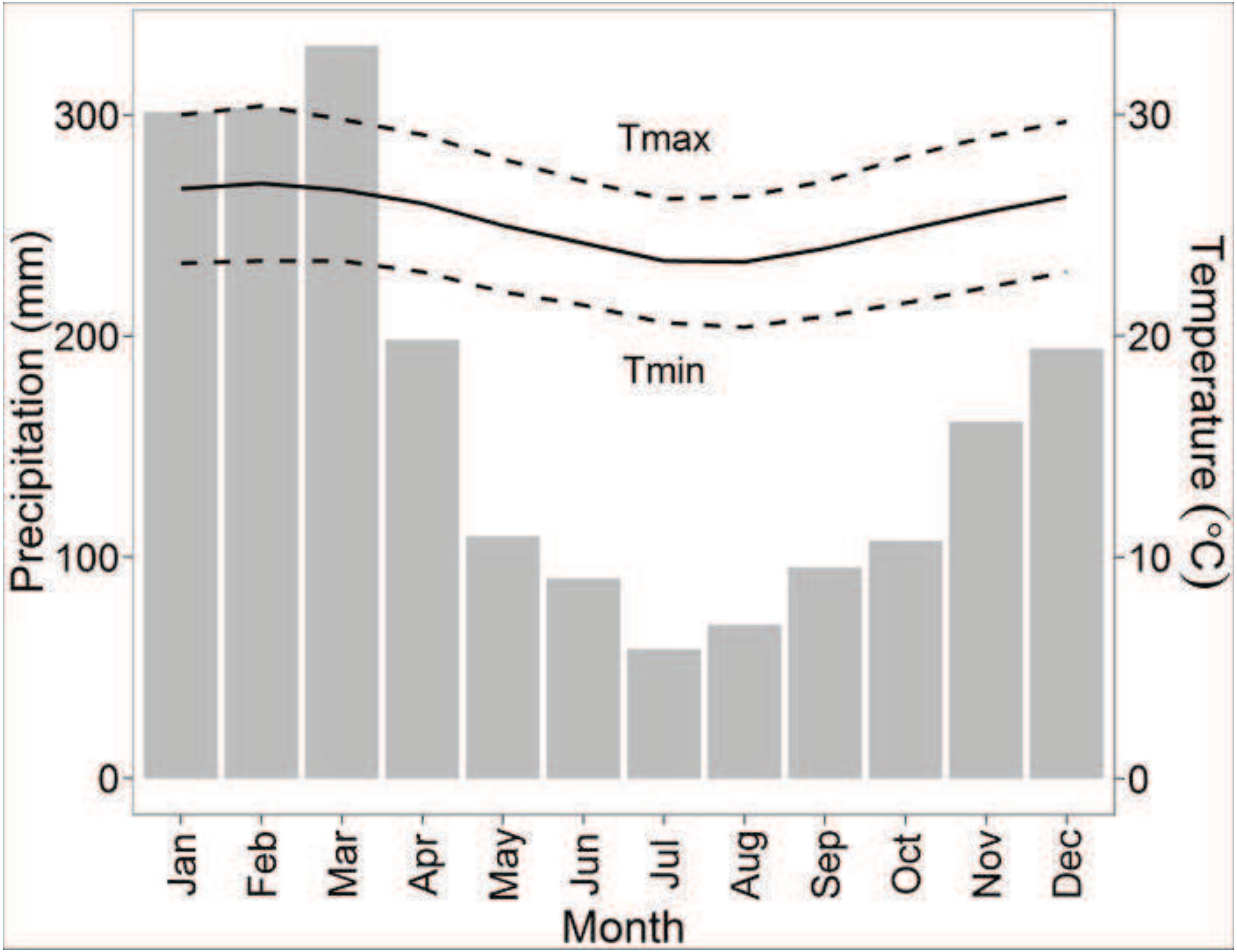
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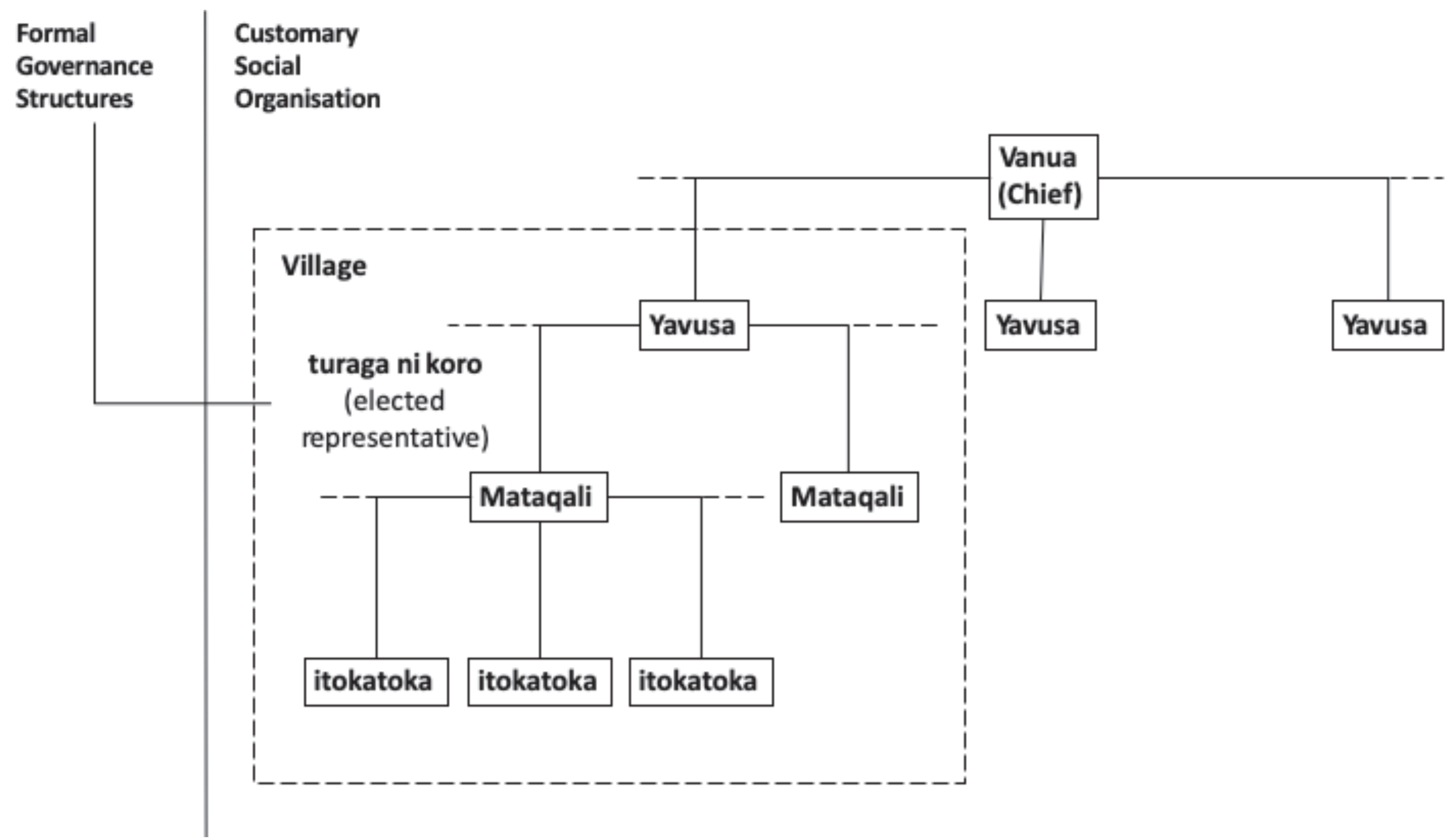
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

Figure


Formal
Governance
Structures
Customary
Social
Organisation
Vanua
(Chief)
Village
Yavusa
Yavusa
Yavusa
turaga ni koro
(elected
representative)
Mataqali
Mataqali
itokatoka
itokatoka
itokatoka

***Declaration of Interest Statement**

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: