‘The Reef is our Garden’
Expanding Analysis of Ecosystem services in Coastal Communities

Jacqueline Lau
April 2019

A thesis submitted for the degree of Doctor of Philosophy
at the Australian Research Council
Centre of Excellence for Coral Reef Studies
James Cook University

For my Nan, Dr. Dorothy Chong (1922-2018).

The highest art is living an ordinary life in an extraordinary manner

~ Zen proverb

Acknowledgements

Throughout my PhD, I have had the wonderful good fortunate to work with and learn from three outstanding environmental social scientists, who value interdisciplinary research, and think deeply and creatively about real-world problems. Deep thanks to my advisory panel, Joshua Cinner, Christina Hicks, and Georgina Gurney, for your intellectual guidance, genuine engagement, and kindness. Josh, thank you for maintaining the perfect balance of support, enthusiasm, trust, and pragmatism! Chris, thank you for welcoming me so warmly to Lancaster, and for sharing your thoughtful approach to science and life. Georgie, thank you for many a conversation that kept me on track, your friendship, and invaluable advice on academic life. It has been a joy and an honour to work with each of you.

This thesis would have been impossible without the hospitality and generosity of the people of Papua New Guinea. Thank you to the communities of Ahus, Muluk, and Wadau for welcoming me, and sharing your experiences, thoughts and perspective on life beside the reef. An especially big thanks to the Karah family, Kasus family, Malai family, Puchin family, Aumal family, and Limik family for hosting me so generously. *Mi hamamas tru long mi ken stap wantaim yupela na stori wantaim yupela. Tenkyu tru. Bai mi lukim yu gen long behain taim!* Thank you also to my wonderful research assistants, Lawrence Gandong, Santina Memes, Otto Selan, Rhoda Pominis, and Douglas Ah Kau. A special thanks to John Ben, for his invaluable guidance in the field.

This thesis has benefited greatly from conversations, critiques, and ideas from students, officemates, and colleagues at the Centre of Excellence for Coral Reef Studies. Thank you all for sitting through many a practice talk, sharing successes and frustrations, and buoying me along with your enthusiasm. To the growing Cinner Lab (and alumni), it has been a pleasure to work with you. To Janet, Viv, and the Centre of Excellence office staff, thank you for ironing out any problem, big or small, and for brightening the corridor with your friendly smiles.

Finally, thank you to my family. Mum and Dad, your encouragement and support have made this thesis, and all my endeavours, possible. Thank you for always being there for me, through thick and thin. Michael, thank you for your love and calm patience. It has been a joy to share this adventure with you.

Declaration of the Contribution of Others

Funding

Australian Post-graduate Award Research Scholarship | $75,000 (stipend)
Supervisory support | $25,000 (Fieldwork, conference attendance, institutional visits)

Research support

Research assistance | John Ben, Santina Memes, Fiona Naron, Otto Selan, Rhoda Pominis, Laurence Gandon
Survey design | Prof. Joshua Cinner, Dr. Michele Barnes (social network survey, *Chapter Six*)
Interview transcription | Douglas Ah Kau
Editorial Support | Prof. Joshua Cinner, Prof. Christina Hicks, Dr. Georgina Gurney[1]
Logistical support | Angela Knight, Derek Middleton

Multi-disciplinary collaboration (Chapter Six) | As part of research training at JCU and the ARC Centre of Excellence for Coral Reef Studies, students are encouraged to build skills in collaboration and interdisciplinary research. Chapter Six is part of a collaborative project between social scientists and ecologists, led my Primary Advisor, Prof. Joshua Cinner. I use the pronoun 'we' throughout the chapter to reflect the collaborative nature of the project.

Ecological data collection, analysis and reporting (Chapter Six) | Dr. David Feary, Dr. Andrew Bauman, Dr. Fraser Januchowski-Hartley, Dr. Brock Bergseth, Prof. Nick Graham[1]

Microsoft Word thesis template: provided freely by Kayla Friedman, Malcolm Morgan (University of Cambridge University, UK), and Charles Weir (Lancaster University, UK).

The proposed research received human ethics approval from the JCU Human Research Ethics Committee Approval Number H6617. I obtained informed consent verbally prior to all interviews.

[1] Further details of contributions of others are included at the beginning of each data chapter.

Contributions

Related to PhD thesis

Peer-reviewed publications

Lau, J., Hicks, C., Gurney., G & Cinner, J. 2019. What matters to whom and why? Understanding the importance of coastal ecosystem services in developing coastal communities. Ecosystem Services 35:219-230

Lau, J., Hicks, C., Gurney., G & Cinner, J. 2018. Disaggregating ecosystem service values and priorities by wealth, age, and education. Ecosystem Services 28:91-98

Cinner, J., **Lau, J.,** Bauman, A., Feary, D., Januchowski-Hartley, F., Rojas, C., Barnes, M., Bergseth, B., Shum, E., Lahari, R., Ben, J. & Graham, N. (*submitted*) Social and ecological outcomes of adaptive management in a coral reef bright spot. Science Advances.

Lau, J., Cinner, J., Fabinyi, M., Gurney, G. & Hicks, C (*submitted*). Access to Marine Provisioning Services: Incorporating Entanglement and Legitimacy. World Development.

Conference presentations | invited talks | organized symposia

Lau, J. 2019. Local to Global: From Access and Equity in Coral Reef Communities to a Climate Change Research Agenda. Fish Learning Hour (invited talk), WorldFish Headquarters, Penang, Malaysia

Lau, J. 2018. What's Fair and Why? Empirical Equity and Customary Management in Papua New Guinea. 5th International Marine Conservation Congress (IMCC), Kuching, Malaysia

Lau, J & Gurney, G. 2018. Conference Symposia: Justice and equity in marine conservation: theory, empirical analysis, and practice. 5th International Marine Conservation Congress, Kuching, Malaysia

Lau, J. 2017 'We need to yell about our reefs': Fishing and Fairness in PNG's Coral Reefs. PNG Impact Conference, University of Papua New Guinea, Port Moresby, Papua New Guinea

Lau, J. 2017. Equity and Ecosystem Services in Coral Reef Small-Scale Fisheries: Understanding social difference, values, priorities, and fairness. WorldFish Resilient Small-Scale Fisheries Symposium, WorldFish Headquarters, Penang, Malaysia

Other Publications, Reports, and Presentations during candidature

Cinner, J., Adger, W., Allison, E., Barnes, M., Brown, K., Cohen, P., Gelcich, S., Hicks, C., Hughes, T., **Lau, J.**, Marshall, N. & Morrison, T. 2018. Building adaptive capacity to climate change in tropical coastal communities. Nature Climate Change 8:117-123

Lau, J. & Scales, I. 2016. Identity, subjectivity and natural resource use: How ethnicity, gender and class intersect to influence mangrove oyster harvesting in The Gambia. Geoforum 69 (1):136-146

Stokes, C., Addison, J., Macintosh, A., Jarvis, D., Higgins, A., Doshi, A., Waschka, M., Jones, J., Wood, A., Horner, N., Barber, M., Bruce, C., Austin, J. & **Lau., J**. 2017. Costs, benefits, institutional and social considerations for irrigation development. A technical report to the Australian Government from the CSIRO Northern Australia Water Resource Assessment, part of the National Water Infrastructure Development Fund: Water Resource Assessments. CSIRO, Australia.

Lau, J. 2018. Identity and Molluscs: How gender, ethnicity and class shape oyster harvesting in the Gambia. Tropical Futures Seminar (invited talk), Lancaster Environment Centre, Lancaster University, United Kingdom

Lau, J. 2018. Identity and Molluscs: How gender, ethnicity and class shape oyster harvesting in the Gambia. Invited presentation, Interdisciplinary Approaches to the Study of Human and Mollusc Interactions from Prehistory to Present, *Muséum national d'Histoire naturelle*, Paris, France

Abstract

Humans have changed the climate, lands and seas, forests and coasts, in ways that may destabilize earth's key systems. In response to these declines, ecosystem services are fast becoming the new paradigm and framework that policy-makers, environmental organisations, funding bodies, and researchers use to understand and govern ecosystems for people's wellbeing. However, ecosystem services frameworks face several limitations wrought by their founding disciplines, including a tendency to focus on aggregate wellbeing and thus obscuring issues of access and justice.

This thesis aims to expand ecosystem services approaches by drawing on progress in the social sciences. I draw on theory in political ecology, anthropology, and environmental justice to extend how ecosystem services approaches capture diverse priorities for ecosystem services, illuminate issues of access and legitimacy, and understand local notions of justice. I use mixed-methods case studies in developing coastal communities in Papua New Guinea. Specifically, I combine quantitative and qualitative methods (including in-depth interviews, socio-economic surveys, participant observation) to investigate; i) how people ascribe importance to ecosystem services, ii) how customary institutions shape access to ecosystem services and retain or lose legitimacy and; iii) local notions of justice around the use and governance of ecosystem services.

I find that people tend to ascribe the most importance to ecosystem services that directly support their livelihoods and material needs. People also express concern about extractive ecosystem services, like fuelwood, that they perceive as destructive. In addition, I found that a range of access mechanisms shape access across ecosystem services value chains. Furthermore, the ways that customary institutions shape access have remained strong for some (i.e. through restricting the reef areas open to women for fishing) and have faded in legitimacy for others (i.e. young men). I also found that social cohesion, with strong relationships between leaders and community members and high participation in community events and decision-making, supported the legitimacy of customary adaptive reef management. Finally, I found similarities in notions of distributive justice across communities; many were concerned about the costs of destructive or over-intensive fishing

methods. However, in one place, local concerns about people's needs stopped leaders banning destructive practices. I also found that although people held similar ideals about decision-making, actual practices manifested very differently in each place. Finally, I found that notions of recognitional justice were often expressed as respect and good conduct in the community.

Drawing on these findings, I argue that ecosystem services approaches would be enhanced by incorporating a relational definition of power, alongside its current emphasis on 'power over'. Secondly, 'need' is an important avenue of research because it shapes how people value ecosystem services, and also conceptualize justice. Thirdly, throughout my thesis, gender and normative positions around ecosystem services governance emerged as cross-cutting themes that shaped people's interactions with their ecosystems. I thus suggest that a more in-depth engagement with how moral principles manifest empirically is a crucial avenue for future research in ecosystem services.

Contents

List of Tables

List of Figures

List of Acronyms

AIC	Akaike information criterion
ESPA	Ecosystem services for Poverty Alleviation
FAD	Fish aggregating device
FAO	Food and Agricultural Organization
FID	Flight initiation distance
IPBES	Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services
LDC	Low-income developing country
MEA	Millennium Ecosystem Assessment
MSL	Material style of life
PCA	Principle component analysis
PES	Payments for ecosystem services scheme
REDD	Reducing Emissions from Deforestation and Degradation

List of Appendices

1 Introduction

‘The reef is our garden’

A little north of Manus Island, Papua New Guinea, lies a small island called Ahus. You can circumnavigate the entire island on foot in about thirty minutes, passing by the palm-leaf homes of the 600 or so people for whom Ahus is home. Ahus is an island in flux, highly vulnerable to climate and environmental change. In 2009, an unprecedented king-tide washed across the island and through people’s home, covering much of the reef lagoon in sand. The change to the reef was dire for Ahus islanders, for whom the reef is both a livelihood and way of life. During my stay on Ahus, people told me time and time again that ‘the reef is our garden’. In Papua New Guinea, your garden is your lifeblood. Ahus islanders live, eat, and earn their livelihoods from the sea. But the idea that the reef was the island’s garden captures the reality that Ahus islanders’ relationship to their seas was one of not only dependence, but co-production and historical stewardship; a garden where things must be cared for and cultivated. As the climate warms and becomes increasingly unpredictable, the garden of Ahus island may lose its ability to bear fruit, and its gardener’s the ability to tend it.

Three hundred kilometres south-west of Ahus, the communities of Muluk and Wadau sit nestled against Karkar island’s volcanic slopes. Here, people tend gardens and cash crops (cacao and copra) growing in the rich volcanic soil behind their village. Yet, here too the reef is a thread in the fabric of everyday life. Unlike Ahus, the people of Muluk and Wadau have a custom of closing the reef to fishing; much like allowing a crop of blackberries run wild, to then enjoy the bountiful harvest. I was lucky that my fieldwork coincided with the week that Muluk was to open their reef, after more than a year untouched. Preparations started five evenings before the opening ceremony. The strongest fishers took their canoes and paddled out into the darkness of the ocean. Long before dawn they returned to the beach with buckets of lobsters, large reef and pelagic fish, to smoke in readiness for the opening ceremony. Hundreds of people attended the ceremony, clustering in small groups in the shade of the coconut trees, to listen to leaders expound the success of the reef closure. After the speeches, young men carried around buckets of smoked fish, handing one to each visitor.

This thesis is an attempt to understand the complex and changing lives of people in developing coastal communities, like Ahus, Muluk, and Wadau, for whom the environment is more than a natural resource or ecosystem service. I argue that to understand the meaning and values of ecosystems to wellbeing, we need to draw on the social sciences to interrogate and extend ecosystem services approaches.

1.1 Ecosystem services

Humans have changed the climate, lands and seas, forests and coasts, in ways that may destabilize earth's key systems (Steffen et al., 2018, 2015). Marine and coastal ecosystems are already highly exploited and rapidly depleting. Already, half of all the world's salt marches, and approximately one third of mangroves, coral reefs, and sea-grasses have been lost or degraded (Barbier, 2017). Yet, responsibility for and vulnerability to these global changes are not equal (Mattoo and Subramanian, 2012). Many of the burdens created by changed marine ecosystems will fall on the world's least developed countries (Blasiak et al., 2017; Sumaila et al., 2019), and communities who most directly depend on marine resources (Cinner et al., 2012). In this context, research and practice in conservation and development has sought to balance the tricky goals of conserving biodiversity and enhancing human wellbeing (Adams et al., 2004; Mace, 2014). The ecosystem services approach merges these goals by emphasizing the need to conserve nature precisely because of its importance to human wellbeing. By measuring the value of ecosystem function for people, ecosystem services approaches aim to make the environment more tangible for decision makers and thereby compel them to conserve it (Daily and Ellison, 2002). The 2005 Millennium Ecosystem Assessment (MEA, 2005) provided the first framework for conceptualizing and measuring these services on a broad scale. It categorized nature's benefits as provisioning (products obtained from ecosystems), regulating (benefits from the regulation of ecosystem processes), cultural (non-material benefits) and supporting (services necessary for all other ecosystem services) and was a first step in the exponential growth in ecosystem services research (Chaudhary et al., 2015).

My thesis investigates and challenges ideas in ecosystem services for two reasons. Firstly, ecosystem services are fast becoming the new paradigm and legitimate framework that policy-makers, environmental organisations, funding bodies, and researchers use to understand, discuss and manage environments for people's wellbeing. Burgeoning research and practical applications of ecosystem services have grounded the concept as a 'new conservation paradigm' (Redford and Adams, 2009; Roe, 2008), the central model for environmental policy (Norgaard, 2010), and as 'mainstream scientific and political thinking' (Nature 2009, p. 674). Indeed, alongside burgeoning research, numerous conservation projects have applied the ecosystem services approach, mostly through market-based mechanisms like carbon trading schemes and payments for ecosystem services (PES). In a PES scheme, resource users are paid to not use an ecosystem service; for instance, not to cut down trees for firewood because of the value they hold in sequestering carbon. The UN's Reducing Emissions from Deforestation and forest Degradation (REDD+)

program is the most well-funded and extensive PES scheme. Conservation practice and discourse in marine and coastal ecosystems will likely follow this terrestrial trend of market-based ecosystem services approaches (Garcia et al., 2014; Granek et al., 2010; Lau, 2013).[2] However, as conservation practice follows the pragmatic, often market-based direction advocated by ecosystem services, it risks privileging big business and economic efficiency at the expense of the most marginalized resource users (Norgaard, 2010).

The second reason that this thesis engages with ecosystem services frameworks and approaches is that they are flexible enough to allow critique and re-framing. The ecosystem services framework itself does not have a strong ethical or philosophical underpinning (Lele et al., 2013; Schröder, 2013), but rather embraces forms of methodological pluralism (Ainscough et al., 2019a).[3] Thus, ecosystem services are being re-fashioned to create a dialogue, a rosetta stone (Diaz et al., 2015) or boundary object (Abson et al., 2014; Star and Griesemer, 1989) across knowledge systems (Rathwell et al., 2015; Schreckenberg et al., 2018). As such, ecosystem services guide numerous approaches (Kull et al., 2015), with different outcomes and different ethical considerations, and therefore offer new 'pragmatic possibilities' (Jackson and Palmer, 2014, p. 123) for framing human-nature relationships. Recognizing and addressing the many implicit choices within ecosystem services is a vital step to realizing these possibilities (Jackson and Palmer, 2014; Kull et al., 2015). For example, the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services (IPBES) marks a concerted, interdisciplinary effort to move ecosystem services approaches beyond the limitations born of their founding disciplines (Berbés-Blázquez et al., 2016; Díaz et al., 2015). The IPBES presents a conceptual framework that embraces multiple ways of knowing and valuing nature. Conceptual frameworks allow different parts of a research problem to be tackled with the most appropriate and useful theories and methods, so that together, multiple disciplines and approaches can contribute to understanding the whole (Ostrom, 2011). Within the epistemic communities that address ecosystem services, there has been a concerted shift towards embracing a broader socio-ecological approach (as opposed to purely biophysical), to include questions of justice and conceptualize plural values (Pascual and Howe, 2018). In this spirit, now is the opportune moment to clarify and deepen ecosystem services approaches, by drawing more widely from the social sciences.

---

[2] For example, the UN established a 'Blue Carbon Initiative' in 2010, and in 2012 the International Oceanographic Commission (IOC) Blueprint for Ocean Sustainability aimed to create "a global blue carbon market as a means of creating direct economic gain through habitat protection" (IOC et al., 2011, p. 33).

[3] There are continuing debates about the trade-offs between pluralism and unity in ecosystem services, see Ainscough et al., (2019).

My thesis starts from the assumption that pro-active and critical engagement with ecosystem services can move research and practice towards fairer engagement with people and their environments. Ecosystem services literature has been limited by the assumptions inherent in its founding disciplines. Ecosystem services emerged from neo-classical economics (Gómez-Baggethun et al., 2010), and thus much work retains assumptions that winners and losers are a natural outcome of market forces. Ecosystem services' logic of monetary evaluation and cost-benefit analysis to make decisions has spurred many critiques (Garmendia and Pascual, 2013; Guerry et al., 2015; Kallis et al., 2013; Scales, 2014). In particular, critics point out that ecosystem services literature often assumes that as the supply of ecosystem service increases, so too will the wellbeing of any given community or society. This assumed 'trickle-down effect' (Berbés-Blázquez et al., 2016; Wieland et al., 2016) masks the existence of inequities in use of and access to ecosystem services (Daw et al., 2011). In other words, placing undue emphasis on the aggregate availability of ecosystem services misses the complexity of *how* people access benefits (Lakerveld et al., 2015; Wieland et al., 2016).

Thus, while the framework aims to explicitly link human wellbeing to ecosystem function, ecosystem services research to date has mostly focused on classifying ecosystem services and understanding ecosystem services functioning (Vihervaara et al., 2010), mapping ecosystem services availability (Bennett et al., 2015), and economic valuation (Brooks et al., 2014; Lele and Srinivasan, 2013). Indeed, between 1990 and 2010, only 40 percent of ecosystem services assessments included an assessment of stakeholders (Seppelt et al., 2011), possibly because of a myopic focus on aggregate supply of services as a proxy for wellbeing. Thus, until recently detailed consideration of inequality and inequity have been mostly absent from ecosystem services assessments (Daw et al., 2011). The resulting inattention to people hampers ecosystem services' aim to improve wellbeing (Fisher et al., 2013, 2014; Schreckenberg et al., 2018).

1.2 Research gaps and relevant literature

Here, I outline key gaps in ecosystem services and contributions from social sciences that could be used to address them. Relevant literature is explored more deeply in *Chapters Three* to *Six*. As discussed above, ecosystem services literature often assumes that as the supply of ecosystem service increases, so too will the wellbeing of a given community or society, missing the complexity of *how* people access benefits (Lakerveld et al., 2015; Wieland et al., 2016). This tendency to assume a uniform increase in wellbeing, obscures three important lines of inquiry

that have implications for justice.

The first line of inquiry is that people hold plural values about the environment, and these are socially differentiated (Díaz et al., 2015). Ecosystem services approaches are making progress in identifying and incorporating the diverse and plural values and worldviews that people hold towards ecosystems (Kenter et al., 2015). Recent work emphasizes the 'multiple ways in which ecosystems and ecosystem services are important for people and how these multiple ways of importance are related' (Arias-Arévalo et al., 2017, p. 43). In addition, the IPBES explicitly recognizes people's plural knowledges, values, and worldviews as key to fair management and assessment (Berbés-Blázquez et al., 2016; Díaz et al., 2018; Pascual et al., 2017). A key aspect of capturing these plural values comes with moving beyond monetary evaluations. Appropriate non-monetary valuations better reflect and capture plural values (Arias-Arévalo et al., 2018) and norms in developing countries, including coastal communities (Folkersen, 2018). However, aside from Hicks and Cinner (2014), non-monetary valuations remain rare in coastal developing communities. I address this gap in *Chapter Three.*

The second line of inquiry is how different groups of people realize different ecosystem service benefits (Daw et al., 2011). In his study of famines in Bengal, Amartya Sen argued that people could starve in the midst of plenty of food if they did not have the *capability* to *access* the food (1981). Since then, work in political ecology (and access theory in particular) has re-emphasized that the availability of a benefit (from natural resources or otherwise) does not *necessarily* translate into more, or uniform benefits for people (Daw et al., 2011; Fisher et al., 2013, 2014). In the 'theory of access', Ribot and Peluso (2003) argue that people's ability to gain, control and maintain benefits from things derives from the specific social and political-economic relations, and the discursive strategies that shape benefit flows. Recent work has illustrated that legitimacy is key to which access and property rights are most important in any given context (Sikor and Lund, 2009). Thus, rather than a 'level playing field', who is able to benefit is determined by existing socio-economic inequalities (Leach et al., 1999) within specific socio-cultural contexts (Ribot and Peluso, 2003).

Ecosystem services studies have made progress into incorporating the theory of access. Two key studies highlight opportunities to deepen ecosystem services' engagement with access through investigating institutions and expanding a definition of power. Firstly, Hicks and Cinner (2014) found that in coral reefs in the Western Indian Ocean, social and institutional mechanisms mediated the most, and most diverse number of ecosystem services benefits (Hicks & Cinner,

2014). This finding emphasizes a need to investigate how customary management and social institutions distribute benefits. Secondly, Berbés-Blázquez et al. (2017) investigated how conventional versus traditional forms of production shaped access to benefits from plantains in Costa Rica. They found that conventional and traditional production systems supported different aspects of wellbeing, including material benefits and also subjective aspects of wellbeing like a sense of identity.

Nonetheless, there are several gaps in ecosystem services' treatment of access to date. Firstly, ecosystem services work has predominantly defined the power relations that shape access as power over (Barnaud et al., 2018; Berbés-Blázquez et al., 2016), rather than relational power. There has also not been a deep engagement with questions of legitimacy of different access mechanisms, including institutions (Sikor and Lund, 2009). Further, ecosystem services studies have yet to engage with theories around the fluidity of customary institutions in the face of social and economic change. Customary institutions are the 'humanly devised constraints or complexes of norms and behaviours that are accepted by the community and persist over time by serving collectively valued purposes' (Nkonya, 2006, p. 52; North, 1990). Customary management institutions, then, are the local practices and norms that directly regulate use, access and transfer of benefits from resources, are culturally embedded in wider land and sea tenure institutions, and are often complex, informal, and dynamic (Cinner and Aswani, 2007; Johannes, 1978). The legitimacy of customary institutions may be particularly important to people's wellbeing because strong institutions may provide high social value and prestige, to the point that people are unwilling to break norms even when such norms may be detrimental to their wellbeing (Coulthard, 2011; Jentoft, 2004).

Thus, the ability for a customary institution to continue shaping access or providing benefits, depends, in part, on whether those abiding by the institution's rules and mores continue to perceive it as legitimate. In contexts like the Pacific, where customary and modern forms of resource governance often overlap and clash, relational power and legitimacy are likely to be highly important for how customary institutions continue to or fail to shape access. There has been little work in ecosystem services examining what social characteristics might support the legitimacy of customary marine management, nor what impacts this may have on ecological outcomes. I address these gaps in *Chapters Four* and *Five*.

The third line of inquiry is how people themselves perceive justice around the distribution and governance of ecosystem services. Scholars working on ecosystem services for poverty

alleviation argue that justice ought to be central to ecosystem services framings (Dawson et al., 2018). There is increasing recognition that people's own perceptions of justice matter to their wellbeing and these 'justice notions' preexist conservation or development interventions. In light of this understanding, there is a need to shift the focus away from the fairness of costs and benefits alone to how ecosystem services are *distributed, governed, and represented* and what implications this has for different people's wellbeing (Daw et al., 2011; Gurney et al., 2015; Milner-Gulland et al., 2014) or harm (Martin, 2017). Environmental justice provides a lens to view the ethical issues crucial to ecosystems services goal to conserve biodiversity and increase human wellbeing (Jax et al., 2013; Martin, 2017). Environmental justice examines fairness across three domains; distribution; procedure; and recognition (McDermott et al., 2013; Walker, 2009). Distributional justice refers to who gets what (in this case) ecosystem service benefits. Procedural justice encompasses who is involved in the decision-making procedures that govern this distribution. Finally, recognitional justice asks whose views, interests, knowledge and worldviews are legitimized and represented.

Environmental justice balances normative and empirical understandings of these three dimensions of justice (Walker, 2014a), emphasizing that what people consider equitable depends on social and cultural context and their position within specific configurations of power. Experiences of unfairness, and perceptions of what is fair are highly important because they can create, exacerbate or ameliorate both social and ecological outcomes. If people feel that they are doing worse than others in resource management this creates conflict across stakeholders (Miller et al., 2012) and impacts environmental governance outcomes (Fabinyi et al., 2013). For example, in the Philippines, fishers' concern about the unfairness of how benefits were distributed far outweighed their concerns about the sustainability of the fishery itself (Fabinyi et al., 2013). In South Korea, fishermen defined equity as those who spent more money on fishing, who worked harder and who lived nearer fishing grounds ought to benefit more from the fishery. This example emphasizes that, while inequality can be objectively and instrumentally measured, inequity and injustice are inherently subjective and specific to the cultural context. Although environmental justice has been applied to payments for ecosystem services schemes (Garmendia and Pascual, 2013; Pascual et al., 2014) these schemes constitute only one (particularly visible) 'moment' that conservation creates injustices. There is an opportunity to learn from and account for 'empirical equity', namely what characteristics underpin local understandings of what is fair (Lecuyer et al., 2018; Pascual et al., 2014). In *Chapter Six,* I build on findings in *Chapter Four* and *Five,* to explore local notions of justice.

1.3 Thesis aims

Broadly, my thesis aims to contribute to ecosystem services approaches that are more informed by progress in the social sciences and grounded in empirical case studies. I seek to realize this aim through four main research objectives:

a) Deepen understanding of how people ascribe importance to ecosystem services and whether and how this importance is socially differentiated
b) Explore how customary institutions shape access to ecosystem services and lose or retain legitimacy in the context of social, ecological and economic change
c) Elicit local notions of justice in the distribution and governance of ecosystem services

And by extension:

d) Address a dearth of in-depth case studies of ecosystem services in coral-reef dependent coastal communities

1.4 Study region

My thesis focuses on marine ecosystem services in coral reef dependent coastal communities in Papua New Guinea. My research objectives are particularly pertinent in these cases and context for three key reasons. Firstly, coastal and marine ecosystems are crucial for the wellbeing and food security of millions of people in coastal communities and small-scale fisheries (Selig et al., 2018), but face the challenges of vast ecological change and depletion (Barbier, 2017). More than 90 percent of small-scale fisheries operate in developing countries, and involve 95 percent of people working in the entire fisheries sector (FAO, 2012; Kolding et al., 2014); around 55 million people are involved in small-scale fisheries and aquaculture. Nonetheless, the relationship between poverty, wellbeing and small-scale fisheries is not straightforward (Béné, 2003; Béné and Friend, 2011). However, small-scale fisheries may work as ‘poverty traps’, whereby poorer fishers with fewer means and alternative livelihood options cannot muster the resources to deal with change such as declining fishery, and so become trapped in a cycle of poverty (Cinner, 2010). Yet, small-scale fisheries may also make important contributions to local economies (Béné, 2003; Weeratunge et al., 2014), provide food security for the poor (Belton and Thilsted,

2014), and bolster socio-cultural events (Kittinger et al., 2015). Thus, there is no simple nexus between poverty and small-scale fisheries livelihoods, because the ways that people benefit from fisheries and coastal livelihoods differ so greatly. Nonetheless, changing patterns of access to coastal resources will result in unequal impacts on human wellbeing.

These challenges are particularly acute in coral reef socio-ecological systems. Along coasts, millions of people are disproportionately dependent on coral reef resources for living space, commodities and economic growth (Weinstein et al., 2007; Whittingham et al., 2003). Thus, investigating the social aspects of coral reef and related coastal tropical socio-ecological systems is crucial (Kittinger et al., 2012). However, those who most need coral reef resources are often overlooked in national statistics, creating further marginalization (Whittingham et al., 2003)(Whittingham et al. 2003). Left unaddressed, the degradation of coral reef ecosystem services (MacNeil et al., 2015) will lead to hardship for those who depend on coral reefs (Newton et al., 2007). Thus, coral-reef dependent communities in Papua New Guinea provide case studies of environmental and social issues facing many millions of people in the Pacific and beyond.

Secondly, I focus on small-scale fisheries because many are navigating changing configurations of customary and formal management (Aswani, 2005; Evans et al., 2011), shifting institutions (Schlüter et al., 2013) and governance (Song et al., 2018). Shifts in customary management systems – in the form of sea-tenure, closed systems, taboo areas, socially-differentiated uses of species – have been documented across the Pacific since at least the 1970s (Hickey, 2006; Hviding, 1998; Johannes, 1978; Macintyre and Foale, 2007; Robbins and Wardlow, 2005). Yet, even as they become increasingly entangled with the socio-economic shifts accompanying capitalism and modernity, customary systems continue to shape local existence, including resource use and rights, in changing forms (Aswani, 2002; Curry et al., 2012; McCormack et al., 2013). These changing configurations of customary systems will have implications for the interrelated ideals of sustainability (Steffen and Stafford Smith, 2013), wellbeing (Berbés-Blázquez et al., 2017), equity (Fisher et al., 2013; McDermott et al., 2013), and adaptive capacity (Cinner et al., 2018).

Finally, to date, ecosystem services research has tended to focus on developed, terrestrial systems. Almost all studies of equity in ecosystem services-based management (i.e. payments for ecosystem services) are in forestry (Dawson and Martin, 2015; Lakerveld et al., 2015; Sikor, 2013). Thus, there is a dearth of empirical evidence on developing coastal communities. Yet in contrast to terrestrial systems (particularly forests, which are dominated by private rights) marine

and coastal spaces are often state owned, common property, or open access, with highly fungible resources (Bennett, 2018; Campling et al., 2012). Social differentiation and dynamics of class tensions thus have their own particular expression in fisheries, compared to agrarian political economies (Campling et al., 2012). For instance, gear is an important social differentiator in fisheries as it has implications for who can catch what. Likewise, ecological knowledge, particularly about the time and location of mobile target species (or times when gleaning is safe), is a crucial aspect of accessing marine resources (Siar, 2003). To date, there has been very little work to test theory, mixed-methods ecosystem services analysis in coral reef contexts, nor ecosystem services studies in Papua New Guinea. Thus, there is pressing need for detailed empirical research in marine and coastal contexts, especially as conservation practice and discourse in coastal and marine ecosystems steers towards market-based ecosystem services approaches (Garcia et al., 2014; Granek et al., 2010; Thomas, 2014).[4]

1.5 Thesis outline

My thesis addresses the research gaps described above by applying social science methods and insights to ecosystem services to extend analysis of social diversity, access, institutions, and environmental justice. Following an outline of my overarching methodology in *Chapter Two*, I address my thesis objectives in four data-based chapters, adapted from manuscripts prepared for peer-reviewed publication (Figure 1-1).[5]

In *Chapter Three*, I ask; how and why do people ascribe importance to coastal ecosystem services? And is this importance socially differentiated? To answer this question, I build on quantitative work understanding how people perceive and value coral reef ecosystem services (Hicks and Cinner, 2014; Lau et al., 2018). Specifically, I use a non-monetary measure of ecosystem services that people deem important, and disaggregate this across social groups including age, economic status, level of education, migrant status, and gender. I combine this

[4] Although, the ecosystem services for poverty alleviation (ESPA) program (Fisher et al., 2014; Schreckenberg et al., 2018) does focus on marine ecosystems.

[5] Appendix E contains a manuscript on disaggregating ecosystem services values and priorities in the Western Indian Ocean, originally prepared for this thesis and published in *Ecosystem Services*. As my project progressed, the geographical focus of this paper no longer fit the overarching narrative of the thesis and it was moved to the appendix.

with qualitative explanations of what makes ecosystem services important. This chapter spans three communities in Papua New Guinea and is thus able to explore patterns in the social diversity of ecosystem service importance that may transcend community scale. This chapter also provides a useful 'lay of the land' to understanding the role of and priorities around ecosystem services in each case study site.

In *Chapter Four*, I examine the role of customary institutions in shaping access to specific ecosystem services in one case study site. Quantitative work has shown that social, knowledge and institutional mechanisms are associated with the largest number of ecosystem services benefits in coral reefs in the western Indian Ocean (Hicks, 2013; Hicks and Cinner, 2014). This chapter fuses access theory (Ribot and Peluso, 2003) and theories of legitimacy (Sikor and Lund, 2009), with anthropological work on 'entanglement' to add in qualitative depth to understanding how customary institutions shape access to ecosystem services. In it, I identify that customary institutions may lose or gain legitimacy for some social groups and not others. I extend this finding in *Chapter Six*, by examining perceptions of justice around the distribution of access.

I build on *Chapter Four's* findings in *Chapter Five* by exploring a contrasting case where customary institutions have retained strong legitimacy. *Chapter Five* takes a case study approach to understand key social dynamics in a place where customary marine management retains a strong legitimacy and there is high compliance with customary rules. The rationale for this chapter also stems from the identification of one of my study sites as an ecological 'bright spot', with more than two standard deviations more fish biomass than expected, given local socio-economic and environmental conditions (Cinner et al., 2016). In *Chapter Five*, I start from emic explanations of what makes the case study bright, to examine what social and ecological characteristics prevail in and support the 'brightness' of this coral reef. This chapter thus builds on themes raised in *Chapter Four*, by examining what conditions enable customary institutions to retain legitimacy, and what this means for ecological outcomes.

Finally, in *Chapter Six*, I extend work that suggests perceptions of justice are crucial to environmental governance and wellbeing (Bennett, 2018; Fabinyi et al., 2013; Marmot and Wilkinson, 2001; Song et al., 2013). I present an empirical account of coral reef communities' perceptions of fair distribution, management of and recognitional issues around ecosystem services. This chapter extends findings from *Chapters Four* and *Five*, by moving beyond description (i.e. what shapes access and for whom?) to how people draw on notions of justice to

interpret and explain their socio-ecological world, and express moral concerns. It extends theories of environmental justice (predominately used in a developed country context) by applying the lens to a developing region and arguing that attention to moral principles may be crucial for realizing environmental justice broadly, and recognitional justice specifically.

In *Chapter Seven*, I conclude by arguing that to address wellbeing across the whole spectrum of social diversity, ecosystem service analysis must attend to the socio-economic and socio-cultural factors that shape how people gain benefits, value aspects of nature differently, and draw on their own moral principles to evaluate what is just or unjust (Daw et al., 2011; Klain et al., 2014; Martin and Rutagarama, 2012). Thus, rather than increasing the ecosystem service itself, identifying and overcoming barriers that prevent marginalized groups from accessing ecosystem services benefits is often more important for reducing their poverty and vulnerability (McDowell and Hess, 2012) and improving their wellbeing (Fisher et al., 2014; Nunan, 2015). I explore several cross-cutting themes (e.g. gender, needs) that emerged through my empirical case studies and explore some of the limitations of the thesis. Broadly, I argue that ecosystem services approaches might better move towards the aim of improving human wellbeing if they were to extend their engagement with definitions of what it is to be human, and to flourish.

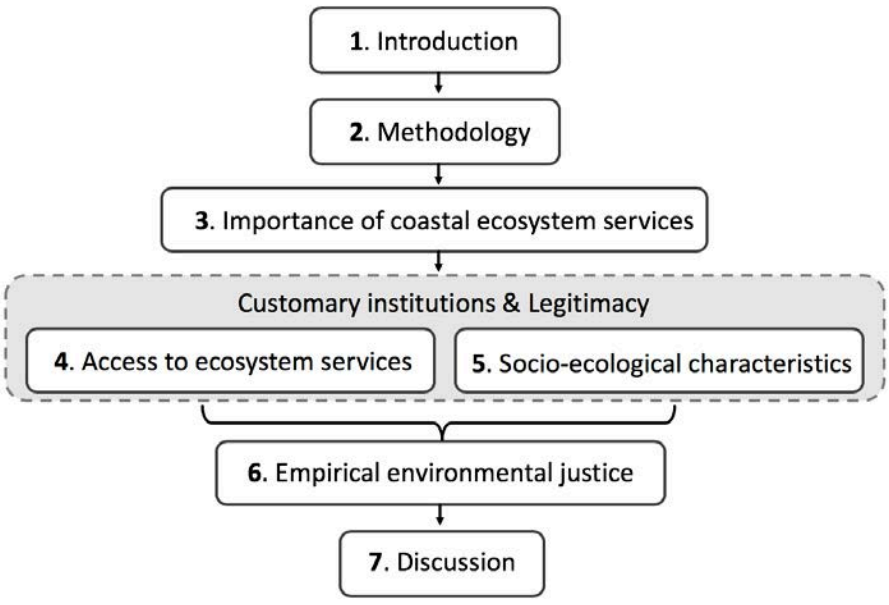


Figure 1-1 Thesis structure.

Note: Numbers refer to chapters. *Chapter Four* and *Five* both address research objective b (p.9) relating to the legitimacy of customary institutions.

2 Methodology

2.1 Introduction

Methodology (etymologically the 'logic of method') refers to the rationale, and theoretical and philosophical assumptions that underpin scientific enquiry (Bryman, 2006; Moon et al., 2019). All social science, whether using qualitative and/or quantitative methods, rests on assumptions about social reality (ontology), the nature of knowledge (epistemology), and the purpose of research (Babbie, 2010; Crotty, 1998). Discussions of subjectivity and bias, reflexivity, data collection and analysis and thus the quality and rigour of social science work require explicit articulation and consideration of the relationship between a study's methodology and methods (Moon et al., 2019). In this chapter, I outline my philosophical approach, research design and methods[6], and study context.

2.2 Philosophical approach

This thesis takes a critical realist approach. Critical realism is a philosophy of science; namely, a theory of what constitutes valuable science and explanation, and the link between knowledge and reality (i.e. epistemology and ontology). Much research concerned with power and the environment, for instance, ecological economics and political ecology, is underpinned by critical realism (Forsyth, 2008; Spash, 2013). Critical realism combines analysis of the socially constructed nature of biophysical nature with politics of the environment (Forsyth, 2008). Critical realists posit that a material, biophysical reality exists, but knowing, talking about, and examining this reality can only ever be constructed and partial, i.e. epistemological scepticism with ontological realism (ibid). In other words, biophysical reality exists, but knowledge claims about this reality are always fallible (Carolan, 2005; Sayer, 2004). By taking this view, critical realism can reconcile work in interdisciplinary fields that fuses biophysical and social analysis.

By allowing for material reality, but detaching the realms of explanation, discourse and interpretation, critical realism allows us to interrogate both the more quantifiable political economy questions of, for instance, who gets what, where do flows of ecosystem services go, as well as who has shaped key discourses, and framed environmental problems in the first place. It allows us to look at how discourses are constructed, but also how ideas begat practices and behaviour that has physical material impacts on the ecology of a system. In addition, critical

[6] More specific descriptions of method and analysis are included in each chapter.

realism offers a useful platform to pursue mixed-methods research, because it encourages engagement with plural methodologies and theories, and using different and multiple techniques to investigate different facets of social phenomena (Olsen, 2004). As such, taking critical realist philosophy allows this thesis to take a mixed-methods approach to span quantitative approaches in *Chapters Three* and *Five*, and a qualitative, observational and anthropological approach in the later half, with an underlying philosophical coherence. In other words, critical realism allowed me to examine both normative and empirical elements around ecosystem services, without reducing the environment to a mere social construction (as in interpretivism), or posit truth claims about people's perceptions of justice, for instance.

2.3 Research strategy: design and methods

To answer the research questions outlined in the Introduction, I took a mixed-methods case study approach. In-depth case studies allow scholars to help revise hypotheses on essential points, and to test and challenge dominant ideas or conventional wisdom (Flyvbjerg, 2006). As such, case studies were a fruitful approach to engage empirically with critiques of ecosystem services, with the aim of building and expanding theory. The thesis starts by examining ecosystem services values more broadly across three communities, before narrowing down to in-depth case studies at each site. I designed the research to start from a broad perspective, enabling me to build on findings from the initial chapters to situate questions for the latter chapters. The initial chapter combines qualitative interviews and quantitative surveys to provide a 'lay of the land' of the ecosystem services important to people in both case studies. I built on these findings to conduct more in-depth interviews in each site to understand access, customary institutions, and ecological outcomes at play around the governance of ecosystem services (see Figure 2-1, Table 2-1).

In each thesis chapter, I triangulate methods (quantitative and qualitative, and different methods within) to gain multiple viewpoints on the objects of study (e.g. perceptions of the importance of ecosystem services', access, justice) (Olsen, 2004). In much of my qualitative coding too, I triangulate between deductive and inductive analysis, by using an iterative process combining thematic and open coding. In triangulation, different methods are given different weight and role. For example, qualitative interviews may inform the design of a quantitative survey, or the analysis of quantitative results (e.g. *Chapter Five*) or may be used to interpret the results of quantitative methods (e.g. *Chapter Two*). Table 1 summarizes how I triangulate between methods in each of my chapters.

Chapter Focus	Research question	Site	Qualitative	Quantitative	Triangulation
3. Ecosystem services values	How and why do people ascribe importance to coastal ecosystem services? Is this importance socially differentiated?	Ahus, Karkar	Semi-structured interviews	Ranking and Rating Social surveys	Qualitative interviews used to interpret quantitative ranking and rating
4. Access and customary institutions	How do customary institutions shape access to specific ecosystem services?	Ahus	Semi-structured interviews Participant and direct observation Informal interviews		Inductive and deductive coding (theme based, generative)
5. Socio-ecological dynamics of strong customary institutions	What social dynamics support the legitmacy of customary marine management? What are the ecological outcomes of strong customary systems?	Karkar	Semi-structured interviews Participant observation	Ecological surveys Social surveys	Qualitative interviews used to generate themes explored using quantitative social data, and interpret quantitative results
6. Environmental Justice	What empirical justice notions and critieria do people express around the use and governance of ecosytem services?	Ahus, Karkar	Semi-structured interviews Participant and direct observation Informal interviews		Inductive and deductive coding (theme based, generative)

Table 2-1.Summary of methods and triangulation used in each chapter.

Note: Further details on methods are included in each chapter.

2.4 Study background and context

My thesis explores questions around ecosystem services in developing coastal communities dependent on coral reefs (see also section 1.4 in *Chapter One*). I focus specifically on coral reef-dependent communities in Papua New Guinea. Papua New Guinea is categorized as a least developed country (LDC) and falls 153rd on the United Nation's Development Index. Marine resources are particularly important for livelihoods and subsistence around Papua New Guinea's coasts. Along the coasts, people consume an average 53.5kg of fish annually (Asian Development Bank, 2014), and thus fish is an important aspect of food and nutrition security. However, coral reef fisheries in Papua New Guinea are declining (Drew et al., 2015), and by 2050 could provide 20% less fish than currently (Bell et al., 2009). Coastal communities in Papua New Guinea are particularly vulnerable to the climate change, and have different levels of existing adaptive capacity (Maina et al., 2016). In Papua New Guinea, customary tenure arrangements remain important for governing coral reef and coastal resources (Foale et al., 2011). However, changing social dynamics, for instance increased migration, may put greater pressure on coastal resources

(Cinner, 2009) and by extension the customary systems that sustain them (Patterson and Macintyre, 2014).

Study Sites

This thesis is based on fieldwork conducted in three coastal communities in Papua New Guinea; Muluk, Wadau and Ahus (Figure 2-1). Muluk and Wadau are neighbouring villages on the eastern side of Karkar Island, Madang Province. Karkar is a highly fertile volcanic island with a population of around 70,000 people. People in Muluk and Wadau pursue a mix of livelihoods, predominantly cash-crop farming (copra, cocoa) and growing subsistence vegetables. Ahus, in contrast, is a low-lying atoll in Manus Province, with very little fertile ground, and a population of around 700 people. Ahus and the two Karkar villages are similar in size but have different ecosystems, livelihoods, wealth, and persistence of customary systems for managing reefs. Ahus Island has been identified as highly vulnerable to climate change, particularly sea-level rise (Maina et al., 2016), and as one of the most overfished sites in a global analysis (MacNeil et al., 2015). Although the people of Ahus are predominantly fisher-folk, many highly-educated Ahus islanders have migrated to pursue careers in cities and send remittances home.

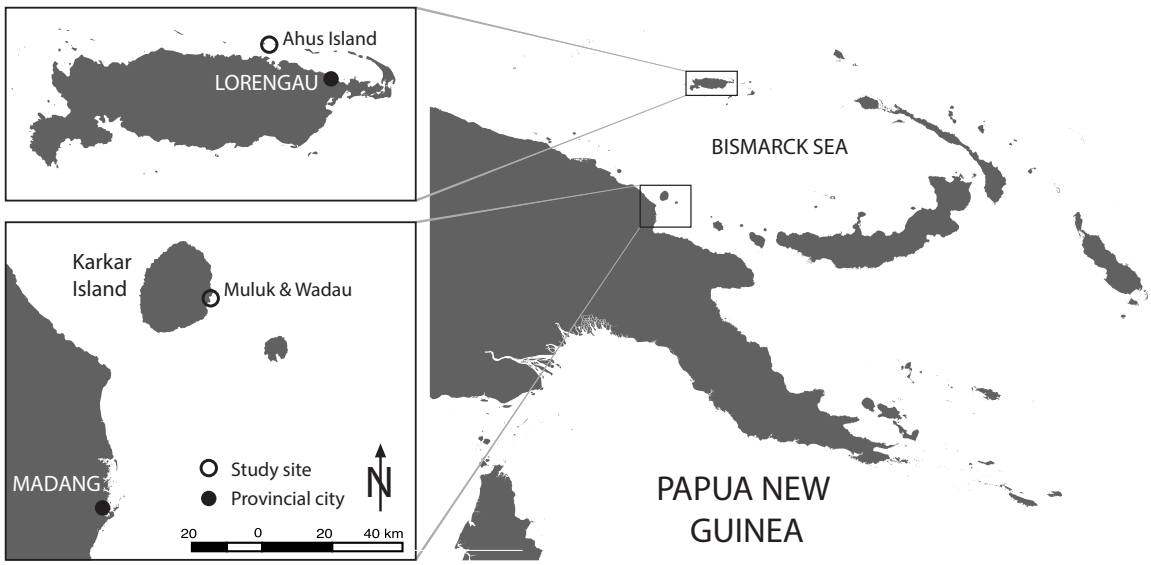


Figure 2-1. Location of study sites in Papua New Guinea.

Historically, all three sites managed their reefs through customary systems passed down through generations (Cinner, 2005). In Muluk and Wadau, clan leaders close the reefs to all gleaning and fishing when fish have become too 'flighty' and hard to catch, and re-open it when there are more

fish, and they are less easily scared (Cinner, 2007; Feary et al., 2010). Closures can sometimes last up to two or more years. Ahus had a similar customary system whereby clan leaders and individuals with sea tenure rights closed certain small areas of the reef at their discretion. Individuals and clans owned rights to certain fishing practices (e.g. bait fishing with special nets), and times (e.g. night time), and others needed to seek permission to use these practices or fish at these times (see *Chapter Four*). In Muluk and Wadau the practice of customary rotational closures remains strong. The reef in front of Muluk was closed during the first round of fieldwork. In contrast, Ahus' customary system has eroded over the past 15 years. Very few people obey customary restrictions on fishing or ask permission to use specific gears or fishing space, although knowledge of the rules remains.

The sites also differ ecologically. A global study of over 1400 reefs identified that the reefs off Muluk and Wadau villages have above average fish biomass given key social and environmental conditions, including population density, and proximity to market (Cinner et al., 2016). In contrast, Ahus' reefs are depleted (MacNeil et al., 2015). The following chapters include more detailed information on study sites, where relevant.

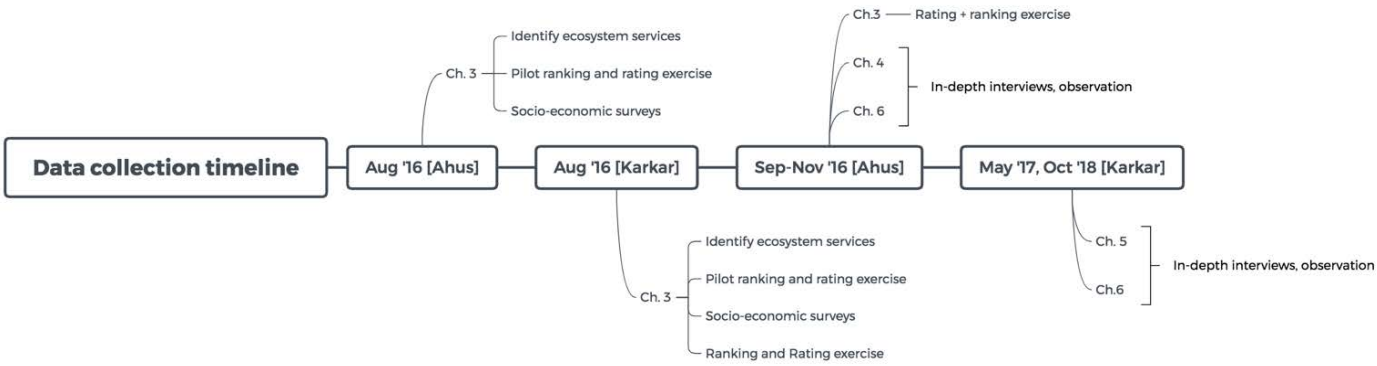


Figure 2-2. Data collection timeline at each site

	Wadau	Muluk	Ahus
Demographics			
Population	447	621	703
Households	72	96	143
Distance to nearest provincial market	68km	70km	24km
Local Geomorphology	Volcanic island	Volcanic island	Coral atoll
Terrestrial ecosystems			
Volcanic rainforest	Extensive, steep	Extensive, steep	None
- Common cultivated species	*Cocos nucifera* (coconut palm), Theobroma cacao (cocoa tree), *Areca catechu* (betel nut), *Canarium indicum* (galip nut tree)	*Cocos nucifera* (coconut palm), Theobroma cacao (cocoa tree), *Areca catechu* (betel nut), *Canarium indicum* (galip nut tree)	
Swamp	Limited	Limited	Very limited
- Common species	*Metroxylon sagu* (sago palm)	*Metroxylon sagu* (sago palm)	
Beach	Rocky	Rocky	Sandy
Reef-limestone terrace	None	None	Extensive
- Common species			Limited fruit trees *cocos nucifera* (coconut palm), *Canarium indicum* (galip nut)
Dependence on terrestrial resources	High	High	Low
Marine ecosystems			
Reef lagoon	Limited	Limited	Extensive
Reef flat	Extensive	Extensive	Extensive
Slope	Steep	Steep	Gradual
Common reef-associated fish species*	*Lutjanus gibbus, Naso caesius, Naso hexacanthus, Pterocaesio tile, Acanthurus lineatus, Macolor macularis, Chlorurus japanensis*	*Acanthurus auranticavis, Chlorurus bleekeri, Acanthochromis, polyacanthus, Chlorus japanensis, Scarus niger, Naso caesius*	*Lutjanus bohar, Lutjanus fulviflamma, Acanthurus olivaceus, Chlorurus bleekeri, Acanthurus auranticavis, Acanthurus grammoptilus, Parupeneus multifasciatus, Siganus vulpinus*
Pelagic (deep water) fishing grounds	Extensive	Extensive	Extensive
Common pelagic fish species**	*Katsuwonus pelamis, Thunnus albacares, Thunnus obesus*	*Katsuwonus pelamis, Thunnus albacares, Thunnus obesus*	*Eythynnus affinis, Thunnus obesus, Elagatis bipinnulata*
Dependence on marine resources	Low	Low	High
Customary marine management			
Type	Rotating reef closures	Rotating reef closures	Clan owned areas with gear restrictions
Strength	Strong	Strong	Weak

Table 2-2. Summary of socioeconomic and ecological conditions of study sites.

Note: *Common species based on biomass. **Pelagic species in Karkar based on Havice and Reed (2012), and in Ahus based on unpublished catch data.

Figure 2-3. Thesis map: *Chapter Two* to *Chapter Three.*

3 What matters to whom? Ecosystem services in developing coastal communities

• Adapted from **Lau, J.**, Hicks, C., Gurney, G. & Cinner, J. 2019. What matters to whom and why? Understanding the importance of ecosystem services in coastal developing communities. Ecosystem Services. 35: 219-230

***Contribution**: I developed the research question for this chapter, collected and analysed data, and wrote the chapter. The rating and ranking exercise was based on Hicks (2013). JEC designed and collected the socio-economic surveys used to elicit socio-economic variables. CCH, JEC, and GGG provided advice on the research question, design of data collection, analysis of data, and assisted with structuring and editing the manuscript.*

Abstract

Coastal ecosystems support the livelihoods and wellbeing of millions of people worldwide. However, the marine and terrestrial ecosystem services that coastal ecosystems provide are particularly vulnerable to global environmental change, as are the coastal communities who directly depend on them. To navigate these changes and ensure the wellbeing of coastal communities, policy-makers must know which coastal ecosystem services matter to whom, and why. Yet, capturing people's perceptions of the importance of ecosystem services is challenging in developing coastal settings for several reasons. Firstly, coastal ecosystem services encompass both terrestrial and marine services across multiple categories (i.e. provisioning, supporting, and cultural) that are difficult to value together. Secondly, widely used monetary valuation techniques are often inappropriate because of culturally specific attributions of value, and the intangible nature of key cultural ecosystem services. Thirdly, people within communities may hold different ecosystem services values. In this chapter, I examine how people ascribe and explain the importance of a range of marine and terrestrial ecosystem services in three coastal communities in Papua New Guinea. I use a mixed-methods approach that combines a non-monetary ranking and rating assessment of multiple ecosystem services, with a socio-economic survey (N=139) and qualitative explanations of why ecosystem services matter. I find that people uniformly ascribe the most importance to marine and terrestrial provisioning services that directly support their livelihoods and material wellbeing. However, within communities, gender, wealth, and years of formal schooling do shape some differences in how people rate ecosystem services. In addition, although cultural ecosystem services were often rated lower, people emphasized that they ranked provisioning services highly, in part, because of their contribution to cultural values like bequest. People also expressed concern about extractive ecosystem services, like fuelwood, that were perceived to be destructive, and were rated low. I contend that comprehensive ecosystem services assessments that include narratives can capture the broad importance of a range of ecosystem services, alongside relational values and normative judgements. This exploratory approach is a useful step towards understanding the complexities of ecosystem services in developing coastal settings.

3.1 Introduction

In the context of global environmental change (Steffen et al., 2018, 2015), safeguarding coastal and marine ecosystems is a crucial challenge. Changes to marine and coastal ecosystems will directly affect the world's least developed countries (Blasiak et al., 2017; Sumaila et al., 2019), and the communities who most directly depend on marine resources (Cinner et al., 2012). Although ecosystem services approaches are uniquely poised to inform management by eliciting the diverse values people hold for coastal ecosystems. However, further research is warranted. The bulk of empirical marine ecosystem services assessments are in Western, developed countries[7] - mostly in Northern Europe and Northern America (Liquete et al., 2013; Schaafsma and Turner, 2015) - rather than the low-income coastal and island countries most vulnerable to environmental change. Work in the Pacific, in particular, is nascent (Folkersen, 2018; Laurans et al., 2013; Liquete et al., 2013). To date, research in the Pacific has highlighted the importance of a range of ecosystem services for developing coastal communities, particularly for livelihoods. For instance, in Navakavu, Fiji, a locally managed marine protected area benefitted people through fisheries (commercial and subsistence), coastal protection, bequest value and education to an estimated total value of $1,795,000 (USD) per year (O'Garra, 2012). In four coastal villages in the Solomon Islands, fisheries products supported both subsistence and cash income for over 90 percent of the population (Albert et al., 2015). Most marine ecosystem services assessments to date have focused on fisheries (often assessed at market value), recreation, and tourism (Liquete et al., 2013). In the Pacific, specifically, studies of coral reef ecosystem services have focused predominantly on fisheries, tourism and coastal protection, but have struggled to include and value subsistence fisheries (Laurans et al., 2013).

Although studies to date emphasize that a range of ecosystem services matter monetarily to coastal developing communities, there is less work that captures how people value ecosystem services in multiple ways (Arias-Arévalo et al., 2018). Thus, although provisioning services are and will remain crucial in the Pacific (and globally, see Lillebø et al., 2017), there is need to capture the variety of ecosystem services that developing coastal communities value, including cultural ecosystem services, across the land and sea-scape (i.e. marine and terrestrial, and cross-overs between these). Like ecosystem services more broadly, most studies of cultural marine

[7] This geographical skew is also evident in ecosystem services research more broadly (Cruz-Garcia et al., 2017).

ecosystem services have been in developed, Western countries and have examined tangible cultural ecosystem services such as leisure and recreation (Garcia Rodrigues et al., 2017). In developing countries, less tangible cultural ecosystem services, like bequest values, may not only be more important (O'Garra, 2009; Oleson et al., 2015), but recreation and tourism benefits may be negligible or non-existent (Laurans et al., 2013; Pascal et al., 2012). For instance, in Fiji, people were willing to pay a significant proportion of household income to protect the bequest values of coral reef fisheries (measured through contingent valuation), whereas they were unwilling to accept loss of fishing grounds to future tourism ventures (O'Garra, 2009).

Capturing the importance of a range of marine and terrestrial ecosystem services across provisioning, cultural and supporting categories (hereafter referred to as a comprehensive assessment) requires a non-monetary methodology. Common economic methodologies fail to capture key cultural considerations (Laurans et al., 2013). For instance, many parts of the Pacific do not operate or value things solely as part of a cash economy, and 'the value that local communities attribute to money, and its function in life, differs widely from common economic assumptions' (Laurans et al., 2013, p. 140). Thus, there is a need to develop valuation that incorporates the needs of low-income countries and places that do not operate solely in a cash economy (van den Belt and Stevens, 2016). Non-monetary valuations can more inclusively reflect the cultural values and social norms of low-income countries (Folkersen, 2018), better capture plural values (Arias-Arévalo et al., 2018), and are thus more appropriate in developing coastal communities. However, studies using such non-monetary techniques are rare (but see Hicks et al., 2015 for a regional study of developing coastal communities in the western Indian Ocean; and Kenter et al., 2011 for deliberative approaches to monetary valuation in developing country contexts).

Alongside a comprehensive assessment of coastal ecosystem services, there is a well-established need to disaggregate ecosystem services valuations by demographic or other relevant socio-economic characteristics. Aggregated assessments may obscure the interests of different groups within a society or community. Within coastal communities, people use, value, and access ecosystem services differently, often based on socio-economic identities like gender, class, and ethnicity (Daw et al., 2011), and the entitlements these characteristics support (Fisher et al., 2014). For example, managers, scientists and fishers differ in the extent to which they prioritize ecosystem services like fishery and coastal protection (Hicks et al., 2013). Furthermore, within the same livelihood group (e.g. smallholder farmers), people's individual preferences for ecosystem services can differ based on differences in generational cohort and education (Tauro et

al., 2018). Different benefits likewise accrue at different scales. For instance, the economic value of tourism at a national level is often far greater than local level contributions to wellbeing (Hicks et al., 2009).

However, although ecosystem services approaches are starting to recognise the need to incorporate different social groups, disciplines that traditionally inform policy and management on coasts, still tend to be blind to the heterogeneity of communities. Fisheries research treats communities (rather than groups within communities) as subjects of resource management and tends to offer technocratic solutions to resource degradation, without attention to power imbalances or competing values (Campling et al., 2012). Fisheries management itself often misses the role that gender and age relationships play in shaping small-scale fisheries (Bavington et al., 2004; Neis et al., 2013). These relationships, and relationships around caste, class, and ethnicity, are likely to come under increasing pressure in the context of global environmental and social change (Coulthard, 2011). For instance, in the Solomon Islands, increasing ties to the global economy have driven up the cost of basic household items like rice, in turn, increasing pressures on coral reefs, which provide some of the only resources for income generation. In this context, new markets for coral extraction (e.g. the aquarium and curio trade) have the potential to exacerbate inequities, by enabling a few community members to make economic gains at the expense of community and reef resilience (Albert et al., 2015). Capturing the different values people place on coastal services (and likewise capturing where values are shared e.g. Kenter et al., 2015), can help decision and policy-makers understand where costs and benefits brought about by changed ecosystems and/or changed management might fall. This knowledge is key for making informed and equitable decisions that do not harm people.

Ecosystem services approaches are making progress in identifying and incorporating the diverse and plural values people hold towards ecosystems. Recent ecosystem services programmes and organizations recognize and emphasize the ‘multiple ways in which ecosystems and ecosystem services are important for people and how these multiples ways of importance are related’ (Arias-Arévalo et al., 2017, p. 43). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) explicitly recognizes people’s plural knowledges, values, and worldviews as key to equitable management and assessment (Berbés-Blázquez et al., 2016; Díaz et al., 2018; Pascual et al., 2017). Eliciting plural values for ecosystem services is a necessary step towards the recognition of different worldviews and perspectives (Kenter et al., 2015). Ecosystem services are important and valued for one or a combination of instrumental (as a means to an end), intrinsic (as an end in itself), and relational (relations and responsibilities

among people, and between people and nature) values (Arias-Arévalo et al., 2017; Chan et al., 2016). A recent study in Colombia emphasized that rather than a dichotomy between instrumental and intrinsic values, people often draw on multiple values, suggesting that integrating value pluralism will be important as environmental valuation progresses (Arias-Arévalo et al., 2017). Exploratory qualitative and narrative work is useful to capture why people ascribe importance to specific ecosystem services or relationships with ecosystems (Satterfield et al., 2013).

In this chapter, I aim to provide a socially differentiated approach to understanding the importance of provisioning, supporting and cultural ecosystem services from both sea- and landscapes (i.e. marine and terrestrial) to coastal communities in Papua New Guinea. I also aim to capture the plural values underpinning people's perceptions of ecosystem service importance. Specifically, I ask which ecosystem services people in coastal communities deem important and why, and whether this importance is socially differentiated. I use a mixed-methods approach, combining quantitative and qualitative methods in the three communities described in *Chapter Two*. These methods include key informant interviews, a ranking and ranking exercise combined with qualitative explanations, and informal interviews and observations in each community. The chapter proceeds as follows, I first introduce my quantitative and qualitative approach and analysis. I then present my key results, beginning with aggregated ecosystem service importance, and then examining whether socially differentiation shapes how importance is ascribed, and how people explain ecosystem services matter to them. I then situate these results with findings in the Pacific more broadly and discuss implications for policy and practice in Papua New Guinea. Finally, I discuss broadly how comprehensive assessments can assist policy-making in the region, and whether qualitative explanations may in fact be useful to elicit values that, in other methods, may be subsumed under cultural ecosystem services.

3.2 Methods

Identifying relevant ecosystem services

I define ecosystem services as the benefits people gain from nature (Costanza et al., 2017), encompassing both direct and indirect services, and services where ecosystems support benefits (e.g. sanitation). I selected ecosystem services through a combination of a literature review (Hicks et al., 2015; drawing particularly on Hicks and Cinner, 2014), key informant interviews, and detailed observations in each community. I then used key informant interviews to pilot

photographs and descriptions of each service (tailored to each community). I selected photographs from previous trips to each village (taken by JEC) or took new photos myself during the pilot phase. The subject of each photo was selected if it was locally relevant and recognizable, and simple enough to depict a specific ecosystem service without needing extensive explanation. In all villages, my first key informants were clan leaders, who then identified one or two other informants from their clan to interview. I specifically asked leaders to identify people with different socio-economic characteristics to ensure a more balanced representation of gender, age and wealth in these initial interviews. Initial key informant interviews were conducted in English and translated into Papua New Guinean Tok Pisin and back by research assistants. Subsequent interviews were conducted in Tok Pisin, assisted by language assistants who clarified meaning and translated to English if needed.

I piloted the ranking and rating exercises that have been used in the western Indian Ocean (Hicks and Cinner, 2014) but not in Papua New Guinea. Although I initially focused on reef-related ecosystem services, interviews and observations quickly highlighted that terrestrial ecosystem services were important to both coastal communities. I therefore included terrestrial services in my final list. Unfortunately, I did not include forest habitat, forest edible foods, or forest bush meat in the list, in part, because of my initial focus on reefs, but more importantly I wanted to keep the list of ecosystem services succinct for the ranking and rating exercise. The eleven ecosystem services identified were crops (including both cash and subsistence garden crops), forest materials, reef materials, fishery (including fish, molluscs etc.), education/ knowledge, bequest values, tradition, recreation, habitat, coastal protection, and sanitation (Figure 3-1). I chose to keep fishery and reef materials separate because in Papua New Guinea, burning coral to produce lime is a common practice. I also observed coral rubble being used to build semi-permanent houses in Ahus.

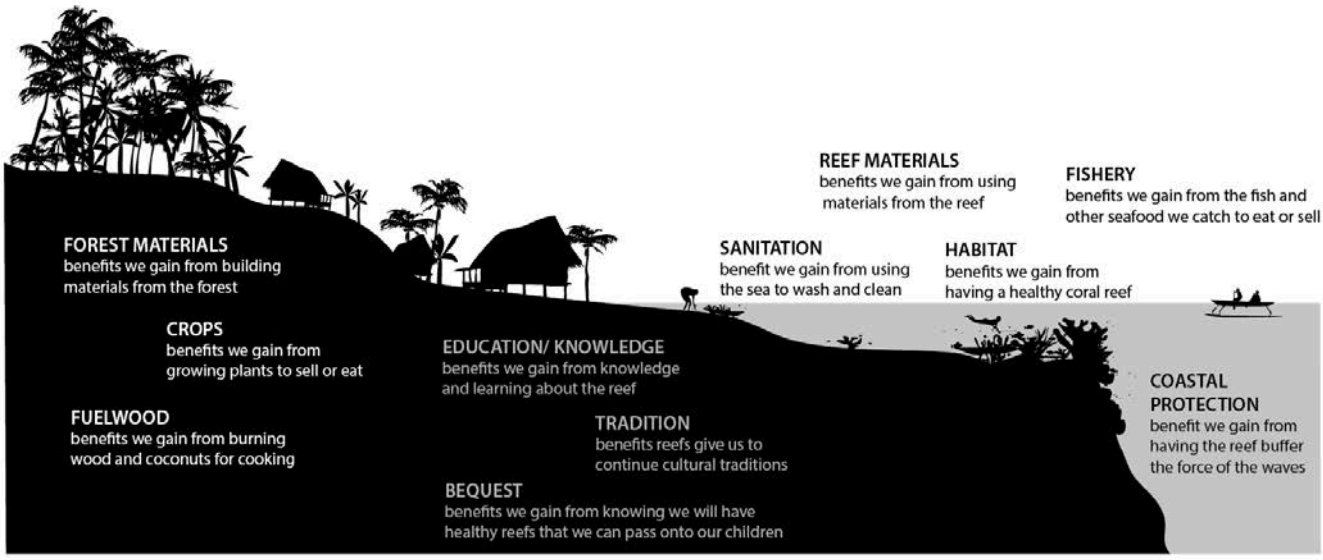


Figure 3-1. Coastal ecosystem services and descriptions.

Notes: Ecosystem services were identified in key informant interviews and used in ranking and rating exercise. Ecosystem services are arranged left to right from terrestrial (white text), to cultural (grey text) and marine (black text).

Sampling strategy

I surveyed a total of 139 community members (67 women and 72 men), from households in Ahus, Muluk, and Wadau (see Table 1). In each site, I systematically sampled every third household, starting in the South of Wadau and moving North into Muluk, and starting on the Eastern side of Ahus island. I surveyed the household head, asked individual level questions to both wife and husband (where applicable), and carried out the rating, ranking and explanation exercise with each respondent individually, away from their partner to avoid bias. Within this sample, I asked three out of every four couples to provide qualitative explanations of the ranking exercise.

Sampling	Wadau	Muluk	Ahus	Total
Women	15	16	36	67
Men	14	19	39	72
Total individuals	29	35	75	139
Total households*	16 (22.2%)	22 (22.9%)	46 (32.2%)	90

Table 3-1. Sampling distribution at Muluk, Wadau, and Ahus.

Note: * Parenthesis indicates percentage of households sampled per total number of households per village.

Selecting and measuring socio-economic characteristics

I included eight socio-economic characteristics that might affect the sorts of ecosystem services that people deemed important. This selection was based on a review of literature in ecosystem services and political ecology (see Table 3-2), and on JEC's detailed knowledge of the sites accumulated over more than a decade of regular fieldwork visits. I take an exploratory approach using pre-defined social differences, rather than a targeted approach that first identifies key differences through a situated case study at a given site (Daw et al., 2011). I examined age, gender, livelihoods (including main source of livelihood and livelihood multiplicity), migrant status, two measures of wealth (material style of life and fortnightly expenditure), and years of formal education (see Table 3-2). Age and years of formal education were measured in years. Gender and migrant status were binary. I measured both people's main livelihood source and livelihood multiplicity. Livelihood multiplicity was measured as the total number of different livelihoods within a household (see Table 3-2). The main source of livelihood was the livelihood respondents ranked most important out of fishing, gleaning, cash crops, farming, informal activities (e.g. a small store), tourism, salaried employment, and other (which I asked respondents to specify). I categorized these into one categorical variable with three categories including marine (fishing and gleaning), terrestrial (cash crops, farming) and other (informal activities, tourism, salaried employment, and other). Alongside livelihood, I used two indicators of wealth to better capture the multidimensional nature of poverty. The first indicator was a material style of life indicator (hereafter wealth), based on the presence or absence of household possessions and structures; e.g. thatched roofing, electricity, poultry (Pollnac and Crawford, 2000). I used a principal component analysis (PCA) to calculate a single indicator from these variables, which explained 59% of variance (see Table S for factor loadings). The second wealth indicator was an estimate of household expenditure in the previous fortnight, in Papua New Guinean Kina.

Socio-economic characteristic	Measurement	Mechanism and examples
Age	Years	People in different life stages and cohorts hold different priorities, levels of family responsibility, and legitimacy around natural resource governance (Colfer, 2011). These age-related differences influence people's entitlements to ecosystem services (Daw et al., 2011; Fisher et al., 2014), and thus their perceived importance. E.g. Age has been shown to correlate with acceptance of certain conservation tactics (e.g. increased taxes) (Blasiak et al., 2015).
Gender	Woman or man (binary)	Gendered identities, norms, responsibilities, and opportunities shape how women and men use, perceive, prioritize and value different ecosystem services. E.g. In Zanzibar, women and men use different ecosystem services across the seascape, and these ecosystem services contribute differently to subsistence and income (de la Torre-Castro et al., 2017). In the USA, women and men hold different readiness to act on conservation issues (Blasiak et al., 2015).
Livelihoods	Main source of livelihood: Marine, Terrestrial and Other (categorical) Livelihood multiplicity: number of different livelihoods pursued per household	Social actors pursuing different livelihoods and with differing levels of livelihood diversity, have different interests in and emphasize different levels of importance of ecosystem services (Caceres et al., 2015). E.g. In four sites in rural Asia, a participatory valuation of aquatic resources found that fishers and farmers valued freshwater ecosystem services very differently to government officials and business owners. (Brooks et al., 2014)
Migrant status*	Migrant or non-migrant (binary)	The context and timing of migration and how migrants assimilate into their host community, is important in explaining associations between migration and environmental impacts (Cassels et al., 2005). E.g. In Papua New Guinea, strong user rights mean that outsiders usually excluded from fishing coral reefs (Cinner, 2009).
Wealth	Material style of life measure based on material possessions (see Table S1) Fortnightly expenditure (in PNG Kina)	Often, but not always, people living in poverty are more directly dependent on ecosystem services (Fisher et al., 2014). Even within livelihood groups, wealth influences how people will respond to environmental change (Cinner et al., 2011). E.g. In Kenya, fishers with higher expenditures and high amenities scores (i.e. those who with greater economic wealth) expressed that they would fish harder and change gear in response to declines in the fishery (Cinner et al., 2011).
Years of formal education	Years of school completed	Formal schooling plays an important role in education for sustainable development (Hopkins and McKeown, 2002), and thus may influence the sorts of ecosystem services people deem important. E.g. In South east Asia people with a higher level of education valued parks for their regulating services (Sodhi et al., 2010).

Table 3-2. Summary of socioeconomic characteristics measured.

Notes: Includes measurement, and summary of how people with these different characteristics may ascribe importance to ecosystem services differently, with examples. *In my sites, migrants are usually women who have married into the villages from outside, and thus marry into clan rights to reef resources

Rating and ranking ecosystem services

I used the ecosystem services photographs with descriptions to elicit the importance people ascribe to marine and terrestrial ecosystem services. I first introduced each ecosystem service by showing respondents the photograph, and briefly describing the ecosystem services that it represented. I then asked respondents to rank the ecosystem services in order of importance to their lives. To capture multiple reasons people may value ecosystem services, I left the specific definition of importance open to interpretation (Díaz et al., 2015). For instance, fish could be important for food and income, social relations through sharing, and/or to a persons' identity as a fisher. When the photographs were lined up in order of importance, I asked people to explain their ranking. These explanations also helped to ensure respondents had understood the point of the ranking and rating exercise. When respondents' explanations suggested they had deviated from ranking in order of importance, I then re-explained the aim of the exercise, and used their subsequent scores in my analysis. Explanations were written down in Tok Pisin and English and checked for accuracy by research assistants.

I then spread the photographs out randomly and asked respondents to place counters on the photographs to indicate which were most important to their lives. Unlike the ranking exercise, respondents could place multiple counters on the same photograph, could spread them equally between more than one, or could place several on one ecosystem service and one or two on another. I handed respondents five counters at a time, waiting for them to place all five before handing them another five. This approach gave respondents more time to consider their placement. In total respondents received 20 counters, over four rounds. Each round was then weighted, with round one given the most weight and round four the least (see Hicks et al., 2015). I normalized these weighted scores to create continuous data.

Analysis

To test for differences between how people with socio-economic characteristics ascribed importance to ecosystem services I ran general linear mixed-models, with the weighted rate score for each ecosystem service as the outcome variable and socio-economic characteristics as the predictor variables. Significant variables indicated a difference in how people rate services. For each model, a priori I specified community and household as random effects to account for the nested structure of the data (i.e. individuals nested in households, nested in community). None of

the socio-economic characteristics used in the models suffered co-linearity, with variance inflation factors all below 5 (see Table S2). I also performed a principle component analysis (PCA) to visualize the relationships between socio-economic characteristics and the importance of key ecosystem services across communities. I included only the ecosystem services and socio-economic characteristics and with significant relationships in my models.

As well as including gender as a binary variable in my models, I also explored intra-household gender differences by calculating the difference between ranks and rating for married pairs of respondents. Specifically, I subtracted the woman's rank score from the man's rank score to calculate the within-household difference in ranking, and the woman's rate score from the man's rate score to calculate the difference in rating. This approach allowed me to control for differences in household livelihoods and wealth because both respondents were from the same household. I performed one-sample t-tests on the household ranking and rating difference scores to determine whether there were significant differences between women and men within households (see Appendix A3).

I coded the qualitative explanations of the importance of ecosystem services thematically around key contributions to wellbeing (material, subjective, and relational) and (where possible) value domains (instrumental, intrinsic and relational) in NVivo (see Appendix A2, table S4 for detailed explanation of coding). I also identified emergent themes including perceptions of links across ecosystem services. I compared these explanations across different social groups (i.e. by age, clan, gender). In the following section, I triangulate between the results from the rating and ranking exercise and respondents' qualitative explanations.

3.3 Results

Across all sites, people ascribed most importance to the provisioning marine and terrestrial ecosystem services that directly contributed to their livelihoods (Figure 3-2). Most people ascribed importance to ecosystem services that directly contributed to material wellbeing, and especially to basic needs, through food, income, and shelter (i.e. forest materials). For instance, in Karkar, one woman explained that "*Crops*[8] are important, we benefit from them and can look

[8] Italicized words emphasize when a respondent was referring to a specific ecosystem service (i

after our kids. That's the only way we get money to buy things". In Ahus, there was emphasis on fish as the only form of food and livelihood; "*Fishing* and work to do with the sea is our only living" (Woman, Ahus). People with different livelihoods ascribed importance to the provisioning services that supported those livelihoods (Figure 3-3, Table 3-3) although the respondent's main source of livelihood was only significantly associated with ascribing importance to crops. This result reflects the different livelihood portfolios of people in Karkar and Ahus (Table 2-2, Figure 3-3).

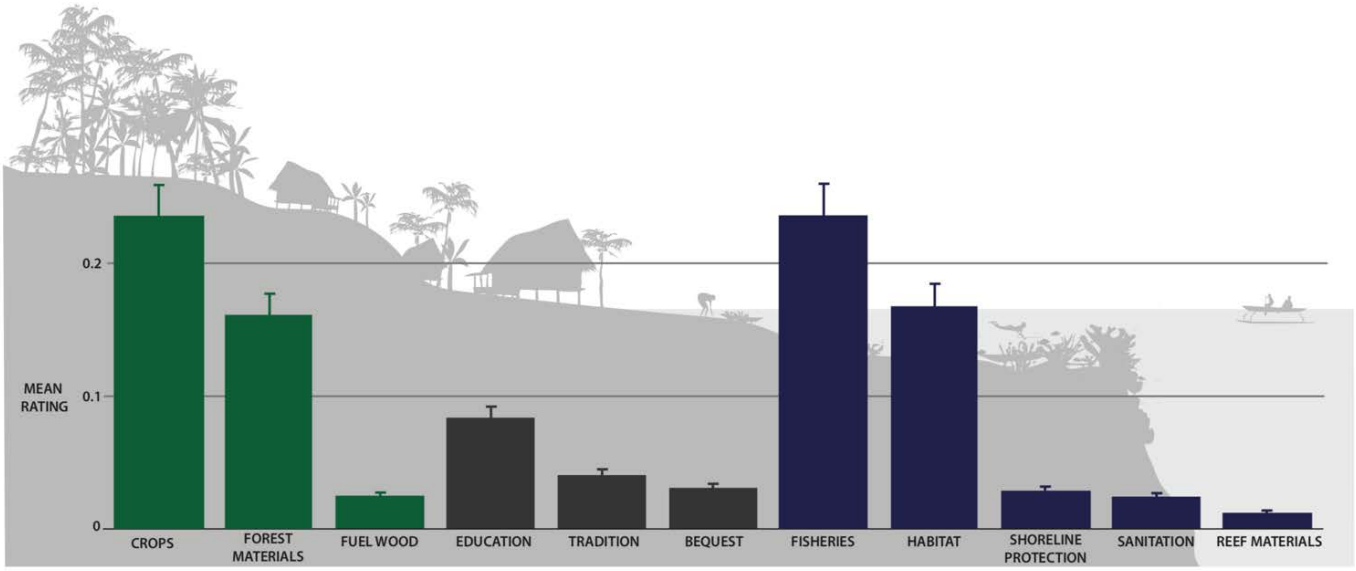


Figure 3-2. Mean weighted rating value for the ecosystem services across all sites.

Notes: Colours represent terrestrial (green), cultural (grey), and marine (blue) ecosystem services. The five ecosystem services rated most important encompassed provisioning, supporting, and cultural categories. Note that there are provisioning and supporting services within marine services.

People also ascribed importance to indirect ecosystem services that they perceived supported direct benefits (e.g. habitat and fisheries). Often, those who perceived that indirect services contributed to direct services had more years of schooling and were wealthier (Table 3-3). For instance, those who had completed more years of formal schooling ascribed higher importance to education and knowledge ecosystem services and habitat, and less to fisheries (Table 3-3). However, many explained that they had ranked and rated these indirect services as important because they directly contributed to other services. For instance, one man in Ahus explained that "*Education/ knowledge* leads to good habitat and good fish, which are good for catching and going to market, and helping family (*bequest value*)". These perceptions were also socially

differentiated by gender. Men tended to rate education and knowledge ecosystem services higher than women (Figure 3-3, Table 3-3, Table 3-4.

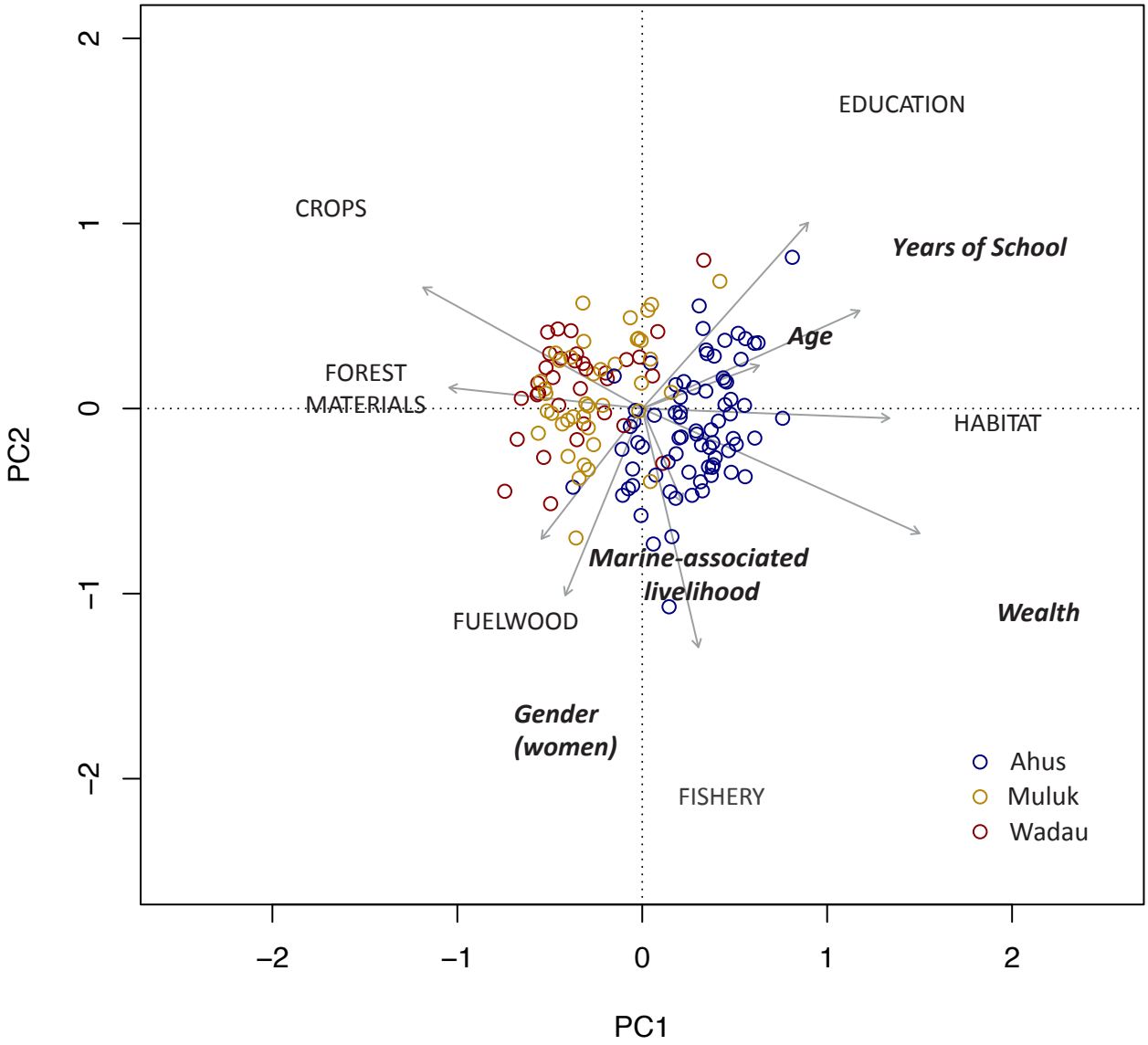


Figure 3-3. Principle component analysis (PCA) of relationship between socio-economic characteristics and importance ascribed to ecosystem services across all sites.

Notes: Socio-economic characteristics are in bold, italicized font and ecosystem services are capitalized. PC1 and PC2 explain 44.74 percent of variance. Socioeconomic characters were included if they were significant in models.

Ecosystem service	Significant variables		
	Variable	Value	P value
Terrestrial			
Crops	Main source of livelihood	0.072	0.0269*
Forest Materials	Wealth (MSL)	-0.052	0.0001***
Fuelwood	Age	-0.001	0.0369*
	Gender (women)	0.026	0.0463*
Cultural			
	Gender (women)	-0.064	0.0141*
Education and knowledge	Years of formal schooling	0.015	0.0046**
Tradition	None		
Bequest value	None		
Marine			
Fishery	Years of formal schooling	-0.018	0.0193*
	Wealth (MSL)	0.041	0.0118*
Habitat	Wealth (MSL)	0.0599	0.0000***
Shoreline protection	None		
Sanitation	None		
Reef materials	None		

Table 3-3. Differences in ecosystem services ratings based on socio-economic characteristics.

Notes: Analysed using General Linear Models. See Table S3 for full models. *p < 0.05, **p < 0.01, ***p < 0.001.

In addition, although cultural ecosystem services were usually ascribed low importance (Figure 3-2), many people expressed that cultural ecosystem services could only be realised through provisioning services. For example, in Ahus, one woman emphasized that "when habitat is good then there are plenty of fish, which we can use for celebrations (*tradition*)". In this explanation, the habitat service ultimately supports fisheries benefits, which in turn supports the cultural service of tradition. People explained that cultural ecosystem services contributed to subjective wellbeing, through a sense of identity and relationships of care towards specific ecosystem services. They were also considered important to maintaining relationships with others in the community. For example, "It's custom (*tradition*) to give fish away and share, this custom is necessary to be happy" (Man, Karkar). Thus, when rating and ranking, people considered the relationships between ecosystem services, rather than viewing them as separate, stand-alone benefits.

People also expressed judgements about what was correct and responsible use of ecosystem services. For example, often people who explained part of their identity as being linked to the sea, also expressed the need for stewardship. For instance, in Ahus one woman said,

> "We are people of the sea, so we must have a good, clean reef [*habitat*], and we must look after it well. The sea is first… It's the place for growing life. All other things depend on conserving the sea. If we look out for the environment, it will look out for us. If not, the environment won't look out for us".

Some articulated a sense of stewardship and care that was necessary in order to enjoy other benefits. For instance, one woman in Ahus emphasized that "[We] can have *traditions* if we respect the *fish*." The emphasis on traditions being possible only when people are respectful, suggests that some people perceive ecosystem quality (or quantity) as a result of good stewardship or correct behaviour or, in other words, hold normative judgements about the correct behaviour towards ecosystem services.

All respondents ascribed less importance to ecosystem services that they perceived as damaging to the environment. Fuelwood, shoreline protection, sanitation, and reef materials were consistently rated low (Figure 3-2). People (in both Ahus and Karkar) perceived that using and benefitting from these more 'destructive' services, especially coral reef materials and sanitation would ruin the environment. One man in Ahus explained that, "*coral materials* come last [in ranking] because [using them] will ruin everything else". In Karkar, one woman said 'I don't think *sanitation* is good; it's bad for the reef. I'm not happy with cutting *fuelwood*, or using *coral materials*, we'll ruin the environment". Others, who ascribed importance to firewood or reef materials, still offered caveats about how these services should be used. Specifically, many emphasized that people should only use dead fuelwood or dead coral materials. For instance, in Ahus, a woman emphasized that with "*fuelwood*, you should only cook with dead firewood, not live". One man in Ahus emphasized that with "*reef materials*… you can collect dead ones; the live ones should be left. Lime: that's live so that's bad. Only the dead stones should be used".

Ecosystem service	Gender differences			
	Ranking (more important)	P value	Rating	P value
Terrestrial				
Crops				
Forest Materials			Women	0.0006***
Fuelwood	Women	0.0056**	Women	0.0001***
Cultural				
Education and knowledge	Men	0.0003***	Men	0.0001***
Tradition				
Bequest value				
Marine				
Fishery				
Habitat				
Shoreline protection	Men	0.0201*		
Sanitation	Women	0.0343*		
Reef materials	Women	>0.000***		

Table 3-4. Within-household gender differences in ranking and rating.

Notes: See Table S5 for more detail. *p < 0.05, **p < 0.01, ***p < 0.001.

Although consistently lowly rated, compared to men, women often ascribed slightly more importance to the ecosystem services that were perceived to be destructive. Specifically, I found that women ascribed more importance to fuelwood (Figure 3-3, Table 3-3). These gender differences held (for both ranking and rating) when I tested at an intra-household level (Table 3-4). In addition to fuelwood, I also found that within households, compared to men, women tended to rank forest materials, sanitation, and reef materials higher (Table 3-5). Finally, within households, men tended to ascribe more importance to indirect ecosystem services including education and knowledge, and, in ranking, shoreline protection.

3.4 Discussion

Material needs, relational values, and social differences

In the context of global environmental change, identifying and safeguarding the coastal ecosystem services most important to developing coastal communities in the Pacific, will be a crucial task for policy-makers, conservationists and development professionals alike.
In developing coastal communities in Papua New Guinea, people ascribe most importance to the provisioning services that support their livelihoods. However, people also emphasize instrumental

and relational values when explaining why ecosystem services matter to them (Arias-Arévalo et al., 2017), and identify that ecosystem services contribute to all aspects of wellbeing (Coulthard et al., 2011). I discuss these key findings in turn, before exploring their wider implications for conservation and development in coastal communities in Papua New Guinea and the Pacific more broadly.

The direct, provisioning services that support coastal livelihoods, are crucially important to developing coastal communities. Similar to existing studies of ecosystem services in the Pacific (Albert et al., 2015; O'Garra, 2012), I found that people attributed most importance to provisioning services that directly contributed to their livelihoods: whether terrestrial or marine. In the Solomon Islands and in other regions, provisioning services support crucial basic needs in developing coastal communities (Albert et al., 2015; Chaigneau et al., 2018). Likewise, in China, people whose livelihoods depend directly on wetland ecosystem services, value ecosystem services very differently to those who were in decision-making roles, who did not derive their livelihoods directly from wetlands (e.g. government officials and business leaders) (Brooks et al., 2014). Work on terrestrial ecosystem services in developed countries, has likewise found that people's livelihoods are key to how they perceive ecosystem services (Caceres et al., 2015). Interestingly, in our study, livelihood multiplicity (i.e. how many livelihoods people pursued) did not differentiate the importance ascribed to ecosystem services.

Many have argued against combining intangible cultural ecosystem services with other categories in integrated ecosystem service assessment, because they are incommensurable with more tangible services (Chan et al., 2012), and can be nebulous (Fish and Church, 2014). Although I pursued an comprehensive assessment of different types of ecosystem services, I also found that cultural ecosystem services tended to be lowly ranked in my sites. However, my qualitative results emphasized key aspects of cultural ecosystem services and relational values that were not apparent in the rating and ranking exercise. For instance, in my sites people did not tend to ascribe high importance to bequest values in the rating exercise. This result contrasts with studies of bequest values in the Asia-Pacific (O'Garra, 2009) and the western Indian Ocean (Oleson et al., 2015), which found bequest to be highly valued. However, rather than not valuing bequest, my respondents tended to see provisioning services as important means to ensuring bequest values, rather than ascribing importance to bequest as a value in itself. They expressed a sense of stewardship and care in their qualitative responses that reflects concerns for bequest values. Hence, I suggest that comprehensive ecosystem services assessments should be tentative about

including cultural ecosystems services. The somewhat blurry line between cultural ecosystem services and relational values seem better elicited in narrative form (see below).

Although people in both sites ascribed most importance to provisioning services, they nonetheless alluded to all aspects of wellbeing (material, subjective and relational) when they explained why ecosystem services mattered to them. These qualitative explanations also elicited a number of relational values and suggest that people drew on local environmental knowledge in their ranking. For instance, people often articulated links between ecosystem services like reef habitat and fisheries and ranked them accordingly. Thus, local environmental knowledge likely played a role in the importance ascribed to ecosystem services because people drew on this knowledge to posit causal pathways between benefits from different services. As in developed countries, in developing communities, plural values (especially relational) are embedded in people's narratives about why ecosystem services matter to them (Arias-Arévalo et al., 2017). This narrative form of eliciting values better captures the sorts of intangible cultural values, like bequest values and tradition, that are underpinned by relational values of respect and reciprocity.

My findings emphasize that a sole focus on the ecosystem services considered important, without attention to why, might hide forms of environmental concern or stewardship that may be an important part of cultural identity. My results support the argument that people judge the utility of an ecosystem service in relation to their identities, place, and pro-social beliefs, alongside economic and instrumental benefits (Kumar and Kumar, 2008; Singh, 2015). In my sites, there were culturally specific ways of perceiving ecosystem services. Specifically, customary marine tenure means that people have a sense of ownership, and thus stewardship over resources, that seems disconnected to how important ecosystem services were in relation to livelihoods. For instance, in Muluk, reliance on reefs for livelihoods is low, but support for and adherence to customary systems of management is strong (Table 2-2, *Chapter Five*). In Ahus, even though customary management systems had eroded, there was still the strong sense of being 'people of the sea' with an accompanying responsibility to look after the environment. Recent work contends that the expression of relational values is in fact a useful way to identify cultural ecosystem services. Fish et al. argue for defining cultural ecosystem services 'as relational processes and entities that people actively create and express through interactions with ecosystems' (2014, p. 211). In all my sites, people expressed concern about the 'correct' or 'appropriate' way of co-producing ecosystem services, particularly services like fuelwood and coral reef materials that were considered extractive and damaging. Many people articulated that only dead coral or dead firewood should be used. People's relationship of concern (including care

and responsibility) towards ecosystem services is a ripe arena for empirical work on ecosystem services (Singh, 2015), including whether accompanying normative judgements are gendered (or otherwise socially differentiated), as I found.

Gender is a key blind spot in ecosystem services studies (Brown and Fortnam, 2018). I found several differences in how women and men ascribed value to ecosystem services, and more when I looked specifically at intra-household differences. Unsurprisingly, the ecosystem services that women ascribed slightly higher value to, were both those that are traditionally used by women. In Ahus, rights to burning coral to create lime (which is chewed with betel nut) are matrilineal, and in Muluk when the reef is open, women also make lime to gain a little extra income (although this practice was banned in 2017 when the reef closure was lifted). In both places, fuelwood was almost the only source of fuel for cooking (women's responsibility), although one or two houses in Ahus had access to gas. Women are also responsible for many sanitation practices, including washing pots, pans and clothes.

My results aligned with gendered preferences for fuelwood as an ecosystem service in Kenya and Mozambique, where women also placed more importance on fuelwood (Chaigneau et al., 2018). This result emphasizes that people's perceptions may not accurately capture the contribution of certain ecosystem services to a household. Men also eat the food prepared using fuelwood but did not rank it highly. Intriguingly, this findings suggest that not only is women's contribution often overlooked in fisheries research and management (Kleiber et al., 2014), but perhaps also at a household level by both men and women. Thus, women's work may be unnoticed or undervalued at a household level and at broader scales. Overlooking these contributions might have implications for both accurately assessing pressure on ecosystem services (Kleiber et al., 2014), and properly valuing women's contribution to the wellbeing of their household. However, the differences I found do not (and cannot) reflect the gendered division of labour or other differences across an ecosystem service cascade (as highlighted by Brown and Fortname, 2018). Feminist political ecology theory on how everyday practices around resources reinforce gender identities, may be a useful avenue for ecosystem services to being exploring how social identities (rather than simply the socio-economic characteristics explored here) are implicated in the very practices that co-produce ecosystem services, and thus sustain gender inequities (Nightingale, 2017).

Finally, assessing the importance of ecosystem services (and how this is socially differentiated) cannot identify whether resource use is equitable or not. I agree with Kull et al.'s (2015) argument for using ecosystem services assessments as evidence through which to assess issues of equity, without assuming that equity is embedded in an ecosystem services assessment itself. In other words, understanding the disaggregated importance of ecosystem services is an important first step, but is ultimately insufficient for fostering or designing equitable management. Instead, understanding participation in decision-making, and how needs and desires are recognized and fulfilled is key to environmental justice (Agyeman et al., 2016; Edwards et al., 2016).

Limitations and caveats

My study has several limitations that point to avenues that would improve future work. Firstly, I took an exploratory approach to defining socio-economic characteristics (Daw et al., 2011), rather than a more grounded approach with in-depth ethnographic work to identify key socio-cultural groups (e.g. Lakerveld et al., 2015). Exploratory analysis like this has strength in making broader claims about socio-economic difference, while a grounded approach provides more case-specific, practice relevant information. In addition, while predefined socioeconomic characteristics are a useful exploratory tool, I agree with Fisher et al., that framing differences this way 'may detract from the structural societal processes perpetuating marginalization and poverty' (2014: 38). Had my study been linked with an ecosystem service-based conservation or management project then a grounded approach would have been more appropriate and, indeed, necessary.

Secondly, the ecosystem services identified in my study were not elicited through participatory, shared ecosystem service valuations (e.g. Kenter et al., 2011). Participatory ecosystem services identification, followed by individual rating and ranking would have been valuable, but was not possible in this case, and I wanted to ensure that I captured diverse values across the community to understand social differentiation. Perhaps, in a more participatory environment, the slight importance ascribed by women to ecosystem services perceived to be destructive (e.g. fuelwood) might not have become apparent. How to best elicit ecosystem services and their importance while still leaving space for different values and judgements within a community will be a key challenge for future scholarship. In addition, I was unable to include a comprehensive list of specific terrestrial ecosystem services for two reasons. Firstly, the rating and ranking exercise is more successful and easier to conduct when there are a limited number of things to rate and rank. Thus, I limited the list to eleven ecosystem services in total. Secondly, additional terrestrial

ecosystem services would not have been not relevant across all sites (i.e. in Ahus, people rarely eat bush meat and forest habitat is limited).

Alongside my ecosystem services, the ways I measured some socio-economic variables may not be appropriate in some other settings. For instance, although migration is an important feature of artisanal fisheries worldwide (Allison and Ellis, 2001), in Papua New Guinea, strong marine tenure means that few fishers have the rights to fish in coral reefs that do not belong to their community. For instance, Ahus Island holds customary fishing rights both to waters within its lagoon and between the island and the mainland. Thus, in my sample, most migrants were women who had married into the village from outside. When someone married in from the outside, they gain the clan rights of their husband's clan (in all my study sites it was women who married into the village, rather than men, but this differs in other parts of Papua New Guinea). Thus, in my sample, migrants are more integrated into their communities than, for instance, temporary migrants. However, migration is often much more dynamic, for instance, with local residents migrating to cities and back. My binary variable (migrant or non-migrant) did not capture this dynamism. People who are able to come and go likely relate differently to their home and host ecosystems. Future studies, particularly in places with more temporary migration, should try to capture the more fluid nature of migration.

Implications

My study has several implications for natural resource management and conservation in Papua New Guinea and the Pacific more broadly. Firstly, my findings have highlighted that the provisioning services that support livelihoods are usually ascribed the most importance. Safe guarding fisheries and crops will thus be highly important as the global environment changes. The overwhelming importance placed on these provisioning services supports the argument that, to address poverty and conservation goals together, ecosystem services approaches might find it useful to assess and protect universal human needs (Chaigneau et al., 2018). Provisioning services likely support poverty alleviation in two ways; poverty reduction and prevention (Fisher et al., 2014). In semi-arid areas in Brazil, for instance, fisheries provide a less lucrative but more stable livelihood than aquaculture, and thus preventing poverty through supporting food and livelihood security (Lopes et al., 2018). In developing tropical contexts, transitions from fisheries to aquaculture, or other industries like tourism, must account for synergies and antagonism between ecosystem services use, especially the security that is lost when transitioning to higher

risk, if more lucrative endeavours (Lopes et al., 2015). Thus, development and conservation projects should investigate not only what ecosystem services are important to which livelihoods, but whether they are important for reducing or preventing poverty. While tourism or aquaculture may seem like win-win options for conservation and development, how they interplay with more stable livelihoods, and who is able to benefit, will be key factors in whether they actually support people's wellbeing (Diedrich and Aswani, 2016).

Secondly, coastal communities differ from each other and from within. There are some gender and wealth differences in how people use and thus value ecosystem services. Disaggregated ecosystem services assessments can begin to identify where these differences lie and may be useful for targeting specific conservation or management strategies. For instance, in my study, people with higher levels of formal schooling seem to perceive key links between in-direct and direct ecosystem services (in this study, between reef habitat and fisheries). Thus, enhancing education may not only improve people's wellbeing directly, but may have a flow on effect to environmental knowledge. As such, ecosystem-based management that, for example, targets reef habitat conservation, may gain more traction in places with more education and who are wealthier.

Thirdly, socially differentiated ecosystem services assessments need to take place over time, as peoples' needs and priorities, and reactions to ecosystem change, change themselves. The importance ascribed to ecosystem services will likely change over time as people's livelihoods and priorities shift. Although I found that coral materials were rated quite low in terms of importance, and people in Ahus emphasized that its best to only use dead coral, increasing affluence means that more and more people are constructing semi-permanent houses that require concrete, often made in part with dead corals. This new sort of use (different to the highly-regulated rights to burn coral for lime for chewing betel nut), may shift use of coral in the future, with impacts for reef fisheries.

Finally, people's own judgements about how their ecosystems should be used and governed are crucial for ensuring that management is fair. Assessments that include a qualitative approach that asks people why things matter to them can capture the sorts of relational values that purely monetary, or quantitative techniques cannot. Alongside individual narratives, participatory focus groups would be a valuable approach to explore these questions (Kenter et al., 2015).

3.5 Conclusion

Coastal ecosystem services provide multiple values to communities in developing countries, who directly depend on them. In Papua New Guinea, provisioning marine and terrestrial ecosystem services matter most to people because they support basic materials needs for food and livelihoods. Nonetheless, people also ascribed importance to ecosystem services because they supported material, subjective and relational aspects of wellbeing, and because of the links between direct and in-direct services (e.g. education/knowledge, habitat, and fisheries). Importantly, I found that people bring normative judgements to the ecosystem services that matter to them. Specifically, people expressed relational values of concern about how more extractive ecosystem services like coral materials and fuelwood are used. These more extractive ecosystem services tended to be used and rated slightly more important by women. In other words, I found that the ecosystems services about which people held particular normative judgements were gendered. In addition, here, as in other studies, I found that cultural ecosystem services tended to be ranked and rated lower that direct provisioning services. However, concerns about bequest values, stewardship and identity, were elicited in people's narratives about why certain ecosystem services matter to them. Thus, in contrast with other approaches, I contend that quantitative comprehensive ecosystem services assessments that include less tangible cultural services are likely to miss crucial relational values and normative judgements. Instead, asking people why ecosystem services matter to them helps to identify aspects of bequest values, care and the cultural aspects of ecosystems. In the context of global environmental change, identifying and safeguarding these important coastal ecosystem services will be crucial for ensuring peoples' wellbeing, particularly in developing country contexts where cultural ecosystem services extend beyond tourism and aesthetic values. To do this, policy-makers, conservationists and development professionals alike can draw on the relational values that people already express towards ecosystem services about what is appropriate use and management.

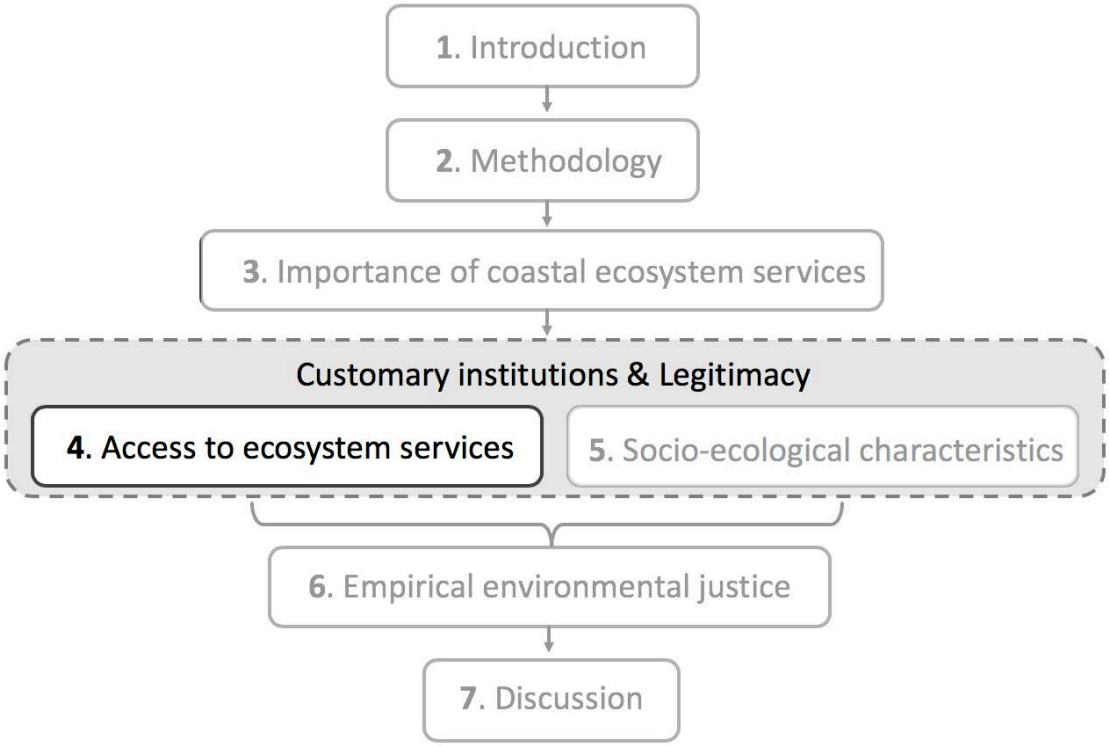


Figure 3-4. Thesis map: *Chapter Three* to *Chapter Four*.

In *Chapter Three* I examined the importance ascribed to coastal ecosystem services and asked whether importance was socially differentiated. However, this Chapter did not capture how people are able to benefit from (i.e. access) ecosystem services. To build on *Chapter Three, Chapter Four* examines dynamics of access more deeply through a case study if Ahus island. It builds on *Chapter Three's* finding that people place importance on provisioning services that support their material wellbeing by explicitly examining access to a range of marine provisioning services in Ahus island.

4 Access to marine provisioning services: incorporating entanglement and legitimacy

• Adapted from Lau, J., Cinner, J., Fabinyi, M., Gurney, G. & Hicks, C (*submitted*). Access to Marine Provisioning Services: Incorporating Entanglement and Legitimacy. World Development.

***Contribution**: I developed the research question for this chapter, collected and analysed the data, and wrote the chapter. JEC, MF, GGG, and CCH provided advice on the research question, study design, data collection and analysis, and assisted with structuring and editing the manuscript.*

Abstract

Ecosystem services have become a dominant paradigm for understanding how people derive wellbeing from ecosystems. However, the framework has been critiqued for over-emphasizing the availability of services as a proxy for benefits, and thus missing the socially-stratified ways that people access ecosystem services. In this chapter I aim to contribute to ecosystem services' theoretical treatment of access by drawing on ideas from political ecology (legitimacy) and anthropology (entanglement). I hypothesize that where customary and modern forms of resource management co-exist, changes in customary institutions will also change people's ability to and means of benefiting from ecosystem services. I ask a) what are the constellations of social, economic, and institutional mechanisms that enable or hinder access to a range of provisioning ecosystem services; and b) how are these constellations shifting as different elements of customary institutions gain or lose legitimacy in the process of entanglement with modernity? Through a qualitative mixed-methods case study in a coastal atoll community in Papua New Guinea, I identify key access mechanisms across the value chain of marine provisioning services. My study finds the legitimacy of customary systems - and thus their power in shaping access - has eroded unevenly for some ecosystem services, and some people within the community (e.g. younger men), and less for others (e.g. women). In addition, different marine provisioning services are shaped by specific access mechanisms, which vary along the value chain. My findings suggest that attention to entanglement and legitimacy can help ecosystem services approaches capture the dynamic and relational aspects of power that shape how people navigate access to resources in a changing world. I contend that viewing power as relational illuminates how customary institutions lose or gain legitimacy as they become entangled with modernity.

4.1 Introduction

Ecosystem services approaches are an increasingly popular paradigm for conceptualizing the relationship between the environment and human wellbeing (Adams, 2014; Díaz et al., 2015; Redford and Adams, 2009). However, there are several theoretical and empirical gaps in how ecosystem services scholarship treats access to benefits. In particular, an overt focus on the aggregate availability of ecosystem services (Wieland et al., 2016) has obscured both the role of people and institutions in coproducing ecosystem services (Palomo et al., 2016) and the uneven distribution of benefits, thereby also obscuring the implications of uneven access to ecosystem services for poverty alleviation and equity (Bennett et al., 2015; Fisher et al., 2014). To better conceptualize how people access benefits from ecosystem services, ecosystem services scholars have turned to political ecology, particularly Ribot and Peluso's theory of access (2003). The theory of access emphasizes that people's *ability* to benefit from things (i.e. natural resources) ultimately derives from a range of social, cultural and economic factors, that fall beyond formal legal or property rights. Thus, analysis of access seeks to 'understand *why* some people or institutions benefit from resources, *whether or not* they have institutionally recognized rights to them' (Ribot and Peluso, 2003: 154; emphases in the original). Access theory emphasized that people benefit from natural resources through a web of means, processes and relations. These means, processes and relations were called access mechanisms. Scholars drawing on access theory seek to understand how these 'webs of power' over a given benefit are created, maintained or controlled, often across large-value chains within broad-scale political economies (Beitl, 2012; Ribot, 2009).

Ecosystem services scholarship has increasingly embraced the theory of access, and a growing number of studies explicitly examine access to ecosystem services (e.g. Berbés-Blázquez et al., 2017; Hicks and Cinner, 2014; Lakerveld et al., 2015; Wieland et al., 2016). For example, along Canada's east coast, geographic location, technical capacity, markets and user conflicts, and (mis-)management are all potential barriers to First Nations people benefiting from shellfish (Wieland et al., 2016). Further, as well as drawing on access theory, ecosystem services scholarship has extended it, by examining what aspects of wellbeing are supported by different constellations of access mechanisms (2017). For instance, Berbés-Blázquez et al. (2017) suggest that the farmers in Costa Rica who pursued the conventional model of plantain production may place greater value on securing material dimensions of wellbeing, while those maintaining traditional practices may do so to maintain a sense of belonging and indigenous identity.

However, the underlying theories of power employed in ecosystem services to date, limit the ability for the framework to engage in the dynamic and relational ways that institutions gain legitimacy to shape access. Specifically, the ideas of entanglement (from anthropology) and legitimacy (from sociology and political ecology) can help ecosystem services extend the treatment of power beyond 'power over' –whereby power resides in stakeholders who have the ability to wield it to their interests (Berbés-Blázquez et al., 2016) – to a relational definition of power that recognizes power as dispersed throughout society (Foucault, 2008). The former approach defines power as a zero-sum game, whereby power is wielded over others or over resources. In the latter approach, power 'circulates and is *exercised* rather than possessed' (Deveaux, 1994, p. 231, emphasis in original). Thus, rather than power residing in individuals or institutions (e.g. Berbés-Blázquez et al., 2016; Felipe-Lucia et al., 2015), power is constantly reconstituted in the relationships that emerge between individuals and institutions. Taken in this sense, power is a 'relational effect of social interaction' (Allen, 2011, p. 1), rather than an existing 'thing' which can be wielded or held. Both structural and relational forms of power are alluded to in Ribot and Peluso's original theory of access (2003); power was broadly defined as both the capacity for actors to affect others' practices and ideas, and as inherent and emergent in relationships, rather than attached to people (2003). I argue that the latter definition has not been adequately incorporated in ecosystem services approaches to access.

I contend that examining entanglement and legitimacy can extend approaches to access in ecosystem services. The idea of entanglement describes how, rather than a linear progression from customary or traditional systems towards modernity (e.g. Rostow, 1971), different parts of customary and modern systems 'entangle' to create multiple forms (Erazo and Jarrett, 2017). Legitimacy and legitimation are seen as a specific form of power that comes from how actors and institutions justify what is or what should be, through moral values and discourses (Hall et al., 2011). Taken together, it follows when modern and customary systems entangle, the aspects that persevere depend on what is successfully legitimized. Incorporating these two ideas deliberately thus moves ecosystem services beyond a definition of power as static or absolute, to capture the dynamic and fluid landscape in which ecosystem services are co-produced. Theories of entanglement and legitimacy are explored in more detail in the following section.

Better understanding the legitimacy and entanglement of institutions shaping access to ecosystem services is particularly important in developing coastal and marine contexts. The ways that customary institutions change, will re-shape people's ability to and means of benefiting from

coastal ecosystem services. What is interesting for scholars of ecosystem services in particular, is how, when and what parts of customary or traditional systems retain legitimacy in the face of this entanglement, what might these mean for access to resources, and by extension, different peoples' wellbeing. Although understanding how informal rules and norms shift with changing economic, social, environmental and political forces has long been the remit of political ecologists (Berry 1992; Elmhirst 2011; Peluso 1996), ecosystem services are only just beginning to incorporate this fluidity (Lakerveld et al., 2015).

In this chapter, I aim to extend and deepen the ecosystem services literature's treatment of access to marine and coastal provisioning ecosystem services and better understand the dynamism of access mechanisms at a local-scale, with a particular focus on changing customary institutions. I focus on customary institutions in particular because of their prominence in my study site and because one of the few existing studies on access to marine and costal ecosystem services (i.e. Hicks and Cinner 2014) suggest that institutions and social relations are important in coral reef contexts. Thus, although I describe a range of access mechanisms, I aim specifically to investigate how institutional mechanisms a) shape access, and b) might be more rigorously conceptualized by drawing on theories of legitimacy and entanglement. I take a case study approach with the aim of contributing to the growing number of ecosystem services studies of localized social processes shaping access to benefits that can be obscured in large-scale studies (Berbés-Blázquez et al., 2017; Lakerveld et al., 2015; e.g. Milgroom et al., 2014; Wieland et al., 2016). I ask, what are the constellations of social, economic, and institutional mechanisms that enable or hinder access to a range of marine and coral provisioning reef ecosystem services? How are these constellations shifting as different elements of customary institutions gain or lose legitimacy in the process of entanglement with modernity?

The chapter proceeds as follows. I begin by outlining theories of entanglement and legitimacy in depth, and then expand on my introduction to Ahus Island (see *Chapter Two*) and introduce my methods. I present my results thematically. First, I broadly describe access to ecosystem services across marine ecosystem services value chains; the range of activities that bring a service from catch or extraction, through production, to consumption and disposal (Kaplinsky and Morris, 2000). I contextualize the socio-economic shift towards a cash economy through a description of market access mechanisms, before examining how entangled customary institutions shape access at the catch stage of the value chain. Finally, I situate these findings in broader questions about the co-management of small-scale fisheries, the changing nature of access, and how to theorize

legitimacy of institutions in ecosystem services. By investigating how institutions retain or lose legitimacy to shape access to a range of ecosystem services, and for whom, I aim to help ecosystem services approaches navigate shifting governance of ecosystems at a local level, and identify points across value chains where intervention may improve wellbeing (or be more equitable, or have fewer ecological consequences); crucial in a period of global social and environmental change.

Theoretical background: Modernity, entanglement, and legitimacy

Theories of entanglement and legitimacy can extend ecosystem services' approach to access, especially in places where customary and modern uses and practices around resources co-exist. Theoretical progress in anthropology emphasizes that customary systems entangle unevenly with modernity. The task of defining the characteristics of modernity is beyond the scope of this paper (and the topic of much theoretical debate). Nonetheless, the modern and modernity are broadly conceptualized as an extension of the ideals of the industrial era, with features (both symptomatic and constitutive) including scientific rationality, individualism, commitment to progress, and capitalist-based forms of exchange (Pratt, 2002). The project of modernity (and capitalism) has been to move towards universalizing relationships of exchange as a framework for power (Tsing, 2005). However, rather than a set, and unchanging configuration of specific relations that constitute the 'modern', social theorists and geographers have emphasized how contemporary societies continually make and re-make 'a multiplicity of cultural programs' (Eisenstadt, 2000, p. 2). This idea of 'multiple modernities' posits that, rather than a clear-cut dichotomy between traditional and modern, modernities manifest in multiple ways, never completely consistent or coherent. Thus, rather than being superseded, customary systems and the values and social relations they underpin, endure in new configurations, as they meet with global changes (Arce and Long, 2000; Erazo and Jarrett, 2017; Filer, 1997; LiPuma, 2000).

The idea of entanglement emphasizes how coexisting modern and customary forms shape and reshape one another through conflicts and clashes. Entanglement thus refers to how 'new forms of relations weave their way into and throughout existing ones, pushing them out of the way or bending to accommodate them' (Stead, 2013, p. 19). This process has also been thought of as 'friction', whereby 'cultures are constantly co-produced… [through] the awkward, unequal, unstable, and creative qualities of interconnection across difference' (Tsing, 2005, p. 4). For instance, in West New Britain and Oro, Papua New Guinea, customary land tenure rights have been able accommodate the changes brought by growth in the oil palm industry, not through the

commodification of land, but rather through new forms of tenure arrangements that reflect and draw on prior customary tenure rights embedded in social relationships (Curry and Koczberski, 2009). In Lihir, Papua New Guinea, the establishment of a nearby goldmine and consequent commodification of sea access resulted in a shift in the meaning and strength of customary land-ownership, clan belonging, and marine tenure rules (Macintyre and Foale, 2007). Thus, entanglement captures how local practices and values are the outcomes of continual tensions between the customary and the modern, and are not easily characterized as one or the other.

Whether and how different parts of customary institutions endure in their entanglement in modernity is linked to legitimacy (or the power of legitimation). In an extension of access theory, political ecologists argue that the legitimacy of institutions and governance systems is constantly established and re-established through conflict and negotiation (Sikor and Lund, 2009). Legitimation refers to the process of justifying 'what is or… what should be and appeal[ing] to moral values' (Hall et al. 2011: 18). Legitimation, and the resulting legitimacy of different forms of regulation or market forces or customary institutions, is itself a form of relational power that shapes access and exclusion to resources (Hall et al. 2011). Legitimation is a form of relational power because it is through conflict and interplay of different discourses and values that access or exclusion become legitimized. Thus, the legitimacy of customary or other management institutions depends on whether an institution meets the standards set by the moral principles and values held by those abiding by it, and by extension, whether the authority or institution they comply with acts in a way congruent with these values (Haugaard, 2008; Jentoft, 2000). This dynamism means that 'not all forms of power to decide who gets access to what resources and benefits, and on what terms, are legitimized with equal effect' (Sikor and Lund, 2009, p. 2). Thus, how aspects of customary institutions are legitimized or not, reflect dynamic and context-specific power relations or 'entanglements'.

4.2 Background and case study

My case study focuses on access to marine ecosystem services in Ahus island (Figure 2-1, see *Chapter Two*). Across the Pacific, customary and modern ways of being are often deeply entangled. Shifts in customary management systems – in the form of sea-tenure, closed systems, taboo areas, socially-differentiated uses of species – have been documented since at least the 1970s (Hickey, 2006; Hviding, 1998; Johannes, 1978; Macintyre and Foale, 2007; Robbins and

Wardlow, 2005). Yet, even as they become increasingly entangled with the socio-economic shifts accompanying capitalism and modernity, customary systems continue to shape local existence, including resource use and rights, albeit in changing forms (Aswani, 2002; Curry et al., 2012; McCormack et al., 2013). For example, in the late 1990s, overlays between traditional and modern fishing rights and sea-tenure complicated the distribution of benefits from baitfish royalties, across the western part of Manus province, Papua New Guinea (Otto, 1997). Thus in many cases, customary systems are re-worked to face the new requirements and desires wrought by cash economies and development across the Pacific (Curry et al., 2012; Patterson and Macintyre, 2014), and it makes little sense to categorize land and sea tenure systems as either wholly customary or wholly modern.

Ahus island is particularly pertinent to understanding access, because historically, the use of the surrounding sea has been governed by a complex customary sea-tenure system (Cinner, 2005, see also Carrier, 1981, for a description of the sea-tenure arrangements of the nearby island, Ponam;; and Otto, 1997 for a description of sea-tenure in Manus more broadly). Ahus has a population of approximately 750 people (including children), and has been identified as highly vulnerable to climate change (Maina et al., 2016), particularly sea-level rise. Like many other parts of Papua New Guinea, Ahus has a clan system, with a customary clan leadership, that intersects with elected officials (local level government representatives), and a local ward development officer. Although the people of Ahus are predominantly fisher-folk, there are many highly-educated Ahus islanders who have migrated to pursue careers in capital cities (as business-folk, teachers, pilots, carpenters), and send remittances home. These migrants have supported numerous community projects to improve people's living situation on Ahus.

Ahus islanders have a mixture of cash economy, and local, customarily managed subsistence fishing. Ahus islanders catch reef and pelagic fish (using a variety of methods and technology including spear-fishing, trolling, and line fishing), glean molluscs and echinoderms (including shells, octopus, sea cucumbers), harvest coral (although rarely), and hunt larger animals including turtles, dugongs and, opportunistically, dolphins. Fish are usually boiled or smoked to be eaten, shared, or sold at local, mainland, or provincial markets. Molluscs are also eaten or sold for meat (octopus or clam shell), as shell handicrafts including necklaces, headbands, wrist-bands and belts, or purely as shells (in this case of trochus shells). Sea cucumbers are sold to middle-men when the fishery is open. Turtles were traditionally hunted for special religious and customary occasions (e.g. St John's day, funerals, weddings), and are now also sold at market. Ahus is approximately a thirty-minute boat ride from the provincial capital, Lorengau. Aside from weekly

markets in Lorengau, there are weekly markets held on the island, and in a neighbouring village on the mainland.

4.3 Methods

I used a qualitative mixed-methods case study approach (Bernard, 2017; Flyvbjerg, 2006; Mason, 2006) including 30 semi-structured interviews with a range of community members in 2016 (over two months) and a return visit in 2018. Interviewees were purposefully selected in liaison with clan chiefs, the local ward development officer, and local research assistants to ensure a mixture of ages, genders, fishing style, wealth and clans. I also conducted informal interviews, and participant observation in reef harvesting activities, at local, mainland and town markets, and at homes. I conducted interviews in Tok Pisin and transcribed and translated by a native speaker of Tok Pisin, and then checked. In interviews, I asked people to describe practices of extraction, (i.e. fishing, gleaning, harvesting), transporting and marketing, and the formal and informal rules about physical access to the sea-scape, as well as the barriers and enablers they perceived to benefiting from marine provisioning services. I asked about gender specific activities related to marine resource use (e.g. shell-jewellery making), gendered divisions of labour and space, the use of marine resources in important cultural events (e.g. Church events, weddings), and how customary management systems had changed. I also wrote detailed fieldnotes (Emerson et al., 2011) during my stay on Ahus island, on community markets, daily life, gleaning, fishing, jewellery making, sharing and bartering.

I coded interviews thematically (Flick et al., 2013) around access mechanisms identified as relevant to coasts and small-scale fisheries (Table 4-1, see Appendix A for details of qualitative analysis), what aspects of the access mechanisms were stated as enablers or a barriers to benefiting, who this applied to, and how this differed for different provisioning services. In addition, I coded for preferred benefits (for example, people mentioned that when they were unable to sell fish, they tried to trade it, or brought it home to eat). I triangulated the results from interviews with observational fieldnotes, and notes on informal interviews and direct observations (Flick et al., 2004). In the following section I present a broad overview of key access mechanisms in Ahus island, identify market access as illustrative of ‘entanglement’ in Ahus, and finally describe the shifting legitimacy of the customary institutions governing catch.

Access mechanisms relevant to coasts and small-scale fisheries	
Rights-based	Rights-based (legal/ illegal) Permits and licenses
Knowledge	Knowledge
Social and institutional	Social relations (including user conflicts) Identity/socially differentiated divisions of labor/ access (e.g. gender, caste) Physical ability Marine protected areas
Economic	Capital Technical capacity (assets)/ technology (e.g. fishing gear, boats, processing facilities) Markets
Contextual	Pollution Climate change Land availability Geographical location

Table 4-1. Access mechanisms relevant to coasts and small-scale fisheries.

Notes: Based on (Berbés-Blázquez et al., 2017; Brown et al., 2008; Hicks and Cinner, 2014; Ribot and Peluso, 2003).

4.4 Results

Overview of access to marine provisioning ecosystem services

A constellation of access mechanisms shape how Ahus islanders benefit from marine provisioning ecosystem services (summarized in Table 4-2). From catching, preparing (by smoking or boiling), to eating, contributing to community celebrations, selling, sharing or bartering, there are distinct processes around benefiting from each marine provisioning service. Different access mechanisms both enable and block who participates in and benefits from these processes along the value chains of each ecosystem service (Figure 4-1). Figure two depicts these key access mechanisms along the local fish value chain, and Table 4-2 includes a summary of access mechanisms for marine provisioning services.

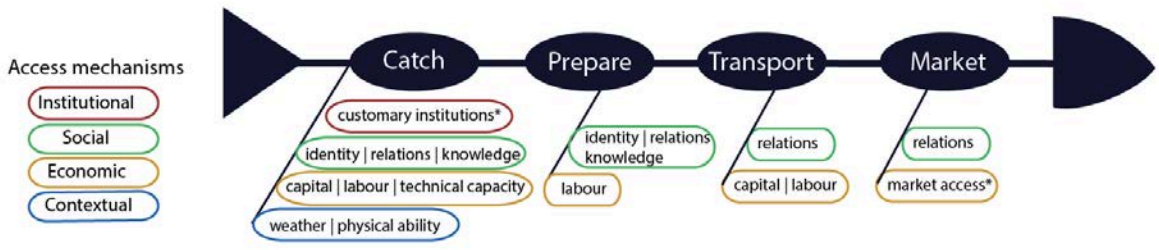


Figure 4-1. Enablers and barriers to accessing benefits along the fish value chain.

Note: Important access mechanisms are depicted below the relevant part of the value chain, and are broadly categorized as institutional, social, economic and contextual. Note that these categories overlap (e.g. gender and clan identity define which institutional rules apply to whom). *Access mechanisms described in detail in the following sections.

Access mechanism	Enabler	Barrier	Ecosystem service	Part of value chain
Rights-based		Illegal to harvest bêche-de-mer (until 2017)	Bêche-de-mer	Catch
Social relations	Clan relations allow fishing in certain areas, linked to customary institutions. Good relations and requesting permission grants access.* Gender relations within households = gendered division of labour (e.g. preparation, markets)	Shifted social relations = more difficult to barter.	All	Catch, preparation, transport, marketing
Identity	Gendered and clan-identity based access to reef areas for fishing and gleaning (see also customary institutions), gendered division of labour across value chain	Barrier to fishing or gleaning in other clan's areas*	Fish, molluscs	Catch, preparation, transport, marketing
Knowledge	Knowledge of areas, techniques, seasons for more effective fishing, knowledge of preparation (smoking), knowledge of how to make Ahus-style shell jewellery		All, particularly fish	Catch, preparation, market
Customary institutions (rules)	Physical access to clan owned fishing areas* Rights to certain gears, areas, timing for fishing* Deviance from customary rules enables easier fishing (e.g. diving at night)	Taboo on collecting bêche-de-mer, trochus shells Inability to access other clan's fishing areas*	Reef fish, Bêche-de-mer, trochus shells, molluscs	Catch
Capital	Able to purchase fuel to fish, transport to market, or boat and motor ownership for trawling for pelagic fish	Inability to make a profit after transport costs, lack of motorized boat a barrier to catching pelagic fish	Fish	Catch, transport, market
Labour	Ability to catch, prepare, transport, and market ecosystem services. Often a gendered division of labour within families (i.e. link to social relations)		All	Catch, preparation, transport, market
Technical capacity (assets, technology)	Able to target specific fish (e.g. trolling with boat and motor), torch diving at night to target bigger reef fish	Lack of access to freezers creates time limit on selling fish, Low price of trochus shells is unprofitable	Fish, molluscs	Catch
Markets	Temporary middle-man for Tuna (ceased) Temporary government-run market with freezers (ceased)	Over-stock at markets (particularly Lorengau) creates a barrier to sell fish for desired price	Fish	Market
Weather		Inclement weather and large-tides a barrier to fishing within and beyond the reef	Fish	Catch
Physical ability	Ability to spearfish deeper, and longer and withstand cold at night.		Large reef fish	Catch

Table 4-2. Key access mechanisms to marine provisioning services.

Note: Includes description of how mechanism enables or blocks benefits, the specific ecosystem services each mechanism applies to on which part of the value chain. * denotes access mechanisms that have weakened or are uneven.

Market access and the entanglement of cash and barter economies

Imperfect market access and the way people navigated their preferences for cash from selling fish exemplifies the way that customary (e.g. barter economy) and modern (e.g. cash economy) forms are entangled in Ahus island. Many identified a lack of well-functioning markets at Lorengau and in neighbouring mainland villages as a barrier to benefits from marine provisioning services. Although many Ahus islanders depend directly on fishing for their livelihood, many struggle to sell fish when the Lorengau market is overstocked, or when customers wait for the price to be dropped at the end of the day. People perceived that market volatility and the overstock of fish had worsened. For example, one woman (33) explained how her husband;

> "gets the fish, I take the fish to the market. When there's a lot of fish it spoils my chances of selling all the fish. Too many fish makes the price drop... there's not a lot of markets for fish so everyone goes to the one place and there is too many people selling fish so the price drops. It does not fulfil my intentions/ needs, it does not fulfil the family's intentions/ needs."

Women selling fish at the markets in Lorengau sometimes do not obtain their desired price, or even recoup enough money to cover the transport costs to and from Ahus.

In the face of an imperfect market, people draw on existing social relations and relations of exchange (e.g. bartering) to gain benefits from ecosystem services. Yet, with increasing participation in, and preference for a cash economy, the norms and practices of bartering have shifted. One woman (50) described how,

> "…if one of your friends or sister, brother sees you and says I need this and that, then we will barter or change foods. One will say "I have sago" or "I have fish" then we will barter. But it is hard now, everyone wants money instead. At the local market, yes it happens, we barter for food but in town it is hard at times, they want money. If it is one of your relatives, like a brother or sister, if they wanted fish then you barter with other foods."

People described bartering with people with whom they already have social connections, for instance relatives or friends from the mainland who will trade sago or garden vegetables for fish. However, bartering is considered second to selling fish for money. For instance, one woman explained that she barters with "people from the mainland too, I ask to exchange and it helps me out a little bit, so I am not paid for it using money, I change it for some sago.' (Woman, 33). Even at local markets in Ahus, or on the mainland, people rarely barter straightaway. Rather, bartering

becomes a second option when people are unable to sell their goods, which they attempt to exchange as the market closes.

This lack of market access may dampen some of the inequality of benefits created by differences in wealth and assets on Ahus. Although some fishers in Ahus own motorized boats for trolling, this does not always translate into better sales of fish. In interviews, men who owned outboard motors and boats expressed particular frustration with the lack of stable markets. For a short time a government sponsored market provided both fish freezers and a stable price for fish (determined by weight and grade). However, with no onward buyers, this project failed. Thus, lack of market access may curtail the benefits of capital and technology to a degree; while owning a boat and outboard motor does enable people to catch bigger and more fish, they still face barriers at the market stage. In sum, rather than a perfectly functioning market, there is a tension between desired cash benefits, and bartering practices. However now, people tend only to barter with their extended family or friends. In these ways, market access exemplifies the way that modernity and custom entangle.

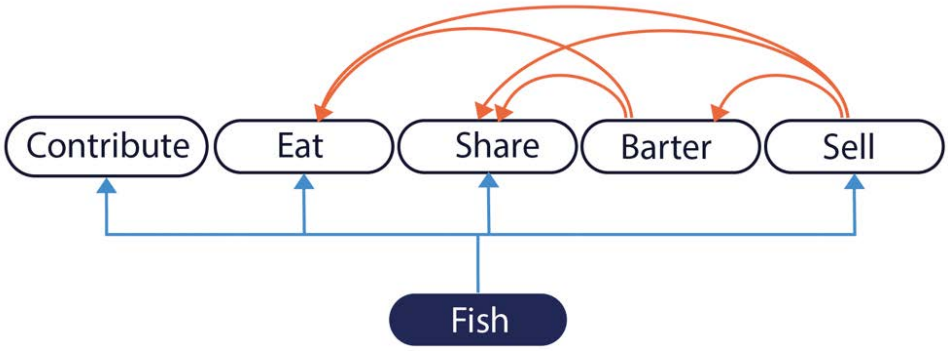


Figure 4-2. Hierarchy of desired benefits from fish.

Note: Fish may either be directly contributed to community events, eaten, shared, , bartered or marked out for sale. Light blue lines indicate direct benefits, red arrows indicate the choices people make if they are unable to sell fish at market, or barter. People rarely prepare fish for the sole purpose of bartering. The need to draw on family relationships to barter emphasizes the entanglement of customary and modern modes of exchange.

Shifting access mechanisms: the legitimacy of customary institutions

Historically, customary institutions shaped who had access to space, species, gears, and times for fishing across Ahus island. However, these rules have shifted unevenly for different groups of people, and different provisioning ecosystem services. In this section I describe the ideal or historical customary rules, before describing changes in their legitimacy and who these changes apply to.

Customary institutions shaping access

For certain parts of the sea-scape (including reefs flats, reef passages, the reef slope, sand flats, and reef areas), there are complex customary rules overseen by those in ownership or caretaker roles. Within clans, certain sub-clans, families or individuals are responsible for a type of method, area, or time, or a combination of these (Table 4-4). Within sub-clans, families or individuals will hold the consanguine role of *papa long solwara*, (literally father of the sea/reef, figuratively caretaker and steward). With the role *papa long solwara* come certain rights. People hold the rights to close (or 'tambu') certain areas or fisheries (e.g. trochus shells). Others may have the right to withhold permission from people seeking to use a certain method (e.g. diving). For example, different historical fishing methods were 'owned' by different people or groups, meaning that only they had the right to use them, or to allow others to do so (Table 4-3).

Traditional fishing method		Clan Green	Clan Red	Clan Blue	Clan Yellow
M'Bruh	Large, woven cane and banana leaf net cast outside the reef - large woven cane for turtles/ fish	Family A	Sub-clan i: Family B	Clan C (different clan to individual C)	Sub-clans ii, iii, iv
Chur	Fire using coconut leaf and bamboo inside the reef - night only	NA	Individual B	Individual C	Individual D
Panho	Basket for attracting fish 'natural FAD'	Family A	Family B	Individual C	Sub-clans ii, iii, iv
Hu	Chasing bait fish into traditional net inside reef (still used today with net)	Family A	NA	NA	Sub-clans ii, iii, iv

Table 4-3. Rights and ownership of traditional fishing methods in Ahus.

Note: Anonymised details of which sub-clan, family, or individual within each of the four main clans in Ahus holds these rights.

Historically, these customary rights also dictated the types of benefits that were obtained from marine provisioning services. For instance, one clan had rights to fishing for bait fish that schooled seasonally in their reef flat area using specific nets. Depending on the type of bait fish, they were either shared between direct family (including women who had married into other clans) or shared out between the four main clans on the island.

Areas beyond the remit of a *papa long solwara* are open to anyone to use any method at any time of the day or night. Clans tend to fish and glean in the areas close to, and owned by, their clans; rarely if ever fishing in other clan's areas. Beyond the reef, the open ocean is broadly considered

open to anyone from Ahus, however for both convenience and due to social norms, people tended to stick to their side of the island (Figure 4-3).

Alongside clan sea tenure, is a strong custom of gendered access to the sea-scape. Both women and men explained that inside the reef crest is for women, and the open sea is for men. This gendered division of space is seen as a combination of respecting customary ways, and because women are perceived to lack the strength necessary to paddle canoes in the open ocean.

> "The women go to the reef nearby and come back. Where the waves break, that is their boundary where they fish. They won't go further out. The big [deep] ocean and further out is for the men to go fishing, and trolling is for the men" (Man, 42).

> "I'd say we all just follow our ancestors and customs from before up to now, and [outside the reef] is not for us, it's something for the men only. The men have rights to go dive outside and the women just stay on the inside part. And maybe we are not strong enough to go further out and that is why we don't go further out" (Woman, 30).

Customarily, outside the reef belongs to men, and inside to women, although younger men do spearfish in the deeper parts of the reef, particularly at night.

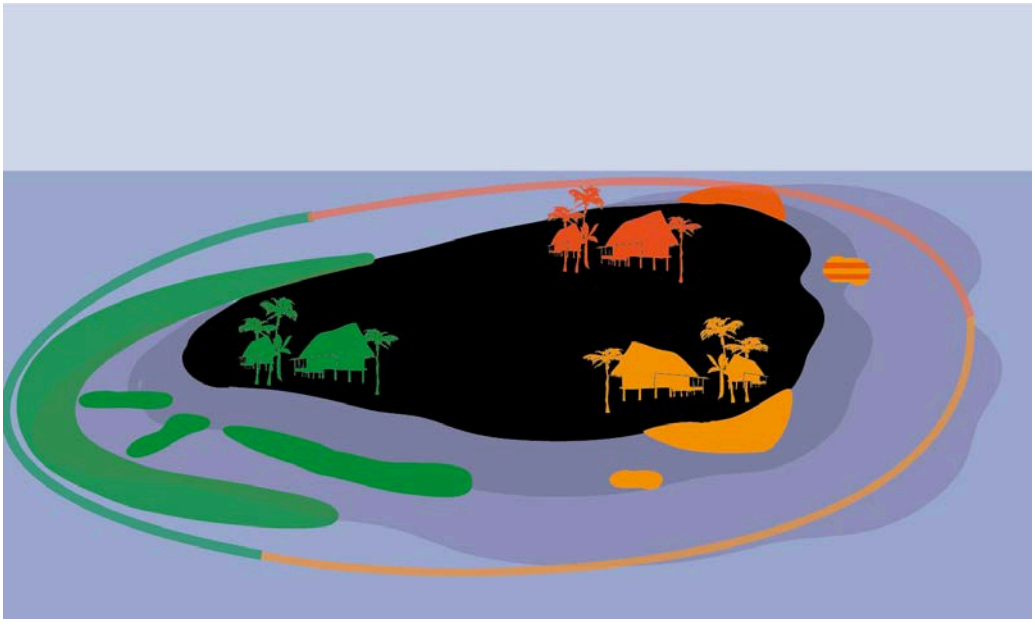


Figure 4-3. Representation of customary rules and ownership in Ahus.

Note*:* Anonymized graphic depiction of information in Table 4-4. Colours refer to different clans, bold coloured areas represent those areas owned by clan, families or individuals (at different times and for different gears – see Table 4 for details), while transparent coloured lines represent the tendency for fishers in the open ocean to stay within their sides of the island.

Clan	Individual or group	Area description	Species/ method	Times applicable	Perceived legitimacy
Green	Sub-clan A	Sandy flat within reef	Running motorboat to catch stingrays, sharks and turtles	Day and night (full moon)	Active. People can catch fish or turtles opportunistically here if passing through, but cannot fish here in this way without permission.
Green	Sub-clan B	Reef passage A (inside reef)	Harvesting fish by chasing them into a net strung across passage-way	Day	Still legitimate but no longer coupled with active tambus in this area.
Green	Sub-clan C	Reef passage B (inside and outside reef)	Harvesting fish by chasing them into a net strung across passage-way	Day	As above.
Green	Individual A	As above	Spearfishing at night	Night	Often broken.
Green	All sub-clans	Behind the reef drop-off (20-30m) for 500m	All activities	All times	Spearfishing was banned but this rule is often broken.
Red	Sub-clan D	As above	As above	As above	A sub-clan from a neighbouring clan shares rights to this area.
Red + Yellow	Individual B (Clan Red) Individual C (Clan Yellow)	Small area within the reef (100m*100m)	M'Bruh fishing (see table 3), line fishing	Night only	Not respected.
Yellow	Individual D (widow of clan leader)	Reef flat	Very low-tide gleaning with bush knife and torch	Night only	Unclear.
Yellow	Individual C	Area of reef 40m*100m	Spear-fishing (banned)	Night only	Not respected but few people go here.
Red + Yellow	Sub-clan E (Clan Red) Sub-clan F (Clan Yellow)	Beach area in front of clan	Net fishing for bait fish	Bait fish seasons	Rights to net are only with Sub-clan E in their area, and sub-clan F in their area. Customarily baitfish were shared but are now also sold.

Table 4-4. Selected subset of customary rules and ownership across three clans in Ahus island.

Note: Clans are anonymised by colours. Table includes the person or group in charge, a description of the area, timing, methods, and perceived legitimacy. Outside applicable times the areas and methods are open to anyone, although women glean and fish within the area of reef adjacent to their clan, and men tend to fish in their clan's reef or side of the island.

Entanglement and shifts in legitimacy

The complex customary systems that dictate who may fish where and how are increasingly fragmented. Access shaped by customary institutions has retained legitimacy for some people within the community (e.g. women) and some ecosystem services (e.g. trochus shells, bêche-de-mer) and not others (e.g. younger men, reef fish). Specifically, the practice of clan leaders and *papa long solwara* to tambu certain practices and areas of aspects of these customary systems have lost legitimacy over time as people, particularly young men, break the rules (Table 4-4). The fading legitimacy of customary bans on certain practices is reflected in people's descriptions of 'stealing' from others. The notion that fishing another clan's area is stealing suggests that people still hold a sense of rightful ownership, and believe this ownership is being violated. Many people argue that population increase, and the need to feed ones family justify this violation. One man explained how everyone was complicit in disrespecting customary stewardship of the ocean.

> "There are areas down there where the people from [clan A] go to, and we just follow them and go there. The ancestors have their ocean areas where we go looking for fish but now there are too many people we do not follow the old ways. *We steal from them and they do the same thing here.* Now that there are too many people, no one listens so we still go diving in the ocean when there are restrictions in place. There are so many people that there is shortage of food, and that is why we must still go look for fish or if not we will starve" (Man, 48, my italics).

Deviance from customary rules is also coupled with physical ability and identity (youth and masculinity), both enable some people to benefit more (by catching more, and bigger fish), and are also implicated in the shifting legitimacy of customary institutions. Men emphasized that physical ability enabled people dive deeper and for longer periods when spear fishing. Being young, fit and able to withstand the cold means that younger men can go spearfishing for longer periods, including at night.

> "[Older men] are not strong enough to dive at this present time, because they would have to dive for long periods, and they are scared of the cold and that's is why they won't go to the ocean. Because for us, younger men like me, I can dive go all the way there to that point and come back to the front of the village. The older men can't do it anymore, they will just go to the middle or half way and they might get cold, the young men are still strong and don't feel cold and we can dive for long periods" (Man, 23).

Clan leaders have been unable to enforce bans in clan-owned deeper passages of the reef, because at night, young men spearfish with torches and are hard to detect and also impervious to threats of court or other consequences. In one clan leader's words;

> "Both of us [clan leaders] put a tambu on diving at night - that's our right - but all the youth go at night while we sleep. I think that happens often. I'm someone with a short-temper! I've fought them countless times, but then if I keep doing that I'll just end up in jail" (Man, 50).

Younger men also more willing to push common boundaries around fishing grounds in the day. For instance, one woman described an incident between young men from one side of the island, and young men from the other side.

> "The young men from here, the boys from the other side went to the ocean and they went fishing there, and they [the boys from here] got angry saying you guys should stay in your area and fish in your area" (Woman, 47).

Young men appear more willing to test the boundaries of customary norms and rules around fishing, and less concerned about the consequences of doing so.

In contrast, women continue to fish solely within their clan's fishing areas. All women interviewed noted that they only fished in their clan areas, or, if they had married in from another clan, would only return to their original clan's fishing ground if they received permission:

> "My clan, on the other side, they can't come here to catch fish, etc. We can only find fish on the other side. It's taboo to come here. And it's the same for here, we go fishing in the area that belongs to us. We can't go fishing or gleaning on the other side. If someone goes fishing here, outside their area, then everyone from here will talk, warn them, or take them to court. So we only go fishing, and diving on our side" (Woman, 38).

Thus, the customary rules that remain are the looser norms around areas of fishing, and the broad ownership (particularly of particular passages), while specific bans no longer retain much legitimacy. Women's use of the sea-scape remains limited by customary systems while the stronger restrictions banning fishing using specific methods in certain areas have gradually eroded, alongside the custom of asking permission to fish in a clan's area.

In addition, for some ecosystem services, the continuing legitimacy of customary access is shaped in part by legal and market access mechanisms at a broader scale (i.e. national and regional) and

underscores the usefulness of the idea of 'entanglement' for understanding how different institutions retain or lose legitimacy for certain groups within communities. Customary rules remain strong for several species that are bolstered by broader scale rights and market access mechanisms. Specifically, there are strong clan taboos on collecting sea cucumbers (bêche-de mer) and trochus shells. The ban on sea cucumbers aligned with a nation-wide moratorium on collecting sea cucumbers (lifted in 2017). At the time of fieldwork, no one collected sea cucumbers, partly because they were banned in the customary system, but also because there was no one to sell them to. In this way, the customary ban was aligned with and gained legitimacy from the government's moratorium. Access to and benefits from trochus shell are likewise still shaped strongly by customary systems. The clan-based taboos on collecting trochus shells are strengthened, in part, due to a drop in the price of trochus shell (see Appendix B2).

4.5 Discussion

My case study emphasizes how entanglement and legitimacy can extend understanding of how customary institutions mediate access to ecosystem services in the context of environmental and social change. Consistent with a growing number of studies, I found that people access a variety of marine ecosystem services through social, economic, and institutional mechanisms that have shifted over time (Berbés-Blázquez et al., 2017; Felipe-Lucia et al., 2015; Hicks and Cinner, 2014; Lakerveld et al., 2015). Here, I highlight several key theoretical implications of incorporating entanglement and legitimacy into studies of access to ecosystem services, particularly around the extension of power.

My findings suggest that the legitimacy of customary institutions may change subtly over time, be socially differentiated, and impacted by governance at broader scales. In Ahus, I found uneven legitimacy in how customary institutions shaped access to marine provisioning ecosystem services for different groups of people, and different services. Some benefits from some provisioning services are still shaped strongly by customary institutions (e.g. ban on collecting trochus and gendered access to the sea-scape), while some are not (e.g. non-compliance to gear bans). Customary taboos around harvesting sea cucumbers were reinforced by a Papua New Guinea-wide moratorium. However, customary institutions and leaders have not retained their legitimacy over the past two decades, in part by ceding their power to government elected officials to call community meetings, and make binding decisions. In my case study, changing legitimacy around customary institutions are less obvious and contested than the 'messy' battlefield of legitimacy brought about by new institutions like payments for ecosystem services

(Ishihara et al., 2017). Instead, in Ahus, the legitimacy of customary institutions has gradually faded. This change mirrors a more creeping change in legitimacy found in an institutional analysis in Hawai'i, where co-management legitimized different parts of local institutions by recognizing and codifying historically legitimate claims and fusing them across governance-scales, within the constraints of the legitimacy of previous governance arrangements (Ayers et al., 2018). Thus, while I agree that decision-makers must 'consider historically legitimate claims by actors… to manage the landscape' (Berbés-Blázquez et al., 2017, p. 139), my findings caution that what is considered historically legitimate may be contested. The contested nature of legitimacy is more readily visible through the relational view of power.

In their original theory of access, Ribot and Peluso (2003) suggest a broad definition of power that includes relational power (Myers and Hansen, 2019). Rather than arguing for one definition or approach to power, I instead contend that ecosystem services' studies of access (in particular) would benefit from a broader view of power offered by the theory of access itself, and the social sciences more broadly (Svarstad et al., 2019). In light of my findings, I contend examining entanglement and legitimacy can extend ecosystem services' treatment of power by incorporating a relational approach to power as well as structural approach of 'power over'. This approach would require going beyond 'identifying the stakeholders… who are able to impose their views on specific issues related to [ecosystem services] management, elucidating their sources of power, and identifying the other stakeholders on which they exercise this power' (Barnaud et al., 2018, p. 7), In Ahus, I found an entanglement of different social relations around access rather than actors making conscious and calculated bids for control over ecosystem services. For example, the decreasing legitimacy of clan leaders, and the *papa long solwara* to enforce use rights in their sea-areas, partly reflects their inability to realize values of stewardship rather than their inability to control resources for their own direct benefit. The changing identities and masculinities of young men in Ahus challenged the legitimacy of customary institutions. In Papua New Guinea, it is likely that the legitimacy of customary institutions will be shaped by the changing meaning of labor, and changing intergenerational relationships (Curry and Koczberski, 2012). Thus, entanglements of custom and modernity reflect entanglements of relationships of power (Sharp et al., 2000). When studying access, investigating where legitimacy lies in 'entangled' institutions, shifts the ecosystem services' treatment of power beyond embodied, possessed and wielded by individuals or institutions themselves, to one where power is emergent (or co-produced) through everyday relationships between institutions, people, and ecosystems.

The metaphor of entanglement can also help to conceptualize how power shifts values related to ecosystem services. In line with the idea that different values for ecosystem services are embedded in changing institutions (Berbés-Blázquez et al., 2017; Pascual et al., 2017), I found that the demise of de-jure clan rights to ban access to certain areas of the reef, was in part a clash of values over protecting bequest values, the relational values of stewardship, and the desire to make a living. In Ahus, there is tension between the desire to benefit monetarily from marine provisioning services, a lack of secure and functioning markets to do so, and the authority of those historically responsible for the customary management of the reefs. Clan chiefs often expressed a sense of frustration and failure at being unable to enforce closures of their reefs, reflecting a decline in relational wellbeing founded on identity and a sense of agency (Weeratunge et al., 2014). Stealing fish by breaking traditional rules has become a social norm ("they steal, so we steal too"). Many Ahus islanders explained these transgressions with narratives of Malthusian overfishing, population growth and material needs (Finkbeiner et al., 2017). In Ahus this entanglement of priorities for material wellbeing (i.e. food and income) and relational wellbeing (i.e. continued customary practices around managing the reef, and identities of stewardship) will continue to play out as the community faces socio-ecological changes brought by new markets or environmental degradation. This finding aligns with work in Costa-Rica that found different agricultural institutions and access mechanisms cohered around different values (profits versus cultural identity and continuity) (Berbés-Blázquez et al., 2017). Given the entanglement of values and legitimacy, how and which aspects of institutions retain or lose legitimacy has important implications for people’s wellbeing.

Alongside and related to these theoretical contributions, I suggest two key practical implications from my case study. First, identifying and understanding how different mechanisms enable (or block) benefits from provisioning ecosystem services, can illuminate where certain groups might be vulnerable to change in a value chain, and thus where development or conservation initiatives might find leverage to change access patterns for poverty alleviation and wellbeing. Constellations of access mechanisms shape who is able to benefit from marine provisioning services and how they do so. For example, in Ahus island, enabling access to motorized boats may alleviate some pressure on reef fisheries, but a lack of direct buyers and fish freezers mean that this might not translate directly into increased livelihood benefits. Similarly, when the National Fisheries Authority introduced a fish aggregating device (FAD) to Ahus, it helped those without motorized boats to catch larger fish, but did not enable access to a more stable or lucrative market. However, providing access to better markets will benefit those with existing capital first; those fishers who can both catch and directly transport fresh fish. Providing other

fishers with fish freezers, however, may also have ecological consequences for the reef (Cinner et al., 2016). Thus, investigating access mechanisms across the value chain can help identify where an intervention's aim may be blocked or undermined by barriers to access.

The second key recommendation for practice stemming from my work is that recognizing the role that conservation or development practices play in strengthening or undermining certain 'entanglements' can help avoid (even inadvertently) legitimizing inequitable access patterns. Conservation and resource management projects themselves entangle in different ways with local institutions (Ishihara et al., 2017). In community-based natural resource management, the way projects engage with and identify communities may first obscure, and then institutionalize socially-stratified and inequitable resource benefits (Agrawal and Gibson, 1999). For instance, in the Philippines, efforts to institutionalize and foster participation in a state-led program to manage coastal resources, missed the opportunity to examine where existing institutions could be strengthened or altered, and instead unequally distributed the burdens of the project across class, ethnic, and gender lines (Eder, 2005). The metaphor of entanglement gives practitioners and researchers a lens to identify where institutions or discourses at different scales, for instance global governance and local management (McDermott et al., 2019), may clash, and what this tension might mean for access.

4.6 Conclusion

Ecosystem services research is beginning to more deeply interrogate the role of power in shaping how people access benefits from their environments. In this chapter, I found that access to ecosystem services within a single coastal community is complex and changing in an entanglement of relations from customary and market-based systems. In the context of changing patterns of exchange and preferences for benefits, I found that the legitimacy of customary systems, and thus their power in shaping access, has eroded around the use of space and time for some (e.g. younger men), and less for others (e.g. women). Thus, I argue that institutional access mechanisms may be entangled in ways that are socially differentiated. I also found that customary access has eroded for some ecosystem services, but not for others, emphasizing the way that multiple access mechanisms (e.g. national level-laws) intersect to shape access at a local level. Identifying what aspects of customary systems remain legitimate and which fade can contribute to a relational understanding of power in ecosystem services and will ultimately assist more pragmatic approaches to ecosystem governance, including the equitable co-management of fisheries.

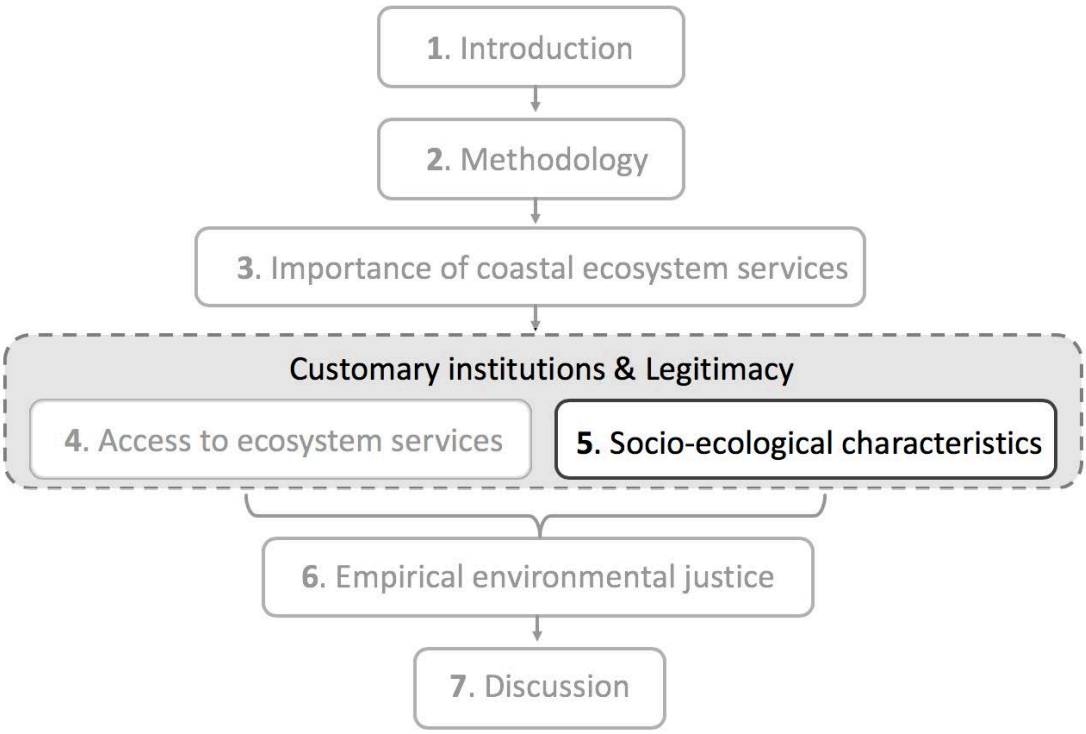


Figure 4-4. Thesis map: *Chapter Four* to *Chapter Five.*

Chapter Five directly contrasts with *Chapter Four* by examining the social and ecological characteristics of two communities where customary institutions have retained strong legitimacy. It likewise extends *Chapter Four* by exploring some of the ecological implications of strong customary institutions.

5 Social and ecological characteristics in a coral reef bright spot

---

• Adapted from Cinner, J., **Lau, J.,** Bauman, A., Feary, D., Januchowski-Hartley, F., Rojas, C., Barnes, M., Bergseth, B., Shum, E., Lahari, R., Ben, J. & Graham, N. (*submitted*) Social and ecological outcomes of adaptive management in a coral reef bright spot. Science Advances.

Contributions*: *Study design was by JEC, JDL, AGB, DAF, FAJ-H, MLB, and NAJ. Data collection was by JEC, JDL, AGB, DAF, FAJ-H, MLB, RL, and NAJ. Analyses and graphics were done by JEC, JDL, FAJ, CR, MLB, ES, and BB. Writing was done by JEC, JDL, AGB, DAF, FAJ-H, CR, MLB, BB, ES, RL, and NAJ.*

** I use the collective noun 'we' throughout this chapter because it is part of a collaborative interdisciplinary project (see Declaration of the Contribution of Others, p. iii. for more information).*

Abstract

Recent efforts to stem degradation of the world's marine ecosystems include attempts to locate and learn from 'bright spots' (i.e. positive deviants that are in better ecological condition than expected given the social and environmental pressures they face). Here, we make a novel contribution to these efforts by presenting a 16-year analysis of social and ecological conditions in a coral reef bright spot. We found that this bright spot had several key social-ecological features that may have relevance to other locations, including (a) strong social cohesion, whereby leaders played a critical role in knowledge exchange; (b) a customary rotational fisheries closure system (akin to fallow agriculture), which helped to increase the biomass of reef fish and make fish less wary (more catchable) relative to openly fished areas; c) high levels of compliance, which was facilitated via a 'carrot and stick' approach that publicly rewarded good behaviour and punished deviant behaviour.

5.1 Introduction

Despite ongoing conservation efforts, many of the world's marine ecosystems and the services they provide to people continue to be degraded by anthropogenic drivers of change; including a warming climate, overfishing, and pollution (Hughes et al., 2017). Of particular interest to scientists and policy makers is locating and learning from positive outliers or 'bright spots'— locations that are in better condition than they should be, given the specific pressures they experience (Cinner et al., 2016; Post and Geldmann, 2018). Determining the social and ecological conditions that enable these so-called bright spots could help to inform local actions aimed at sustaining social-ecological systems in the context of global degradation.

This type of bright spot (positive deviance) approach, has been used in a range of disciplines including business, health, and human development, but applications in the conservation context are nascent (Iyer et al., 2012; Marsh et al., 2004; Post and Geldmann, 2018). The bright spot approach was recently used to systematically identify coral reefs throughout the world that had fish stocks in better condition than expected. By using a range of socioeconomic and environmental factors (e.g. market accessibility, human population, poverty, oceanic productivity) to predict reef fish biomass in over 2600 coral reefs, Cinner et al. (2016) identified 15 bright spots that had >2 standard deviations higher fish biomass than expected. These bright

spots were not necessarily 'pristine' coral reefs, but rather coral reefs where fish biomass was greater than expected given the social and environmental conditions they faced.

To date, no detailed study has described the management practices and other key social-ecological features that support these, or other systematically identified bright spots in conservation. Here, we make a novel contribution to the literature by presenting a 16-year analysis of key social and ecological conditions in a coral reef bright spot. We conducted social and ecological research across five time intervals on a complex of coral reefs and associated coastal communities, which was identified as a bright spot in Cinner et al. (2016). Our novel approach uses qualitative social science research to first identify the key practices and social-ecological processes that local community members believe set them apart from other communities (i.e. what makes it a bright spot?). Specifically, in 2017, we conducted a series of qualitative interviews with key informants (clan leaders, religious leaders, elected officials, and knowledgeable fishers, N = 21). We then content organized these interviews and identified four key themes (Appendix C, Table S7): 1) strong and continuing customs (including an adaptive rotational reef closure system akin to fallow agriculture); 2) leadership and social cohesion; 3) participation and adaptive decision-making; and 4) compliance. We then integrate quantitative social and ecological data collected between 2001-2017 to explore these emically-derived themes. Specifically, we collected a total of 184 household surveys to identify: i) whether and how customary management practices impacted people's livelihoods; ii) information exchange networks; iii) levels of participation in decision-making; and iv) perceived levels of compliance. We also used underwater visual census of reef fish to estimate whether customary management practices were related to: i) the biomass of reef fish; and ii) the flight initiation distance behaviour of six key reef fish species (see Methods). Biomass of reef fish was used to assess the state of the fish stocks, originally used in the global study (Cinner et al., 2016). Flight initiation distance is a key behavioural metric related to fish catchability and is one of the key reasons behind the adaptive rotational closure system used by these communities (Feary et al., 2010).

5.2 Study sites and social context

Our research was conducted in the coastal communities and associated coral reefs of Muluk and Wadau (Karkar Island), Papua New Guinea (Figure 5-1, see *Chapter Two*). Both communities are small but growing; Muluk's population nearly doubled between 2001 and 2016, from ~330 people in 50 households to 615 people in 105 households. Likewise, Wadau's population increased from ~320 people in 50 households in 2001 to 447 people in 72 households in 2012.

Both communities are heavily dependent on agriculture as a primary livelihood activity, with fishing often being considered a secondary livelihood activity (Cinner et al., 2006). The communities are socially organized around kinship-based clans (3 in Muluk, and 6 in Wadau). Although distinct, the two adjacent communities share a common language, cultural practices, form a single unit of local government, and together are often referred to as "Last Karkar" (since they are located on a linguistic border and are the 'last' place to speak the indigenous language dominant on the southern part of Karkar Island) (Figure 5-1). The complex of reefs in front of these communities (Figure 5-1C) was identified in Cinner et al. (2016) as a bright spot, and both the reefs and coastal communities have also been part of a long-term social-ecological research program (Cinner et al., 2006; Cinner et al., 2012; Feary et al., 2010), which forms the basis for this chapter.

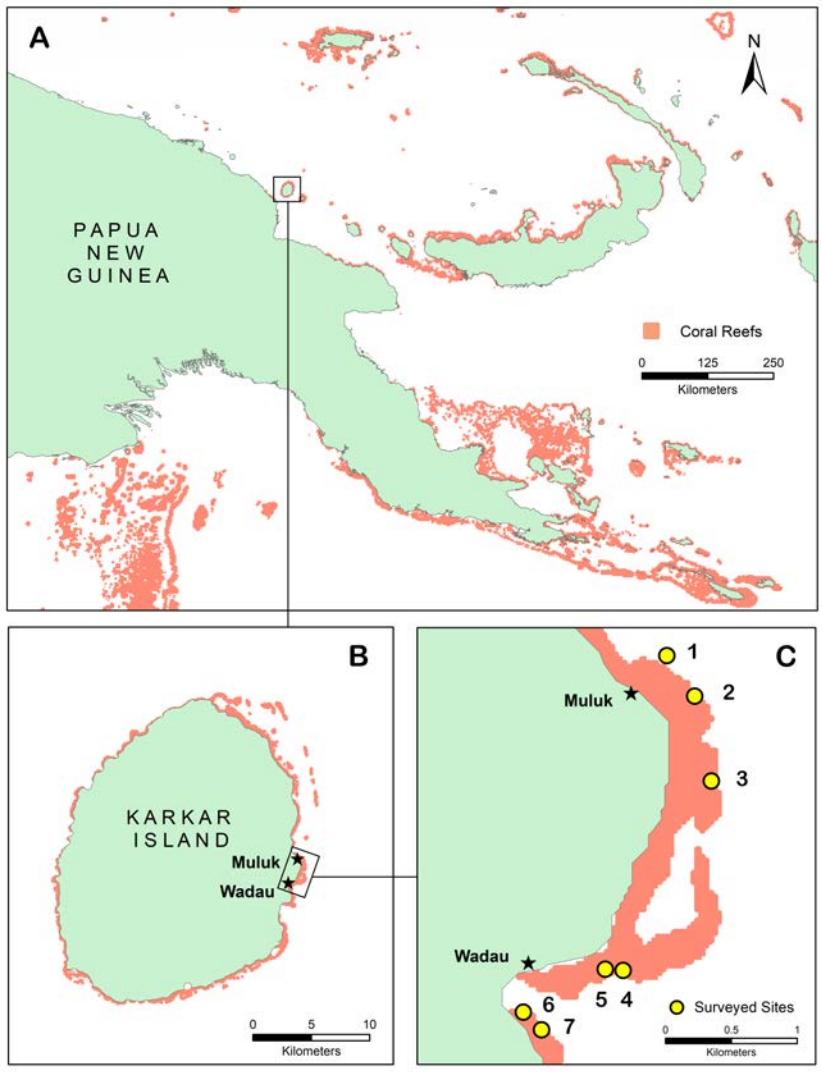


Figure 5-1. Map of study sites.

Note: Points 1-7 in panel C are the locations where ecological surveys were periodically conducted between 2001 and 2017 (Methods).

5.3 Methods

Qualitative social science interviews

We took an exploratory case study approach to qualitative interviews guided by the overarching question, "what is unique about the communities of Muluk and Wadau?" JEC and JDL purposefully sampled clan and community leaders, fishers, and elders as key informants. In Muluk and Wadau, clan leaders have in-depth knowledge of, and responsibility for, customary management in their clan's reef area, and liaise with their clan's members to make decisions about the reef and coordinate customary traditions. All clan and community leaders were men, 50 years or older. We conducted key informant interviews (ranging from ten minutes to one hour) in Papua New Guinean Tok Pisin. Questions were broad and open-ended and encompassed the types of customary practices that exist in Muluk and Wadau, perceptions of what things make Wadau and Muluk unique compared to other communities and places, perceptions of how the customary closure system had been successfully maintained over time, and how transgressions with closure rules are dealt with. Interviews were recorded and translated and transcribed into English by JB and JDL, and the two versions were compared for consistency.

We triangulated the broad themes that arose in interviews with fieldnotes, observations, and informal interviews made by JDL in 2016 and 2017 (over seven weeks) including the opening of the reef, and extended experience (15 years) in both field sites by JEC. Where possible, we also triangulated between the themes that arose from our qualitative interviews and long-term quantitative socio-economic data (see below). We used thematic, concept driven coding (Gibbs, 2007) with themes derived from an initial reading of the interviews. We also coded iteratively, refining and adding codes as we progressed through the interviews. Our final thematic framework is detailed in Appendix C, Table S7.

Quantitative household surveys

We systematically surveyed households within each community. Here, we report the results from fishing households surveyed in 2001 (n= 40), 2009 (n=19), 2012 (n=43), and 2016 (n=82; a more comprehensive sample was needed for the social network component conducted in 2016.). Based on themes arising from our qualitative surveys, we drew upon quantitative household surveys to examine levels of stakeholder participation in management decisions, people's perceptions of

whether management affected their livelihoods, and the degree of perceived compliance. We used a 5-point Likert scale to examine people's perceptions of how management has impacted their livelihoods (ranging from strongly detrimental to strongly beneficial), a 3-point Likert scale to assess the degree to which people were actively, passively, or not involved in resource management decisions, and a 4-point Likert scale to assess perceived levels of compliance by asking whether people perceived that all fishers, most, a few, or no one fished in the closures (though 2001 only included a 3-point scale for compliance- few, most, or all people comply). To examine compliance further, we also asked respondents whether they had witnessed someone breaking management rules in the previous 12 months (Bergseth et al., 2018). We used a Fisher's exact test to examine whether perceptions that the closure system was detrimental to respondents' livelihoods was related to whether the closure was active or not at the time of the survey (i.e. whether the reef in the village being surveyed was open or closed to fishing).

In 2016, we developed a social network of fisheries-related knowledge exchange. Specifically, we asked respondents to nominate people to whom they go for important information and advice (hereafter 'knowledge') about fishing and fisheries management. Based on our qualitative interviews, we wanted to explore three themes with the social network: the role of leaders in knowledge exchange, the degree of cohesion in the knowledge exchange network, and cross-generational knowledge exchange. We used two approaches to analyse these social networks. First, we examined the role of leadership and other social attributes (such as clan membership) in driving tie formation and the level of cohesion in the network using an exponential random graph model (ERGM). ERGMs are statistical models of networks that model each tie as a random variable and specify the probability of observing the network as a function of various local social processes (Lusher et al., 2013). To examine cross-generational information exchange linkages, we divided respondents into three cohorts- the youngest quartile (youth), the oldest quartile (elders), and the middle two quartiles (middle-age). We then used the External versus Internal (E-I) index to examine the proportion of knowledge exchange ties within (internal) each cohort compared to between (external) cohorts. The E-I index is calculated as: (between cohort ties-within cohort ties)/total ties. A higher E-I index indicates substantial information exchange between cohorts.

Fish behaviour

To determine the role of a temporal switch in management impacting the behaviour of fishes, we examined and compared flight initiation distance for six commonly targeted reef fish species

(orange-lined triggerfish (*Balistapus undulatus*), striated surgeonfish (*Ctenochaetus striatus*), daisy parrotfish (*Chlorurus sordidus*), Bleeker's parrotfish (*Chlorurus bleekeri*), yellowbarred parrotfish (*Scarus dimidiatus*) and dusky parrotfish (*Scarus niger*) across 2009 and 2012 in both Muluk and Wadau reef areas. Observers swam haphazardly (using SCUBA) throughout the shallow fringing reef (3–4 m deep) within reefs that were both open and closed to fishing. Focal fishes were identified and then approached horizontally from a distance of 10–15 m; benthic features where the fish was positioned before approaching were noted. When the individual changed behaviour (i.e., started to flee), the observer immediately dropped a weighted marker. A second marker was then placed at the benthic feature where the fish had been prior to flight initiation. The distance between the two benthic markers was then measured (cm). If the fish exhibited a change in behaviour that was not obviously a result of the approaching diver (e.g., it was disturbed by another fish) the trial was abandoned (Feary et al., 2010). Care was given to avoid sampling the same fish repeatedly: divers swam 5-10m in the opposite direction before beginning the next trial and continually moved throughout the reef area. To examine the relationship between FID, status (closed, open), and site (Muluk, Wadau) we developed a linear mixed effect model using the *lmer* function in the R package *lme*, with species included as a random effect.

Ecological surveys

We conducted underwater visual censuses (UVCs) on SCUBA to determine reef fish biomass and benthic cover at 4-7 replicate reef sites (Figure 5-5). At each site, we surveyed multiple belt transects, totalling 304 belt transects (2001: 40, 50 x 5-m, 2009: 24, 50 × 5-m, 2012: 72, 30 × 5-m, 2016 and 2017: each 84, 30 × 5-m). We estimated the abundance and body size (total length) of all diurnal non-cryptic reef fishes via standard belt transects on the reef crest (~3m) and reef slope (~7m). Species density estimates were converted to biomass (kg/ha^{-1} per transect) using published species length-weight relationships (Froese and Pauly, 2017). For 2001, only summary biomass estimates (kg/ha^{-1}) for six key families (*Acanthridae, Scaridae, Siganidae, Lutjanidae, Haemulidae, Serranidae*) were available. Consequently, temporal comparisons including 2001 are restricted to these families. For all other years (2009 to 2017) we calculated biomass estimates for the entire assemblage, and for nine key functional fish feeding groups (scrapers/excavators, grazers, browsers, macro-invertivores, micro-invertivores, piscivore-invertivores, piscivores, planktivores, and detritivores). In 2016, we complemented this with a series of 10 minute timed swim surveys (4 transects per depth per site, 14m width (Bozec et al., 2011)) to estimate the biomass of large roving fishes unlikely to be encountered on standard belt transects (specifically mobile carnivores and browsers). We determined the benthic community composition using a

point intercept method on the same belt transects as within the UVC surveys, and quantified percent cover of live hard coral (including growth forms), macroalgae (>10 mm height), epilithic algal matrix (EAM; algae ≤10 mm height) and other living organisms ("others") every 0.5 m (2009, 2012, 2016) or 1m (2017) across all transects. Live corals were identified to genus level, while reef structural complexity was visually estimated 5 times per transect using a 6-point scale (Polunin and Roberts, 1993) from 2009 to 2017. Unfortunately, benthic surveys in 2001 were not included in the final analysis because of incompatible methodological differences (Cinner et al., 2006).

We used a series of hierarchical models to examine the relationship between log (natural) biomass of fish communities and closure, while accounting for potential effects of structural complexity, depth, and percent cover of hard coral, macroalgae, and EAM (Figure 5-5). The models were developed using the lmer function in the lme4 package in R (Bates et al., 2014) with site and year included as random effects. We used the step function in R to develop the most parsimonious model, then compared AIC values of each model with those from a null model (i.e. only the random structure). Given the timed swim surveys (used for piscivores and browsers) did not correspond to any of the benthic transects, we only included closure in these models. Similarly, the 2001 biomass data did not have complimentary benthic data. Thus, we ran a supplemental analysis that examined whether biomass from all years (2001, 2009, 2012, 2016, 2017) was higher inside closures compared to outside, then compared this to a null model.

5.4 Results

Theme 1: Strong and continuing customs

A key theme emerging from the qualitative interviews regarding what community members felt made Muluk and Wadau (Last Karkar) different to other places, was the maintenance of strong customary laws and practices (Table S8). Chief among these practices is a rotational closure system, whereby reef-associated fishing grounds are periodically closed to all fishing activity (heretofore referred to as 'closure') for a period of one to several years. When closed, all fishing and gleaning on a specific section of reef is prohibited. Men may still fish in deeper water beyond the reef crest (Figure 5-1C) (women are traditionally excluded from this deep-water fishing, see *Chapter Three* also). The rotational closures are founded on a strong customary marine tenure system, whereby clans have the right to exclude both clan and non-clan members from specific

fishing grounds. Since 2001, the reefs in each village underwent cycles of rotational closure (Table 5-1). The closures are adaptive; the specific location, size, and duration of the closure can vary (i.e. the closure size can range from a specific portion of the reef to the entire community's reefs and can last from 2-7 years). The ending of a closure is often marked by a large harvesting event and an accompanying celebratory feast (Figure 5-2A-C). For example, in 2017, a reef opening culminated in a ceremony attended by around 300 people from Muluk and surrounding communities. Following speeches about conserving the reef from clan leaders, the local pastor, and visiting political candidates, community members and visitors were gifted fish (Figure 5-2C), which were caught in the week preceding the ceremony (Figure 5-2A) and smoked for preservation (Figure 5-2B). Both villages also employ a traditional bamboo harpoon method of fishing (called 'bom bom'; Figure 5-2D used at night. Fishers use light (traditionally fire, but now a lamp (Figure 5-2D) to attract flying fish (family: *Exocoetidae*) and needle fish (family: *Belonidae*) that are then speared. To use this method, fishers not only adhere to a strict set of customary laws, but must also first undergo an initiation process (Table S8).

Site	Community	2001	2009	2012	2016	2017
1	Muluk	Closed	x	Open	Closed	Open
2	Muluk	Closed	Closed	Open	Closed	Open
3	Muluk	Closed	Closed	Open	Closed	Open
4	Wadau	Open	Open	Closed	Open	Open
5	Wadau	Open	Open	Closed	Open	Open
6	Wadau	Open	x	Open	Open	Open
7	Wadau	Open	x	x	Open	Open
Closure duration		1 year	9 years*	2 years	3 years	NA

Table 5-1. Reef sites and closure status by year of survey.

Note: Sites correspond to Fig.5-1C, X=not surveyed in a specific year. * open for ~2 weeks during this 9-year period.

Both the bom bom fishing method and the rotational closure practices have been passed down through generations, with living memory of them pre-dating World War II. Many respondents emphasized that the strength and continuity of these customs set them apart from other communities. To illustrate, one interviewee noted: "This custom for catching fish ['bom bom'], and the custom of closing the sea… this was created by the ancestors and we haven't lost these practices. We are still here keeping these customs going, and we will keep maintaining them long into the future."

Figure 5-2. Customary fishing practices.

Note: The ending of reef closures is often marked by community harvests of the reef. Harvests (A) are dried and smoked (B) in preparation for a feast (C). (D) re-enactment of the traditional harpoon fishing method known as 'bom bom'.

Perceived benefits of customary management

Our quantitative survey revealed that both villages perceived the closure system as beneficial to people's livelihoods, even though the closure limited fishing opportunities. Specifically, a strong majority of resource users (60-85%, depending on whether reefs were closed or open to fishing at the time of data collection) perceived the closure system as beneficial to their livelihoods (Figure 5-3). Only a small minority (<24%, depending on the year and location) of respondents perceived the closure system to be detrimental to their livelihoods, and only when closures were active (Figure 5-3). The prevalence of negative opinions was significantly related to closed status (Fisher's test, $p<0.02$).

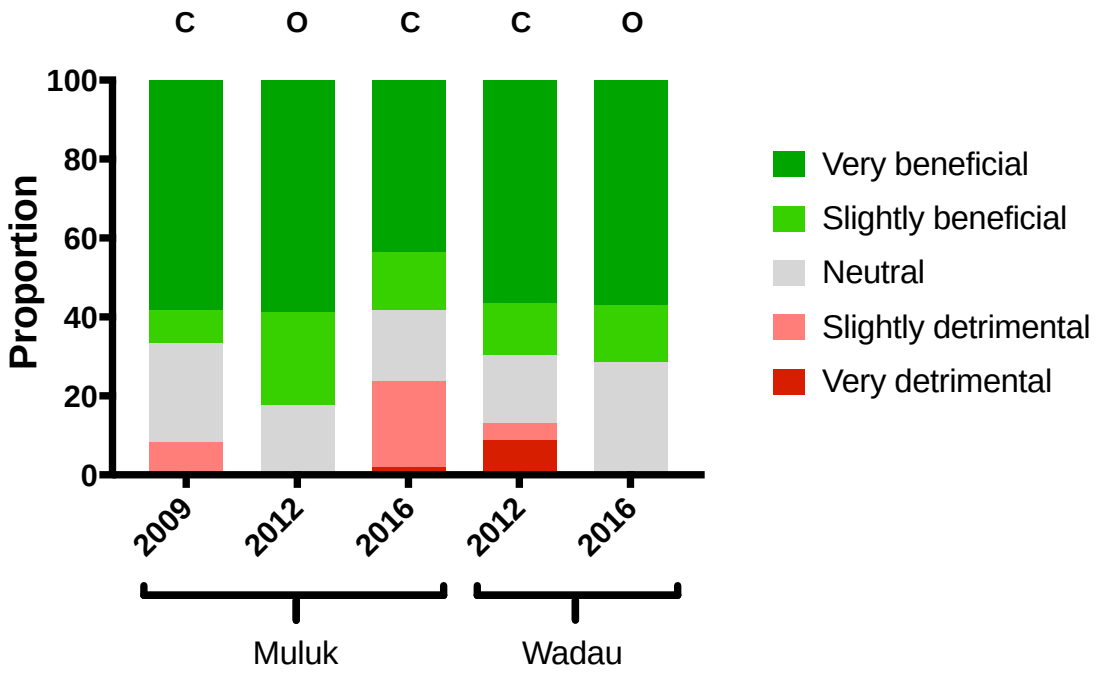


Figure 5-3. Proportion of respondents who perceived beneficial and detrimental impacts of the periodic closure system to their livelihood.

Note: C= closure in place, O= open to fishing.

Our qualitative interviews helped to elucidate three keys reasons why people felt they benefited from the closure system (Table S2). First, people perceived that good fortune befalls people who follow customary laws such as the closure (and vice versa — harm will come to people who break customary rules). Customary laws dictate certain practices and rules around fishing (including abstaining from eating certain fruit and abstaining from fishing while one's wife is menstruating). For instance, one clan leader explained that "you must follow [the customary law], and you will see that you have plenty of fish and plenty of pigs and plenty of whatever you need. If you don't follow the law, you will lose all these things. This custom, it's so important here..." Thus, benefiting from the reef is seen as inextricable from following the customary laws. Second, customs are perceived to create important connections among people, to ancestors, and to place, which helped shape collective identities. For example, an interviewee mentioned: "It's something good that we have here; the way that we help other people and work together and participate in big customary events in the community. Other places don't have this. Other places have gradually lost these ways". Indeed, part of this identity stems from the prestige awarded from being able to host a feast and gift food to visitors (Figure 5-2C).

Finally, respondents perceived that the closure would make fishing easier for men and women in the community, in part through changing fish behaviour (making fish less wary) and in part

through increasing the amount of fish (both of these potential benefits are further explored below). For example, one interviewee noted:

> "…by closing the sea, we let it rest. No one can go into the sea to disturb the reef or disturb the fish. No one can go and frighten the fish in the reef. It'll be easier in the future… all the fish will grow up and then men and women from the community will find it easier to catch fish, even close to the beach, and bring them home to eat."

We further investigated these perceptions of changing fish behaviour and increases in fish numbers using ecological data.

Changing fish behavior

A primary outcome identified by community members was that closures alter fish behaviour in ways that make fishing easier. Interviewees noted that exposure to fishing activities makes fish more 'afraid' of people, resulting in flighty behaviour that makes it difficult to get close to fish. These flightier fish are perceived to be much harder to catch, particularly with spear-guns. To explore the efficacy of the closure on reducing fish wariness, we examined how close a diver could approach six species of fishes before they fled (flight initiation distance; FID- see Methods) in open and closed reefs over time. We build on previous work that compared FID inside and outside a closure at this location (Feary et al., 2010) by conducting a temporal analysis of how FID changes as reefs are opened and closed. Specifically, we compared FID in Muluk and Wadau in 2009 (Muluk's reefs closed, Wadau's reefs open; Table 5-1) and 2012 (Muluk's reefs open, Wadau's reefs closed; Table 5-1) to see how FID changed on the same reefs when open reefs became closed to fishing and when closed reefs became open to fishing. We found that FID was higher (i.e. fish were more wary) when reefs were open to fishing compared when they were closed (Figure 5-4; Table S9). Specifically, in 2009, Wadau (when reefs were open to fishing) estimates of FID were 128cm higher than in 2012, when the same reefs were closed to fishing ($t=-11.3$, $df=372$, $p<0.001$). Alternatively, we observed the opposite trend in FID when reefs closed to fishing were subsequently opened. In Muluk, estimates of FID in 2009 when the reef was closed were 84cm lower than those found for fishes observed in 2012, when the reef was open to fishing ($t=-8.4$, $df=476$, $p<0.001$; Table S9).

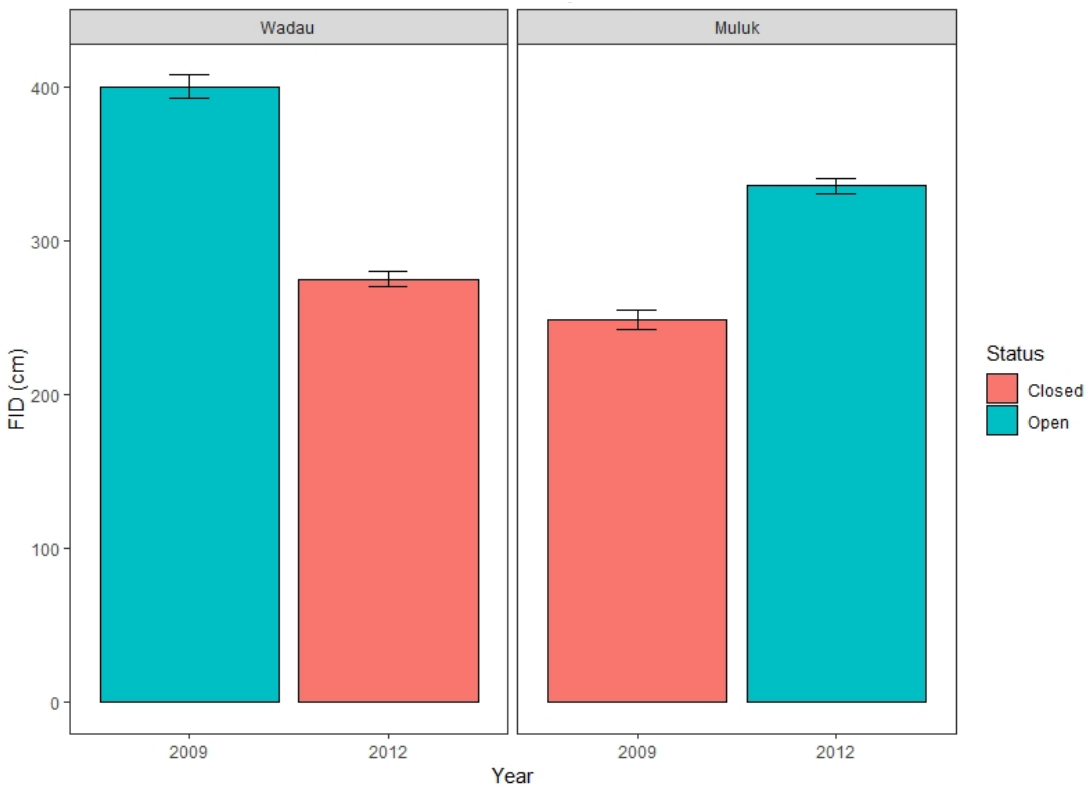


Figure 5-4. Model of predicted fish flight initiation distance (FID).

Note: From open to closed to fishing (Wadau 2009-2012) and from closed to open (Muluk 2009-2012). Model controlled for differences in species composition.

Fish biomass

Our reef surveys also revealed that, overall, reefs closed to fishing had more than double the mean total biomass (650.7 kg/ha^{-1} ± 109.6 SE) of reefs open to fishing (255.7 kg/ha^{-1} ± 17.3SE) (Figure 5-5; p = <0.01). Moreover, certain types of fishes thought to play important functional roles in reef ecosystems (excavators/scrapers, grazers, micro-invertivores, and macro-invertivores) exhibited significantly higher biomass when closures were in place Figure 5-5B, C, E, F, Table S10). Due to a high prevalence of zero abundance of select families in the transect data, we used roving surveys to examine browsers and piscivores (Methods). We found the biomass of browsers and piscivores were also higher when closures were in place, but this difference was only significant at p<0.1 (Figure 5-5D, H). Although there was higher fish biomass inside closures relative to openly fished areas throughout the study, the absolute amount of fish biomass showed signs of decline over time, despite increasing coral cover (Figure 5-5A). Indeed, biomass in openly fished reefs in 2017 [158 (±9.4 SE) kg/ha] was less than a third of estimated biomass in 2001 [517(±124.75 SE) kg/ha].

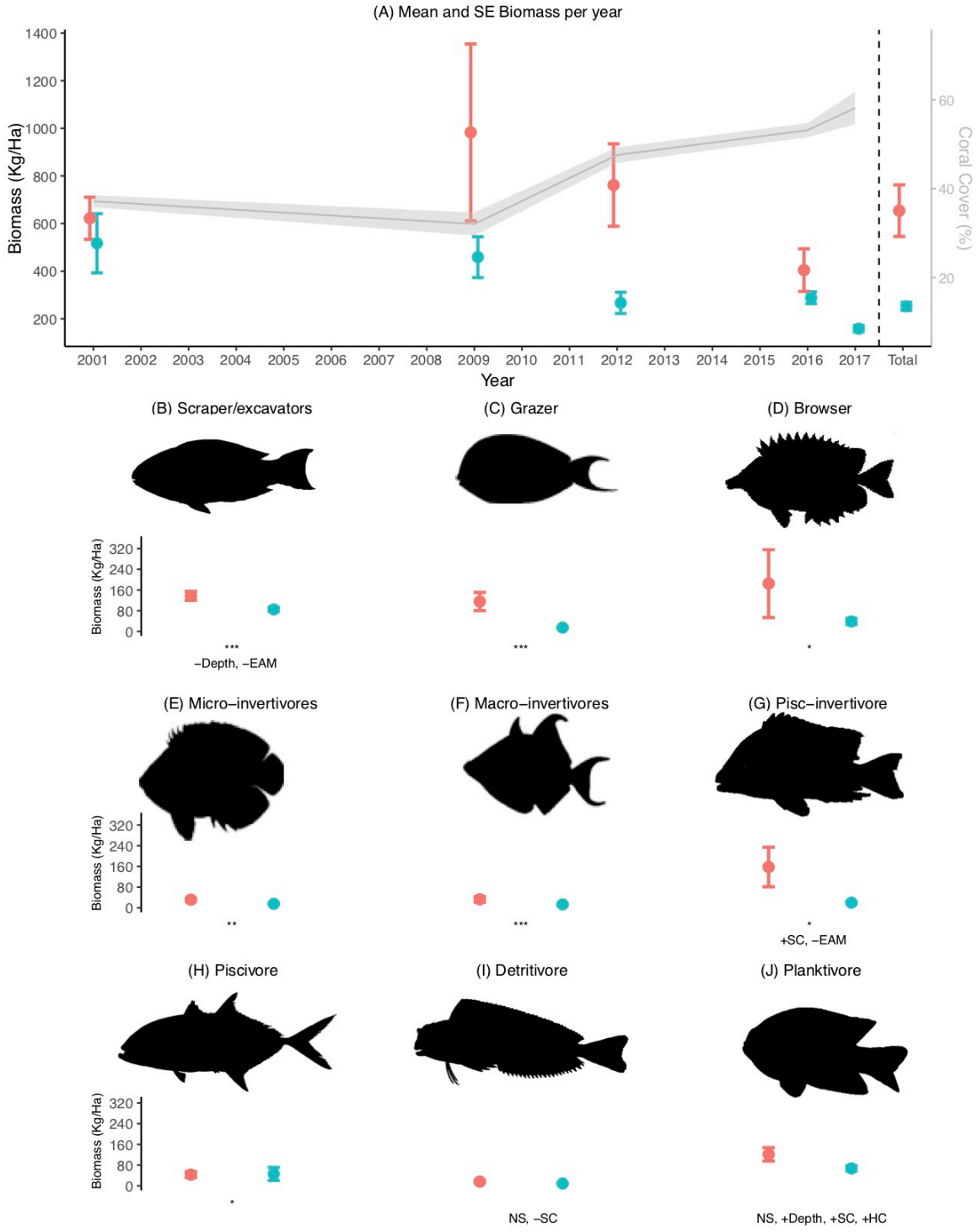


Figure 5-5. Reef fish biomass (mean + standard error) within (red) and outside (green) customary closures.

Note: (A) Reef fish biomass of six select families (*Acanthridae, Scaridae, Siganidae, Lutjanidae, Haemulidae, Serranidae*: y axis) in closed (red) and open (blue) areas, plus coral cover (grey line, z axis) for 2001, 2009, 2012, 2016, 2017, and total of all years). (B-C, E-G, I-J) Aggregate differences in functional group (feeding guild) biomass between open and closed reefs across years from 2009-2017. * indicate level of significant difference between biomass estimates within each group (*p<0.10, **p<0.05, ***p<0.01), with the relationship to key biotic (benthic community taxa) and abiotic factors listed below each graph. EAM= epilithic algal matrix, SC= structural complexity, HC=hard coral (- = negative relationship, + = positive relationship). Biomass estimates of browsers (D) and piscivores (H) are from timed swims in 2016 only, and models do not include other covariates.

Theme 2. Leadership and social cohesion

The second key theme identified by our qualitative interviews centred around the integration of leadership and social cohesion. Strong and respected leadership was considered an essential aspect of the uniqueness of Muluk and Wadau. In addition, respondents also highlighted a strong sense of social cohesion. For example, one respondent noted:

> "So, you'll see that our community isn't divided. We are all together as one whole community. If you go to other communities you'll see, over there is a little part of the village, another is over there, and over there, it's all broken up. So it's hard to communicate and bring people together to talk and come to common understandings. But not here; here, our community is intact, and we must stay like this."

Furthermore, respondents also identified youth-elder ties as a critical part of their social cohesion. To examine leadership and social cohesion, including youth-elder ties, quantitatively we conducted an analysis of fisheries-related knowledge exchange networks using social network analysis methods in Muluk in 2016 (Figure 5-6). Specifically, we fit an exponential random graph model (ERGM) on directed (i.e., knowledge seeking) ties to illuminate underlying social processes driving the formation and maintenance of knowledge exchange relationships (Lusher et al., 2013). We found that found that traditional leaders received significantly more knowledge seeking ties (Table S14), demonstrating that many people in the community consider leaders important sources of fisheries-related knowledge and advice. Thus, the knowledge sharing networks are loosely clustered around traditional leaders. Our ERGM model did not reveal any significant effects of age on the formation of directed knowledge sharing ties. However, when we examined patterns of knowledge exchange across age cohorts (elders, middle-aged, and youth), we find that elders have a much higher level of between cohort ties than within cohort ties (E-I Index of 0.667; Methods; Table S15). By comparison, youth and middle-age fishers tended to form slightly more within cohort ties (Table S15). Elders also have over twice as many incoming ties (indegree) as outgoing ties (outdegree). Combined, these results suggest that elders are seen as important sources of information and advice and play a key role in knowledge communication across generations.

However, we also found evidence of a very open, non-hierarchical social structure where people are not necessarily bound by any specific group membership and thus have more or less equal opportunities to engage in knowledge exchange with all others in the community (Figure 5-6).

Importantly, leaders are more or less evenly distributed throughout the network (rather than clustered in a center 'core'), and they do not preferentially interact with each other (i.e., there is no homophily among leaders). In addition, contrary to common relational patterns found in many types of social networks (Lusher et al., 2013), there is no substantial tendency toward network closure (i.e., clustering) or centralization (which can be indicative of a hierarchical network structure). There is also no significant tendency for people to preferentially share knowledge within their clan (homophily), which is often seen in fishing communities (Barnes-Mauthe et al., 2013). Moreover, members of one clan are not more or less active in the network than members of other clans.

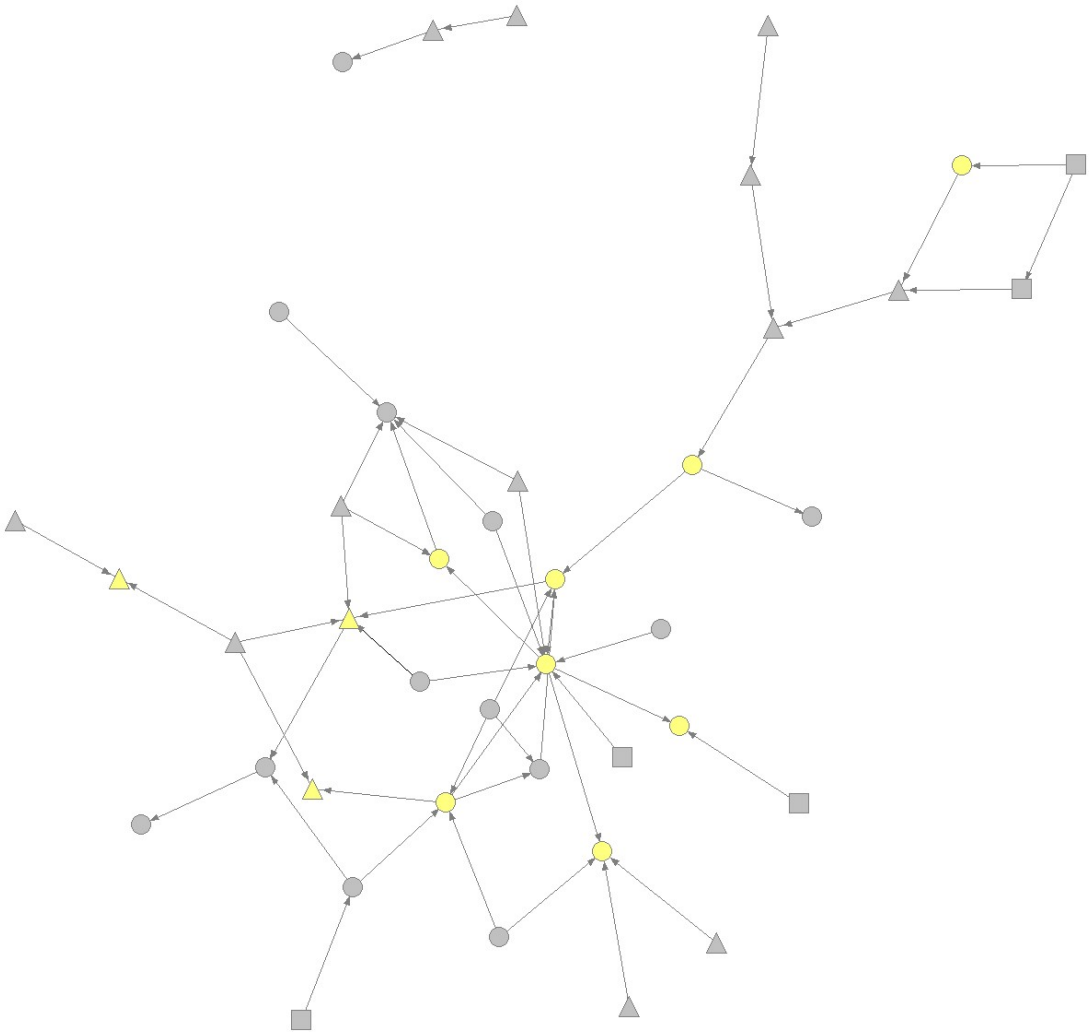


Figure 5-6. Fisheries-related knowledge sharing network.

Note: Network among respondent fishers in Muluk (n = 41) in 2016. Arrows point to sources of information and advice. Node shapes represent different clans; traditional leaders are shaded in yellow. An exponential random graph model of this directed network indicates a very open (i.e., non-clustered) and non-hierarchical social structure loosely organized around traditional leaders (Table S14). Results also indicate that clan-membership does not significantly influence the formation of knowledge sharing ties.

Theme 3: Participatory adaptive decision-making

Both Wadau and Muluk have regular deliberative and adaptive processes in place to make decisions, including those about the closure. Each community holds a weekly meeting to discuss community issues, and individual clans hold meetings when necessary. Several interview respondents considered this deliberative decision-making a key part of ensuring customary practices remained strong (Table S11). For instance, one interviewee emphasized that 'all the leaders meet, and argue about [issues], and make sure the customs stay strong.' Although clan leaders are ultimately responsible for decisions, people in both communities are highly involved in decision making. Between 2001-2016, 95% of respondents reported being involved in community decisions (61% reported being actively involved whereby they spoke and shared ideas at community meetings, and 34% reported being passively involved, whereby they attended but did not contribute to meetings). These figures were broadly consistent across years with active involvement ranging from 58-73% of respondents, passive involvement ranging from 26-42%, and no involvement ranging from 0-10%, depending on the year. Likewise, between 2009-2016, 92% of respondents reported being involved in decision-making specifically related to the reef (55% actively involved and 37% passively; decision-making specific to reef not asked in 2001).

Decisions about when to close or open reefs to fishing activities were reportedly made based on social and ecological feedbacks. One interviewee noted: "If the leader sees that the number of fish has gone down and we're ruining the sea, then the leader will say, it's closed. Ok. If the leader says, there are plenty of fish, now I can catch fish." In addition, ending of closures can also be timed to provide for social gatherings within or between clans (i.e., opening reef sections to provide food for a feast following the death of a community leader or for Christmas), or when community members feel the reef has been closed long enough. In Muluk, each clan also deliberates on the fishing rules within their reef section before it is opened to fishing activities. In 2017, all three clans banned night spear-fishing, limited the use of nets, and banned derris root (a poison that stuns fish). Rules were passed by consensus among clan members.

Theme 4. Compliance

Interviews with clan leaders suggested that social norms and sanctioning processes play a large role in sustaining high compliance levels (Table S12). A 'carrot and stick' approach is used. On

the stick side, clan chiefs single out and penalize rule-breakers, thereby increasing social pressure to comply. For example, an interviewee in Muluk noted: “If [a youth] is disobedient, then we’ll bring him here to talk, and to follow the law of custom. Custom is the same as law, the law of the village… you can’t flaunt it. You can’t mess with it.” On the carrot side, respectful behaviour is rewarded. Every few years, clan leaders, parents and elders select well-behaved, strong, and respectful young men to undergo the prestigious fishing initiation ritual that provides the ‘license’ to fish at night using the ‘bom bom’ method described above (Figure 5-2D). Our quantitative surveys found that compliance rates were generally high. For example, in 2001, 70% of respondents noted that closures were fully or mostly complied with, and this proportion increased to 84% in 2016. Only 8% of Muluk respondents in 2016 reported seeing someone poach within closed reefs in the past 12 months.

5.5 Discussion

Positive deviance approaches have been used in health, development, and business to identify novel solutions in the context of widespread failure. For example, in Vietnam, the NGO ‘Save the Children’ used a bright spots approach to identify a novel solution to childhood malnutrition among poor rice farming families (Marsh et al., 2004). Our study is the first to use social and ecological data over time to investigate a systematically identified positive deviant (bright spot) in a natural resource management context. Specifically, Muluk and Wadau had been identified in Cinner et al. (2016) as having >2 standard deviations more reef fish biomass than expected, given the socioeconomic and environmental conditions they are exposed to. Our detailed investigation of this bright spot revealed two key findings; first that the social and cultural processes that create the bright spot may have important lessons for governance in other locations, and second that the bright spot may be dimming.

First, the management of reef resources in this bright spot is enabled by social and cultural processes that may have important lessons for collective governance of common pool resources in other locations. In particular, key aspects of the customary rotational closure system appear to harness both social influence levers and cognitive biases to foster compliance and the acceptability of management (Cinner, 2018; Kahneman, 2011). Existing research demonstrates that people’s behaviour is profoundly influenced by their desire to maintain prestige, conformity, and reciprocity, and these desires are often based on social norms about acceptable behaviour (Cinner, 2018). In Muluk and Wadau, both the public sanctioning and initiation ritual reinforce injunctive social norms (i.e. what is ‘the right thing to do’) around compliance (Bergseth and

Roscher, 2018). The public sanctioning identified by community members as part of their compliance mechanisms (Table S12) likely invokes a sense of shame for the rule-breaker by publicly calling out bad behaviour. Alternatively, being selected for the initiation ritual to be able to access the 'bom bom' fishery provides positive incentives for following the rules, reinforcing the norms around compliance. This type of 'carrot and stick' approach to compliance which targets social norms can likely help complement compliance efforts in other locations (Bergseth and Roscher, 2018).

The existence of only positive or neutral perceptions about the closure when it was inactive, but some negative perceptions when it was active, can potentially be explained by a variation of the 'peak-end heuristic' (Kahneman, 2011). Peak-end is a phenomenon in which there is a distinction between what people experience and what they remember, with people remembering only the peak (most intense part) and the end of an experience (whether positive or negative), regardless of length (Kahneman, 2011). While the closure was in place (and people could not fish on the reef), some people had a negative perception of it (Figure 5-3). However, the end of the closure coincides with changes in fish behaviour that have been shown to improve fish catch (Januchowski-Hartley et al., 2014) and an event that brings prestige to the community, which may result in people having a more positive view of the closure when asked about it when the reef is open to fishing. Thus, the long-term support for these customary closures may in part be derived from leveraging cognitive biases in community members- a concept that has potential applications for resource management in other locations (Cinner, 2018). More detailed longitudinal data would be needed to confirm this potential explanation for the pattern we observed; but regardless, the lack of negative perceptions after a closure may mean that people are likely more agreeable to initiating the next closure cycle.

Other key enabling social and cultural processes include strong leadership and social cohesion, high levels of participation in deliberative and adaptive decision-making, and the customary marine tenure property-rights that serve as a foundation for developing and enforcing rules. Though leadership and social cohesion are known to be important for successful resource management outcomes, they are often grouped together with other important social drivers, particularly social cohesion, which tends to be discussed under the broad umbrella term 'social capital' (e.g. Gutiérrez et al., 2011). This grouping skews our understanding of how these two attributes interact to facilitate successful outcomes. Here, we show through our qualitative and quantitative results that despite a customary clan-based social system, there is a strong sense of community that transcends clan membership and age-cohorts and involves shared views,

perceptions, and norms. This strong sense of community (i.e., social cohesion) is in part upheld by proactive leaders and elders who hold a high level of respect among the community (Alexander et al., 2018). The deliberative and adaptive processes highlighted in Muluk and Wadau likely also contribute to strong social cohesion among the community, because these processes suggest a high level of procedural justice (Lind and Tyler, 1988), which can foster perceived legitimacy and acceptability of management. Although the specific decision-making arenas used in Muluk and Wadau (weekly community meetings) might not be appropriate or applicable in other places, the broader practice of deliberative and adaptive management certainly is. Lastly, customary practices such as 'bom bom' fishing and the rotational closure system depend on the cultural and legal norm of customary marine tenure, which enables the exclusion of 'outsiders' from certain fishing practices and grounds (in this case, tenure is decided at the clan level). This tenure system provides a rights-based foundation critical to the development and enforcement of locally appropriate rules. In many parts of the world, rights-based systems of fisheries management are proliferating, with varying degrees of success (Cinner and Mcclanahan, 2015; Gelcich et al., 2010). Further understanding the establishment, transmission, and maintenance of norms in rights-based systems may elucidate reasons for failures or successes (Cinner, 2005).

The second key finding is that, sadly, this bright spot may be 'dimming' ecologically, as fish biomass appears to be declining over time. When customary rotational closures in Muluk and Wadau were in place, the overall biomass of reef fish tended to be more than double that of open reefs (Figure 5-5A) — an outcome that contributed to this location being identified as a bright spot (Cinner et al., 2016). But are the ecological benefits of this closure enough to sustain key ecological processes? On one hand, this rotational closure system was associated with considerable ecological success. There was significantly higher biomass of select functional fish groups that are thought to aid in sustaining healthy, coral dominated, tropical reef ecosystems (Table S10). These groups include, for example, grazers and scrapers/excavators, which are vital for removing EAM and sediment, creating open space for coral settlement (Fox and Bellwood, 2007; Robinson et al., 2018), and transferring energy and nutrients to other consumers in the food web (Choat, 2013). Thus, while the closures are in place, it is possible that certain functions are bolstered. Additionally, in stark contrast to the global trend of declining coral cover (Hughes et al., 2018), overall coral cover at these sites increased substantially over the 16-year study period. However, on the other hand, the overall amount of biomass in reefs open to fishing has eroded dramatically over the 16-year study period. Indeed, the biomass levels in 2017 (158 kg/ha) were approaching the reference point of a collapsed reef fishery (10% of unfished biomass or

~100kg/ha) identified in MacNeil et al. (MacNeil et al., 2015). While the fish biomass in the closures was at or above the levels thought to maintain reefs above key ecological thresholds (McClanahan et al., 2011), the biomass in the fished areas was below these thresholds, especially in more recent years. This finding suggests that the rotational closure system may provide a temporary boost to biomass, but may not be enough to stem the overall impacts of overfishing. In 2017, we specifically conducted our fish and benthic surveys as close as possible following the end of the closure (and associated large harvesting event) to try and capture the low baseline (Fig 2). It is possible that the biomass will build from this low baseline closer to the long-term average (Figure 5-5A).

A critical question is why a system that has been in place for generations has recently resulted in the erosion of reef fish biomass to a concerning level? Plausible explanations include the substantial increase in human population (the population of Muluk more than doubled between 2001 and 2016). This increase in population may increase harvest intensity on the relatively small reef area (~92 ha (Cinner et al., 2006)) not only during the opening harvest (more people to feed at a feast and more fishers), but also throughout the open cycle as more people access fishery resources, and may also increase the number of harvest events (e.g., more marriages, community events). Importantly, closure duration and harvest intensity are malleable aspects of this management system that can be adjusted by decision-makers and community members resulting in dynamic and changing timing of closure cycles (Table 5-1), and it is likely that the duration of closure relative to harvest intensity is decreasing over time, although details about historical closure durations were not known. Closure duration can have big impacts on the ecological efficacy of non-permanent closure systems (Cohen and Foale, 2013; Goetze et al., 2017; Jupiter et al., 2012). With the increase in human population, and potentially increases of harvesting events (e.g., increased numbers of marriages, school fees etc.), changing closure duration may also interact with one of the reasons for implementing closures: the change in fish behavior. Our temporal analysis building on previous inside-outside comparisons (Feary et al., 2010) demonstrates how fish flightiness decreases as reefs are closed to fishing, and increases as reefs are open to fishing. Fish behavioural change can be more sensitive than biomass to temporally short closures (Goetze et al., 2017; Januchowski-Hartley et al., 2014), and increased ease of catching fish may mask declines in fish biomass between rotational openings (i.e. a form of hyperstability where catches appear stable despite declining stocks). The sustainability of the resource base may therefore fluctuate with changes in fish behaviour. However, the very malleability of the system can allow decision-makers and community members to adjust closure cycles to allow a rebuilding of their fish stocks.

One rationale for exploring both social and ecological features of this bright spot, was to investigate whether this site was bright ecologically, but dark socially (i.e. that the positive ecological state identified in Cinner et al. (2016) could have been a result of processes that exclude people from accessing resources, negatively affecting their livelihoods). Given the extremely positive views towards the management system's effect on people's livelihoods, it seems unlikely that this spot is socially dark. If anything, the system may be trending toward the opposite way; where people perceived a range of benefits from the management system (socially bright), but the resource is dwindling over time (ecologically dimming). Nonetheless, despite diminishing fish stocks, people perceived a range of benefits from the closure system, which will likely facilitate continued and active participation in and acceptance of resource management in the future. The harvest ceremony after the opening not only provides the community with direct benefits, such as improved fishing opportunities and food for a feast, but also prestige from being able to gift fish to other communities. Indeed, deliberately including positive experiences (like celebratory harvests) in other resource management systems could potentially shape positive perceptions. A critical challenge will be adapting the management system so it can continue to generate key benefits without eroding the ecological system upon which it isfounded.

Our investigation was an important first step in exploring the social and ecological conditions that may enable systematically identified bright spots but has several key shortcomings that may limit the inferences and transferability of the key findings. First, our paper essentially harnessed serendipity, whereby one of the systematically identified bright spots happened to be a place where we had been collecting social and ecological data for a decade and a half. Our exploration required using previously collected data (i.e., 2001-2016) to examine themes identified in 2017. Fortunately, we happened to have data on each of the key themes that arose from the qualitative interviews, but this required us to be somewhat opportunistic about how we explored these themes (i.e. using the data we had rather than developing indicators *de novo*). As a consequence, although our study represents one of the longest-term analysis of a coral reef social-ecological system to date, funding and fieldwork realities meant that the sampling intervals were uneven and not all questions were asked at each sampling interval. Second, our methodology did not allow us to make causal inferences about the conditions we identified. Our emic approach was designed to explore key social and ecological phenomena as identified from the perspective of people in local communities, rather than demonstrate causality. Future studies employing experimental designs will be required to test how the key conditions identified in this paper lead to social and ecological outcomes. Third, because this is a single case study of how a rotational reef closure

system provided benefits in Muluk and Wadau, the transferability of this specific form of management to other social-ecological settings may be limited (Williams et al., 2006). Muluk and Wadau are small communities, where transgressors can be easily identified and punished by leveraging social norms such as shame and ostracism. However, larger, more anonymous communities might struggle to implement these specific strategies (Nyborg et al., 2016). Likewise, people's livelihoods in Muluk and Wadau tended to primarily focus on agriculture, rather than fisheries (Cinner et al., 2006, *Chapter Two*). Communities with higher dependence on fisheries may not have the flexibility to close their fishing grounds for extended periods of time without impacting their primary livelihood activity. Thus, the specific type of rotational closure employed here may not be desirable in other locations.

5.6 Conclusion

Our 16-year analysis of social and ecological conditions in a coral reef bright spot makes a novel contribution to the literature by highlighting four key social-ecological features that may have relevance to other locations: 1) management practices were built on a strong customary foundation, which included a marine tenure system whereby 'outsiders' could be excluded. These customary and right-based foundations allow management practices to be tailored to the local context and adaptive to changing conditions; 2) compliance was managed using a 'carrot and stick' approach that publicly rewarded good behaviour and punished deviant behaviour (Bergseth and Roscher, 2018). This approach essentially leveraged people's desire to align with social norms, an area of increasing interest in conservation (Mackay et al., 2019; Nyborg et al., 2016); 3) the long-term support for these rotational closures may in part be bolstered by people's cognitive biases regarding how they remember experiences (i.e. peak-end heuristic (Kahneman, 2011)). There may be opportunities to better leverage these, and other cognitive biases in marine conservation (Cinner, 2018; Mackay et al., 2019); and 4) there were high levels of participatory decision-making and strong social cohesion (whereby leaders played a critical role in knowledge exchange). These are key elements of procedural justice which should form a crucial foundation of marine conservation efforts. Although fish biomass in this bright spot appears to be declining over time, there is hope that this can be reversed by further adapting and refining the management system using both local and scientific knowledge systems to maximize benefits while minimizing ecological impacts.

Figure 5-7. Thesis map: *Chapter Four* and *Five* to *Chapter Six.*

Chapter Six builds on the findings of *Chapters Four* and *Five* by moving beyond descriptive questions (i.e. who has access to what) to examine how people experience and articulate justice around the use and governance of ecosystem services. *Chapter Six* thus builds on and deepens understanding of the socio-ecological characteristics of Ahus, Muluk and Wadau explored in the preceding chapters.

6 Exploring empirical environmental justice in Papua New Guinea

• **Lau, J.** (*in prep*). Exploring Empirical Environmental Justice in Coastal Communities

Abstract

Justice is both ethically vital and a key ingredient for conservation success. Conservation interventions or natural resource management perceived to be unfair, can cause conflict, distrust and a failure to reach biodiversity outcomes. However, in the ecosystem services literature, studies of empirical equity (i.e. what's considered fair by local people) remain nascent. To fill this gap, in this chapter I apply an environmental justice lens to two case studies of the use and customary management of coastal ecosystem services in Papua New Guinea. Specifically, I ask how people express their perceptions of justice in the distribution of benefits and costs in the governance of coral reefs, how governance manifests in practice, and what moral principles and values are recognized or not. I find that in both case studies, people were concerned about the costs of destructive or over-intensive fishing methods. However, in one case, local concerns about people's needs were in tension with strongly enforcing compliance with bans on these practices. In the other case, deliberative decision-making formed a key practice for negotiating criteria around the distribution of costs and benefits and redefining moral principles collectively. In both places, issues of recognition were expressed through ideas of respect and good conduct in the community. To achieve socially just conservation and resource governance, ecosystem services studies and projects need move beyond dichotomies of costs and benefits, to identify local definitions of what is fair, why, and the gap between these ideals and practice. Environmental justice theory provides a useful framework that now needs more grounding in empirical research in coastal contexts, and greater attention to moral principles.

6.1 Introduction

Issues of justice are often at the forefront of conservation and development conflicts. Attention to justice in conservation, including in ecosystem services, is growing, with increasing recognition that the pursuit of justice matters for both ethical and pragmatic reasons; for peoples' wellbeing and the instrumental outcomes of conservation (Martin et al., 2016, 2015; Springer, 2009). In a pragmatic sense, perceptions and experiences of justice and injustice are key to shaping social and ecological outcomes (Chambers, 2013; McGregor et al., 2015; Melamed et al., 2012), in part because sensitivity to issues of justice shape human behaviour and may override motives like financial gain (Fehr and Falk, 2002; Martin, 2017). Indeed, people's perceptions and experiences of injustice may be a key factor in environmental governance outcomes (Fabinyi et al., 2013), and can create conflict across stakeholders (Miller et al., 2012). For example, in fisheries, perceived social inequity may be a more important influence on peoples' view of fisheries management, than more commonly reported socio-economic factors such as wealth, education and social capital (McClanahan and Abunge, 2015). In fact, people's concerns about unfairness may even concerns about whether or not a resource is being sustainably managed (Bennett and Dearden, 2014; Fabinyi et al., 2013; Twinamatsiko et al., 2014).

Nonetheless, capturing the often complex trade-offs in criteria around what is just or un-just, remains a key challenge for practitioners and scholars working in conservation. Environmental justice scholars have emphasized that issues of justice manifest across three dimensions; distribution (how costs and benefits are distributed), procedure (how decisions are made), and recognition (whose views, interests and knowledge is respected and valued). A key challenge for conservation lies in engaging with this literature to move beyond assumptions that pre-defined criteria like equality are ample measure of justice (Friedman et al., 2018). Rather, what people consider fair depends on social and cultural context and their position within specific configurations of power (Walker, 2014b). By extension, local actors have diverse perceptions of justice that may vary across and within communities and issues (Lecuyer et al., 2018; Paavola, 2003). For instance, in Korea, fishers felt it was fair that those who worked harder or more diligently and/or invested more in the fishery gain more benefits, i.e. criteria of merit (Song and Chuenpagdee, 2015). In case studies in Papua New Guinean and the Philippines, fisherfolk were concerned by the inequalities in benefits from fisheries management, i.e. criteria of equality (Fabinyi et al., 2013). In sum, environmental justice is important to people, but definitions of

what justice entails may vary in different contexts (Chan and Satterfield, 2007). Understanding these locally embedded perceptions of justice can help conservationists better navigate conservation conflicts by identifying where there might be clashes in perceptions (Lecuyer et al., 2018). In addition, the variation in peoples' perceptions of justice matters to their wellbeing because these perceptions and the 'moral principles' people hold inform people's definitions of flourishing or suffering (Lehmann et al., 2018; Narayan, 2000; Sayer, 2011).

Like conservation more broadly, incorporating justice scholarship is a key challenge in ecosystem services literature. Although much early work valued nature so as to make decisions using cost-benefit analysis without thought to equity or justice (Garmendia and Pascual, 2013; Guerry et al., 2015; Kallis et al., 2013), attention to justice is growing in ecosystem services. An ecosystem services approach itself can help expand investigations of justice beyond narrow sectoral interests, to focus on whole ecosystems. Thus, rather than asking, for instance, what are the justice issues facing fishers in a fishery, ecosystem services approaches might examine how other people in the community or who interact with the same ecosystems, perceive justice around ecosystem services (Dawson et al., 2018). However, there are several key empirical gaps that limit ecosystem services' scholarship from deeply understanding local perceptions of justice. Research often starts from narrow definitions (usually predefined) of what is fair and rarely investigating directly people's own perceptions of justice (Friedman et al., 2018; Lehmann et al., 2018, although see Lecuyer et al., 2018; Zia et al., 2011 for recent examples). There has also an overt focus on the distributional dimension of justice, possibly because it is the easiest to measure, with little attention to recognitional justice issues (Martin et al., 2016). In addition, most ecosystem services explorations or applications of environmental justice are centred on projects or interventions (e.g. payments for ecosystem services schemes), and few have examined justice for non-human subjects (Schlosberg, 2013). Finally, there is a lack of analysis of the spaces for participation and how they are perceived by different actors (Nunan et al., 2018). These empirical gaps suggest an opportunity to explore local perceptions justice criteria prior to a conservation or ecosystem services intervention.

To address these gaps and expand treatment of empirical environmental justice in coastal communities, I explore people's perceptions and articulations of justice issues and criteria in the communities of Ahus, Muluk, and Wadau, empirically. These sites provide the opportunity to contrast notions of justice in places with differing legitimacy of customary management systems (see *Chapter Four* and *Chapter Five*), in the midst of the challenges of social and environmental change. Specifically, I ask what justice notions and criteria do people articulate around the use

and governance of ecosystem services across dimensions of distribution, procedure, and recognition? The chapter proceeds as follows. I first outline key theoretical contributions of the field of environmental justice, including the rationale behind a focus on empirical justice and moral principles. Then, after describing my methods, I present the results from my two case studies, on the justice issues and criteria people expressed around the use and governance of coastal ecosystem services. By contrasting justice issues and criteria across the two sites, I argue that justice criteria are based on local perceptions of change and need, and that successful deliberative decision-making can help communities successfully negotiate and continually re-define fair distribution of costs and benefits. I contend that need may be a crucial aspect of moral discourse around non-compliance in fisheries, and that people's perceptions of justice reflect underlying moral principles that may a core aspect of recognitional justice. Finally, I argue that ecosystem services approaches could elicit a deeper understanding of justice issues by expanding their definition of what it is to be morally evaluative human-being.

6.2 Environmental Justice

Work in environmental justice has deepened and extended approaches to justice in conservation. Alongside emphasizing that criteria for justice are embedded in local contexts (see previous section), environmental justice scholarship also emphasizes that justice issues apply to different subjects (Sikor, 2013; Sikor et al., 2014). The subjects of justice may include different people, across different spatial and temporal scales (e.g. different groups within communities, current and future generations) and non-human subjects (e.g. animals and nature itself)(Schlosberg, 2013). Secondly, rather than a narrow focus on the distribution of costs and benefits, the field of environmental justice takes a broader view by incorporating three key dimensions; distribution, procedure, and recognition (McDermott et al., 2013; Walker, 2009). Distributional justice refers to how costs and benefits, opportunities, risks and responsibilities are distributed between groups, including who suffers from ecosystem disservices. These costs and benefits may be material or non-material, objective or subjective (Walker, 2014b). Procedural justice encompasses the procedures through which decisions about ecosystems are made, who is involved, and how these procedures and participation govern this distribution. While there has been less focus on procedural justice to date, studies have found that conservation projects that enhanced local decision-making in Tanzania, resulted in more support for forestry management, even without notable material benefits (Gross-Camp, 2017). Finally, recognitional justice encompasses questions about whose views, interests, knowledge and worldviews are legitimized, respected,

and valued in interpersonal encounters, discourse and practice. Recognitional justice requires understanding the status of social groups with specific cultural values and identities but is poorly understood and relatively neglected in conservation (Martin et al., 2016). Within ecosystem services, concerns about recognitional justice have often manifested in critiques of the way that ecosystem services framings automatically narrow the possibilities of different worldviews and ontologies of human-nature relations (Chan et al., 2016; Martin et al., 2014; Pascual and Howe, 2018). These concerns are, in part, being addressed by embracing and attempting to capture plural values (Díaz et al., 2015).

Environmental justice scholarship also conceptualized justice dimensions as interlinked. For example, a study of a marine protected area in Zanzibar, Tanzania, that found that without proper procedural justice, distributional justice could not be realised, because those most in need were marginalized and had less control of how government benefits were distributed (Gustavsson et al., 2014). In addition, benefit sharing in conservation projects in developing countries often require groups to assimilate dominant discourses of society and nature, leading to recognitional-injustice (Martin et al., 2013). In other words, focusing solely on re-distribution of costs and benefits may obscure injustices in other dimensions, particularly in how conservation problems are framed. Lecuyer et al. (2018) argue that justice-as-recognition actually underpins both distribution and procedural justice because recognition determines whose values matter in evaluating fair costs and benefits, whose knowledge counts in decision-making, and whose justice norms or notions themselves are considered legitimate in comparison to others. Analysing ecosystem services use and governance through the lens of the interconnected justice dimensions thus shifts the focus from aggregated costs and benefits to local criteria of fairness in how ecosystem services are distributed, governed, how people and guiding moral principles are recognized, and what implications this has for different people's wellbeing (Daw et al., 2011; Gurney et al., 2015; Milner-Gulland et al., 2014; Sikor, 2013) or harm (Martin et al., 2016).

6.3 Methods

To explore different notions of justice empirically, within and across the coastal communities of Ahus and Karkar, I used qualitative mixed methods (see *Chapter Two*). I conducted 48 semi-structured interviews with younger and older women and men, from different clans in the communitis of Ahus, Wadau and Muluk. Questions were deliberately open-ended. I asked people to describe what they considered the 'ideal, best, fair, and good' ways of distributing costs and benefits, making decisions and conserving the reef, and to describe any conflicts related to

ecosystem services and how these were resolved (or not). I also asked about people's priorities for future generations. To ensure questions were locally relevant, I asked about specific issues and practices that were particular to each site (identified through observations and informal interviews). In Ahus I included specific questions about a Fish Aggregating Device (FAD) installed by the National Fisheries Authority, and in Muluk I included questions about customary reef management, including about clan meetings and by-laws created prior to opening the reef (which I also observed, see *Chapter Five*). I conducted all interviews in Papua New Guinean Tok Pisin, and they were then transcribed into English by a native speaker of Tok Pisin and checked for accuracy. The semi-structured nature of interviews allowed me to probe more deeply into people's normative opinions about governance and use of the reef, and also allowed me to explore, where appropriate, people's ideas about what was meant by a good life, or a good code of conduct within the community more broadly. In addition to interviews, I observed, participated in and took comprehensive fieldnotes (Emerson et al., 2011) at community meetings, clan meetings, markets, fishing trips, and the opening ceremony of Muluk's closed fishing area.

I analysed interviews iteratively, using a combination of thematic and open coding. Initially, I coded a random selection of interviews to generate key themes, particularly around important issues and moral principles (e.g. respect). In this initial coding I also coded for descriptions of change (demographic and environmental) that people identified or justified their justice criteria with. In the second round of coding (all interviews) I retained and refined these initial codes and coded thematically around distributional, procedural, and recognitional aspects of justice, who articulated them and to whom they applied (i.e. subjects including different groups within the community like women, young people, but also future generations, and non-human actors (e.g.fish)) (Sikor and Newell, 2014). Codes are described in Appendix D.

6.4 Results

Broadly, I found both similarities and differences in people's justice concerns and criteria, and several gaps between what was considered ideally fair and what happened in practice. In this section, I present my results around the three dimensions of justice; distribution, procedure, and recognition, and describe how local perceptions of justice criteria are shaped by evaluation of specific local circumstances.

Site	Issue	Criteria	Concerns (incl. moral principles)	Subjects
Distribution				
Ahus	Night spear-fishing	Equality Need	Unequal costs + benefits Unequal effort Unfair to ban because of need	Community; future generations; Non-human agents (fish); Young men; Fishers' using specific gear/ methods
	Women's cooperative fishing	Equality	Unequal costs Not considered unfair to ban	Women; Fishers' using specific gear/ methods
	Fish aggregating device (FAD) placement	Equality	Equality of opportunity	Fishers from different clans and locations
Karkar	Night spear-fishing Damaging fishing practices (e.g. poison rope)	Equality	Unequal cost Unequal benefits Fair to ban	Fishers' using specific gear/ methods
	Monetary benefits from bêche de mer and trochus	Equality Need	Ensure equality of benefits go to those less able	Clan A members, older women
	Benefits and harms entwined with right conduct and luck	See recognition		Men and women, families
Procedure				
Ahus	Community-based decision making considered 'ideal'. Not realized in practice	Equality	Equality of opportunity to participate	Community members Leaders
	Low participation in meetings due to perceived lack of follow through	Responsibility	Agency	Young men Leaders
Karkar	Regular deliberative decision-making at clan and community level with high participation	Deliberative-reasoning Constructive conflict	Equality of opportunity to participate	Clan members Community members
Recognition				
Ahus	Loss of respect towards clan leadership and customary law	Respect		Young men Clan leaders Community
Karkar	Worldview that moral conduct creates benefits	Obedience Respect		Community
	Emphasis placed on continual recognition of customary practices and clan leadership	Respect		Community Fishers Families

Table 6-1. Summary of justice issues identified in Ahus and Karkar.

Note: Including description of the issue, criteria, concerns and moral principles, and subjects across distributional, procedural and recognitional justice dimensions.

Distributional justice

In both Ahus and Karkar, issues of distributional justice centred on the distribution of fishing effort and resulting unequal costs to others in the community and non-human subjects (i.e. fish). In Ahus, these concerns were in tension with perceptions of the needs and welfare of fishers and their families (i.e. a needs-based criteria of justice), whereas in Karkar, they underpinned strict customary rules about ecosystem services use. In this section I describe and contrast the key issues, criteria, and principles related to distributional justice in both places.

Ahus

In Ahus, people articulated concern about unequal distribution of fishing effort and intensity, linked to fishing techniques including night spear-fishing with a torch and cooperative fishing within the reef. People saw relentless fishing; i.e. fishing every day and night, without giving the reef or fish a chance to rest, as creating unequal and thus unfair costs to future generations, others in the community and non-humans (fish). For instance, one women argued that:

> "If you go get fish now, then don't go tomorrow or the day after. We should leave the ocean alone. With fishing at night time as well… just fish only once and just leave it at that…don't go to the ocean all the time especially at night time when the fish are sleeping… Going every single day is not good at all… We must give time for the fish to reproduce and increase their numbers" (Young woman, Ahus).

These broad concerns about the timing and frequency of fishing effort were linked to concerns people expressed around certain fishing gears or styles. The practice of spear-fishing at night with a torch was perceived to be particularly bad because it required much less effort to catch fish. One women emphasized that;

> "Our husbands shouldn't go diving at night time because at night time the fish are sleeping and its easy for them to get fish [of] all sizes and disturb them from breeding. During the day, the fish are wake and alert but if you go at night time they are sleeping and it is easier to get them." (Woman, Ahus)

Thus, people perceived that spear-fishing generated unequal benefits - more fish for some - and costs - less for other community members and future generations. People likewise expressed that it was unfair to fish themselves, who were sleeping.

> "With night diving, fish are sleeping and we decrease the number of fish… So we have to stop that kind of fishing and diving inside the reef… if we just line fish that will be ok. If you line fish you will only get one fish but if you dive at night you will get a lot of fish and [night divers] are just everywhere." (Man, Ahus)

Thus, torch spear-fishing is viewed as unfair because it affords fishers an advantage over other types of fishing, and over non-humans. Spear-fishing at night requires physical strength and stamina, and was often practiced by young men (See *Chapter Four)*.

In addition to spear-fishing, several respondents identified a form of collective fishing within the reef as unfair and destructive. The method involves a group of women (usually around ten), gathering in the reef lagoon and creating a commotion to herd fish into a specific area where they are speared. This method is rarely used because it has been disrupted by men, who argued that women were too likely to catch small fish, and ruin the reef:

> "Sometimes the women go and splash the ocean. There are like ten canoes that are involved but when we go and do that our husbands get angry… and tell us that we should only go diving. We should only get fish by hard work and not like that because we get undersize fish and we are destroying the ocean. They get angry at us because of that." (Woman, Ahus)

In interviews, women did not perceive being prevented from using this technique as unfair, though seemed to be testing to see what happens (i.e. they tried to use the method a few times and were prevented a few times before giving up).

The advantage of these two methods over other methods, and the ability to catch a lot of fish, was seen as the 'wrong' kind of fishing effort. Namely, people felt that one should earn the fish one catches through appropriate hard work. In both these examples, people's ideas of unfair costs were linked to the idea of appropriate hard work. Spear-fishing at night is too easy because the fish are sleeping, and women's cooperative fishing, likewise, is not viewed as too easy compared to spear and line fishing.

However, the perceived unfairness of intensive fishing and spear-fishing at night was in direct tension with a needs-based criteria of justice. Namely, people (including elders and young people, men and women) described how men needed to spear-fish at night to feed and support their families. Likewise, people fished day and night, constantly, to fulfil their needs and stop

struggling. For instance, one leader described how he no longer reprimanded people for diving in his area of the reef.

> "I'll hear about people diving in my area but I won't really say much, I won't argue because the population has increased and if I stop that person then that person will be hungry or have no food so I leave it." (Man, Ahus)

Thus, justice criteria of subsistence and livelihoods needs were also directly tied to the decreasing legitimacy of customary systems, at least for men (see *Chapter Four*). Yet, women's more destructive practices have been stopped.

People explained the tension between needs-based criteria and fishing effort, population growth, and climate and environmental change. Young men, in particular, emphasized population growth and environmental change as the reason for intense fishing effort, including diving, and at the same time, the changes in attitude away from respect and towards individualism. For instance, one man described that:

> "Just my observation of the village, when the ocean was damaged, the attitude or ways of sharing stopped. People were thinking about themselves; 'If I give it to someone I won't have anything for myself.' The people here on the island, source of income and food is dependent on the ocean. If you have a job than you will be ok but if not everything we need comes from the ocean, if the ocean is spoilt and I don't have any rice I won't give anything to anyone. I think that climate change has affected the way in which people share." (Young man, Ahus)

> "I don't have intentions of damaging the ocean but on the other hand there is the population. The population is increasing and that is the cause… I don't mean to cause damage to the ocean but if I go today and tomorrow I will go back again because I have to live and survive, and just because of that they are insisting on looking after the ocean." (Young Man, Ahus)

In these quote, need outweighs the costs to future generation caused by overfishing. In Ahus concerns about the distribution of effort are not considered wholly unfair or fair, but rather a trade-off between both criteria (equality, need), and subjects (young people, families, future generations, non-humans). The criteria and definition of justice in this situation is therefore in constant tension, likely an unresolvable trade-off. People held in tension the criteria of equality (of costs) and concern of benefits for future generations, non-human subjects (fish), and the criteria of need.

Finally, in Ahus, equality of opportunity was also considered important an important criteria for fisheries benefits coming from outside projects. For instance, many people mentioned the placement of National Fisheries Authority Fish Aggregating Devices (FAD)as an issue of fairness. Many argued that firstly, FADs should be places so that people from all clans and sides of the island had easy and ready access to them, and that, because of this, one FAD was not enough for the whole island. Young men on the Eastern side of the island were reticent about fishing at the one FAD in place during fieldwork (which since detached and floated away), because it fell within the fishing grounds of the clans on the other side of the island (see *Chapter Four*).

Karkar

Similarly to Ahus, people in Karkar held concerns about the distribution of costs from sustained and destructive fishing practices. Like Ahus, diving at night was considered unfair because the fish were sleeping and too easy to catch. However, in contrast to Ahus, it was considered fair to ban not only torch spear-fishing and the use of nets but also to ban the use of the reef entirely (see *Chapter Five*), even though this effectively stopped women and children fishing at all for certain periods. One man explained:

> "And we stopped the use of nets as well because when using nets, the bottom of the net gets hooked on the reef and when you pull it breaks the reef and when you splash the water the fish will go out and not come back and we also stop the use of poison ropes, using that we spoil the chances of the smaller fish getting bigger, the poison rope destroys the fish and the reef as well so we have stopped that too. We also stopped using the reef that we make lime out of, because there are fish that live in that type of reef." (Man, Karkar)

The conceptions and criteria of justice in Karkar, are linked to a particular worldview and strong adherence to customary law (see *Chapter Five*). Specifically, a sense of luck or good fortune (and harms or bad luck) from fishing were seen to be directly related to adherence to the proper code of conduct set out in custom law. Thus, the distribution of benefits from fishing, in particular, was perceived to be directly tied to a whole family's obedience to custom law, at least in Muluk, which included, to a degree, being generous and community-minded. In other words, people linked reciprocity towards others in the community, and also ecosystems as key to benefiting. In this way, in Karkar, the distribution of benefits, is perceived to come from ones' own behaviour and adherence to moral principles like respect.

Procedural justice

In both case studies, people held similar ideals about procedural justice. People in both cases argued that participatory, community decision-making, preferably through deliberation, was the best and fairest way to govern the ocean. However, these ideals manifested quite differently in Ahus and Karkar.

Ahus

In Ahus, issues procedural and recognitional justice are linked to tensions over non-compliance with customary rules. Procedures and accompanying legitimacy to follow through on customary rules no longer exist in practice, but remain as ideals (see *Chapter Four*). Almost all respondents in Ahus emphasized that community deliberation and communication was the best way to make environmental decisions. In practice, this would involve clan level and community level meetings where leaders would discuss possible conservation measures and take ideas from the community to inform their decisions. Many also stated that there needed to be strong action from leaders on rules about ecosystem services, rather than protracted talking. However, despite this ideal version of fair decision-making procedures around the reef, a shift in the legitimacy of clan chief leadership (see *Chapter Three*), and challenges with current governance (not enough power with the people to call meetings), means that what is ideally fair, is no longer an active practice. Clan leaders expressed frustration at dying respect and changes in attitudes, and a resulting inability to enforce rights. Punishments like taking people to court, no longer work to deter people, and leaders are tentative about violence. People also described how 'the attitude and style of looking after the community has changed compared to the past. The leaders used to go through the chief and the government leaders to give the ok but people don't go to where they are supposed to go to so there is a difference between leaders' (Man, Ahus).

There was a distinct lack of participation by younger men in community meetings and decision-making, perhaps partially because they perceive a lack of action, but also because of a lack of communication across generations.

> "A lot of [young men] don't participate, they don't really listen when we have to vote. Normally it's the youths, when decisions are made and the older men and women that are there listen but they don't listen to the younger ones. And most times the youths won't participate and most of the time they don't know that people are gathering like that and things are not going well because of that." (Young Man, Ahus)

Young women also (but women more broadly), rarely actively participate in decisions about the sea. Women are rarely confident to raise issues at the rare meetings that do occur. Participation in decision-making was closely linked to respect in Ahus, and is described in more detail in relation to recognitional justice (p. 109).

Karkar

In contrast to Ahus, Muluk and Wadau both have active, deliberative decision-making processes in place for community issues, including concerns about distribution of costs and benefits from the reef (see *Chapter Five*). Firstly, and most commonly, each community meets as a whole every Monday, to raise and discuss any community issues. Secondly, to organize the opening of the reef in Muluk, each clan had a number of clan-only meetings, to decide how to organise fishing trips leading up to the ceremony, expected contributions from each family, and, importantly, what by-laws would be in place once the reef was opened. These meetings were held after a communal meal, and continued late into the night. At them, one man explained how 'everyone gives their input or ideas and when they make decisions it is based on what has gone wrong or what is damaged, when that happens than they talk about how to bring it back or improve it, when something is damaged than that is how they make decisions' (Man, Karkar). Thus, meetings are both for proactive and reactive governance of the reef.

In Karkar, deliberation is crucial for determining, and constantly redefining what is a fair distribution of costs and benefits. For example, in their meeting, one clan decided that the benefits from sea cucumbers should be shared equally between households when the fishery opened, because 'some of the older women would find it hard to pick up' (Woman, Muluk). Alongside providing an arena for constructive conflict, community and clan meetings provide a forum for issues and concerns about non-compliance to clan boundaries to be raised, which in turn re-draws, re-defines, strengthens boundaries. For instance, in one meeting, a woman from clan A came forward, yelling, she had seen a woman from a different clan fishing in her reef area. After discussion, the community collectively re-iterated the rules around clan boundaries, to the woman's satisfaction and agreement from women from other clans.

These deliberative decision-making practices thus provide a forum for constructive conflict. One young woman exemplified the role of this deliberative forum when she said:

> ‘We argue over the land and the ocean... When we argue about it is a good thing because it means that we care. And we must argue and dispute over it so it will be in a good way. The next generation will live of these things so when we argue it means that we want it to be in a good way. If the elders don’t dispute and talk about it, then I will destroy it and there will be nothing in the future for the kids because I have destroyed it. Fighting and arguing maintains a balance in life. We must look after the land and plant food and earn from it, so it is ok to fight about it. It’s the same with the ocean, we must argue over the fish so there will be fish. But if we do not do any of that than there will be nothing. Those are my thoughts, we must talk about these things.’ (Young Women, Karkar)

In this quote, arguing and conflict is seen as part of the process of stewardship, and care for future generations. Leaders are positioned as responsible for these disputes, and conflict (i.e. ‘fighting and arguing’ is viewed as constructive

Part of the reason that this deliberative system seems to work so well is the well-established legitimacy of leadership, particularly in Muluk (see *Chapter Five*). In Muluk, clan leaders hold more legitimacy, and reef boundaries are much more clearly delineated. Each clan has a defined area of reef marked out by land-marks on the shore. The role of the elected government councillor also differs from Ahus. He describes his role as attending and guiding decisions made by the clans through suggestions, as a participant rather than the leader and instigator of meetings. Finally, meetings and the decisions reached during meetings, are quite fluid. Decisions are codified (in writing by the councillor) when the clans have come to a consensus decision – which seemed to take several weeks around the by-laws.

Nonetheless, as in Ahus, although some, usually older, slightly more educated women, were vocal in meetings, the issues they raised usually only pertained to women’s fishing and women’s benefits; in other words they rarely weighed in on debates about men’s fishing or behaviour.

> “The women agreed, no diving at night time using the torch, no casting the net, no poison ropes, the women are not allowed to pick the reef to bring back up here to make lime, they have stopped all that.” (Woman, Karkar)

In general, women tended to sit at the edge of groups during meetings, and were responsible preparing and delivering coffee and food for participants.

Recognitional justice

In both Ahus and Karkar, respondents raised issues of respect across generations, and respect for customary rules. Respect is part of the recognition of legitimacy, and in both Ahus and Karkar, disrespect is seen as pressing social issue. Here, I describe how issues of recognition in the form of respect permeate people's perceptions of distribution and procedural justice.

Ahus

In Ahus, many people were concerned with younger generations' declining respect towards customary ways of managing the reef. Many respondents expressed frustration at the 'big-headed' (disrespectful, or disobedient behaviour of youths), particularly when it came to drinking and violence. These concerns about respect fed into underlying principles of need (see p. 102).

A key tension is how respect between the community leaders and young men is changing. Declining respect was linked to perceived need for income and subsistence:

> "They do listen sometimes and sometimes they do not respect it. They know that the ocean is a place where they can go looking for fish. So, they do listen to an extent and then they just stop listening. What can we say, it is hard. The way people look for fish here it is too much, as families are getting bigger." (Woman, Ahus)

However, young men also expressed frustration at the lack of follow up (i.e. punishment) on discussions about conserving the ocean. There was a perception that leaders talked a lot, but rarely followed ideas through to action. Leadership has oscillated between proactive and reactive governance. One man emphasized this shift towards 'damage control' saying that:

> "Things are clearer now with the good and bad. And that is why it'll change the way and style of the leaders. Sometimes they concentrate on doing good things like developing the village and when something bad happens it stops the good idea of developing the village and they react to the bad things. When it comes to talking about developing the village… the youths that are involved won't participate with that leader's idea because there are differences that are already there and that creates a lot of differences with the leaders and the community." (Man, Ahus)

This shift is respect and attitude are part of broader social changes to do with generational shifts in obedience, but also, young men performing certain masculinities and power through deviance. One young man explained how, for some, non-compliance was an act of power.

> "Like bullying, some of the young men do it, if the leaders of the village restrict an area and I went wanted to go diving at night time I won't hide, everyone will see me and I'll go diving. If you tried to come talk to I might try and shoot you with my fishing gun… that's how I see the men doing things… Like I said earlier that because I wanted to show that I'm tough or hard headed and I won't listen to you. You want to try and talk to me, I will just argue with you, there is no other reason and that is the reason. I just want to show you that I'm strong, I only listen to myself. When the elders talk I won't listen to them, if they tell me not to do this I'm not going to listen. I will just do what I want." (Young Man, Ahus)

Thus, in Ahus, recognitional justice issues around respect are inextricable from the context of a changing socio-ecological environment, including changing and new identities.

Karkar

In contrast, upholding respect for leadership and customs is important in Muluk, and instilled at a family level. This legitimacy is reinforced by understanding of harms and luck wrought by ones compliance. For instance, one man emphasized that 'Muluk people are humble and they are under their clan leaders and community leaders, government leaders and church leaders and that is why you will see that they are different, and their leaders are advanced in looking after things' (Man, Wadau). In addition, leaders in the community were reflective about changes in practices and values brought by westernization. Specifically, people identified a gradual fading of norms around sharing:

> "It is big in our community or Ward, we have the attitude of liking others and sharing things with each other but now that modern technology has come and the western ways of doing things is here, it has influenced us a bit and [this attitude] is fading away." (Man, Karkar)

Several interviewees spoke of the danger of 'too much knowledge', and fragmentation of ideas at expense of community cohesion.

> "A lot of changes that have happened are because of the modern technology that is coming here. Even western ways, or the cultures are coming in and that is restricting the customs and the Melanesian way of living and it is splitting people up… They think that our old ways are not right,

> so they are adapting to the western ways and that brings a lot of friction between us and we talk about that a lot." (Man, Karkar)

And yet, in Muluk particularly, these changes are taken as the very reason that it is important to strengthen the management of reefs and resources.

> "We have followed the ways of our ancestors and we are following it because we see that the population is increasing. If we don't care for it and take charge than we would face big strife… other people around the island are not like us and they do whatever they want and damage their reef. There won't be much coral growing and they don't rest." (Man, Karkar)

This represents a very different attitude towards population increase than in Ahus where it was seen as an insurmountable pressure on the reef, and the reason that leaders could not enforce bans on certain practices. Thus, in Karkar, identities and issues of recognition are changing less rapidly than in Ahus.

6.5 Discussion

My case studies suggest four key findings relevant to extending the study of justice in ecosystem services. Firstly, I found that people in all communities held similar concerns about the unequal distribution of costs from using ecosystem services, but that these were offset and in tension with a criteria of need in Ahus. I argue that need may be a crucial justice criteria in fisheries, and is an important moral dimension of investigations into non-compliance. Secondly, I found that people broadly supported participatory, deliberative decision-making, but that this only manifested in practice in Karkar. Deliberative decision-making in Karkar highlights the value of procedural spaces and practices that support constructive conflict. Thirdly, I found that, despite gender inequality in access to ecosystem services, and inequalities in monetary benefits from reefs, these were not considered unjust within communities, either by women or men. This finding suggests a need for justice scholarship to incorporate feminist political ecology theories of subjection, whereby marginalizing norms are internalized and shape the identity of certain people (Nightingale, 2011a). Finally, I found that within both communities, issues around respect underpinned both perceptions of justice and the procedures of ecosystem governance. In places experiencing socio-economic change and the 'entanglement' of new and customary forms of governance, concerns about respect (for leadership, between generations, and of customary

practices) may be particularly important to recognitional justice. I discuss each of these findings in turn.

Distributions of cost and need

Unequal distribution of costs from destructive and intensive fishing appear to be a key justice concern in fisheries. In both Ahus and Karkar, use of intensive or destructive gear (torches and nets respectively), damage to the reef, and intensive fishing effort (i.e. fishing day and night without rest) were perceived to have unequal, and thus unfair costs to both the community, future generations, and non-humans (fish). This finding aligns with work in the Solomon Islands and Papua New Guinea, that found that even if people were aware of impending sustainability issues in their fishery, this concern was often outweighed by distributional issues, including who was responsible for the problems and who was benefiting more (Fabinyi et al., 2013). In Milne Bay, people resented bêche de mer compressor divers because their more intensive method resulted in income inequality and in overfishing (Fabinyi et al., 2013). In both Ahus and Karkar, spear-fishing was considered unfair because it afforded fishers an advantage over other types of fishing, even if it did not result in a large disparity in monetary benefits. In Ahus, the more intensive methods (spear-fishing at night) tended to be seen as necessity, rather than aimed at higher profits. In Ahus, those who made more money from the sea, were those who had outboard motors and could fish for pelagic species (see *Chapter Four*). Unequal distribution of monetary benefits from marine ecosystem services benefits were not often defined as unfair or fair, because they are often linked to luck. In other words, unequal monetary benefits are not seen as a moral issue. People in both places raised luck as a key reason for differential benefits from the sea, and in Karkar, the perceived link between luck, harm, and correct conduct was an important part of normative aspect of ecosystem services' governance (see p. 108).

My findings from Ahus support the argument that non-compliance to resource laws (including customary) does not necessarily reflect a 'moral deficit' on the part of non-compliers. In other words, my findings support a conceptual move away from non-compliers as solely self-interested (Cepića and Nunan, 2017). Recent work in the fisheries sector has aimed to more deeply investigate the normative elements of non-compliance. For instance, in Lake Victoria, Tanzania, small-scale fishers justify illegal fishing with diverse and competing understandings of fairness, including the principle of necessity (i.e. need) and the futility of adhering to laws given the extent of illegal fishing (Cepića and Nunan, 2017). In small-scale fisheries in developed countries too, need often shaped which activities people viewed as 'acceptable' illegal fishing. For instance, in

the Galician shellfish sector, licensed shell-fishers accept certain acts of poaching if poachers are members of the local community and harvest for self-consumption (i.e. not to sell) or because of financial need (Ballesteros and Rodríguez-rodríguez, 2018). Likewise, in Ahus, financial need and supporting one's family made non-compliance with customary rules of fishing justifiable. Like the poachers from within the shellfishing community in Galencia, in Ahus, the young men who spearfish at night are part of the community; they are people's sons, nephews, brothers. Indeed, clan leaders – those who would traditionally enforce the rules and punish non-compliers – explained a lack of willingness to punish and enforce, because they recognized the needs of non-compliers.

Interestingly, in Galencia, Lake Victoria, Lithuania, and in Ahus, need outweighed unequal costs to others caused by non-compliance. Taken together, these findings support the argument that ecosystem services should be governed to reconcile basic needs and poverty alleviation (Chaigneau et al., 2018), not only because a range of philosophical perspectives support it (Lehmann et al., 2018) but also because perceptions of need may be at the heart of people's perceptions of what is fair behaviour and conduct. My results, taken with other findings on the moral dimensions of non-compliance (Bergseth and Roscher, 2018), suggest that alongside soliciting locally relevant measures of need (i.e. who is doing well and doing badly), ecosystem services approaches may broaden their investigation to how interpretation of need justifies certain ways of co-producing ecosystem services that may be either illegal, or create unequal costs for others in the community. Trade-offs between the needs of vulnerable community members and the sustainability of ecosystem services are likely to be taboo (Daw et al., 2015). As Bavinck (2018) argues, addressing people's distributive and justice concerns about their resources, may help to identify drivers of resource health problems.

Constructive conflict

Identifying the gap between people's ideal forms of procedural justice and what happens in practice, could open up a path towards more equitable co-management. My findings suggest that identifying people's justice notions before a conservation project starts could be a valuable first step (Wallner-hahn and Torre-castro, 2018). For instance, were a conservation project to begin in either Ahus or Karkar, it would face a two very different existing patterns and processes for decision-making; even though ideally, in both places, people valorized participatory, deliberative decision-making, led by leaders. In Karkar, regular deliberative practices constantly re-define boundaries and what is fair in terms of distribution of costs and benefits. This aligns with work on

an marine protected area in Zanzibar, Tanzania, that found that without proper procedural justice, distributional justice could not be realised, because those most in need were marginalized and had less control of how government benefits were distributed (Gustavsson et al., 2014). In Karkar, however, deliberative decision-making was a regular community practice and habit, rather than a once-off participatory session about a particular project. The repetition of the process of deliberation may be key to its success, because deliberation is a learnable skill (Martin and Rutagarama, 2012). For instance, in the Gambia, regular participatory meetings enabled oyster harvesters to gain confidence in co-managing their fishery and expanded their sense of identity (Lau and Scales, 2016). Thus, deliberative processes and constructive conflict may be important for facilitating confidence in co-management and a sense of ownership of the process.

The procedures in place for making decisions seemed to fulfil another role in Muluk. Namely, to provide a space and platform for transgressions or grievances to be raised and recognized. This finding suggests that there may be some procedural processes that, in the right context, may facilitate better recognition. In fact, deliberative decision-making in Muluk, demonstrates how normative truths can be arrived at through joint reasoning, or communicative rationality (Habermas, 1984). Thus, the process of re-iteration and coming to consensus around subjective and normative concerns, may actually lend further value to deliberation, by providing a process for joint reasoning, at a clan- and community-scale, about what is fair or unfair. This idea aligns with work in Rwanda that found well-managed spaces of deliberation can temporarily empower more marginalized participants, even if it was impossible to completely eliminate power and prejudice from deliberations (Martin and Rutagarama, 2012).

These spaces for deliberation are important for finding common ground on justice notions. People can hold contradictory justice criteria at once or hold justice criteria without abiding by the behaviours they entail. For instance, fishers in Lithuania, including those who poached, recognised the importance of protecting fish stocks, and poachers even claimed that fines for poaching were too low (Hampshire et al., 2004). In Karkar, individual's desires that their resources to be governed for the benefit of others and for future generations was explicit, as captured in the quote; 'we need to yell about our reef… otherwise I will destroy it'. In Ahus, it was more covert. Young men all expressed frustration at a lack of leadership follow through – all talk, and no action – even though follow through would mean harsher punishment and stronger regulation of the very fishing grounds and gears they were using. Thus, my findings support the idea that people's judgements about ecosystem services' management, and fairness, draw on criteria beyond pure self-interest. There are multiple examples in terrestrial conservation, where

local people support parks and projects despite a lack of or even detrimental impact on their livelihoods (Martin et al., 2017). In Laos, this seemingly contradictory attitude is captured in the quote, 'the park is ruining our livelihoods, we support the park'. Martin et., al. (2017) suggest attitude is a confluence of social, economic and psychological factors, including a need to resolve cognitive dissonance. These findings are interesting because they are both from within communities, emphasizing that justice concerns are not necessarily between outsiders and insiders.

Limits to studying perceptions of justice

Thirdly, I found that, despite marked gender inequities in access to ecosystem services, these were not considered unjust within communities, either by women or men. This finding suggests a need for justice scholarship to incorporate feminist political ecology theories of subjection, whereby marginalizing norms are internalized and shape the identity of certain people (Ahlborg and Nightingale, 2017; Nightingale and Ojha, 2013). For instance, in Karkar, one's code of conduct is inherently linked with ones' good or bad fortune (See *Chapter Five*). This connection places the responsibility for the distribution of benefits from ecosystem services firmly within households and families, and often specifically on women's behaviour. Thus, perceived unequal distributions of benefits are not perceived to be an issue of injustice but rather improper adherence to customary codes of conduct. This finding corresponds to much work in Anthropology in the Pacific, that finds that ideas around luck and fortune and fishing are often linked to taboos around women's bodies, especially around what women can and cannot do when menstruating or pregnant (Mohamed et al., 2018). Through the lens of feminist political ecology, my findings suggest that in Karkar, women are subjected in a way that restricts their use of space, but that, having internalized this norm, women do not raise it as a justice issue.

Respect and recognition

Finally, I found that within both communities, issues around respect underpinned both perceptions of justice and the procedures of ecosystem governance. In places experiencing socio-economic change and the 'entanglement' of new and customary forms of governance, concerns about respect (for leadership, between generations, and of customary practices) may be particularly important to recognitional justice. Thus, although recognitional justice is often studied at a larger scale (e.g. the recognition of rights and world views of indigenous people in conservation policy and discourse), I agree with Lecuyer et al., (2018) that recognitional justice

underpins the other justice dimensions, even within-communities. I contend that attention to moral principles like respect, will be a useful way of investigating recognitional justice at a community scale because 'morality is primarily about relations to others, about how people should treat one another in ways conducive to well-being.' (Sayer, 2005, p. 951). In Ahus, leaders were continually navigating their concerns about stewardship of the reef, and care for the wellbeing and needs of the young men who were non-compliers. Thus, moral principles (like respect) capture the timbre or the texture of the relationships of value that may or may not be recognized. Moral principles require an evaluation or judgement, and thus investigating them illuminates people's judgements about moral conduct. Examining the moral principles people hold and use to judge their and others' actions, requires a turn in ecosystem services thinking towards seeing people as moral beings with agency and 'to whom things matter' (Sayer, 2011).

Together, my findings suggest that pre-defined environmental justice criteria or more concrete values schematics might not capture the recursive, fluid nature of local perceptions. While comparable metrics are useful for broad, comparative studies at a community level, justice criteria shape and are shaped by local context and cannot be easily separated. Investigating justice through previous conflicts, trade-offs, and identifying underlying moral principles is a useful step towards analysis of how moral mechanisms work to justify and support certain behaviours (Cepića and Nunan, 2017). Analysing justice in this open, exploratory way not only contributes to understanding how people negotiate and perceive justice but may be a key aspect of local context necessary to understand before beginning even the initial stages of a conservation initiative. By engaging with existing notions of justice, conservation practitioners and ecosystem services-based projects could then more delicately navigate the trade-offs and understand how new projects would fit with existing patterns and practices of governance. Put more broadly, attention to justice as a starting point, allows for a tailored approach to bottom up conservation and decision-making that does not assume that all communities or individuals within them will participate, or even be practiced in, the kinds of participatory approaches proposed.

6.6 Conclusion

Exploratory studies of perceptions of justice provide ecosystem services approaches with opportunity to widen the scope engaging with environmental justice. Although I found many similarities in perceptions of justice around unequal fishing pressure and destructive methods, I also found key differences. I found that in Ahus, need was an important moral criteria, that overrode concerns about non-compliance. In Karkar, deliberative decision-making served as a

platform for not only negotiating and re-defining the distribution of costs and benefits, but also airing grievances, thereby strengthening recognition of different people's values and concerns. In both places, criteria of justice were shaped by the ways that people interpreted and judged their social and environmental context. In addition, in both places, gender inequities were not perceived to constitute issues of justice, suggesting that the feminist political ecology theory of subjection may be an important lens for framing what is not illuminated in empirical justice studies, and why. How and why the use and governance of ecosystems services matters to people, the moral principles that guide what is right or wrong, and the degree of flexibility or acceptability when these ideals are not upheld, are crucial to govern sustainably, with proper recognition of the plural values in peopled-ecosystems.

7 Discussion

Introduction

Ecosystem services are ever more dominant in understanding human-nature relationships. Increasingly, ecosystem services research guides projects aiming to conserve biodiversity, alleviate poverty, and enhance human wellbeing (Howe et al., 2018). This thesis started from the premise that, given ecosystem services' popularity, flexible disciplinary boundaries and multiple epistemic communities (Pascual and Howe, 2018), critical engagement could help realise the 'pragmatic possibilities' of ecosystem services approaches (Jackson and Palmer, 2014). To this end, I drew on insights from the social sciences (anthropology, geography, and environmental justice) to deepen engagement with the human dimensions of ecosystem services in values, access, and justice. Here, I outline the contributions of each chapter and how I addressed the key objectives (*italicised*), synthesize emergent cross-cutting themes and opportunities for future research, before outlining several limitations.

7.1 Summary of contributions

Deepen understanding of how people ascribe importance to ecosystem services and whether and how this importance is socially differentiated.

In *Chapter Three*, I looked broadly at the ecosystem services that were important to people in Ahus, Muluk, and Wadau. I used a mixed-methods approach that combined a non-monetary ranking and rating assessment of multiple ecosystem services, combined with a socio-economic survey that allowed me to disaggregate by social sub-groups. In addition, I gathered qualitative explanations of why ecosystem services matter. I found that people uniformly ascribed the most importance to marine and terrestrial provisioning services that directly support their livelihoods and material wellbeing; i.e. that were associated with direct material needs. Yet, although cultural ecosystem services were often rated lower, people emphasized that they ranked provisioning services highly, in part, because of their contribution to cultural values like bequest. People also expressed concern about extractive ecosystem services, like fuelwood, that were perceived to be destructive, and were rated low.

Within communities, I found that gender, wealth, and years of formal schooling shaped some differences in the importance people ascribed to ecosystem services. Those who perceived that indirect services contributed to direct services (i.e. those who ranked habitat higher because it contributed to fisheries benefits) tended to have completed more years of school and were wealthier. For example, people who had attained more years schooling ascribed higher importance to education(Kaltenborn et al., 2017) and knowledge ecosystem services and habitat, and less to fisheries. In addition, unsurprisingly, people with different livelihoods ascribed importance to the provisioning services that supported their livelihoods.

My findings from *Chapter Three* highlighted the importance of provisioning services that support livelihoods, and thus suggest that sustaining and conserving fisheries and agriculture will be crucial as the global environment changes. They also emphasized that cultural ecosystem services tend to be lowly ranked compared to provisioning services, and thus may be better separated or addressed differently in ecosystem services assessments (Kirchhoff, 2012), for instance through mixed qualitative methods (Kaltenborn et al., 2017). This finding aligns with literature that suggests that cultural services in fact underpin or are deeply related to other types of services and thus do not necessarily constitute a separate category by themselves (Fish et al., 2016).
In addition, my findings echo work emphasising that communities are not homogenous; in this case, wealth, education and gender, shaped several differences in the ecosystem services important to people. However, I emphasize that disaggregating priorities for ecosystem services cannot address whether the use and governance of ecosystem services is equitable or not, and that this will require examination of access, and environmental justice.

Explore how customary institutions shape access to ecosystem services and retain or lose legitimacy in the context of social, ecological, and economic change.

In *Chapter Four*, I undertook an in-depth case study of access to marine ecosystem services in Ahus Island, with a specific focus on how customary institutions shaped this access, how this had changed over time, and for whom. This chapter built on progress in anthropology, which examines how modernity and customary institutions entangle. Through qualitative interviews and participatory observation, I identified that a range of mechanisms shaped access across ecosystem services value chains. Further, I found that the ways that customary institutions shaped access had remained strong for some (i.e. through restricting the areas open to women for fishing) and had faded in legitimacy for others (i.e. young men who broke customary bans on spear-fishing in

specific areas). Through this case study, I argue that ecosystem services would be served by a relational definition of power, alongside its current emphasis on 'power over' (Berbés-Blázquez et al., 2016). Rather than being a zero-sum game, relational power is exercised, and emerges through relationships between people and institutions. I suggest that attention to legitimacy (i.e. the way that the rules and actions of an authority or institutions aligns with values, moral principles and expectations of those who abide by it) can illuminate this relational power. This focus has implications for projects and management that seeks to engage with local institutions. Firstly, my findings suggest a need to ensure that projects consider how intervening at one part of a value chain may thwart, support, and/or be supported by access to benefits along other parts. It also highlights that an outside intervention itself may impact (by strengthening or undermining) the legitimacy of local institutions.

Chapter Five contrasts with findings from *Chapter Four*, because Muluk and Wadau's customary institutions are far stronger and have retained greater legitimacy than in Ahus. In it, I collaborated with interdisciplinary colleagues, to explore the social characteristics underpinning customary management that has maintained strong legitimacy, and the ecological outcomes of this strength, using data over time. We used a mixed-methods, multi-disciplinary approach that began with qualitative interviews with community leaders and fishers to understand what they believed to be unique about their community and its reef system. The themes generated from these interviews were then used to analyse existing socio-economic and ecological data that had been collected over a 16-year time period. We found that Muluk and Wadau had strong social cohesion, with strong relationships between leaders and community members, and high participation in community events and decision-making. This strong social cohesion supported and was reinforced through a system of customary adaptive management of the reef, using rotational fishing closures. This system helped increase fish biomass on the reef and made fish less flighty and thus easier to catch. The customary system had retained strong legitimacy in Muluk. There was very high compliance, and many people perceived that the closures were beneficial to their livelihoods. This legitimacy was also supported by a worldview that perceived luck and benefits from fishing as intimately entwined with obeying and respecting customary laws, and a 'carrot and stick' approach within the community that publicly rewarded good behaviour and punished deviant behaviour. However, we also found that fish biomass is declining, and suggest that this may challenge the strength of customary management in governing the reef.

Elicit local notions of justice in the use and governance of ecosystem services.

Finally, in *Chapter Six,* I built on findings about the socio-ecological dynamics of Ahus and Karkar (*Chapters Three, Four* and *Five*) to explore the notions of justice people in each community hold around the use and governance of their ecosystems. This chapter was intentionally exploratory and aimed to elicit empirical perceptions of justice to build on theories of environmental justice. I found similarities in the ways that people in Ahus and Karkar talked about distributive justice. In both places, people were concerned about the costs of destructive or over-intensive fishing methods. However, in Ahus, there was a tension between local justice criteria around needs-based fairness, and the desire to stop destructive practices. In addition, I found that in both places, people held similar notions of procedural justice; that decision-making should be participatory, deliberative, and involve the whole community. However, actual practices of decision-making manifested very differently in each place. In Karkar, regular deliberative decision-making helped negotiate criteria around the distribution of costs and benefits, and also collectively defining and redefining moral principles. However, in Ahus, while deliberative decision-making was upheld as the 'ideal' way to make decisions about the reef, it was not often practiced. In both places, issues of recognition were expressed through ideas of respect and good conduct in the community.

7.2 Cross-cutting contributions and future research

Taken together, *Chapters Three to Six* contribute to several cross-cutting themes that support a turn towards a relational understanding of human-nature interactions in ecosystem services. I discuss each of these themes and suggest opportunities for future research to expand understanding of normative and moral issues, relational values like need and respect, and gender identities.

Relational values and moral principles

Throughout my chapters normative evaluations and moral principles emerged as important in explaining how people value and think about justice in relation to ecosystem services. These moral principles emerged in people' evaluations of the relationship between humans and nature, and humans and other humans. For instance, in *Chapter Three,* people in both Ahus and Karkar articulated concerns about the correct or appropriate way of using different ecosystem services, particularly services like fuelwood and coral reef materials that were considered extractive and

damaging. In Karkar, the strong social capital underpinned and was shaped by strong legitimacy of leadership (*Chapter Five*). Legitimacy itself is ultimately an alignment of deeply held values, belief, and moral principles, with the actions and rules of authority. In other words, legitimacy is at heart, the relationship between how people believe the world ought to be, and how they perceive it is. Investigating moral principles might serve to highlight taboo trade-offs in governance (Daw et al., 2015); e.g. clan leaders in Ahus unwilling to enforce harsh penalties on young men who do not comply with customary rules. Thus, my findings in *Chapters Three* and *Six* support that people's relationship of concern (including care and responsibility) towards ecosystem services is a ripe arena for empirical work on ecosystem services (Singh, 2015).

Conservation biology (including the conservation social sciences) is a 'mission driven' discipline; to conserve biodiversity. As such, research and practice in conservation is built on assumptions about how and why biodiversity should be conserved, particularly in relation to people (Adams et al., 2004). Likewise, ecosystem services frameworks are also inherently value laden (Díaz et al., 2015), and may have multiple normative positions, especially when addressing issues of poverty alleviation (Howe et al., 2018). Explicitly identifying the normative positions inherent in biodiversity conservation (Matulis and Moyer, 2016) and ecosystem services approaches is important to ensure that fundamental differences in underlying goals and assumptions are not obscured (Howe et al., 2018). For instance, the 'normative gap' between ideas of what and how things should be governed, may is a key barrier to realising greater justice in environmental governance (Dawson et al., 2018). Conversely, explicitly examining these differences may allow for 'unity in diversity' (Montana, 2017), by helping facilitate action towards a common goal, despite underlying normative differences.

While attention to normative positions no doubt matters at the higher level of governance (Howe et al., 2018; Pascual and Howe, 2018), my thesis has emphasized an opportunity to investigate more deeply how normative judgements play out by those whose lives are impacted by ecosystem services projects, or who are more directly dependent on ecosystem services. With the turn to plural and relational values (Jax et al., 2018), there is the opportunity to examine how people negotiate and draw on normative judgements in the use and governance ecosystem services, and in turn contribute to understandings of what it is to be an evaluative human being (Sayer, 2011). I suggest that my findings about need, care and respect, could be more easily identified in other cases with a more explicit framing of how people make normative judgements. I suggest that ecosystem services approaches may do well to re-consider assumptions about the role of the social sciences in taking normative judgements as more than simply subjective values, but a

legitimate form of practical reasoning. Thus, I introduce key ideas from sociology that suggest a view of human beings as ultimately evaluative and shaped by their moral engagement with the material and discursive processes around ecosystems; not simply as a relation value of care towards nature (Jax et al., 2018), but also towards other people.

Sociologist Andrew Sayer argues that the social sciences have sidelined normative judgements and evaluations by identifying them as subjective values (2011). As a result, normative concerns have been relegated to the realm of philosophy or abstract theory, rather than grounded in empirical research. Rather than evaluating, the social sciences have interrogated the historical production of social norms and values. Sayer's concern is that the social sciences' main aim has become to describe and explain, and as a result that social sciences are too tentative in exploring normative conceptions of moral good and human flourishing. As an alternative, Sayer argues for investigating people's evaluative judgements empirically as products of reasoning (rather than subjective values), by blurring the conceptual line between what is considered objectivity and values. This turn will require taking people's moral and normative evaluations seriously:

> 'We need evaluative descriptions of our states of being. It is a mistake to think of values and objectivity as necessarily opposed. This is the shared error of conservatives who want to exclude values in order to allow objectivity, and radicals who accept values and trash objectivity' (Sayer, 2015, p. 292).

This lack of 'evaluative descriptions' leaves the conservation social sciences, and social sciences engaging with ecosystem services, without a theoretical toolkit for understanding seemingly intractable, and invariably social issues around, for instance, moral conflict and care. In conservation, these issues include engaging with trade-offs between well-being and conservation or evaluating plural value claims, including taking seriously moral aspects of relational values like care (Jax. et al., 2018).

Environmental justice approaches only recently have there been moves to study empirical justice – how fairness and equity is defined in any given place (Walker, 2014b). Taking Sayer's challenge seriously would require social science and environmental justice scholars to move a step further to investigate how "moral" and "immoral" come to be defined, practiced and reproduced in distinctive ways across space and time (2004, p. 7) and to evaluate this in terms of human suffering and flourishing. My thesis suggests that normative concerns are not only at the heart of people's articulations of justice but may even be embedded in seemingly more 'objective' measures of the perceptions of the important of ecosystem services. These findings

are evidence that examining human-nature relationships without looking at people's moral principles and judgements will obscure a key aspect of people's behaviour and components of wellbeing (Chan et al., 2018). This argument aligns directly with recent work on relational values that espouse a 'care perspective' on human-nature relations. Taking a care-based framework 'accepts emotions, context, and concern for particular others as comprehensible reasons. Instead of being excluded from the moral discourse, caring feelings are considered as valuable complements and legitimate arguments' (Jax et al., 2018). My findings, alongside sociological progress in evaluating and investigating normative judgements suggest that future work in ecosystem, services and environmental justice would benefit from a deeper understanding of how people perceived and judge the governance of their ecosystem services against their own (likely changeable) normative pillars and morals.

One avenue for ecosystem services approaches to achieve this, is through a widened interpretation of power to include relational power. In *Chapter Four*, I illustrated how ecosystem services might benefit from a relational framing of power, rather than a definition of power over. I argue that examining legitimacy and changing relationships to authority better captures the sometimes-fraught power relations around customary institutions and customary authority, as it entangles with modernity. A relational approach to power sees power as emergent in the social interactions and relationships around ecosystem services (Allen, 2011). Indeed, the social network analysis in *Chapter Five*, suggested that more diffuse forms of power (represented through non-hierarchical knowledge ties) were an important part of maintaining the legitimacy and strength of customary management, through community cohesion. A turn to relational power aligns with wider work examining how the institutional change brought about by payments for ecosystem services schemes interacts with existing institutional logics, resulting in a 'messy' institutional process, whereby the final institutional design is determined through negotiation among all stakeholders (Ishihara et al., 2017). In Ahus and Karkar, the strength and forms of customary institutions are likewise, being reshaped, challenged and also strengthened, through social relationships within both communities (*Chapters Three*, *Four* and *Five*). This relational power is, at the same time, may manifests through adherence or resistance to moral principles like respect, and care. For instance, people's articulations of justice were often relational. Respect across generations was a key concern. People perceived that levels of respect were important to the success of customary institutions in governing the reef (*Chapter Six*). Respect is a moral principle that capture a sense of reciprocity and responsibility with a relationship (either between people and authority, but also between people and institutions).

This turn to moral reasoning was also evident in the recurring emphasis that people in Ahus, Muluk and Wadau placed on human need as a justice criteria and in ascribing importance to ecosystem services. Identifying, recognizing and prioritizing need requires a normative evaluation; i.e. of having, not having, what one should have, of what constitutes enough. Concerns about peoples' need emerged as a key theme across most Chapters. In *Chapter Three*, most people explained that the ecosystem services that were important to them, fulfilled material needs like providing a livelihood and sustenance. I found that, in Ahus and Karkar, perceptions of need are, unsurprisingly, embedded and tied to people's moral assessments of living a good life. In Ahus, perceptions of and concern for the needs of young fishermen prevented clan leaders and elders from carrying out harsh punishment on those who broke customary rules around the reef (*Chapter Six*). In Karkar, need shaped some decisions about how the benefits from collectively harvested ecosystem services (sea cucumbers) were to be shared (*Chapter Six)*. The persistence of concerns about need support current arguments that ecosystem services ought to be governed, first and foremost, to enhance basic needs (Chaigneau et al., 2018) and support poverty alleviation (Lehmann et al., 2018). My thesis supports these arguments with evidence that justice criteria related to the needs of the community, of groups within the community, of future generations, and non-human subjects are an important part of why people prioritize, negotiate and understand justice around the governance of their ecosystem services. Building on these findings, I suggest that seeing normative judgements as a legitimate, if not highly important, topic of study for the social sciences will also greatly benefit the conservation social sciences and social science contributions to ecosystem services.

Gender

Despite wide-ranging literature on gender and the environment (e.g. Meinzen-Dick 1997; 2014), gender has been a key blind spot in ecosystem services (Brown and Fortnam, 2018). Of the papers published on ecosystem services since 1900, less than one percent included gender, and of these, few were in Oceania, few addressed mangrove and marine ecosystems, and almost none addressed cultural ecosystem services (Yang et al., 2018). Gender norms, relationships, and attitudes shape how people interact with their environments; from the resources they extract, to their values, preferences, participation in decision making, and capabilities (MacGregor, 2017). If ecosystem services research leaves out gender, it risks missing crucial data on the factors shaping people's everyday lived experiences and hence wellbeing, and opportunities to transform inequitable systems (Corbera et al., 2007). Throughout my thesis, gender norms and relationships emerged as an important to how people ascribed importance to and accessed ecosystem services.

Yet, I also found that, despite gendered differences in the distribution of ecosystem services costs and benefits, gender inequalities around ecosystem services did not tend to be articulated as unjust.

In *Chapter Three*, I identified community level and intra household gender differences in the ecosystem services people deemed important. Women ascribed slightly higher importance to the ecosystem services related to roles that traditionally fall to women; e.g. fuelwood, reef materials and sanitation. For example, fuelwood was the main source of fuel for cooking in both Ahus and Karkar, and cooking was predominantly (if not completely) women's responsibility. These findings align with recent work in rural and urban coastal ecosystems (including mangroves and coral reefs) in Kenya and Mozambique, where preferences, the use of, and human input into ecosystem services were gendered, in ways reflecting women and men's cultural and responsibilities (Fortnam et al., 2019).

I also found that, even as they faded in legitimacy, customary institutions continued to constrained access to ecosystem services more strongly for women (*Chapter Four*). This finding has important implications for the Pacific and Oceanic coastal communities; as customary institutions interact and change with modernity, the outcomes and manifestations of this 'entanglement' are likely to be gendered. For instance, in Karkar, the strong relationship between clan leaders and younger fishermen was a key to supporting and strengthening customary laws and practices (*Chapter Five*). However, in Ahus, changing masculinities played a role in eroding the legitimacy of customary rules about the reef (*Chapter Four*). Other work in Papua New Guinea has emphasized that the way that economic pressure and social changes have led to a re-casting of masculinity among young small-holders, leading them to challenge relationship of authority and obligation that underpin father-son relationships (Koczberski and Curry, 2016).

Nonetheless, I also found that gendered differences in the use of space and costs of customary measures to manage the reef, was not perceived as unjust by men or women (*Chapter Six)*. In Karkar, decision-making around the reef was participatory and deliberative, and gendered. Women voice opinions and guide debate in meetings, but only on issues that were directly related to women's existing use of the reef. In Ahus, destructive fishing practices were viewed as unfair, because of their costs on other community members and future generations. However, while women's cooperative fishing practices were stopped, men's fishing continued, likely partially because of perceptions of men as the main providers of food and livelihood for the family. Thus,

Chapter Six illuminated that justice notions overlay gendered use and governance of ecosystem services.

These broad contributions to the gendered nature of ecosystem services are a first step towards a more comprehensive engagement. Given gender is a relational and culturally embedded construct (Connell, 2013), deeper engagement with gender and identity may be a useful step forward for theorizing cultural ecosystem services. Insights from feminist political ecology suggests that the symbolic and material practices around ecosystem services co-production are inherently gendered, with implications for justice and wellbeing. Ecosystem services research has begun to emphasize that ecosystem service benefits do not simply flow unhindered or unaided to the waiting arms, (or mouths, or pockets) of recipients (Wieland et al., 2016). Rather, people labour and draw on technology to co-produce ecosystem services within complex political and moral economies (Chan et al., 2011; Fischer and Eastwood, 2016; Palomo et al., 2016). Feminist political ecology emphasizes that this sort of co-production and labour may be an important part of what makes peoples' lives meaningful or something that creates injustice. For example, gendered differences across labour impact how men and women formulate their livelihood strategies (Hapke and Ayyankeril, 2004), and hence on their wellbeing, and adaptive capacity (Van Aelst and Holvoet, 2016). In addition, perceptions and norms of masculinity around men's labour may undermine wellbeing (Westaway et al., 2007). For example, in Pulicat, India, the intersection between masculinity and caste identity and pride in tradition prevented people from abandoning a traditional fisheries management institution that was ultimately entrenching them in poverty (Coulthard, 2011). Peoples' coproduction of ecosystems services thus enables their ability to benefit in the first place, and contributes to their continued sense of meaningful identity, or subjective wellbeing. For instance, in California, constructions of Karuk masculinity were deeply influenced by changes in ecosystem services flows. Men interviewed expressed 'anger, grief, guilt, and shame over of the absence of salmon in the river and their consequent inability to perform social responsibilities for their families and communities' (Norgaard et al., 2017, p. 6).

A feminist political ecology approach intersects with progress in theorizing cultural ecosystem services. Cultural ecosystem services research has moved beyond 'nonmaterial benefits of ecosystems' to engage more deeply with material and symbolic practices of people's engagement with ecosystems. Fish et al. (2016) argue that 'cultural ecosystem services are about understanding modalities of living that people participate in, that constitute and reflect the values and histories people share, the material and symbolic practices they engage in, and the places they inhabit.' Cultural ecosystem services impact wellbeing through 'the identities they help

frame, the experiences they help enable and the capabilities they help equip (Fish et al. 2016: 6). Feminist political ecology insights can enhance the focus on cultural ecosystem services as modalities of living. They emphasize the need to focus on how everyday material and symbolic practices re-entrench or challenge relational values around ecosystem services, and across identities including gender. A commitment to gender equity requires careful attention to how these values are articulated (Pascual et al. 2017), because marginalized people often do not articulate their experiences of marginalization (Deb et al. 2014). Feminist political ecology views individuals' lived experience (or subjectivity), as continually reconstituted through everyday practices and the bounds of identity they reinforce (Nightingale, 2011b). Taking this lens helps explain how marginalizing norms are internalized and shape the identity of certain people (Ahlborg and Nightingale, 2017; Nightingale and Ojha, 2013). In turn, this vein of research expands the idea that symbolic and material practices result in social norms that may be a key leverage point for behavioural and policy change (Nyborg et al., 2016). Future work could attempt to bridge theory in cultural ecosystem services, with theories of subjectivity in feminist political ecology, and with normativity.

7.3 Critiques and Caveats

My thesis has a number of assumptions and limitations associated with interdisciplinary research, and particular to the ecosystem services. Firstly, the flip-side of ecosystem services' position as a boundary object (Ainscough et al., 2019b) is the challenge of navigating the ideologies, approaches and interests of many epistemic communities (Díaz et al., 2015; Pascual and Howe, 2018). Pascual and Howe (2018), emphasize that 'core' and 'satellite' frameworks have emerged within communities of research on ecosystem services. For them, core frameworks, like the Millennium Ecosystem Assessment (MEA, 2005), are 'a fundamental part of the mainstream approach to addressing ecosystem services for human wellbeing' (ibid: 5). In contrast, 'satellite' frameworks either influence 'core' frameworks or deepen key aspects within them (e.g. the social co-production of ecosystem services) (ibid). This thesis contributes to a particular vein of research in ecosystem services focused on enhancing justice (Sikor et al., 2014), and that aligns with many of the objectives of the Ecosystem Services for Poverty Alleviation (ESPA) framework (Pascual and Howe, 2018). I attempted to overcome the challenge of combining multiple disciplines, by grounding the thesis in the philosophy of critical realism (*Chapter Two).* Critical realism is able to ground the epistemological approaches of different disciplines without reverting to a constructionist approach that would deny the material existence of the underpinning

biological and ecological components underpinning the ecosystem services framework. Nonetheless, while critical realism is able to align different methods and theoretical approaches effectively, it cannot address the challenges of balancing ecosystem services' methodological pluralism with tools and approaches that directly contribute to decision-making and practice.[9] There is a risk inherent in critical work that aims to shift ecosystem services approaches, that critiques do not create research that can be quickly applied applications (Ainscough et al., 2019b). Balancing the role of the ecosystem services' idea as a boundary object not only between epistemic communities, but also entirely different fields of practice (e.g. academia, international governance, conservation and development practice) will continue to be a pressing challenge for the field.

Secondly, the aim of my thesis was to inform theory rather than posit causality and as a result, the case study approach and methods in my thesis preclude extrapolating my findings to large scales. There have been some calls for work to move towards a consensus around measurement that would allow for larger, aggregate analysis in ecosystem services (Nahlik et al., 2012) and in environmental justice (Friedman et al., 2018). The findings in Appendix E were at a larger, regional scale (Lau et al., 2018), and the rating and ranking method could potentially be used at a larger scale. Taken together, these two limitations suggest that a next step from my exploratory work would be identifying whether there are ways of applying theoretical insights on, for instance, the different interactions between local criteria of justice dimensions, that could be used at a larger scale, or that could provide tools and methods (e.g. diagnostic questionnaires) that were open enough to capture plural justice notions.

Finally, within my case studies, I was also unable to carry out a range of methods that would have strengthened my thesis and allowed for greater triangulation. For instance, recent, progress in eliciting ecosystem services values has emphasized that participatory, deliberative research likely leads to better, more culturally appropriate depictions of ecosystem service importance (Kenter et al., 2011). I predominantly used individual interviews, and house-hold scale surveys, and participatory observation rather than participatory approaches. Ideally, my thesis would have taken both an individual scale approach, and contrasted it with findings taken from larger,

[9] Critical social science critique still plays an important role in informing conservation practice by reflecting on the practice of conservation and conservation paradigms (like ecosystem services) themselves (Sandbrook et al., 2013).

participatory focus groups. However, the scope and timeline of my thesis prevented me from pursuing these more time-intensive, participatory methods.

7.4 Conclusions

Ecosystem services are fast becoming the paradigm for framing and understanding human-nature relationships in research, policy and practice. In part, the strength of the concept lies in drawing together disciplines and epistemic communities around a single, powerful idea. In my thesis, I aimed to contribute to the ecosystem services approaches capture diverse priorities for services, to illuminate issues of access in the context of socio-ecological change, and to enhance understandings of local perceptions of justice. I pursued this aim by addressing three key objectives aimed at understanding the socially differentiated use, access to and perceptions of justice around ecosystem services. In the process, I found that relational aspects, moral principles and ecosystem services governance shaped and were shaped by people's interactions with their ecosystems. I thus argued that a more relational and in-depth engagement with the way the moral principles manifest empirically is a crucial future research arena for ecosystem services.

Like the comings and goings of the tide, change is inevitable for the people of Ahus Island, and the communities of Muluk and Wadau. How the communities navigate the drift towards capitalism, and the new aspirations and identities of their growing generations, will be intimately entwined with how they use and govern their reefs and coastal resources. This thesis has been an attempt to ground ecosystem services theory in the everyday lives of the people of Karkar and Ahus Island; three small communities charting a course through the vast changes shaping our planet.

8 References

Abson, D.J., von Wehrden, H., Baumgärtner, S., Fischer, J., Hanspach, J., Härdtle, W., Heinrichs, H., Klein, A.M., Lang, D.J., Martens, P., Walmsley, D., 2014. Ecosystem services as a boundary object for sustainability. Ecol. Econ. 103, 29–37. https://doi.org/10.1016/j.ecolecon.2014.04.012

Adams, W.M., 2016. Do you speak Lion? Science (80-.). 17, 626–629. https://doi.org/10.1126/science.aaf8056

Adams, W.M., 2014. The value of valuing nature. Science (80-.). 346, 549–552.

Adams, W.M., Averling, R., Brockington, D., Dickson, B., Elliott, J., Hutton, J., Roe, D., Vira, B., Wolmer, W., 2004. Biodiversity Conservation and the Eradication of Poverty. Science (80-.). 306, 1146–1149. https://doi.org/10.1126/science.1097920

Agrawal, A., Gibson, C.C., 1999. Enchantment and Disenchantment: The Role of Community in Natural Resource Conservation. World Dev. 27, 629–649. https://doi.org/http://dx.doi.org/10.1016/S0305-750X(98)00161-2

Agyeman, J., Schlosberg, D., Craven, L., Matthews, C., 2016. Trends and Directions in Environmental Justice: From Inequity to Everyday Life, Community, and Just Sustainabilities. Annu. Rev. Environ. Resour. 41, 321–340. https://doi.org/10.1146/annurev-environ-110615-090052

Ahlborg, H., Nightingale, A.J., 2017. Theorizing power in political ecology: the where of power in resource governance projects. J. Polit. Ecol. 25, 381–401.

Ainscough, J., de Vries Lentsch, A., Metzger, M., Rounsevell, M., Schröter, M., Delbaere, B., de Groot, R., Staes, J., 2019a. Navigating pluralism: Understanding perceptions of the ecosystem services concept. Ecosyst. Serv. 36, 100892.

https://doi.org/10.1016/j.ecoser.2019.01.004

Ainscough, J., de Vries Lentsch, A., Metzger, M., Rounsevell, M., Schröter, M., Delbaere, B., de Groot, R., Staes, J., 2019b. Navigating pluralism: Understanding perceptions of the ecosystem services concept. Ecosyst. Serv. 36, 100892. https://doi.org/10.1016/j.ecoser.2019.01.004

Albert, J.A., Olds, A.D., Albert, S., Cruz-Trinidad, A., Schwarz, A.M., 2015. Reaping the reef: Provisioning services from coral reefs in Solomon Islands. Mar. Policy 62, 244–251. https://doi.org/10.1016/j.marpol.2015.09.023

Alexander, S.M., Bodin, Ö., Barnes, M.L., 2018. Untangling the drivers of community cohesion in small-scale fisheries. Int. J. Commons 12, 519–547. https://doi.org/10.18352/ijc.843

Allen, J., 2011. Lost Geographies of Power. Blackwell Publishing, Oxford.

Allison, E.H., Ellis, F., 2001. The livelihoods approach and management of small-scale fisheries. Mar. Policy 25, 377–388. https://doi.org/http://dx.doi.org/10.1016/S0308-597X(01)00023-9

Arce, A., Long, N., 2000. Anthropology, development, and modernities: exploring discourses, counter-tendencies, and violence. Routledge.

Arias-Arévalo, P., Gómez-Baggethun, E., Martín-López, B., Pérez-Rincón, M., 2018. Widening the evaluative space for ecosystem services: A taxonomy of plural values and valuation methods. Environ. Values 27, 29–53. https://doi.org/https://doi.org/10.3197/096327118X15144698637513

Arias-Arévalo, P., Martín-López, B., Gómez-Baggethun, E., 2017. Exploring intrinsic, instrumental, and relational values for sustainable management of social-ecological systems. Ecol. Soc. 22, 43. https://doi.org/10.5751/ES-09812-220443

Asian Development Bank, 2014. State of the Coral Triangle: Papua New Guinea, Department of State publication. Background notes series.

Aswani, S., 2005. Customary sea tenure in Oceania as a case of rights-based fishery management: Does it work? Rev. Fish Biol. Fish. 15, 285–307. https://doi.org/10.1007/s11160-005-4868-x

Aswani, S., 2002. Assessing the Effects of Changing Demographic and Consumption Patterns on Sea Tenure Regimes in the Roviana Lagoon, Solomon Islands. Ambio 31, 272–284.

Ayers, A.L., Kittinger, J.N., Vaughan, M.B., 2018. Whose right to manage? Distribution of property rights affects equity and power dynamics in comanagement. Ecol. Soc. 23.

https://doi.org/10.5751/ES-10124-230237

Babbie, E.R., 2010. The practice of social research. Centage Learning, Boston.

Ballesteros, H.M., Rodríguez-rodríguez, G., 2018. “Acceptable” and “unacceptable” poachers: Lessons in managing poaching from the Galician shell fish sector. Mar. Policy 87, 104–110. https://doi.org/10.1016/j.marpol.2017.10.015

Barbier, E.B., 2017. Marine ecosystem services. Curr. Biol. 27, 507–510. https://doi.org/10.1016/j.cub.2017.03.020

Barnaud, C., Corbera, E., Muradian, R., Salliou, N., Sirami, C., Vialatte, A., Choisis, J., 2018. Ecosystem services, social interdependencies, and collective action: a conceptual framework. Ecol. Soc. 23, 1–14.

Barnes-Mauthe, M., Arita, S., Allen, S.D., Gray, S. a., Leung, P.S., 2013. The influence of ethnic diversity on social network structure in a common-pool resource system: Implications for collaborative management. Ecol. Soc. 18. https://doi.org/10.5751/ES-05295-180123

Bates, D., Mächler, M., Bolker, B., Walker, S., 2014. Fitting Linear Mixed-Effects Models using lme4.

Bavinck, M., Jentoft, S., Scholtens, J., 2018. Fisheries as social struggle: A reinvigorated social science research agenda. Mar. Policy 94, 46–52. https://doi.org/10.1016/j.marpol.2018.04.026

Bavington, D., Grzetic, B., Neis, B., 2004. The Feminist Political Ecology of Fishing Down: Reflections from Newfoundland and Labrador. Stud. Polit. Econ. 73, 159–182. https://doi.org/10.1080/19187033.2004.11675156

Beitl, C.M., 2012. Shifting policies, access, and the tragedy of enclosures in Ecuadorian mangrove fisheries: Towards a political ecology of the commons. J. Polit. Ecol. 19, 94–113.

Bell, J.D., Kronen, M., Vunisea, A., Nash, W.J., Keeble, G., Demmke, A., Pontifex, S., Andréfouët, S., 2009. Planning the use of fish for food security in the Pacific. Mar. Policy 33, 64–76. https://doi.org/10.1016/j.marpol.2008.04.002

Belton, B., Thilsted, S.H., 2014. Fisheries in transition: Food and nutrition security implications for the global South. Glob. Food Sec. 3, 59–66. https://doi.org/10.1016/j.gfs.2013.10.001

Béné, C., 2003. When fishery rhymes with poverty: A first step beyond the old paradigm on poverty in small-scale fisheries. World Dev. 31, 949–975. https://doi.org/10.1016/S0305-750X(03)00045-7

Béné, C., Friend, R., 2011. Poverty in small-scale fisheries: old issues, new analysis. Prog. Dev. Stud. 119–144.

Bennett, E.M., Cramer, W., Begossi, A., Cundill, G., Díaz, S., Egoh, B.N., Geijzendorffer, I.R., Krug, C.B., Lavorel, S., Lazos, E., Lebel, L., Martín-López, B., Meyfroidt, P., Mooney, H.A., Nel, J.L., Pascual, U., Payet, K., Harguindeguy, N.P., Peterson, G.D., Prieur-Richard, A.H., Reyers, B., Roebeling, P., Seppelt, R., Solan, M., Tschakert, P., Tscharntke, T., Turner, B.L., Verburg, P.H., Viglizzo, E.F., White, P.C.L., Woodward, G., 2015. Linking biodiversity, ecosystem services, and human well-being: three challenges for designing research for sustainability. Curr. Opin. Environ. Sustain. 14, 76–85. https://doi.org/10.1016/j.cosust.2015.03.007

Bennett, N.J., 2018. Navigating a just and inclusive path towards sustainable oceans. Mar. Policy 97, 139–146. https://doi.org/10.1016/j.marpol.2018.06.001

Bennett, N.J., 2016. Use of perceptions to improve conservation and environmental management. Conserv. Biol. 30, 582–592. https://doi.org/10.1007/s13398-014-0173-7.2

Bennett, N.J., Dearden, P., 2014. Why local people do not support conservation: Community perceptions of marine protected area livelihood impacts, governance and management in Thailand. Mar. Policy 44, 107–116. https://doi.org/10.1016/j.marpol.2013.08.017

Berbés-Blázquez, M., Bunch, M.J., Mulvihill, P.R., Peterson, G.D., van Wendel de Joode, B., 2017. Understanding how access shapes the transformation of ecosystem services to human well-being with an example from Costa Rica. Ecosyst. Serv. 28, 320–327. https://doi.org/https://doi.org/10.1016/j.ecoser.2017.09.010

Berbés-Blázquez, M., González, J.A., Pascual, U., 2016. Towards an ecosystem services approach that addresses social power relations. Curr. Opin. Environ. Sustain. 19, 134–143. https://doi.org/10.1016/j.cosust.2016.02.003

Bergseth, B.J., Gurney, G.G., Barnes, M.L., Arias, A., Cinner, J.E., 2018. Addressing poaching in marine protected areas through voluntary surveillance and enforcement. Nat. Sustain. 1, 421–426. https://doi.org/10.1038/s41893-018-0117-x

Bergseth, B.J., Roscher, M., 2018. Discerning the culture of compliance through recreational fisher's perceptions of poaching. Mar. Policy 89, 132–141. https://doi.org/10.1016/j.marpol.2017.12.022

Bernard, H.R., 2017. Research methods in anthropology: qualitative and quantitative approaches, 6th ed. Rowman and Littlefield Publishers, Lanham.

Blaikie, P., 2006. Is Small Really Beautiful? Community-based Natural Resource Management in Malawi and Botswana. World Dev. 34, 1942–1957.

https://doi.org/http://dx.doi.org/10.1016/j.worlddev.2005.11.023

Blasiak, R., Spijkers, J., Tokunaga, K., Pittman, J., Yagi, N., Österblom, H., 2017. Climate change and marine fisheries: Least developed countries top global index of vulnerability. PLoS One 12, 1–15. https://doi.org/10.1371/journal.pone.0179632

Blasiak, R., Yagi, N., Kurokura, H., Ichikawa, K., Wakita, K., Mori, A., 2015. Marine ecosystem services: Perceptions of indispensability and pathways to engaging citizens in their sustainable use. Mar. Policy 61, 155–163. https://doi.org/10.1016/j.marpol.2015.08.005

Bozec, Y.M., Kulbicki, M., Laloë, F., Mou-Tham, G., Gascuel, D., 2011. Factors affecting the detection distances of reef fish: Implications for visual counts. Mar. Biol. 158, 969–981. https://doi.org/10.1007/s00227-011-1623-9

Britton, E., Coulthard, S., 2013. Assessing the social wellbeing of Northern Ireland's fishing society using a three-dimensional approach. Mar. Policy 37, 28–36. https://doi.org/10.1016/j.marpol.2012.04.011

Brooks, E.G.E., Smith, K.G., Holland, R.A., Poppy, G.M., Eigenbrod, F., 2014. Effects of methodology and stakeholder disaggregation on ecosystem service valuation. Ecol. Soc. 19, 18. https://doi.org/http://dx.doi.org/10.5751/ES-06811-190318

Brown, K., Daw, T., Rosendo, S., Bunce, M., Cherret, N., 2008. Synthesis Report - Ecosystem Services for Poverty Alleviation: Marine & Coastal Situational Analysis. Norwich.

Brown, K., Fortnam, M., 2018. Gender and Ecosystem Services: A Blind Spot, in: Schreckenberg, K., Mace, G., Poudyal, M. (Eds.), Ecosystem Services and Poverty Alleviation: Trade-Offs and Poverty Alleviation. Routledge, Oxon.

Bryman, A., 2006. Integrating quantitative and qualitative research: how is it done? Qual. Res. 6, 97–113. https://doi.org/10.1177/1468794106058877

Caceres, D.M., Tapella, E., Quetier, F., Diaz, S., 2015. The social value of biodiversity and ecosystem services from the perspectives of different social actors. Ecol. Soc. 20. https://doi.org/10.5751/ES-07297-200162

Campbell, B.M., Sayer, J.A., Walker, B., 2010. Navigating trade-offs: Working for conservation and development outcomes. Ecol. Soc. 15, 2. https://doi.org/http://www.ecologyandsociety.org/ vol15/iss2/art16/ Guest

Campling, L., Havice, E., Mccall Howard, P., 2012. The Political Economy and Ecology of Capture Fisheries: Market Dynamics, Resource Access and Relations of Exploitation and Resistance. J. Agrar. Chang. 12, 177–203. https://doi.org/10.1111/j.1471-

0366.2011.00356.x

Carolan, M.S., 2005. Realism without reductionism: Toward an ecologically embedded sociology. Hum. Ecol. Rev. 12, 1–20.

Carrier, J., 1981. Ownership of productive resources on Ponam Island, Manus Province. J. Soc. Ocean. 37, 205–217. https://doi.org/10.3406/jso.1981.3061

Cassels, S., Curran, S.R., Kramer, R., 2005. Do migrants degrade coastal environments? Migration, natural resource extraction and poverty in North Sulawesi, Indonesia. Hum. Ecol. 33, 329–363. https://doi.org/10.1007/s10745-005-4142-9

Cepića, D., Nunan, F., 2017. Justifying non-compliance: The morality of illegalities in small scale fisheries of Lake Victoria, East Africa. Mar. Policy 86, 104–110. https://doi.org/10.1016/j.marpol.2017.09.018

Chaigneau, T., Coulthard, S., Brown, K., Daw, T.M., Schulte-Herbrüggen, B., 2018. Incorporating basic needs to reconcile poverty and ecosystem services. Conserv. Biol. 0, 1–10. https://doi.org/10.1111/cobi.13209

Chambers, R., 2013. Ideas for Development. Taylor and Francis, Hoboken.

Chan, K., Goldstein, J., Satterfield, T., Hannahs, N., Kikiloi, K., Naidoo, R., Vadeboncoeur, N., Woodside, U., 2011. Cultural services and non-use values, in: Kareiva, P., Tallis, H., Ricketts, T., Daily, G., Polasky, S. (Eds.), Natural Capital: Theory and Practice of Mapping Ecosystem Services. Oxford Scholarship Online, Oxford, pp. 206–225.

Chan, K.M. a, Satterfield, T., 2007. Justice, Equity, and Biodiversity. Encycl. Biodivers. 431–441. https://doi.org/10.1016/B978-012226865-6/00527-4

Chan, K.M. a, Satterfield, T., Goldstein, J., 2012. Rethinking ecosystem services to better address and navigate cultural values. Ecol. Econ. 74, 8–18. https://doi.org/10.1016/j.ecolecon.2011.11.011

Chan, K.M., Gould, R.K., Pascual, U., 2018. Editorial overview: Relational values: what are they, and what's the fuss about? Curr. Opin. Environ. Sustain. 1–7. https://doi.org/10.1016/j.cosust.2018.11.003

Chan, K.M.A., Balvanera, P., Benessaiah, K., Chapman, M., Díaz, S., Gómez-Baggethun, E., Gould, R., Hannahs, N., Jax, K., Klain, S., Luck, G.W., Martín-López, B., Muraca, B., Norton, B., Ott, K., Pascual, U., Satterfield, T., Tadaki, M., Taggart, J., Turner, N., 2016. Opinion: Why protect nature? Rethinking values and the environment. Proc. Natl. Acad. Sci. 113, 1462–1465. https://doi.org/10.1073/pnas.1525002113

Chaudhary, S., McGregor, A., Houston, D., Chettri, N., 2015. The evolution of ecosystem services: A time series and discourse-centered analysis. Environ. Sci. Policy 54, 25–34.

https://doi.org/10.1016/j.envsci.2015.04.025

Choat, J., 2013. The Biology of Herbivorous Fishes on Coral Reefs, in: Sale, P. (Ed.), The Ecology of Fishes on Coral Reefs. pp. 120–153.

Cinner, J., 2018. How behavioral science can help conservation. Science (80-.). 362, 889–890. https://doi.org/10.1126/science.aau6028

Cinner, J., 2005. Socioeconomic factors influencing customary marine tenure in the Indo-Pacific. Ecol. Soc. 10. https://doi.org/Artn 36

Cinner, J., Marnane, M., Mcclanahan, T., Almany, G., 2006. Periodic Closures as Adaptive Coral Reef Management in the Indo-Pacific. Ecol. Soc. 11. https://doi.org/10.5751/ES-01618-110131

Cinner, J., McClanahan, T., Graham, N., Daw, T., Maina, J., Stead, S.M.M., Wamukota, A., Brown, K., Bodin, Ö., 2012. Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. Glob. Environ. Chang. 22, 12–20. https://doi.org/10.1016/j.gloenvcha.2011.09.018

Cinner, J., McClanahan, T.R., MacNeil, M. a., Graham, N. a. J., Daw, T.M., Mukminin, A., Feary, D. a., Rabearisoa, a. L., Wamukota, A., Jiddawi, N., Campbell, S.J., Baird, a. H., Januchowski-Hartley, F. a., Hamed, S., Lahari, R., Morove, T., Kuange, J., 2012. Comanagement of coral reef social-ecological systems. Proc. Natl. Acad. Sci. 109, 5219–5222. https://doi.org/10.1073/pnas.1121215109

Cinner, J.E., 2010. Poverty and the use of destructive fishing gear near east African marine protected areas. Environ. Conserv. 36, 321–326. https://doi.org/10.1017/S0376892910000123

Cinner, J.E., 2009. Migration and coastal resource use in Papua New Guinea. Ocean Coast. Manag. 52, 411–416. https://doi.org/10.1016/j.ocecoaman.2009.06.003

Cinner, J.E., 2007. Designing marine reserves to reflect local socioeconomic conditions: lessons from long-enduring customary management systems. Coral Reefs 26, 1035–1045. https://doi.org/10.1007/s00338-007-0213-2

Cinner, J.E., Adger, W.N., Allison, E.H., Barnes, M.L., Brown, K., Cohen, P.J., Gelcich, S., Hicks, C.C., Hughes, T.P., Lau, J., Marshall, N.A., Morrison, T.H., 2018. Building adaptive capacity to climate change in tropical coastal communities. Nat. Clim. Chang. 8, 117–123. https://doi.org/10.1038/s41558-017-0065-x

Cinner, J.E., Aswani, S., 2007. Integrating customary management into marine conservation. Biol. Conserv. 140, 201–216. https://doi.org/10.1016/j.biocon.2007.08.008

Cinner, J.E., Bodin, Ö., 2010. Livelihood diversification in tropical coastal communities: A

network-based approach to analyzing “livelihood landscapes.” PLoS One 5. https://doi.org/10.1371/journal.pone.0011999

Cinner, J.E., Folke, C., Daw, T., Hicks, C.C., 2011. Responding to change: Using scenarios to understand how socioeconomic factors may influence amplifying or dampening exploitation feedbacks among Tanzanian fishers. Glob. Environ. Chang. 21, 7–12. https://doi.org/10.1016/j.gloenvcha.2010.09.001

Cinner, J.E., Huchery, C., MacNeil, M.A., Graham, N.A.J., McClanahan, T.R., Maina, J., Maire, E., Kittinger, J.N., Hicks, C.C., Mora, C., Allison, E.H., D’Agata, S., Hoey, A., Feary, D.A., Crowder, L., Williams, I.D., Kulbicki, M., Vigliola, L., Wantiez, L., Edgar, G., Stuart-Smith, R.D., Sandin, S.A., Green, A.L., Hardt, M.J., Beger, M., Friedlander, A., Campbell, S.J., Holmes, K.E., Wilson, S.K., Brokovich, E., Brooks, A.J., Cruz-Motta, J.J., Booth, D.J., Chabanet, P., Gough, C., Tupper, M., Ferse, S.C.A., Sumaila, U.R., Mouillot, D., 2016. Bright spots among the world’s coral reefs. Nature 535, 416–419. https://doi.org/10.1038/nature18607

Cinner, J.E., Mcclanahan, T.R., 2015. A sea change on the African coast ? Preliminary social and ecological outcomes of a governance transformation in Kenyan fisheries. Glob. Environ. Chang. 30, 133–139. https://doi.org/10.1016/j.gloenvcha.2014.10.003

Cinner, J.E., McClanahan, T.R., Wamukota, A., 2010. Differences in livelihoods, socioeconomic characteristics, and knowledge about the sea between fishers and non-fishers living near and far from marine parks on the Kenyan coast. Mar. Policy 34, 22–28. https://doi.org/10.1016/j.marpol.2009.04.003

Cohen, P.J., Foale, S.J., 2013. Sustaining small-scale fisheries with periodically harvested marine reserves. Mar. Policy 37, 278–287. https://doi.org/10.1016/j.marpol.2012.05.010

Colfer, C.J.P., 2011. Marginalized forest peoples’ perceptions of the legitimacy of governance: An exploration. World Dev. 39, 2147–2164. https://doi.org/10.1016/j.worlddev.2011.04.012

Connell, R., 2013. Gender and Power: Society, the Person and Sexual Politics. Polity Press, Cambridge.

Corbera, E., Brown, K., Adger, N.W., 2007. The equity and legitimacy of markets for ecosystem services. Dev. Change 38, 587–613. https://doi.org/10.1111/j.1467-7660.2007.00425.x

Costanza, R., Arge, R., Groot, R. De, Farberk, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O’Neill, R. V, Paruelo, J., Raskin, R.G., Suttonkk, P., van den Belt, M., 1997. The value of the world’s ecosystem services and natural capital. Nature 387, 253–

260. https://doi.org/10.1038/387253a0

Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., Farber, S., Grasso, M., 2017. Twenty years of ecosystem services: How far have we come and how far do we still need to go? Ecosyst. Serv. 28, 1–16. https://doi.org/10.1016/j.ecoser.2017.09.008

Coulthard, S., 2011. More than just access to fish: The pros and cons of fisher participation in a customary marine tenure (Padu) system under pressure. Mar. Policy 35, 405–412. https://doi.org/10.1016/j.marpol.2010.11.006

Coulthard, S., Johnson, D., McGregor, J., 2011. Poverty, Sustainability and Human Wellbeing: A social wellbeing approach to the global fisheries crisis. Glob. Environ. Chang. 21, 453–463. https://doi.org/https://doi.org/10.1016/j.gloenvcha.2011.01.003

Crotty, M., 1998. The foundations of social research : meaning and perspective in the research process. Sage Publications, London.

Cruz-Garcia, G.S., Sachet, E., Blundo-Canto, G., Vanegas, M., Quintero, M., 2017. To what extent have the links between ecosystem services and human well-being been researched in Africa, Asia, and Latin America? Ecosyst. Serv. 25, 201–212. https://doi.org/10.1016/j.ecoser.2017.04.005

Curry, G.N., Koczberski, G., 2012. Relational Economies, Social Embeddedness and Valuing Labour in Agrarian Change: An Example from the Developing World. Geogr. Res. 50, 377–392. https://doi.org/10.1111/j.1745-5871.2011.00733.x

Curry, G.N., Koczberski, G., 2009. Finding common ground: Relational concepts of land tenure and economy in the oil palm frontier of Papua New Guinea. Geogr. J. 175, 98–111. https://doi.org/10.1111/j.1475-4959.2008.00319.x

Curry, G.N., Koczberski, G., Connell, J., 2012. Introduction: Enacting modernity in the Pacific? Aust. Geogr. 43, 115–125. https://doi.org/10.1080/00049182.2012.682291

Daily, G., 1997. Nature's Services: Societal Dependence On Natural Ecosystems. Island Press, Washington.

Daily, G.C., Ellison, K., 2002. The new economy of nature: the quest to make conservation profitable.

Daw, T., Brown, K., Rosendo, S., Pomeroy, R., 2011. Applying the ecosystem services concept to poverty alleviation: the need to disaggregate human well-being. Environ. Conserv. 34, 370–379. https://doi.org/https://doi.org/10.1017/S0376892911000506

Daw, T.M., Coulthard, S., Cheung, W.W.L., Brown, K., Abunge, C., Galafassi, D., Peterson, G.D., McClanahan, T.R., Omukoto, J.O., Munyi, L., 2015. Evaluating taboo trade-offs

in ecosystems services and human well-being. Proc. Natl. Acad. Sci. 201414900. https://doi.org/10.1073/pnas.1414900112

Dawson, N., Coolsaet, B., Martin, A., Coolsaet, B., Martin, A., 2018. Justice and equity : Emerging research and policy approaches to address ecosystem service trade-offs, in: Schreckenberg, K., Mace, G., Poudyal, M. (Eds.), Ecosystem Services and Poverty Alleviation: Trade-Offs and Governance. Routledge, London, pp. 22–38. https://doi.org/10.4324/9780429507090-3

Dawson, N., Martin, A., 2015. Assessing the contribution of ecosystem services to human wellbeing: A disaggregated study in western Rwanda. Ecol. Econ. 117, 62–72. https://doi.org/10.1016/j.ecolecon.2015.06.018

de la Torre-Castro, M., Fröcklin, S., Börjesson, S., Okupnik, J., Jiddawi, N.S., 2017. Gender analysis for better coastal management – Increasing our understanding of social-ecological seascapes. Mar. Policy 83, 62–74. https://doi.org/10.1016/j.marpol.2017.05.015

Degnbol, P., Gislason, H., Hanna, S., Jentoft, S., Raakjær Nielsen, J., Sverdrup-Jensen, S., Clyde Wilson, D., 2006. Painting the floor with a hammer: Technical fixes in fisheries management. Mar. Policy 30, 534–543. https://doi.org/10.1016/j.marpol.2005.07.002

Deveaux, M., 1994. Feminism and Empowerment: A Critical Reading of Foucault. Fem. Stud. 20, 223–247.

Díaz, S., Demissew, S., Carabias, J., Joly, C., Lonsdale, M., Ash, N., Larigauderie, A., Adhikari, J.R., Arico, S., Báldi, A., Bartuska, A., Baste, I.A., Bilgin, A., Brondizio, E., Chan, K.M.A., Figueroa, V.E., Duraiappah, A., Fischer, M., Hill, R., Koetz, T., Leadley, P., Lyver, P., Mace, G.M., Martin-Lopez, B., Okumura, M., Pacheco, D., Pascual, U., Pérez, E.S., Reyers, B., Roth, E., Saito, O., Scholes, R.J., Sharma, N., Tallis, H., Thaman, R., Watson, R., Yahara, T., Hamid, Z.A., Akosim, C., Al-Hafedh, Y., Allahverdiyev, R., Amankwah, E., Asah, T.S., Asfaw, Z., Bartus, G., Brooks, A.L., Caillaux, J., Dalle, G., Darnaedi, D., Driver, A., Erpul, G., Escobar-Eyzaguirre, P., Failler, P., Fouda, A.M.M., Fu, B., Gundimeda, H., Hashimoto, S., Homer, F., Lavorel, S., Lichtenstein, G., Mala, W.A., Mandivenyi, W., Matczak, P., Mbizvo, C., Mehrdadi, M., Metzger, J.P., Mikissa, J.B., Moller, H., Mooney, H.A., Mumby, P., Nagendra, H., Nesshover, C., Oteng-Yeboah, A.A., Pataki, G., Roué, M., Rubis, J., Schultz, M., Smith, P., Sumaila, R., Takeuchi, K., Thomas, S., Verma, M., Yeo-Chang, Y., Zlatanova, D., 2015. The IPBES Conceptual Framework - connecting nature and people. Curr. Opin. Environ. Sustain. 14, 1–16. https://doi.org/10.1016/j.cosust.2014.11.002

Diaz, S., Demissew, S., Joly, C., Lonsdale, W.M., Larigauderie, A., 2015. A Rosetta Stone for Nature's Benefits to People. PLoS Biol. 13, 1–9. https://doi.org/10.1371/journal.pbio.1002040

Díaz, S., Pascual, U., Stenseke, M., Martín-López, B., Watson, R.T., Molnár, Z., Hill, R., Chan, K.M.A., Baste, I.A., Brauman, K.A., Polasky, S., Church, A., Lonsdale, M., Larigauderie, A., Leadley, P.W., van Oudenhoven, A.P.E., van der Plaat, F., Schröter, M., Lavorel, S., Aumeeruddy-Thomas, Y., Bukvareva, E., Davies, K., Demissew, S., Erpul, G., Failler, P., Guerra, C.A., Hewitt, C.L., Keune, H., Lindley, S., Shirayama, Y., 2018. Assessing nature's contributions to people. Science (80-.). 359, 270–272. https://doi.org/10.1126/science.aap8826

Díaz, S., Quétier, F., Cáceres, D.M., Trainor, S.F., Pérez-Harguindeguy, N., Bret-Harte, M.S., Finegan, B., Peña-Claros, M., Poorter, L., 2011. Linking functional diversity and social actor strategies in a framework for interdisciplinary analysis of nature's benefits to society. Proc. Natl. Acad. Sci. U. S. A. 108, 895–902. https://doi.org/10.1073/pnas.1017993108

Diedrich, A., Aswani, S., 2016. Exploring the potential impacts of tourism development on social and ecological change in the Solomon Islands. Ambio 45, 808–818. https://doi.org/10.1007/s13280-016-0781-x

Drew, J.A., Amatangelo, K.L., Hufbauer, R.A., 2015. Quantifying the human impacts on Papua New Guinea reef fish communities across space and time. PLoS One 10, 1–11. https://doi.org/10.1371/journal.pone.0140682

Dunlap, R.E., York, R., 2008. The Globalization of Environmental Concern and the Limits of the Postmaterialist Values Explanation : Evidence from Four Multinational Surveys. Sociol. Q. 49, 529–563. https://doi.org/10.1111/j.1533-8525.2008.00127.x

Eder, J.F., 2005. Coastal resource management and social differences in Philippine fishing communities. Hum. Ecol. 33, 147–169. https://doi.org/10.1007/s10745-005-2430-Z

Edwards, G.A.S., Reid, L., Hunter, C., 2016. Environmental justice, capabilities, and the theorization of well-being. Prog. Hum. Geogr. 40, 1–16. https://doi.org/10.1177/0309132515620850

Eisenstadt, S.N., 2000. Multiple Modernities. Daedalus 129, 1–29.

Emerson, R.M., Fretz, R.I., Shaw, L.L., 2011. Writing ethnographic fieldnotes, 2nd ed. University of Chicago Press, Chicago.

Erazo, E., Jarrett, C., 2017. Managing alterity from within: the ontological turn in anthropology and indigenous efforts to shape shamanism. J. R. Anthropol. Inst. 24, 145–

163. https://doi.org/doi/epdf/10.1111/1467-9655.12756

Evans, L., Cherrett, N., Pemsl, D., 2011. Assessing the impact of fisheries co-management interventions in developing countries: A meta-analysis. J. Environ. Manage. 92, 1938–1949. https://doi.org/10.1016/j.jenvman.2011.03.010

Fabinyi, M., Foale, S., Macintyre, M., 2013. Managing inequality or managing stocks? An ethnographic perspective on the governance of small-scale fisheries. Fish Fish. 1–15. https://doi.org/10.1111/faf.12069

FAO, 2012. The State of World Fisheries and Aquaculture 2012, Sofia. https://doi.org/10.5860/CHOICE.50-5350

Feary, D., Cinner, J., Graham, N., Januchowski-Hartley, F., 2010. Effects of Customary Marine Closures on Fish Behavior, Spear-Fishing Success, and Underwater Visual Surveys. Conserv. Biol. 25, no-no. https://doi.org/10.1111/j.1523-1739.2010.01613.x

Fehr, E., Falk, A., 2002. Psychological foundations of trust. Curr. Dir. Psychol. Sci. 46, 687–724. https://doi.org/10.1111/j.1467-8721.2007.00517.x

Felipe-Lucia, M.R., Martín-López, B., Lavorel, S., Berraquero-Díaz, L., Escalera-Reyes, J., Comín, F.A., 2015. Ecosystem Services Flows: Why Stakeholders' Power Relationships Matter. PLoS One 10, 1–21. https://doi.org/10.1371/journal.pone.0132232

Filer, C., 1997. Compensation, rent and power in Papua New Guinea, in: Toft, S. (Ed.), Compensation for Resource Development in Papua New Guinea. Law Reform Commission of Papua New Guinea and Resource Management in Asia and the Pacific, Research School of Pacific and Asian Studies, Canberra, pp. 156 – 90.

Finkbeiner, E.M., Bennett, N.J., Frawley, T.H., Mason, J.G., Briscoe, D.K., Brooks, C.M., Ng, C.A., Ourens, R., Seto, K., Switzer Swanson, S., Urteaga, J., Crowder, L.B., 2017. Reconstructing overfishing: Moving beyond Malthus for effective and equitable solutions. Fish Fish. 18, 1180–1191. https://doi.org/10.1111/faf.12245

Fischer, A., Eastwood, A., 2016. Coproduction of ecosystem services as human-nature interactions—An analytical framework. Land use policy 52, 41–50. https://doi.org/10.1016/j.landusepol.2015.12.004

Fish, R., Church, A., 2014. Cultural ecosystem services: stretching out the concept. Environ. Sci. 23, 31–36.

Fish, R., Church, A., Winter, M., 2016. Conceptualising cultural ecosystem services: a novel framework for research and critical engagement. Ecosyst. Serv. 21, 208–217. https://doi.org/10.1016/j.ecoser.2016.09.002

Fisher, J. a., Patenaude, G., Meir, P., Nightingale, A.J., Rounsevell, M.D. a, Williams, M.,

Woodhouse, I.H., 2013. Strengthening conceptual foundations: Analysing frameworks for ecosystem services and poverty alleviation research. Glob. Environ. Chang. 23, 1098–1111. https://doi.org/10.1016/j.gloenvcha.2013.04.002

Fisher, J.A., Patenaude, G., Giri, K., Lewis, K., Meir, P., Pinho, P., Rounsevell, M., Williams, M., 2014. Understanding the relationships between ecosystem services and poverty alleviation: A conceptual framework. Ecosyst. Serv. 7, 34–45. https://doi.org/https://doi.org/10.1016/j.ecoser.2013.08.002

Flick, U., Kardorff, E. von, Steinke, I., Flick, U., 2004. A companion to qualitative research. Sage Publications, London.

Flick, U., Metzler, K., Scott, W., 2013. The SAGE handbook of qualitative data analysis. Sage Publications, California.

Flyvbjerg, B., 2006. Five Misunderstandings About Case-Study Research. Qual. Inq. 12, 219–245. https://doi.org/10.1177/1077800405284363

Foale, S., Cohen, P., Januchowski-Hartley, S., Wenger, A., Macintyre, M., 2011. Tenure and taboos: Origins and implications for fisheries in the Pacific. Fish Fish. 12, 357–369. https://doi.org/10.1111/j.1467-2979.2010.00395.x

Folkersen, M.V., 2018. Ecosystem valuation: Changing discourse in a time of climate change. Ecosyst. Serv. 29, 1–12. https://doi.org/10.1016/j.ecoser.2017.11.008

Forsyth, T., 2008. Critical realism and political ecology, in: Lopez, J., Potter, G. (Eds.), After Postmodernism: An Introduction to Critical Realism? Athlone Press, London, pp. 146–154.

Fortnam, M., Brown, K., Chaigneau, T., Crona, B., Daw, T.M., Gonçalves, D., Hicks, C., Revmatas, M., Sandbrook, C., Schulte-herbruggen, B., 2019. The Gendered Nature of Ecosystem Services. Ecol. Econ. 159, 312–325. https://doi.org/10.1016/j.ecolecon.2018.12.018

Foucault, M., 2008. The history of sexuality : the will to knowledge: vol. 1. Penguin.

Fox, R.J., Bellwood, D.R., 2007. Quantifying herbivory across a coral reef depth gradient. Mar. Ecol. Prog. Ser. 339, 49–59. https://doi.org/10.3354/meps339049

Friedman, R., Law, E., Bennett, N., Ives, C., Thorn, J., Wilson, K., 2018. How just and just how? A systematic review of social equity in conservation research. Environ. Resour. Lett. 13, 1–13.

Froese, R., Pauly, D.. available at https://www. fishbase. de/)., 2017. Fishbase [WWW Document]. Fishbase. URL https://www.fishbase.de/

Garcia Rodrigues, J., Conides, A., Rivero Rodriguez, S., Raicevich, S., Pita, P., Kleisner, K.,

Pita, C., Lopes, P., Alonso Roldán, V., Ramos, S., Klaoudatos, D., Outeiro, L., Armstrong, C., Teneva, L., Stefanski, S., Böhnke-Henrichs, A., Kruse, M., Lillebø, A., Bennett, E., Belgrano, A., Murillas, A., Sousa Pinto, I., Burkhard, B., Villasante, S., 2017. Marine and Coastal Cultural Ecosystem Services: knowledge gaps and research priorities. One Ecosyst. 2, e12290. https://doi.org/10.3897/oneeco.2.e12290

Garcia, S.M., Rice, J.C., Charles, A., 2014. Governance of Marine Fisheries and Biodiversity Conservation: A History, in: Garcia, S., Rice, J., Charles, A. (Eds.), Governance of Marine Fisheries and Biodiversity Conservation: Interaction and Coevolution. John Wiley & Sons, London, pp. 3–17. https://doi.org/10.1002/9781118392607

Garmendia, E., Pascual, U., 2013. A Justice Critique of Environmental Valuation for Ecosystem Governance, in: Sikor, T. (Ed.), The Justices and Injustice of Ecosystem Services. Routledge, New York, pp. 161–187.

Gaspare, L., Bryceson, I., Kulindwa, K., 2015. Complementarity of fishers' traditional ecological knowledge and conventional science: Contributions to the management of groupers (Epinephelinae) fisheries around Mafia Island, Tanzania. Ocean Coast. Manag. 114, 88–101. https://doi.org/10.1016/j.ocecoaman.2015.06.011

Gelcich, S., Hughes, T.P., Olsson, P., Folke, C., Defeo, O., Fernandez, M., Foale, S., Gunderson, L.H., Rodriguez-Sickert, C., Scheffer, M., Steneck, R.S., Castilla, J.C., 2010. Navigating transformations in governance of Chilean marine coastal resources. Proc. Natl. Acad. Sci. 107, 16794–16799. https://doi.org/10.1073/pnas.1012021107

Gibbs, G., 2007. Analyzing qualitative data. SAGE, London.

Goetze, J.S., Claudet, J., Januchowski-Hartley, F., Langlois, T.J., Wilson, S.K., White, C., Weeks, R., Jupiter, S.D., 2017. Demonstrating multiple benefits from periodically harvested fisheries closures. J. Appl. Ecol. 1102–1113. https://doi.org/10.1111/1365-2664.13047

Gómez-Baggethun, E., de Groot, R., Lomas, P.L., Montes, C., 2010. The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. Ecol. Econ. 69, 1209–1218. https://doi.org/10.1016/j.ecolecon.2009.11.007

Granek, E.F., Polasky, S., Kappel, C. V., Reed, D.J., Stoms, D.M., Koch, E.W., Kennedy, C.J., Cramer, L. a., Hacker, S.D., Barbier, E.B., Aswani, S., Ruckelshaus, M., Perillo, G.M.E., Silliman, B.R., Muthiga, N., Bael, D., Wolanski, E., 2010. Ecosystem services as a common language for coastal ecosystem-based management. Conserv. Biol. 24, 207–216. https://doi.org/10.1111/j.1523-1739.2009.01355.x

Gross-Camp, N., 2017. Tanzania's community forests: Their impact on human well-being and persistence in spite of the lack of benefit. Ecol. Soc. 22. https://doi.org/10.5751/ES-09124-220137

Guerry, A.D., Polasky, S., Lubchenco, J., Chaplin-Kramer, R., Daily, G.C., Griffin, R., Ruckelshaus, M., Bateman, I.J., Duraiappah, A., Elmqvist, T., Feldman, M.W., Folke, C., Hoekstra, J., Kareiva, P.M., Keeler, B.L., Li, S., McKenzie, E., Ouyang, Z., Reyers, B., Ricketts, T.H., Rockström, J., Tallis, H., Vira, B., 2015. Natural capital and ecosystem services informing decisions: From promise to practice. Proc. Natl. Acad. Sci. 112, 7348–7355. https://doi.org/10.1073/pnas.1503751112

Gurney, G.G., Cinner, J., Ban, N.C., Pressey, R.L., Pollnac, R., Campbell, S.J., Tasidjawa, S., Setiawan, F., 2014. Poverty and protected areas: An evaluation of a marine integrated conservation and development project in Indonesia. Glob. Environ. Chang. 26, 98–107. https://doi.org/10.1016/j.gloenvcha.2014.04.003

Gurney, G.G., Pressey, R.L., Ban, N.C., Alvarez-Romero, J.G., Jupiter, S., Adams, V.M., 2015. Efficient and equitable design of marine protected areas in Fiji through inclusion of stakeholder-specific objectives in conservation planning. Conserv. Biol. 29, 1378–1389. https://doi.org/10.1111/cobi.12514

Gustavsson, M., Lindström, L., Jiddawi, N.S., 2014. Procedural and distributive justice in a community-based managed Marine Protected Area in Zanzibar , Tanzania. Mar. Policy 46, 91–100. https://doi.org/10.1016/j.marpol.2014.01.005

Gutiérrez, N.L., Hilborn, R., Defeo, O., 2011. Leadership, social capital and incentives promote successful fisheries. Nature 470, 386–389. https://doi.org/10.1038/nature09689

Habermas, J., 1984. The theory of communicative action. Beacon Press, Boston.

Hall, D., Hirsch, P., Li, T.M., 2011. Introduction to Powers of Exclusion: Land Dilemmas in Southeast Asia. National University of Singapore Press and University of Hawaii Press, Hawaii.

Hampshire, K., Bell, S., Wallace, G., Hampshire, K., 2004. "Real" Poachers and Predators : Shades of Meaning in Local Understandings of Threats to Fisheries. Soc. Nat. Resour. 305–318. https://doi.org/10.1080/08941920490278656

Hapke, H., Ayyankeril, D., 2004. Gender, the work-life course, and livelihood strategies in a South Indian fish market. Gender, Place Cult. A J. Fem. Geogr. 11, 229–256. https://doi.org/10.1080/0966369042000218473

Haugaard, M., 2008. Power and habitus. J. Power 1, 189–206. https://doi.org/10.1080/17540290802227593

Havice, E., Reed, K., 2012. Fishing for Development? Tuna Resource Access and Industrial Change in Papua New Guinea. J. Agrar. Chang. 12, 413–435. https://doi.org/10.1111/j.1471-0366.2011.00351.x

Hickey, F., 2006. Traditional marine resource management in Vanuatu: Acknowledging, supporting and strengthening indigenous management systems. SPC Tradit. Mar. Resour. Manag. Knowl. Inf. Bull. 11–23.

Hicks, C., 2013. Ecosystem service values and societal settings for coral reef governance. Aust. Res. Counc. Cent. Excell. Coral Reef Stud. Sch. Bus. James Cook University, Townsville.

Hicks, C.C., Cinner, J.E., 2014. Social, institutional, and knowledge mechanisms mediate diverse ecosystem service benefits from coral reefs. Proc. Natl. Acad. Sci. 111, 17791–17796. https://doi.org/10.1073/pnas.1413473111

Hicks, C.C., Cinner, J.E., Stoeckl, N., McClanahan, T.R., 2015. Linking ecosystem services and human-values theory. Conserv. Biol. 29, 1471–1480. https://doi.org/10.1111/cobi.12550

Hicks, C.C., Graham, N.A.J., Cinner, J.E., 2013. Synergies and tradeoffs in how managers, scientists, and fishers value coral reef ecosystem services. Glob. Environ. Chang. 23, 1444–1453. https://doi.org/10.1016/j.gloenvcha.2013.07.028

Hicks, C.C., McClanahan, T.R., Cinner, J.E., Hills, J.M., 2009. Trade-offs in values assigned to ecological goods and services associated with different coral reef management strategies. Ecol. Soc. 14, 1–10.

Hind, E.J., 2015. A review of the past, the present, and the future of fishers' knowledge research: a challenge to established fisheries science. ICES J. Mar. Sci. 72, 341–358. https://doi.org/10.1093/icesjms/fsu169

Hopkins, C., McKeown, R., 2002. Education for Sustainable Development: an International Perspective, in: Tilbury, D., Stevenson, R., Fien, J., Schreuder, D. (Eds.), Education and Sustainability: Responding to the Global Challenge. IUCN--The World Conservation Union, Cambridge, pp. 13–24.

Howe, C., Corbera, E., Vira, B., Brockington, D., Adams, W.M., 2018. Distinct positions underpin ecosystem services for poverty alleviation. Oryx 1–8. https://doi.org/10.1017/S0030605318000261

Howe, C., Suich, H., Vira, B., Mace, G., 2014. Creating win-wins from trade-offs? Ecosystem services for human well-being: A meta-analysis of ecosystem service trade-offs and synergies in the real world. Glob. Environ. Chang. 28, 263–275.

https://doi.org/10.1016/j.gloenvcha.2014.07.005

Hughes, T., Anderson, K., Connolly, S., Heron, S., Kerry, J., Lough, J., Baird, A., Baum, J., Berumen, M., Bridge, T., Claar, D.C., Eakin, M., Gilmour, J., Graham, N., Harrison, H., Hobbs, J.-P., Hoey, A., Hoogenboom, M., Lowe, R., McCulloch, M., Pandolfi, J., Pratchett, M., Schoepf, V., Torda, G., Wilson, S., 2018. Spatial and temporal patterns of mass bleaching of corals in the Anthropocene. Science (80-.). 359, 80–83. https://doi.org/10.1126/science.aan8048

Hughes, T.P., Barnes, M.L., Bellwood, D.R., Cinner, J.E., Cumming, G.S., Jackson, J.B.C., Kleypas, J., Leemput, I.A. van de, Lough, J.M., Morrison, T.H., Palumbi, S.R., Nes, E.H. Van, Scheffer, M., 2017. Coral reefs in the Anthropocene. Nature 546, 82–90. https://doi.org/10.1038/nature22901

Hviding, E., 1998. Contextual flexibility: Present status and future of customary marine tenure in Solomon Islands. Ocean Coast. Manag. 40, 253–269. https://doi.org/10.1016/S0964-5691(98)00042-8

IOC, UNESCO, IMO, FAO, UNDP, 2011. A Blueprint for Ocean and Coastal Sustainability. Paris.

Ishihara, H., Pascual, U., Hodge, I., 2017. Dancing With Storks: The Role of Power Relations in Payments for Ecosystem Services. Ecol. Econ. 139, 45–54. https://doi.org/10.1016/j.ecolecon.2017.04.007

Iyer, G., Hanrahan, J., Milowsky, M., Al-Ahmadie, H., Scott, S., Janakiraman, M., Pirun, M., Sander, C., Socci, N., Ostrovnaya, I., Viale, A., Heguy, A., Peng, L., Chan, T., Bochner, B., Bajorin, D.F., Berger, M.F., Taylor, B.S., Solit, D.B., 2012. Genome Sequencing Identifies a Basis for Everolimus Sensitivity. Science (80-.). 338, 221–221. https://doi.org/10.1126/science.1226344

Jackson, S., Palmer, L.R., 2014. Reconceptualizing ecosystem services: Possibilities for cultivating and valuing the ethics and practices of care. Prog. Hum. Geogr. 39, 122–145. https://doi.org/10.1177/0309132514540016

Januchowski-Hartley, F.A., Cinner, J.E., Graham, N.A.J., 2014. Fishery benefits from behavioural modification of fishes in periodically harvested fisheries closures. Aquat. Conserv. Mar. Freshw. Ecosyst. 24, 777–790. https://doi.org/10.1002/aqc.2388

Jax, K., Barton, D.N., Chan, K.M.A., de Groot, R., Doyle, U., Eser, U., Görg, C., Gómez-Baggethun, E., Griewald, Y., Haber, W., Haines-Young, R., Heink, U., Jahn, T., Joosten, H., Kerschbaumer, L., Korn, H., Luck, G.W., Matzdorf, B., Muraca, B., Neßhöver, C., Norton, B., Ott, K., Potschin, M., Rauschmayer, F., von Haaren, C.,

Wichmann, S., 2013. Ecosystem services and ethics. Ecol. Econ. 93, 260–268. https://doi.org/10.1016/j.ecolecon.2013.06.008

Jax, K., Calestani, M., Chan, K.M., Eser, U., Keune, H., Muraca, B., O'Brien, L., Potthast, T., Voget-Kleschin, L., Wittmer, H., 2018. Caring for nature matters: a relational approach for understanding nature's contributions to human well-being. Curr. Opin. Environ. Sustain. 35, 22–29. https://doi.org/10.1016/j.cosust.2018.10.009

Jentoft, S., 2004. Institutions in fisheries: What they are, what they do, and how they change. Mar. Policy 28, 137–149. https://doi.org/10.1016/S0308-597X(03)00085-X

Jentoft, S., 2000. Legitimacy and disappointment in fisheries management. Mar. Policy 24, 141–148. https://doi.org/10.1016/S0308-597X(99)00025-1

Johannes, R., 1978. Traditional Marine Conservation Methods in Oceania and their Demise. Annu. Rev. Ecol. Syst. 9, 349–364.

Johannes, R.E., Freeman, M.M.R., Hamilton, R.J., 2000. Ignore fishers' knowledge and miss the boat. Fish Fish. 1, 257–271. https://doi.org/10.1111/j.1467-2979.2000.00019.x

Jupiter, S.D., Weeks, R., Jenkins, A.P., Egli, D.P., Cakacaka, A., 2012. Effects of a single intensive harvest event on fish populations inside a customary marine closure. Coral Reefs 31, 321–334. https://doi.org/10.1007/s00338-012-0888-x

Kahneman, D., 2011. Thinking, fast and slow. Penguin Books, London.

Kallis, G., Gómez-Baggethun, E., Zografos, C., 2013. To value or not to value? That is not the question. Ecol. Econ. 94, 97–105. https://doi.org/10.1016/j.ecolecon.2013.07.002

Kaltenborn, B.P., Linnell, J.D.C., Baggethun, E.G., Lindhjem, H., Thomassen, J., Chan, K.M., 2017. Ecosystem Services and Cultural Values as Building Blocks for 'The Good life'. A Case Study in the Community of Røst, Lofoten Islands, Norway. Ecol. Econ. 140, 166–176. https://doi.org/10.1016/j.ecolecon.2017.05.003

Kaplinsky, R., Morris, M., 2000. A handbook for value chain research, Institute for Development Studies: Brighton, UK. Institute for Development Studies, Brighton. https://doi.org/10.1057/9781137373755.0007

Katikiro, R., Ashoka Deepananda, K.H.M., Macusi, E., 2015. Interplay between perceived changes in fishery and social structures in Tanzanian coastal fishing communities. Fish. Res. 164, 249–253. https://doi.org/10.1016/j.fishres.2014.12.009

Kenter, J.O., Hyde, T., Christie, M., Fazey, I., 2011. The importance of deliberation in valuing ecosystem services in developing countries-Evidence from the Solomon Islands. Glob. Environ. Chang. 21, 505–521. https://doi.org/10.1016/j.gloenvcha.2011.01.001

Kenter, J.O., O'Brien, L., Hockley, N., Ravenscroft, N., Fazey, I., Irvine, K.N., Reed, M.S.,

Christie, M., Brady, E., Bryce, R., Church, A., Cooper, N., Davies, A., Evely, A., Everard, M., Fish, R., Fisher, J., Jobstvogt, N., Molloy, C., Orchard-Webb, J., Ranger, S., Ryan, M., Watson, V., Williams, S., 2015. What are shared and social values of ecosystems? Ecol. Econ. 111, 86–99. https://doi.org/10.1016/j.ecolecon.2015.01.006

Kirchhoff, T., 2012. Pivotal cultural values of nature cannot be integrated into the ecosystem services framework. Proc. Natl. Acad. Sci. 109, 3146. https://doi.org/10.1073/pnas.1212409109

Kittinger, J.N., Finkbeiner, E.M., Glazier, E.W., Crowder, L.B., 2012. Human dimensions of coral reef social-ecological systems. Ecol. Soc. 17. https://doi.org/10.5751/ES-05115-170417

Kittinger, J.N., Teneva, L.T., Koike, H., Stamoulis, K. a., Kittinger, D.S., Oleson, K.L.L., Conklin, E., Gomes, M., Wilcox, B., Friedlander, A.M., 2015. From Reef to Table: Social and Ecological Factors Affecting Coral Reef Fisheries, Artisanal Seafood Supply Chains, and Seafood Security. PLoS One 10, e0123856. https://doi.org/10.1371/journal.pone.0123856

Klain, S.C., Satter, T. a, Chan, K.M. a, 2014. What matters and why ? Ecosystem services and their bundled qualities. Ecol. Econ. 107, 310–320. https://doi.org/10.1016/j.ecolecon.2014.09.003

Kleiber, D., Harris, L.M., Vincent, A.C.J., 2014. Gender and small-scale fisheries: a case for counting women and beyond. Fish Fish. 16, 547–562. https://doi.org/10.1111/faf.12075

Koczberski, G., Curry, G.N., 2016. Changing Generational Values and New Masculinities Amongst Smallholder Export Cash Crop Producers in Papua New Guinea. Asia Pacific J. Anthropol. 17, 268–286. https://doi.org/10.1080/14442213.2016.1178323

Kolding, J., Béné, C., Bavinck, M., 2014. Small-scale fisheries: Importance, vulnerability and deficient knowledge, in: Garcia, S., Rice, J., Charles, A. (Eds.), Governance of Marine Fisheries and Biodiversity Conservation: Interaction and Co-Evolution. Wiley-Blackwell, London, pp. 317–331. https://doi.org/10.1002/9781118392607.ch22

Kull, C., Arnauld de Sartre, X., Castro-Larrañaga, M., 2015. The political ecology of ecosystem services. Geoforum 61, 122–134. https://doi.org/10.1016/j.geoforum.2015.03.004

Kumar, M., Kumar, P., 2008. Valuation of the ecosystem services: A psycho-cultural perspective. Ecol. Econ. 64, 808–819. https://doi.org/10.1016/j.ecolecon.2007.05.008

Lakerveld, R.P., Lele, S., Crane, T.A., Fortuin, K.P.J., Springate-Baginski, O., 2015. The social distribution of provisioning forest ecosystem services: Evidence and insights from

Odisha, India. Ecosyst. Serv. 14, 56–66. https://doi.org/10.1016/j.ecoser.2015.04.001

Lau, J., Scales, I., 2016. Identity , subjectivity and natural resource use : How ethnicity , gender and class intersect to influence mangrove oyster harvesting in The Gambia. Geoforum 69, 136–146. https://doi.org/10.1016/j.geoforum.2016.01.002

Lau, J.D., Hicks, C.C., Gurney, G.G., Cinner, J.E., 2018. Disaggregating ecosystem service values and priorities by wealth, age, and education. Ecosyst. Serv. 29, 91–98. https://doi.org/10.1016/j.ecoser.2017.12.005

Lau, W.W.Y., 2013. Beyond carbon: Conceptualizing payments for ecosystem services in blue forests on carbon and other marine and coastal ecosystem services. Ocean Coast. Manag. 83, 5–14. https://doi.org/10.1016/j.ocecoaman.2012.03.011

Laurans, Y., Pascal, N., Binet, T., Brander, L., Clua, E., David, G., Rojat, D., Seidl, A., 2013. Economic valuation of ecosystem services from coral reefs in the South Pacific: Taking stock of recent experience. J. Environ. Manage. 116, 135–144. https://doi.org/10.1016/j.jenvman.2012.11.031

Leach, M., Mearns, R., Scoones, I., 1999. Environmental entitlements: Dynamics and institutions in community-based natural resource management. World Dev. 27, 225–247. https://doi.org/10.1016/S0305-750X(98)00141-7

Leach, M., Mearns, R., Scoones, I., 1997. Environmental entitlements: a framework for understanding the institutional dynamics of environmental change. IDS Discuss. Pap. 359, 1–39.

Lecuyer, L., White, R.M., Schmook, B., Lemay, V., Calmé, S., 2018. The construction of feelings of justice in environmental management: An empirical study of multiple biodiversity conflicts in Calakmul, Mexico. J. Environ. Manage. 213, 363–373. https://doi.org/10.1016/j.jenvman.2018.02.050

Lehmann, I., Martin, A., Fisher, J.A., 2018. Why Should Ecosystem Services Be Governed to Support Poverty Alleviation? Philosophical Perspectives on Positions in the Empirical Literature. Ecol. Econ. 149, 265–273. https://doi.org/10.1016/j.ecolecon.2018.03.003

Lele, S., Springate-Baginski, O., Lakerveld, R., Deb, D., Dash, P., 2013. Ecosystem Services: Origins, Contributions, Pitfalls, and Alternatives. Conserv. Soc. 11, 343. https://doi.org/10.4103/0972-4923.125752

Lele, S., Srinivasan, V., 2013. Disaggregated economic impact analysis incorporating ecological and social trade-offs and techno-institutional context: A case from the Western Ghats of India. Ecol. Econ. 91, 98–112. https://doi.org/10.1016/j.ecolecon.2013.03.023

Lillebø, A.I., Pita, C., Garcia Rodrigues, J., Ramos, S., Villasante, S., 2017. How can marine ecosystem services support the Blue Growth agenda? Mar. Policy 81, 132–142. https://doi.org/10.1016/j.marpol.2017.03.008

Lind, E.A., Tyler, T.R., 1988. The social psychology of procedural justice. Plenum Press, New York.

LiPuma, E., 2000. Encompassing Others: the magic of modernity in Melanesia. The University of Michigan Press, Michigan.

Liquete, C., Piroddi, C., Drakou, E.G., Gurney, L., Katsanevakis, S., Charef, A., Egoh, B., 2013. Current Status and Future Prospects for the Assessment of Marine and Coastal Ecosystem Services: A Systematic Review. PLoS One 8. https://doi.org/10.1371/journal.pone.0067737

Lopes, P.F.M., Carvalho, A.R., Villasante, S., Henry-Silva, G.G., 2018. Fisheries or aquaculture? Unravelling key determinants of livelihoods in the Brazilian semi-arid region. Aquac. Res. 49, 232–242. https://doi.org/10.1111/are.13452

Lopes, P.F.M., Pacheco, S., Clauzet, M., Silvano, R. a M., Begossi, A., 2015. Fisheries, tourism, and marine protected areas: Conflicting or synergistic interactions ? https://doi.org/10.1016/j.ecoser.2014.12.003

Lusher, D., Koskinen, J., Robins, G., 2013. Exponential Random Graph Models for Social Networks, The SAGE Handbook of Social Network Analysis. Cambridge University Press, Cambridge. https://doi.org/10.4135/9781446294413.n32

Mace, G.M., 2014. Changes in the perception and goals of nature conservation require a solid scientific basis. Science (80-.). 345, 1558–1560.

MacGregor, S., 2017. Routledge Handbook of Gender and Environment. Routledge, New York.

Macintyre, M., Foale, S., 2007. Land and Marine Tenure, Ownership and New forms of Entitlement on Lihir: Changing Notions of Property in the Context of a Goldmining Project. Hum. Organ. 66, 11. https://doi.org/10.17730/humo.66.1.g81616400585qk75

Mackay, M., Yamazaki, S., Jennings, S., Sibly, H., Putten, I.E. Van, Emery, T.J., 2019. The influence of nudges on compliance behaviour in recreational fisheries: a laboratory experiment. Zool. J. Linn. Soc. https://doi.org/10.1093/zoolinnean/zly093

MacNeil, M.A., Graham, N.A.J., Cinner, J.E., Wilson, S.K., Williams, I.D., Maina, J., Newman, S., Friedlander, A.M., Jupiter, S., Polunin, N.V.C., McClanahan, T.R., 2015. Recovery potential of the world's coral reef fishes. Nature 520, 341–344. https://doi.org/10.1038/nature14358

Maina, J., Kithiia, J., Cinner, J., Neale, E., Noble, S., Charles, D., Watson, J.E.M., 2016. Integrating social–ecological vulnerability assessments with climate forecasts to improve local climate adaptation planning for coral reef fisheries in Papua New Guinea. Reg. Environ. Chang. 16, 881–891. https://doi.org/10.1007/s10113-015-0807-0

Marmot, M., Wilkinson, R., 2001. Psychosocial and material pathways in the relation between income and health: a response to Lynch et. BMJ 322, 1233–1236.

Marsh, D.R., Schroeder, D.G., Dearden, K.A., Sternin, J., Sternin, M., 2004. The power of positive deviance. BMJ 329, 1177–1179.

Martin, A., 2017. Just conservation: biodiversity, well-being and sustainability. Routledge, London.

Martin, A., Akol, A., Gross-Camp, N., 2015. Towards an Explicit Justice Framing of the Social Impacts of Conservation. Conserv. Soc. 13, 166–178. https://doi.org/10.4103/0972-4923.164200

Martin, A., Coolsaet, B., Corbera, E., Dawson, N.M., Fraser, J.A., Lehman, I., Rodriguez, I., 2016. Justice and conservation: The need to incorporate recognition. Biol. Conserv. 197, 254–261. https://doi.org/10.1016/j.biocon.2016.03.021

Martin, A., Gross-Camp, N., Kebede, B., McGuire, S., Munyarukaza, J., 2014. Whose environmental justice? Exploring local and global perspectives in a payments for ecosystem services scheme in Rwanda. Geoforum 54, 167–177. https://doi.org/10.1016/j.geoforum.2013.02.006

Martin, A., McGuire, S., Sullivan, S., 2013. Global environmental justice and biodiversity conservation. Geogr. J. 179, 122–131. https://doi.org/10.1111/geoj.12018

Martin, A., Myers, R., Dawson, N.M., 2017. The Park is Ruining our Livelihoods. We Support the Park! Unravelling the Paradox of Attitudes to Protected Areas. Hum. Ecol. 1–13. https://doi.org/10.1007/s10745-017-9941-2

Martin, A., Rutagarama, E., 2012. Just deliberation: Can communicative rationality support socially just environmental conservation in rural Africa? J. Rural Stud. 28, 189–198. https://doi.org/10.1016/j.jrurstud.2012.02.001

Martinez-Alier, J., 2014. The environmentalism of the poor. Geoforum 54, 239–241. https://doi.org/10.1016/j.geoforum.2013.04.019

Mason, J., 2006. Mixing methods in a qualitatively driven way. Qual. Res. 6, 9–25. https://doi.org/10.1177/1468794106058866

Mattoo, A., Subramanian, A., 2012. Equity in Climate Change: An Analytical Review. World Dev. 40, 1083–1097. https://doi.org/10.1016/J.WORLDDEV.2011.11.007

Matulis, B.S., Moyer, J.R., 2016. Beyond Inclusive Conservation: The Value of Pluralism, the Need for Agonism, and the Case for Social Instrumentalism. Conserv. Lett. 10, 279–287. https://doi.org/10.1111/conl.12281

McClanahan, T.R., Abunge, C. a, 2015. Perceptions of fishing access restrictions and the disparity of benefits among stakeholder communities and nations of south-eastern Africa. Fish Fish. n/a-n/a. https://doi.org/10.1111/faf.12118

McClanahan, T.R., Graham, N.A.J., MacNeil, M.A., Muthiga, N.A., Cinner, J.E., Bruggemann, J.H., Wilson, S.K., 2011. Critical thresholds and tangible targets for ecosystem-based management of coral reef fisheries. Proc. Natl. Acad. Sci. 108, 17230–17233. https://doi.org/10.1073/pnas.1106861108

McCormack, F., Barclay, K., Wood, D., 2013. Engaging with capitalism: cases from Oceania. Emerald, Bingley.

McDermott, C.L., Hirons, M., Setyowati, A., 2019. The Interplay of Global Governance with Domestic and Local Access: Insights from the FLEGT VPAs in Ghana and Indonesia. Soc. Nat. Resour. 0, 1–19. https://doi.org/10.1080/08941920.2018.1544679

McDermott, M., Mahanty, S., Schreckenberg, K., 2013. Examining equity: A multidimensional framework for assessing equity in payments for ecosystem services. Environ. Sci. Policy 33, 416–427. https://doi.org/10.1016/j.envsci.2012.10.006

McDowell, J.Z., Hess, J.J., 2012. Accessing adaptation: Multiple stressors on livelihoods in the Bolivian highlands under a changing climate. Glob. Environ. Chang. 22, 342–352. https://doi.org/10.1016/j.gloenvcha.2011.11.002

McGregor, A., Coulthard, S., Camfield, L., 2015. Measuring What Matters Workshop Report 33.

McShane, T.O., Hirsch, P.D., Trung, T.C., Songorwa, A.N., Kinzig, A., Monteferri, B., Mutekanga, D., Thang, H. Van, Dammert, J.L., Pulgar-Vidal, M., Welch-Devine, M., Peter Brosius, J., Coppolillo, P., O'Connor, S., 2011. Hard choices: Making trade-offs between biodiversity conservation and human well-being. Biol. Conserv. 144, 966–972. https://doi.org/10.1016/j.biocon.2010.04.038

MEA, 2005. Ecosystems and human well-being: synthesis., Ecosystems. Island Press, Washington, D.C. https://doi.org/10.1196/annals.1439.003

Melamed, C., Scott, A., Mitchell, T., 2012. Separated at birth, reunited in Rio? A roadmap to bring environment and development back together, Overseas Development Institute Background Note.

Milcu, A.I., Leventon, J., Hanspach, J., Fischer, J., 2015. Disaggregated contributions of

ecosystem services to human well-being in low-intensity farmland. Reg. Environ. Chang. 16, 117–163. https://doi.org/10.1007/s10113-016-0926-2

Milgroom, J., Giller, K.E., Leeuwis, C., 2014. Three Interwoven Dimensions of Natural Resource Use: Quantity, Quality and Access in the Great Limpopo Transfrontier Conservation Area. Hum. Ecol. 42, 199–215. https://doi.org/10.1007/s10745-013-9635-3

Miller, B.W., Caplow, S.C., Leslie, P.W., 2012. Feedbacks between Conservation and Social-Ecological Systems. Conserv. Biol. 26, 218–227. https://doi.org/10.1111/j.1523-1739.2012.01823.x

Milner-Gulland, E.J., Mcgregor, J.A., Agarwala, M., Atkinson, G., Bevan, P., Clements, T., Daw, T., Homewood, K., Kumpel, N., Lewis, J., Mourato, S., Palmer Fry, B., Redshaw, M., Rowcliffe, J.M., Suon, S., Wallace, G., Washington, H., Wilkie, D., 2014. Accounting for the impact of conservation on human well-being. Conserv. Biol. 28, 1160–1166. https://doi.org/10.1111/cobi.12277

Mohamed, Y., Durrant, K., Huggett, C., Davis, J., Macintyre, A., Menu, S., Wilson, J.N., Ramosaea, M., Sami, M., Barrington, D.J., McSkimming, D., Natoli, L., 2018. A qualitative exploration of menstruation-related restrictive practices in Fiji, Solomon Islands and Papua New Guinea. PLoS One 13, e0208224. https://doi.org/10.1371/journal.pone.0208224

Montana, J., 2017. Accommodating consensus and diversity in environmental knowledge production: Achieving closure through typologies in IPBES. Environ. Sci. Policy 68, 20–27. https://doi.org/10.1016/j.envsci.2016.11.011

Moon, K., Blackman, D.A., Adams, V.M., Colvin, R.M., Sherren, K., Davila, F., Evans, M.C., Januchowski-hartley, S.R., Bennett, N.J., St, F.A. V, Lorrae, J., Carina, V.K., Moon, K., 2019. Expanding the role of social science in conservation through an engagement with philosophy, methodology, and methods. Methods Ecol. Evol. 10, 294–302. https://doi.org/10.1111/2041-210X.13126

Moshy, V.H., Bryceson, I., 2016. Seeing Through Fishers' Lenses. SAGE Open 6, 215824401664171. https://doi.org/10.1177/2158244016641716

Myers, R., Hansen, C.P., 2019. Revisiting A Theory of Access: A review. Soc. Nat. Resour. 0, 1–21. https://doi.org/10.1080/08941920.2018.1560522

Nahlik, A.M., Kentula, M.E., Fennessy, M.S., Landers, D.H., 2012. Where is the consensus? A proposed foundation for moving ecosystem service concepts into practice. Ecol. Econ. 77, 27–35. https://doi.org/10.1016/j.ecolecon.2012.01.001

Narayan, D., 2000. Voices of the Poor. Published by Oxford University Press for the World Bank, Oxford.

Nature, 2009. Natural value. Nature 457, 764. https://doi.org/10.1038/457764a

Nayak, P.K., Oliveira, L.E., Berkes, F., 2014. Resource degradation, marginalization, and poverty in small-scale fisheries: Threats to social-ecological resilience in India and Brazil. Ecol. Soc. 19. https://doi.org/10.5751/ES-06656-190273

Neis, B., Gerrard, S., Power, N.G., 2013. Women and Children First: the Gendered and Generational Social- ecology of Smaller-scale Fisheries in Newfoundland and Labrador and. Ecol. Soc. 18, 64. https://doi.org/10.5751/ES-06010-180464

Newton, K., Côté, I.M., Pilling, G.M., Jennings, S., Dulvy, N.K., 2007. Current and Future Sustainability of Island Coral Reef Fisheries. Curr. Biol. 17, 655–658. https://doi.org/10.1016/j.cub.2007.02.054

Nightingale, A., 2011a. Beyond Design Principles: Subjectivity, Emotion, and the (Ir)Rational Commons. Soc. Nat. Resour. 24, 119–132. https://doi.org/10.1080/08941920903278160

Nightingale, A., 2011b. Bounding difference: Intersectionality and the material production of gender, caste, class and environment in Nepal. Geoforum 42, 153–162. https://doi.org/http://dx.doi.org/10.1016/j.geoforum.2010.03.004

Nightingale, A.J., 2017. Environment and Gender, in: Richardson, D., Castree, N., Goodchild, Mi., Kobayashi, A., Liu, W., Marston, R. (Eds.), International Encyclopedia of Geography: John Wiley & Sons, Ltd, pp. 1–13. https://doi.org/10.1002/9781118786352.wbieg0667

Nightingale, A.J., Ojha, H.R., 2013. Rethinking Power and Authority: Symbolic Violence and Subjectivity in Nepal's Terai Forests. Dev. Change 44, 29–51. https://doi.org/10.1111/dech.12004

Nkonya, L.K., 2006. Customary laws for access to and management of drinking water in tanzania. Law, Environ. Dev. J. 2, 52–66.

Norgaard, K.M., Reed, R., Bacon, J.M., 2017. How Environmental Decline Restructures Indigenous Gender Practices: What Happens to Karuk Masculinity When There Are No Fish? Sociol. Race Ethn. 4, 98–133. https://doi.org/10.1177/2332649217706518

Norgaard, R., 2010. Ecosystem services: From eye-opening metaphor to complexity blinder. Ecol. Econ. 69, 1219–1227. https://doi.org/10.1016/j.ecolecon.2009.11.009

North, D., 1990. Institutions, Institutional Change, and Economic Performance. Cambridge University Press, Cambridge.

Nunan, F., 2015. Understanding Poverty and the Environment: Analytical Frameworks and Approaches. Routledge, New York.

Nunan, F., Metnon, M., McDermott, C., Schreckenberg, K., 2018. Governing for Ecosytem Health and Human Wellbeing, in: Schreckenberg, K., Mace, G., Poudyal, M. (Eds.), Ecosystem Services and Poverty Alleviation: Trade-Offs and Governance. Routledge, London.

Nyborg, B.K., Anderies, J.M., Dannenberg, A., Lindahl, T., Schill, C., Schlüter, M., Adger, W.N., Arrow, K.J., Barrett, S., Carpenter, S., Stuart, F., Iii, C., Crépin, A., Daily, G., Ehrlich, P., Folke, C., Jager, W., Kautsky, N., Levin, S.A., Madsen, O.J., Polasky, S., Scheffer, M., Weber, E.U., Wilen, J., Xepapadeas, A., Zeeuw, A. De, 2016. Social norms as solutions. Science (80-.). 354. https://doi.org/10.1126/science.aaf8317

O'Garra, T., 2012. Economic valuation of a traditional fishing ground on the coral coast in Fiji. Ocean Coast. Manag. 56, 44–55. https://doi.org/10.1016/j.ocecoaman.2011.09.012

O'Garra, T., 2009. Bequest values for marine resources: How important for indigenous communities in less-developed economies? Environ. Resour. Econ. 44, 179–202. https://doi.org/10.1007/s10640-009-9279-3

Obdura, D., Smits, M., Chaudhry, T., McPhillips, J., Beal, D., Astier, C., Gamblin, P., Tanzer, J., Burgener, V., Owen, S., Gonzales, A., 2017. Reviving the Western Indian Ocean Economy: Actions for a Sustainable Future. WWF International, Gland, Switzerland.

Oleson, K.L.L., Barnes, M., Brander, L.M., Oliver, T.A., Van Beek, I., Zafindrasilivonona, B., Van Beukering, P., 2015. Cultural bequest values for ecosystem service flows among indigenous fishers: A discrete choice experiment validated with mixed methods. Ecol. Econ. 114, 104–116. https://doi.org/10.1016/j.ecolecon.2015.02.028

Olsen, W., 2004. Triangulation in Social Research: Qualitative and Quantitative Methods Can Really Be Mixed. Dev. Sociol. 1–30. https://doi.org/10.1002/jhbs.20022

Orenstein, D.E., Groner, E., 2014. In the eye of the stakeholder: Changes in perceptions of ecosystem services across an international border. Ecosyst. Serv. 8, 185–196. https://doi.org/10.1016/j.ecoser.2014.04.004

Ostrom, E., 2011. Background on the Institutional Analysis and Development Framework. Policy Stud. J. 39, 7–27. https://doi.org/10.1111/j.1541-0072.2010.00394.x

Otto, T., 1997. Baitfish royalties and customary marine tenure in Manus, Papua New Guinea. Anthropol. Forum 7, 667–690. https://doi.org/10.1080/00664677.1997.9967479

Paavola, J., 2003. Protected Areas Governance and Justice: Theory and the European Union's

Habitats Directive. Environ. Sci. 1, 59–77. https://doi.org/10.1076/evms.1.1.59.23763

Palomo, I., Felipe-Lucia, M.R., Bennett, E.M., Martín-López, B., Pascual, U., 2016. Disentangling the Pathways and Effects of Ecosystem Service Co-Production, in: Woodward, G., Bohan, D. (Eds.), Advances in Ecological Research. Elsevier, London, pp. 245–283. https://doi.org/10.1016/bs.aecr.2015.09.003

Pascal, N., Brander, L., Clua, E., David, G., Laurans, Y., Seidl, A., 2012. What impacts to expect from economic valuation of coral reefs ?, in: Proceedings of the 12th International Coral Reef Symposium.

Pascual, U., Balvanera, P., Diaz, S., Pataki, G., Roth, E., Stenseke, M., Watson, R., Dessane, E., Breslow, S., Islar, M., Kelemen, E., Keune, H., Maris, V., Pengue, W., Quaas, M., Subramanian, S., Wittmer, H., Mohamed, A., Al-Hafedh, Y., Asah, S., Berry, P., Bilgin, E., Bullock, C., Cáceres, D., Golden, C., Gómez-Baggethun, E., González-Jiménez, D., Houdet, J., Kumar, R., May, P., Mead, A., O'Farrell, P., Pacheco-Balanza, D., Pandit, R., Pichis-Madruga, R., Popa, F., Preston, S., Saarikoski, H., Strassburg, B., Verma, M., Yagi, N., Ahn, S., Amankwah, E., Daly-Hassen, H., Figueroa, E., Ma, K., van den Belt, M., Wickson, F., 2017. Valuing nature's contributions to people: The IPBES approach. Curr. Opin. Environ. Sustain. 26, 7–16. https://doi.org/10.1016/j.cosust.2016.12.006

Pascual, U., Howe, C., 2018. Seeing the wood for the trees: Exploring the evolution of frameworks of ecosystem services for human wellbeing, in: Schreckenberg, K., Mace, G., Poudyal, M. (Eds.), Ecosystem Services and Poverty Alleviation: Trade-Offs and Governance. Routledge, London. https://doi.org/10.1038/climate.2007.69

Pascual, U., Phelps, J., Garmendia, E., Brown, K., Corbera, E., Martin, A., Gomez-Baggethun, E., Muradian, R., 2014. Social Equity Matters in Payments for Ecosystem Services. Bioscience 64, 1027–1036. https://doi.org/10.1093/biosci/biu146

Patterson, M., Macintyre, M., 2014. Managing modernity in the Western Pacific. UQ EPress, Brisbane.

Pauly, D., 1990. On Malthusian Overfishing. Naga, ICLARM Q. 13, 3–4.

Pikitch, E.K., Santora, C., Babcock, E.A., Bakun, A., Bonfil, R., Conover, D.O., Dayton, P., Doukakis, P., Fluharty, D., Heneman, B., Houde, E.D., Link, J., 2004. Ecosystem-Based Fishery Management. Science (80-.). 305, 346–347.

Pollnac, R., Crawford, B., 2000. Assessing behavioural aspects of coastal resource use. Narragansett, RI.

Polunin, N.V.C., Roberts, C.M., 1993. Greater biomass and value of target coral-reef fishes in two small Caribbean marine reserves. Mar. Ecol. Prog. Ser. 100, 167–176.

https://doi.org/10.3354/meps100167

Post, G., Geldmann, J., 2018. Exceptional responders in conservation. Conserv. Biol. 32, 576–583. https://doi.org/10.1111/cobi.13006

Pratt, M., 2002. Modernity and Periphery: Towards a Global and Relational Analysis, in: Mudimbe-boyi, E. (Ed.), Beyond Dichotomies: Histories, Identities, Cultures, and the Challenge of Globalization. State University of New York Press, pp. 21–48.

Rathwell, K.J., Armitage, D., Berkes, F., 2015. Bridging knowledge systems to enhance governance of the environmental commons : A typology of settings. Int. J. Commons 9, 851–880.

Redford, K.H., Adams, W.M., 2009. Payment for ecosystem services and the challenge of saving nature: Editorial. Conserv. Biol. 23, 785–787. https://doi.org/10.1111/j.1523-1739.2009.01271.x

Reed, M.S., 2008. Stakeholder participation for environmental management: A literature review. Biol. Conserv. 141, 2417–2431. https://doi.org/10.1016/j.biocon.2008.07.014

Reyers, B., O'Farrell, P.J., Cowling, R.M., Egoh, B.N., le Maitre, D.C., Vlok, J.H.J., 2009. Ecosystem services, land-cover change, and stakeholders: Finding a sustainable foothold for a semiarid biodiversity hotspot. Ecol. Soc. 14, 38.

Ribot, J., 2009. Authority over Forests: Empowerment and Subordination in Senegal's Democratic Decentralization. Dev. Change 40, 105–129. https://doi.org/10.1111/j.1467-7660.2009.01507.x

Ribot, J., Peluso, N.L., 2003. A Theory of Access. Rural Sociol. 68, 153–181. https://doi.org/10.1111/j.1549-0831.2003.tb00133.x

Rivero, S., Villasante, S., 2016. What are the research priorities for marine ecosystem services? Mar. Policy 66, 104–113. https://doi.org/10.1016/j.marpol.2016.01.020

Robbins, J., Wardlow, H., 2005. The making of global and local modernities in Melanesia: humiliation, transformation, and the nature of cultural change. Ashgate, Burlington.

Robinson, J.P.W., Williams, I.D., Yeager, L.A., McPherson, J.M., Clark, J., Oliver, T.A., Baum, J.K., 2018. Environmental conditions and herbivore biomass determine coral reef benthic community composition: implications for quantitative baselines. Coral Reefs 37, 1157–1168. https://doi.org/10.1007/s00338-018-01737-w

Roe, D., 2008. The origins and evolution of the conservation-poverty debate: a review of key literature, events and policy processes. Oryx 42, 491. https://doi.org/10.1017/S0030605308002032

Rostow, W., 1971. Politics and the Stages of Growth, Cambridge Books. Cambridge

University Press.

Sagie, H., Morris, A., Rofè, Y., Orenstein, D.E., Groner, E., 2013. Cross-cultural perceptions of ecosystem services: A social inquiry on both sides of the Israeli-Jordanian border of the Southern Arava Valley Desert. J. Arid Environ. 97, 38–48. https://doi.org/10.1016/j.jaridenv.2013.05.007

Sandbrook, C.G., Adams, W., Büscher, B., Vira, B., 2013. Social Research and Biodiversity Conservation. Conserv. Biol. 27, 1487–1490. https://doi.org/10.1111/cobi.12141

Satterfield, T., Gregory, R., Klain, S., Roberts, M., Chan, K.M., 2013. Culture, Intangibles and metrics in environmental management. J. Environ. Manage. 117, 103–114. https://doi.org/10.1016/j.jenvman.2012.11.033

Sayer, A., 2015. Time for moral economy? Geoforum 65, 291–293. https://doi.org/10.1016/j.geoforum.2015.07.027

Sayer, A., 2011. Why Things Matter to People: Social Science, Values and Ethical Life.

Sayer, A., 2005. Class, Moral Worth and Recognition 39, 947–963. https://doi.org/10.1177/0038038505058376

Sayer, A., 2004. Why Critical Realism?, in: Fleetwood, S., Ackroyd, S. (Eds.), Critical Realist Applications in Organisation and Management Studies. Routledge, New York, p. 366.

Scales, I.R., 2014. Paying for nature: what every conservationist should know about political economy. Oryx 49, 1–6. https://doi.org/10.1017/S0030605314000015

Schaafsma, M., Turner, R.K., 2015. Valuation of Coastal and Marine Ecosystem Services: A Literature Review, in: Coastal Zones Ecosystem Services: From Science to Values and Decision Making. Springer, Cham, pp. 103–125. https://doi.org/10.1007/978-3-319-17214-9_6

Schlosberg, D., 2013. Theorising environmental justice: the expanding sphere of a discourse. Env. Polit. 22, 37–55. https://doi.org/10.1080/09644016.2013.755387

Schlüter, A., Wise, S., SchwerdtnerMánez, K., de Morais, G., Glaser, M., 2013. Institutional Change, Sustainability and the Sea. Sustainability 5, 5373–5390. https://doi.org/10.3390/su5125373

Schreckenberg, K., Mace, G., Poudyal, M., 2018. Evolving framings and contexts, in: Schreckenberg, K., Mace, G., Poudyal, M. (Eds.), Ecosystem Services and Poverty Alleviation: Trade-Offs and Governance. Routledge, London, p. 352.

Schröder, T., 2013. Sustainability in Practice: A study of how reflexive agents negotiate multiple domains of consumption, enact change, and articulate visions of the ‘good life.’

https://doi.org/10.13140/2.1.4516.8968

Selig, E.R., Hole, D.G., Allison, E.H., Arkema, K.K., McKinnon, M.C., Chu, J., de Sherbinin, A., Fisher, B., Gallagher, L., Holland, M.B., Ingram, J.C., Rao, N.S., Russell, R.B., Srebotnjak, T., Teh, L.C.L., Troëng, S., Turner, W.R., Zvoleff, A., 2018. Mapping global human dependence on marine ecosystems. Conserv. Lett. 1–10. https://doi.org/10.1111/conl.12617

Sen, A., 1981. Poverty and Famines: An Essay on Entitlements and Deprivation. Oxford University Press, Oxford.

Seppelt, R., Dormann, C.F., Eppink, F. V., Lautenbach, S., Schmidt, S., 2011. A quantitative review of ecosystem service studies: Approaches, shortcomings and the road ahead. J. Appl. Ecol. 48, 630–636. https://doi.org/10.1111/j.1365-2664.2010.01952.x

Sharp, J., Routledge, P., Paddison, R., Philo, C., 2000. Entanglements of power: geographies of domination/resistance. Routledge, New York.

Siar, S. V, 2003. Knowledge, Gender, and Resources in Small-Scale Fishing: The Case of Honda Bay, Palawan, Philippines. Environ. Manage. 31, 569–580. https://doi.org/10.1007/s00267-002-2872-7

Sikor, T., 2013. The Justices and Injustices of Ecosystem Services. Routledge, London and New York.

Sikor, T., Baggio, J.A., 2014. Can Smallholders Engage in Tree Plantations? An Entitlements Analysis from Vietnam. World Dev. 64, S101–S112. https://doi.org/10.1016/j.worlddev.2014.03.010

Sikor, T., Lund, C., 2009. Access and Property: A Question of Power and Authority. Dev. Change 40, 1–22. https://doi.org/10.1111/j.1467-7660.2009.01503.x

Sikor, T., Martin, A., Fisher, J., He, J., 2014. Toward an Empirical Analysis of Justice in Ecosystem Governance. Conserv. Lett. 7, 524–532. https://doi.org/10.1111/conl.12142

Sikor, T., Newell, P., 2014. Globalizing environmental justice? Geoforum 54, 151–157. https://doi.org/10.1016/j.geoforum.2014.04.009

Singh, N.M., 2015. Payments for ecosystem services and the gift paradigm: Sharing the burden and joy of environmental care. Ecol. Econ. 117, 53–61. https://doi.org/10.1016/j.ecolecon.2015.06.011

Sodhi, N.S., Lee, T.M., Sekercioglu, C.H., Webb, E.L., Prawiradilaga, D.M., Lohman, D.J., Pierce, N.E., Diesmos, A.C., Rao, M., Ehrlich, P.R., 2010. Local people value environmental services provided by forested parks. Biodivers. Conserv. 19, 1175–1188. https://doi.org/10.1007/s10531-009-9745-9

Song, A.M., Chuenpagdee, R., 2015. Eliciting Values and Principles of Fishery Stakeholders in South Korea: A Methodological Exploration. Soc. Nat. Resour. 28, 1075–1091. https://doi.org/10.1080/08941920.2015.1020976

Song, A.M., Chuenpagdee, R., Jentoft, S., 2013. Values, images, and principles: What they represent and how they may improve fisheries governance. Mar. Policy 40, 167–175. https://doi.org/10.1016/j.marpol.2013.01.018

Song, A.M., Johnsen, J.P., Morrison, T.H., 2018. Reconstructing governability: How fisheries are made governable. Fish Fish. 19, 377–389. https://doi.org/10.1111/faf.12262

Spash, C.L., 2013. Influencing the perception of what and who is important in ecological economics. Ecol. Econ. 89, 204–209. https://doi.org/10.1016/j.ecolecon.2013.01.028

Springer, J., 2009. Addressing the social impacts of conservation: Lessons from experience and future directions. Conserv. Soc. 7, 26–29. https://doi.org/10.4103/0972-4923.54794

Star, S.L., Griesemer, J.R., 1989. Institutional Ecology, 'Translations ' and Boundary Objects: Amateurs and Professionals in Berkeley's Museum of Vertebrate Zoology , 1907-39. Soc. Stud. Sci. 19, 387–420.

Stead, V., 2013. Greeting the State: Entanglements of Custom and Modernity on Papua New Guinea's Rai Coast. Anthropol. Forum 23, 16–35. https://doi.org/10.1080/00664677.2012.724008

Steffen, W., Richardson, K., Rockstrom, J., Cornell, S.E., Fetzer, I., Bennett, E.M., Biggs, R., Carpenter, S.R., de Vries, W., de Wit, C.A., Folke, C., Gerten, D., Heinke, J., Mace, G.M., Persson, L.M., Ramanathan, V., Reyers, B., Sorlin, S., 2015. Planetary boundaries: Guiding human development on a changing planet. Science (80-.). 347, 1259855-. https://doi.org/10.1126/science.1259855

Steffen, W., Rockström, J., Richardson, K., Lenton, T.M., Folke, C., Liverman, D., Summerhayes, C.P., Barnosky, A.D., Cornell, S.E., Crucifix, M., Donges, J.F., Fetzer, I., Lade, S.J., Scheffer, M., Winkelmann, R., Schellnhuber, H.J., 2018. Trajectories of the Earth System in the Anthropocene. Proc. Natl. Acad. Sci. 115, 8252–8259. https://doi.org/10.1073/pnas.1810141115

Steffen, W., Stafford Smith, M., 2013. Planetary boundaries, equity and global sustainability: Why wealthy countries could benefit from more equity. Curr. Opin. Environ. Sustain. 5, 403–408. https://doi.org/10.1016/j.cosust.2013.04.007

Suich, H., Howe, C., Mace, G., 2015. Ecosystem services and poverty alleviation: A review of the empirical links. Ecosyst. Serv. 12, 137–147. https://doi.org/10.1016/j.ecoser.2015.02.005

Sumaila, U.R., Tai, T.C., Lam, V.W.Y., Cheung, W.W.L., Bailey, M., Cisneros-montemayor, A.M., Chen, O.L., Gulati, S.S., 2019. Benefits of the Paris Agreement to ocean life, economies, and people. Sci. Adv. 5, 1–10.

Svarstad, H., Benjaminsen, T.A., Overå, R., 2019. Power theories in political ecology. J. Polit. Ecol. 25, 350. https://doi.org/10.2458/v25i1.23044

Tauro, A., Gómez-Baggethun, E., García-Frapolli, E., Lazos Chavero, E., Balvanera, P., 2018. Unraveling heterogeneity in the importance of ecosystem services: individual views of smallholders. Ecol. Soc. 23, art11. https://doi.org/10.5751/ES-10457-230411

Thomas, S., 2014. Blue carbon : Knowledge gaps , critical issues , and novel approaches. Ecol. Econ. 107, 22–38. https://doi.org/10.1016/j.ecolecon.2014.07.028

Tsing, A.L., 2005. Friction: an ethnography of global connection. Princeton University Press, New Jersey.

Twinamatsiko, M., Baker, J., Harrison, M., Shirkhorshidi, M., Bitariho, R., Wieland, M., Asuma, S., Milner-Gulland, E.., Franks, P., Roe, D., 2014. Equity and poverty alleviation understanding profiles and motivations of resource users and local perceptions of governance at Bwindi Impenetrable National Park. https://doi.org/10.13140/2.1.4853.4409

Van Aelst, K., Holvoet, N., 2016. Intersections of Gender and Marital Status in Accessing Climate Change Adaptation: Evidence from Rural Tanzania. World Dev. 79, 40–50. https://doi.org/10.1016/j.worlddev.2015.11.003

van den Belt, M., Stevens, S.M., 2016. Transformative agenda , or lost in the translation? A review of top-cited articles in the first four years of Ecosystem Services. Ecosyst. Serv. 22, 60–72. https://doi.org/10.1016/j.ecoser.2016.09.006

Vihervaara, P., Rönkä, M., Walls, M., 2010. Trends in Ecosystem Service Research: Early Steps and Current Drivers. Ambio 39, 314–324. https://doi.org/10.1007/s13280-010-0048-x

Villamor, G.B., van Noordwijk, M., 2016. Gender specific land-use decisions and implications for ecosystem services in semi-matrilineal Sumatra. Glob. Environ. Chang. 39, 69–80. https://doi.org/10.1016/j.gloenvcha.2016.04.007

Walker, G., 2014a. Editorial: Environmental Justice as Empirical and Normative. Anal. Krit. 36, 221–227.

Walker, G., 2014b. Environmental Justice: Empirical Concerns and Normative Reasoning. Anal. Krit. 36, 4–5.

Walker, G., 2009. Beyond distribution and proximity: Exploring the multiple spatialities of

environmental justice. Antipode 41, 614–636. https://doi.org/10.1111/j.1467-8330.2009.00691.x

Wallner-hahn, S., Torre-castro, M. De, 2018. Early steps for successful management in small-scale fisheries : An analysis of fishers', managers' and scientists' opinions preceding implementation. Mar. Pollut. Bull. 134, 186–196. https://doi.org/10.1016/j.marpolbul.2017.07.058

Weeratunge, N., Béné, C., Siriwardane, R., Charles, A., Johnson, D., Allison, E.H., Nayak, P.K., Badjeck, M.-C.C., 2014. Small-scale fisheries through the wellbeing lens. Fish Fish. 15, 255–279. https://doi.org/10.1111/faf.12016

Weinstein, M.P., Baird, R.C., Conover, D.O., Gross, M., Keulartz, J., Loomis, D.K., Naveh, Z., Peterson, S.B., Reed, D.J., Roe, E., Swanson, R.L., Swart, J. a a, Teal, J.M., Turner, R.E., Van Der Windt, H.J., 2007. Managing coastal resources in the 21st century. Front. Ecol. Environ. 5, 43–48. https://doi.org/10.1890/1540-9295(2007)5[43:MCRITS]2.0.CO;2

Westaway, E., Seeley, J., Allison, E., 2007. Feckless and reckless or forbearing and resourceful? Looking behind the stereotypes of HIV and AIDS in "fishing communities." Afr. Aff. (Lond). 106, 663–679. https://doi.org/10.1093/afraf/adm055

Whittingham, E., Campbell, J., Townsley, P., 2003. Poverty and reefs, Volume 1: A Global Overview. Exeter.

Wieland, R., Ravensbergen, S., Gregr, E.J., Satterfield, T., Chan, K.M.A., 2016. Debunking trickle-down ecosystem services: The fallacy of omnipotent, homogeneous beneficiaries. Ecol. Econ. 121, 175–180. https://doi.org/10.1016/j.ecolecon.2015.11.007

Williams, I.D., Walsh, W.J., Miyasaka, A., Friedlander, A.M., 2006. Effects of rotational closure on coral reef fishes in Waikiki-Diamond Head Fishery Management Area, Oahu, Hawaii. Mar. Ecol. Prog. Ser. 310, 139–149. https://doi.org/10.3354/meps310139

Yang, Y.C.E., Passarelli, S., Lovell, R.J., Ringler, C., 2018. Gendered perspectives of ecosystem services: A systematic review. Ecosyst. Serv. 31, 58–67. https://doi.org/10.1016/j.ecoser.2018.03.015

Zia, A., Hirsch, P., Songorwa, A., Mutekanga, D.R., O'Connor, S., McShane, T., Brosius, P., Norton, B., 2011. Cross-Scale Value Trade-Offs in Managing Social-Ecological Systems: The Politics of Scale in Ruaha National Park, Tanzania. Ecol. Soc. 16, 7.

Zurba, M., Trimble, M., 2014. Youth as the inheritors of collaboration: Crises and factors that influence participation of the next generation in natural resource management. Environ. Sci. Policy 42, 78–87. https://doi.org/10.1016/j.envsci.2014.05.009

9 Appendices

Appendix A Supplementary Material for Chapter Three

A1. General Linear models

Table S1. Material Style of Life Principle Component Analysis (PCA) loadings

Variable	Factor loading
Roofing	-0.506
Flooring	-0.578
Wall	-0.473
Garden	-0.431

Table S2. Variance inflation factors for socio-economic variables

Variable	Variance inflation factor
Years_School	1.195535
Material style of life	1.359079
Last expenditure	1.115972
Migrant	1.067086
Gender	1.105806
Age	1.129096
Main source of livelihood	1.200537
Different occupations	1.052677

Table S3. Linear Mixed Models

Linear Mixed Models for importance of ecosystem service values including household and village as random effects. We ran a model for each ecosystem service with household and village specified as a priori random factors. We used the step function to select the most parsimonious model. We then used the Akaike information criteria values (AIC) to select the best model fit. In cases where the null model remained the best fit we discontinued analysis. These models are not included in this supplementary material. For the remaining models, we examined which socio-economic variables were significant in explaining ecosystem services rankings, taking this to mean that people with differences in these socio-economic characteristics ascribe importance to the ecosystem service in question, differently.

a) Fishery

Model: FISH ~ Yrs_School + MSL + log(LastExpend) + Migrant + important.livelihood + (1 | Household) + (1 | Village)

	Value	Std.Error	DF	t-value	p-value
(Intercept)	0.5789736	0.12103191	79	4.783644	0.0000
Yrs_School	-0.0199223	0.00825857	53	-2.412318	0.0193
MSL	0.0412983	0.01602981	79	2.576343	0.0118
log(LastExpend)	-0.0311442	0.01905521	79	-1.634418	0.1062
Migrant1	0.0646804	0.05951766	53	1.086743	0.2821
important.livelihood	-0.0561830	0.02977098	79	-1.887172	0.0628

b) Habitat

Model: HABITAT ~ Yrs_School + MSL + log(LastExpend) + Age + important.livelihood + (1 | Household) + (1 | Village)

	Value	Std.Error	DF	t-value	p-value
(Intercept)	-0.17360596	0.11281901	79	-1.538801	0.1278
Yrs_School	0.01146164	0.00591378	53	1.938123	0.0579
MSL	0.05992463	0.01319800	79	4.540434	0.0000
log(LastExpend)	0.02674564	0.01565133	79	1.708842	0.0914
Age	0.00190567	0.00156991	53	1.213876	0.2302
important.livelihood	0.03096638	0.02473458	79	1.251947	0.2143

c) Forest materials

MODEL: FOREST_MATERIALS ~ MSL + GENDER + Age + Different_occupation + (1 | Household) + (1 | Village)

	Value	Std.Error	DF	t-value	p-value
(Intercept)	0.29681411	0.10861625	80	2.732686	0.0077
MSL	-0.05205641	0.01260569	80	-4.129596	0.0001
GENDER	0.03808869	0.02673905	53	1.424459	0.1602
Age	-0.00202567	0.00163202	53	-1.241204	0.2200

Different_occupation	-0.01613554	0.01817615	80	-0.887732	0.3773

d) Education and knowledge

MODEL: EDU_M ~ Yrs_School + MSL + GENDER + important.livelihood + (1 | Household) + (1 | Village)

	Value	Std.Error	DF	t-value	p-value
(Intercept)	-0.03716837	0.05574045	80	-0.6668113	0.5068
Yrs_School	0.01613039	0.00545286	53	2.9581517	0.0046
MSL	0.02017984	0.01098696	80	1.8367079	0.0700
GENDER	-0.06520844	0.02568638	53	-2.5386390	0.0141
important.livelihood	0.02288237	0.02065782	80	1.1076858	0.2713

e) Fuelwood

MODEL: FUEL_M ~ Yrs_School + GENDER + Age + important.livelihood + (1 | Household) + (1 | Village)

	Value	Std.Error	DF	t-value	p-value
(Intercept)	0.08903729	0.03318499	81	2.6830591	0.0088
Yrs_School	-0.00244157	0.00229920	52	-1.0619215	0.2932
GENDER	0.02595144	0.01271109	52	2.0416382	0.0463
Age	-0.00123097	0.00057465	52	-2.1421296	0.0369
important.livelihood	-0.00441983	0.00797504	81	-0.5542072	0.5810

f) Crops

MODEL: CROP_M ~ important.livelihood + (1 | Household) + (1 | Village)

	Value	Std.Error	DF	t-value	p-value
(Intercept)	0.08594522	0.06107808	81	1.407137	0.1632
important.livelihood	0.07169284	0.03181760	81	2.253245	0.0269

A2. Qualitative coding

We coded the qualitative responses thematically, into three categories of wellbeing (i.e. material, subjective, and relational), and, where possible, into value domains (i.e. instrumental, intrinsic and relational). Mention of monetary, subsistence or livelihood was coded as material wellbeing. References of the importance of ecosystem services because of personal taste were coded as subjective. Relation wellbeing included references to the importance of ecosystem services for maintaining human-human and human-nature relationships, and included reference to a particular sense of identity. We did not find any intrinsic values expressed here, but that perhaps reflects the exploratory nature of this data, which was not aimed at capturing all aspects of value. The references that expressed material wellbeing were likewise coded as expressing instrumental values, while references to stewardship, care, identity, and normative judgements (i.e. how one should use and care for ecosystem services) were coded as relational values. The following table presents a subsection of quotes coded at each node. Note that most references indicate more than one aspect of wellbeing or value domain, particularly between material wellbeing and instrumental values, and relational wellbeing, and relational values. For example, we coded the quote “Education/ knowledge leads to good habitat and good fish, which are good for catching and going to market, and helping family (bequest value)” (Man, Ahus) as both a contribution to material wellbeing (i.e through supporting livelihood), and an instrumental value (i.e. education etc. leading eventually to the instrumental value of directly benefiting from fish). The quote “We are people of the sea, so we must have a good, clean reef (habitat), and we must look after it well. The sea is first.” **(**Woman, Ahus) was coded as both relational wellbeing, and relational value (i.e. identity, and stewardship).

Table S4. Examples of quotes coded at each wellbeing theme and value domain.

Wellbeing	
Material **basic needs, subsistence, livelihoods**	Crops are important, we benefit and look after our kids with them. That's the only way we get money to buy things. ~ Woman, Karkar We survive on cocoa, copra and gardens (crops), [that's why its ranked first]. ~ Man, Karkar We like the reef (habitat) to be good so we can find things to eat…we catch fish, we eat it, we smoke it and sell it at market. ~ Woman, Ahus Fishing and work to do with the sea is our only living. ~ Woman, Ahus
Relational **care, stewardship, identity, continuity of custom and tradition**	We are people of the sea*, so we must have a good, clean reef (habitat), and we must look after it well. The sea is first. ~ Woman, Ahus We only use reef materials and fuel wood if they die. ~ Man, Ahus [We] can have traditions if we respect the fish. ~ Woman, Ahus I'm not a fisher, I don't dive. I'm a bush man, I'm not interested in fishing. ~ Man, Karkar It's custom to give fish away and share, this custom is necessary to be happy. ~ Man, Karkar
Subjective **taste, enjoyment**	I don't want to finish drinking soup that has no fish, but with fish it tastes good. ~ Man, Karkar Fish is the best food; good taste. ~ Man, Ahus
Value domains	
Instrumental	Habitat is important because fish hide there, live there. With big events (tradition) we can catch fish and celebrate, that's important. ~ Woman, Karkar When habitat is good then there are plenty of fish, which we can use for celebrations (tradition). ~ Woman, Ahus Education/ knowledge leads to good habitat and good fish, which are good for catching and going to market, and helping family (bequest). ~ Man, Ahus
Relational	We are people of the sea*, so we must have a good, clean reef (habitat), and we must look after it well. The sea is first. ~ Woman, Ahus I don't think sanitation is good; it's bad for the reef. I'm not happy with cutting firewood, or using coral materials, we'll ruin the environment. ~ Woman, Karkar If you care (for the reef habitat), it will grow, if you break it, it will die. If you care for it you get plenty of fish and they're important for life. ~ Man, Karkar

A3. Intra-household gender differences

To calculate intra-house hold differences, within each partnership we subtracted each women's score from each man's score to get a variable for the gendered difference in ranking and in rating. We then conducted one sample t-tests to test whether there were any patterns in gender differences for each ecosystem service.

One sample t-tests

Alternative hypothesis: true mean is not equal to 0, meaning there is a difference in how women and men rank or rate this ecosystem service.

Table S5 One sample t-tests results for ecosystem services where there was a significant gender difference in ranking and/or rating of ecosystem services.

Ecosystem service	t=	df	p-value	95% confidence interval	Mean of X
RANKING					
Fuelwood	-2.814	133	0.005629	-1.322 -0.231	-0.776
Education & knowledge	3.690	133	0.0003258	0.512 1.696	1.104
Shoreline protection	2.352	133	0.02014	0.078 0.907	0.493
Reef materials	-4.274	133	3.64e-05	-1.659 -0.609	-1.134
Sanitation	-2.138	133	0.03431	-1.121 -0.044	-0.582
RATING					
Forest Materials	-3.5048	133	0.0006232	-0.103 -0.029	-0.066
Fuelwood	-3.9042	133	0.0001496	-0.0520 -0.0170	-0.035
Education & knowledge	3.9278	133	0.0001371	0.039 0.117	0.078

Figure S1a. Boxplots of intra-household differences in ranking of ecosystem services

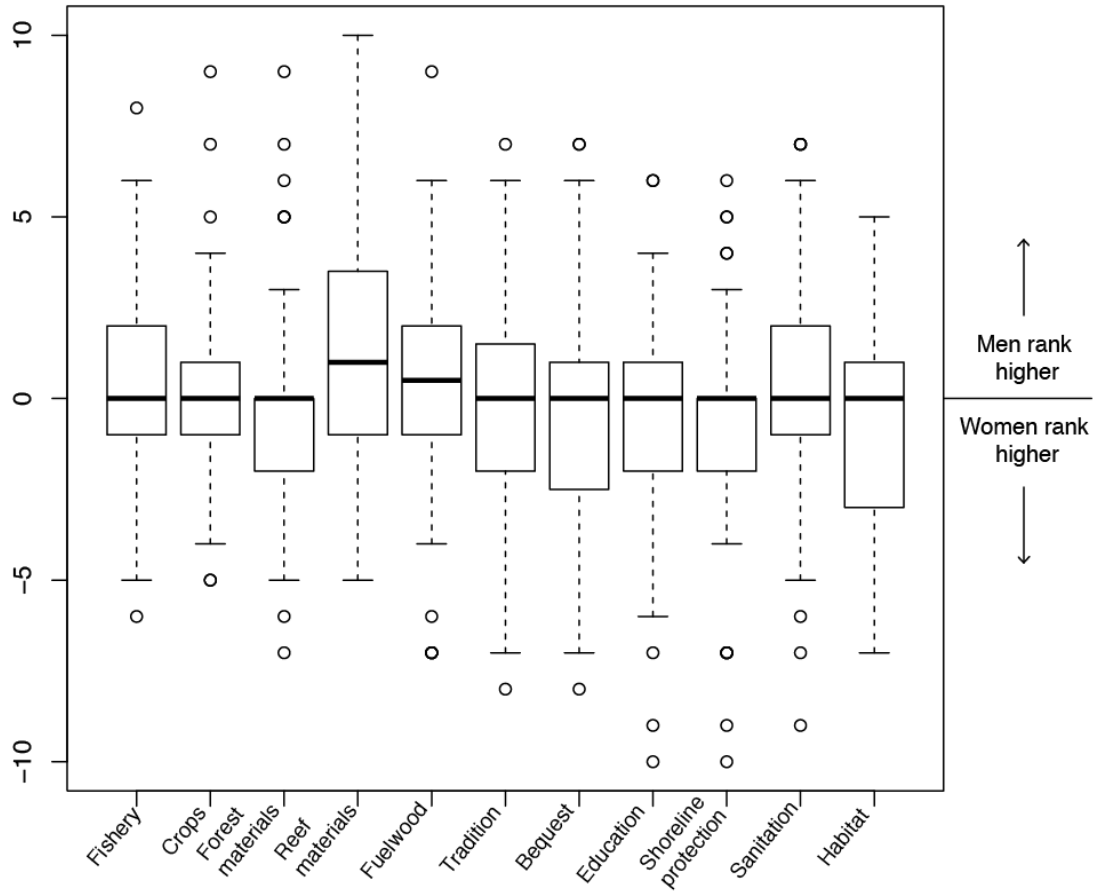
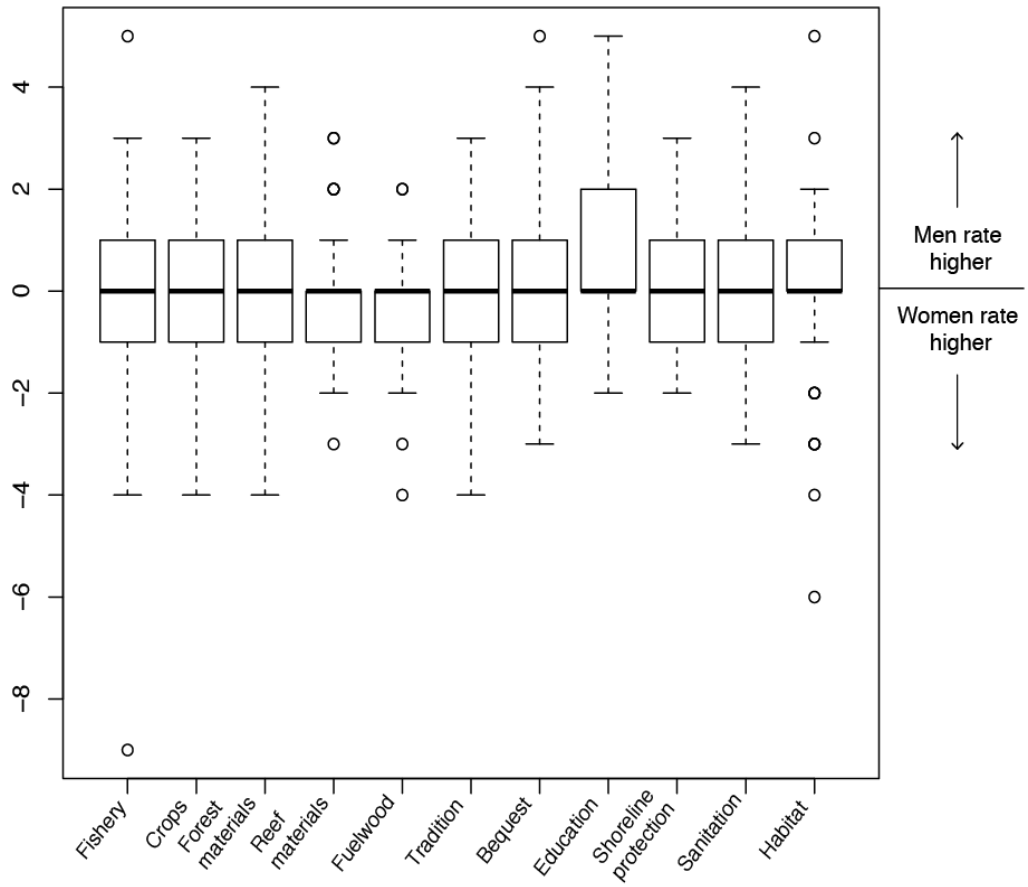


Figure S1b. Box plots of within household differences in rating of ecosystem services.



Appendix B Supplementary Material for Chapter Four

B1. Qualitative analysis

We took coded thematically, with codes for benefits derived from an initial reading of the interviews, and codes for access mechanisms derived from those identified by Ribot and Peluso (Ribot and Peluso, 2003). Table S6 explains each code, and provides an illustrative quote.

Table S6. Thematic codes with explanation and illustrative quotes for a. Types of benefits and b. Access mechanisms.

Codes	Explanation	Illustrative quotes
a. Types of benefits		
Money (sell)	Sold for money in village, mainland market, town market	"When the quality or quantity of the fish is good we sell at the market" (woman, 45)
Consumption (eat)	Consumed either post-market if not sold, or before	"…during the day it's normal. We go diving and get one or two to eat" (man, 28)
Barter	Fish exchanged for garden food (sago etc.)	"but if not [selling it] I'll do the barter system and I will change it with another food type because I know that I will go back to the ocean and get more fish. So the fish I have I can change it for a bag of sago or some garden food" (woman, 27)
Contribution (to custom, community events)	Fish or shells contributed to events or a pool of money that goes towards community projects (e.g. building school)	"When there is a death we will have to go and get fish and there's ways to do that… they [Chiefs/ family] put out the word and… the next day everyone will go and get fish from that area. We have celebrations like that." (Man, 60)
Share	Fish are given away (gift)	"if I get a lot or I only get some…if a family member comes along I will still give fish to them. Our way in the village is that when someone goes to the reef or I go to the reef and someone comes to the village and they want fish I would share it with them" (Woman, 27)
Efficiency/ efficacy	The ability to benefit from more effective fishing by using certain gears/ methods/ areas. Often linked to social identity, relations and customary institutions.	[Barrier] "Santina and I used the net and the men saw us and reported us to the owners [of the net/ area] but we didn't go to court. They just told us that in our custom only the men are allowed to throw the net or to catch fish using the net but not the women. And that was the first and last time for me to use the net and now I don't use the net anymore" (Woman, 27)
Physical access	Ability to fish/ access certain areas	"When I go, I go to our part of the ocean that belongs to my family, I won't go to the other side" (Woman, 45)
Codes	Explanation	Illustrative quotes
b. Access mechanisms		
Rights	Legal rights (see customary institutions re. informal rights)	"The other things like Beche de mer and all this… when the fisheries department gives the ok, then we go and get them." (Man, 51)
Capital	Money to buy petrol, boat fares, or assets (e.g. outboard motor and boat)	"If you are fishing for tuna then you go in an outboard motor so you can go out there… You can hire boats. There are hire boats that are there or friends who have motors and cannot go and do heavy fishing, you can ask them and they will give it to you." (Man, 60)
Customary institutions	Clan ownership of certain areas, gears, times of fishing. Many have fallen away but fishing on 'your side' of the island, tends to be followed.	"When the boys from the other side come here to Rai - only the people from Rai will go there - and when the people from the other side come here people get angry" (Woman, 45)
Deviance from rules	Benefiting by disobeying customary rules around times and places to fish. Particularly around diving at night, and diving in what used to	"The boys from the other side went to the ocean and they went fishing there and [the young men from here] got angry saying you guys should stay in your area and fish in your area" (Woman, 45) "With diving at night time when people don't ask and just go swimming in the area for fish - we all depend on the ocean and when you go and you get good things - and when you don't ask the owner, the person [owner] won't agree with that and arguments happen."

	be restricted areas.	(Woman, 27)
Emotional circumstances	Beliefs around emotions/ social relations (e.g. arguments) and fishing	"If I argue with a family member I won't go to the ocean because I will waste my time going to the ocean." (Man, 27)
Environmental circumstances	Weather, tides, rough seas [barriers] Low tide [enabler] – can dive deeper	"If the water level is high we won't go. If we go the tides might take us to the big ocean and we might die, so if the water level is ok then we will go but not when the water level is high." (Woman, 45) "…when the north west winds are here then the fathers and the brothers don't go to the ocean. The shells are for times like that and the women will go collect shells… we go collect shells when the weather is bad" (Woman, 27)
Knowledge	LEK, fish seasons, areas, patterns, good bait/ gear	"If I want to look for yellow fin tuna I must go out and I know where the tuna will come out from and there are times for the fish to come, weather" (Man, 60)
Labour	To fish, market/ sell, collect (shells), smoke etc.	"[Collecting trochus shells] is a combined job for the husband, wife and the children and if you have a big family than you are lucky, many hands" (Man, 60)
Market	Over-supplied market = key barrier to benefiting. Requires transport money, and labour (women) and is unpredictable.	"A lot of fish go to the market, or we dry the fish or smoke the fish. It's making things difficult for our women here… If only there was a good market and access to exporting to other provinces. We can get into selling fresh fish, someone in Ahus should be a buyer." (Man, 60) "When there is a lot of fish and we go sell it, people won't buy the fish" (Woman, 27) "If there is a lot of fish at the market then there is no need to go to the market. Sometimes people will buy it and sometimes they won't because the fish might go off." (Man, 27)
Technology/ gear/ methods	Gear types, technology for catching fish (sometimes limitied – i.e. barrier) sometimes shared innovation (e.g. 'chicken feather method')	"I must have fishing lines, must have fishing hooks, I must find bait for me to use when fishing, and reels." (Man, 27) "we fish out there. Night fishing is with the lamp or torch but that's this area but that area we can't go - it belongs to the clan from the other side." (Man, 60) – linked to social relations/ clan/ customary rules
Social identity (incl. gender, clan, age, family)	Intersects with customary institutions, clan ownership (sides of the island) and space (men outside, women inside reef)	"If I wanted to go and fish over there I would have to go and see the chief over there and ask to go and look for fish over there" (Man, 60) "The custom of the village only men are meant to throw the net but not the women" (Woman, 27)
Social relations (as above)	Asking permission, borrowing things, sending fish to market with relatives, sharing with friends, family	"You can hire boats. There are hire boats that are there or friends who have motors and cannot go and do heavy fishing, you can ask them and they will give it to you." (Man, 60) "If I wanted to go and fish over there I would have to go and see the chief over there and ask to go and look for fish over there" (Man, 60)
Combinations		
To identify where mechanisms work together (e.g. gender and customary institutions)	"If I argue with a family member I won't go to the ocean because I will waste my time going to the ocean" (Man, 27) – customary belief that fishing when in an argument = no fish. (social relations, emotional circumstances, customary institutions)	

B2. Access to Trochus shells

Each clan leader has the right to close and reopen trochus shell collection in their clan area. During fieldwork, trochus shell collection was banned across the island. Partially, the price of trochus shells had dropped and so the collecting and selling them was not lucrative enough. However, the way trochus shells are collected and the socially sanctioned ways of benefiting from them, tell a more complex story. When a clan leader decides that it is time to harvest trochus shells, he announces it and puts out a marker (usually, a large tree branch, stood up in the sand), to mark the boundaries of the clan's area. Then, over several days, families go collecting trochus shells together. Part of the money made from trochus shells is supposed to be shared among the community, put towards school fees, rather than solely benefitting the family who collected the shells initially.

"All trochus shells across the whole reef are tambu. When they're alright then people can harvest them. It's because of the price. So, they are waiting for the price and the size to go up… Yes, trochus shells used to help us pay school fees. They help to support education. We use trochus shells to benefit the children. By collecting and selling it – when they get the money they can support their children by getting school fees. And it's more valuable." (Clan leader, ~60)

'There are landowners for trochus shells. It belongs to the community… They say that after 3 or 5 years so trochus shells are ok, and the community goes and gets it to pay for school fees for the kids' (Woman, ~35).

Harvesting of trochus shells is collective, and it is considered appropriate to both share the money, put it specifically towards education, or use it to do community work. Yet, this customs around trochus shells are entangled with the market system. The drop in trochus shell price likely contributes to how strongly people adhere to the island-wide ban. Indeed, in interviews, while the tambu on trochus shells was often the only one that people confidently said was a tambu that was in place, and followed, often it was mentioned as an afterthought.

Appendix C Supplementary Material for Chapter Five

Table S7. Broad themes and codes used for coding qualitative interviews

Theme	Codes
Customary law + practices	Improved fishing Good fortune & harm Creates identity and connection to ancestors/place Fulfilling customary obligations
Leadership & social relations	Leadership, obedience, and respect Youth-elder Responsibility Collective identity Caring and sharing Listening to leaders Conflict management
Participatory & adaptive management	Deliberative decision-making Participation in decision-making & customary events
Compliance	Good behaviour rewarded Deviance punished

Table S8. Illustrative quotes for Customary law and practices

Code	Quote[s]
Improved fishing	Well, closing the sea, we rest it (maloloim), no one can go into the sea to disturb the reef or disturbing the fish, no one can go and frighten the fish in the reef. It'll be easier in the future… all the fish will grow up and then men and women from the community will find it easier to catch fish. Even close to the beach, and bring them home to eat. Yes, its very important. So, other communities in Karkar island, they don't have this, and they don't know about it [bom bom]... They don't know how to go fishing at night. Only Muluk. Just Muluk. We have knowledge about how to go out at night and get fish. They smash the bamboo to use as a light for catching fish at night.
Good fortune and harms	This fulfils us, when we follow custom that the ancestors dictated. We live by the customs and we see the good things that come from following customs, and we know that custom is good. There's a law for it. You must follow it, and you will see that you have plenty of fish and plenty of pigs and plenty of whatever you need. If you don't follow the law, you will lose all these things. This custom, it's so important here in Muluk. Women, this custom is strong with them. Women are very, very important. Now, if your husband wants to go out fishing at this time, and you are feeling unwell, then you have to tell him. If you have your period, or this sort of thing. Ok, you have to stop your husband from going out. And if don't and instead you go wandering off while your man is out fishing, that's very bad. If you don't tell him and he goes fishing, a fish will kill him. So women have a very important role. And if the fish break the net, that's because my wife or the kids, when I'm out there netting, they're throwing nets close to shore, or chopping wood, and that's when the fish break through the net and

	escape. You're breaking the custom law. And custom has the power to cause you trouble, and custom has the power to help you live well. If you want to go to the sea, and your wife is menstruating, you cannot go. If you go a fish will shoot you and you will die. You can't eat tallis nut. If you eat tallis nut, then a fish will come and kill you dead. If you eat marita, a fish will kill you. If you eat 'pikpik', a fish will kill you. If you go fishing, and your daughter is mucking around the house, your home, then you won't catch anything. The fish too will come and just muck around, and you'll just end up shooting the sea water and coming back

Code	Quote[s]
Creates identity & connection to ancestors/place	It's something good that we have here; the way that we help other people, and work together and participate in big customary events in the community. Other places don't have this. Other places have gradually lost these ways. One thing is, the nice outlook of the community here, the way that people like and care, the way people share, the way people fulfil their customary obligations, family to family, I think that's all that makes this community special. we will talk about gathering all the young people together to learn these customs, and about our songs and the ancestors and everything, so that the young people know, and know properly (save gud) about these things and how they are important for the community (the siddaun), they will know properly about their customs and their culture. In terms of our thinking, practices and customs, we hold these ways strongly because our parents, and grandparents and ancestors taught us these ways. It's these things that make us who we are. Our young people see them, respect them, and see the fruits of these practices. We won't forsake them. Our ancestors have blessed these customs, and God has blessed them. And we hold onto them strongly. In terms of our thinking, practices and customs, we hold these ways strongly because our parents, and grandparents and ancestors taught us these ways. The leaders of Muluk, the leaders that Muluk has… this is a blessing form the ancestors. This custom for catching fish [bombom], and custom for tambuing the sea, this is… this was created by the ancestors and we haven't lost these practices. We are still here keeping these customs going, and we will keep maintaining them long into the future. So, our great-grandparents, they cultivated this way of giving to others, of sharing, and participating in customs, they were always unified.
Fulfilling customary obligations	So if there's customary work to be done in the community, everyone comes together to participate and listens and everyone cooperates, even if the call is last minute. These customs are very strong. We have to follow every single one of these. All three clans in Muluk, Boner, GanGan, Marror – our customs are very strong

Table S9. Flight initiation distance models for a) Wadau and b) Muluk

Estimate		Std. Error	df	t value	Pr(>|t|)
Wadau					
(Intercept)	416.54	38.27	5.50	10.88	6.29e-05 ***
Closure	-128.72	11.39	371.79	-11.30	< 2e-16 ***
Muluk					
(Intercept)	348.352	29.670	5.149	11.741	6.52e-05 ***
Closure	-84.397	10.005	476.620	-8.436	3.96e-16 ***

Table S10. Summary of relationships between reef fish biomass (total and by functional group) and management, depth, and benthos. + = significant positive impact, - = significant negative impact. Data from 2009, 2012, 2016, 2017.

	Rotational Closure	Depth (3m,7m)	Structural Complexity	% Cover Hard Coral	% Cover Epilithic Algal Matrix
Total Biomass	+		+		-
Micro-invertivore	+				
Grazer	+				
Excavator/Scraper	+	-			-
Piscivore-Invertivore	+	+			-
Macro-invertivore	+				
Planktivore		+	+	+	
Corallivore				+	
Detritivore			-		

Table S11. Illustrative quotes for participatory decision-making

Code	Quote
Deliberative decision-making	For example, so now, us three are sitting here (refers to 3 family members), and we will sit here and discuss all sort of things, things about tomorrow and the future and how we will maintain the ways of hunting, singing We will have to have a meeting to discuss it. The practices that the ancestors followed, that continue today, these customs, we follow them. If we don't follow it, then we have to meet and talk about it, about how to do the right thing (kisim gudpela). It's by respecting custom that we can catch fish, with the net, that we make ourselves. All the leaders meet, and argue about it, and make sure the customs stay strong.
Participation	It's something good that we have here. The way that we help other people, and working together and participating in big customary work in the community. Other places don't have this. Other places have gradually lost these ways.

Table S12. Illustrative quotes for compliance

Code	Quote
Good behaviour rewarded	One important thing is, our ancestors, when they wanted to bestow these rights on the young men, they chose the young men who respected their leadership, who obeyed the laws. A respectful man who obeyed the rules. The person's parents, the leaders, all the elders, and all three clans leaders, Boner, Gangan and Marror, they'd all meet and assess the person. And they'd say, this man, he's got good behaviour [gudpela pasin], ok and in Marror, they'd choose them, and Boner would choose them, and Gangan would choose them, ok and then, they'd all get a number. [bombom license] Not all men get it. Not everyone. All the leaders of the clans, Boner, Gangan, Maror, they choose who gets it. They must see that they're a good man, a respectful man, a law-abiding, obedient man.
Deviance punished	J: Have you witnessed a time when a man didn't follow the laws and he met with misfortune? P: [emphatic], yes, yes, yes. Plenty. J: Can you tell me about that? P: Now, the leaders of the clans will gather and will decide that this man's no good, he can't go out again. J: So if something bad has happened then it'll get discussed… at the community meeting? P: No, at a special meeting. J: In each clan, or all the clans? P: All the clan leaders, they'll all come and meet. If it was your husband who had misfortune, they'll all sit down and discuss and decide on what to do. All the young people, they cannot talk back to us. If one is disobedient, then we'll bring him here to talk, and to follow the law of custom. Custom is the same as law. The law of the village. The custom law of this village, you cannot flaunt it. You can't mess with it. No outsiders would mess with it ('kalapim'), no one from outsidewould dare come here and ruin it. The law will get you, the customs… the leaders will get angry. This is the most important custom we have, bombom.

Table S13. Illustrative quotes for leadership & social cohesion

Code	Quote
Leadership, obedience, and respect	When the leaders talk, everyone listens. The leader is responsible for looking after the reef. The leader is responsible and speaks for all culture and custom… that's what the leaders are for. Clan leaders, community leader, they all look after the people, the young people from here. But, there are some other customs that come in from outside, some outside things that come in to ruin the customs here, but we have strong leaders, clan leaders and community leaders, the leaders strengthen the customs. They argue and talk strongly about these things. All the leaders meet, and argue about it, and make sure the customs stay strong When it comes to closing and opening the reef, we have leaders for that, you respect the leader. like all my brothers here, they're all talking about the customs and culture of the community… and its very important inside our community. Respecting and leading, that's very important for us. Because, in the time of the ancestors, there was one man who was responsible, the village leader [ples man], and when he gave an order, everyone quickly came together to make sure they could fulfil his order, or fulfil the work required, like this, everyone obeyed the leader. So this way of doing things, we hold onto it today If the leader sees that the number of fish has gone down and we're ruining the sea, then the leader will say, it's closed (tambu). Ok. If the leader says, there are plenty of fish, now we can catch fish. We have clan leaders, community leaders, and we listen to and respect them all.
Social cohesion	So, you'll see that our community isn't divided. We are all together as one whole community. If you go to other communities you'll see, over there is a little part of the village, another is over there, and over there, it's all broken up. So it's hard to communicate and bring people together to talk and come to common understandings. But not here, here, our community is intact, and we must stay like this. It's the way we listen and respect. We can go about our own lives, but when we hear news, then we always come together to help So, in our community, you can see all these kinds of arguments, and people get cross at each other, but something special we have is this way of bringing people together, all the time, and we keep living peacefully, and make sure the peace is maintained. Interviewer: What do you do to resolve conflicts? Interviewee: Well, we… the leaders speak out, we all meet, and sit down to sort it out. And once we've sorted it out, then its peaceful again. Our lives are very good here, before.
Youth-elder ties	Now all the young people, the young boys and girls, mums and dads, everyone knows that underneath the leader, whoever talks, all the young people respect and listen and follow the customs and culture of the community. The leaders, we all sit down and talk with the young people, about respecting the customs and the culture. We here in Muluk, this community, we, all of us young people from here, we've learned how to tambu the reef from the leaders here, and how to tambu the bush from hunting. They [youth] can't go around being bigheaded, or getting drunk, or causing trouble.. no, we don't have that here. They follow the laws of the leaders, and their parents, and the customary practices, that's all

Table S14. Parameter estimates from an exponential random graph model fit to directed knowledge sharing ties among fishers in Muluk in 2016 (n = 41). Structural effects capture self-organizing network processes, such as closure (path closure) and centralization (activity and popularity spread). The arc parameter is akin to the intercept in a linear regression. Clan-based and leader effects are attribute-based, and capture whether leaders or people in particular clans are more or less active in the network (either as a sender or receiver) or whether they preferentially interact with others within their group (interaction). Results show that leaders are significant 'receivers' in the network, indicating they are popular sources of information and advice. Results from a goodness-of-fit test (Lusher et al. 2012) indicated all features of the observed network were fit well by the model.

Effects	Lambda	Parameter	Stderr	t-ratio	SACF	
Structural effects						
Arc	2	-4.493	1.167	-0.002	0.053	*
Reciprocity	2	-0.0273	1.13	0.006	-0.027	
Popularity spread (AinS)	2	0.3687	0.343	0	0.04	
Activity spread (AoutS)	2	-0.4583	0.384	-0.007	0.061	
Path closure (AT-T)	2	-0.1088	0.592	-0.04	-0.013	
Clan-based effects						
Clan A_Sender	2	-0.4374	0.662	0.032	-0.008	
Clan A_Receiver	2	0.3561	1.127	0.002	0.021	
Clan A_Interaction	2	1.2875	1.036	-0.023	0.037	
Clan B_Sender	2	-0.518	0.978	-0.05	-0.009	
Clan B_Receiver	2	0.7943	1.105	0.004	0.017	
Clan B_Interaction	2	0.9209	1.021	-0.053	-0.049	
Leader effects						
Traditional leader_Sender	2	-0.1446	0.588	-0.014	-0.03	
Tradional leader_Receiver	2	0.9667	0.416	-0.033	0.016	*
Traditional leader_Interaction	2	0.2953	0.681	-0.045	0.067	

Table S15. External vs. internal (E-I) knowledge exchange ties within and across age cohorts. The E-I index is calculated as the number of external group ties minus the number of internal group ties divided by the total number of ties. Values range from -1 to 1, where -1 indicates complete homophily (internal ties only) and 1 indicates complete heterophily (external ties only). The E-I index for elders (shaded in gray) indicates a high level of external group ties.

	Internal	External	Total	E-I Index
Youth (youngest quartile)	12	9	21	-0.143
Middle Age	40	17	57	-0.404
Elders (oldest quartile)	4	20	24	0.667

Table S16. Summary of social and ecological covariates

Covariate	Description
Closed	Refers to whether closure of reef was in place.
Depth	Reef fish and benthic visual surveys were undertaken within two depths: 3 m (corresponding to the reef flat habitat), 7 m (corresponding to the reef crest habitat).
Site	Seven individual reef sites (each 900 m^2), where reef fish biomass and benthic community structure were estimated.
Structural complexity (SC)	A measure of complexity provided by live corals, the underlying reef matrix and other geological features. Visual estimates of structural complexity were quantified five times along each transect using a 6-point scale: 0 = no vertical relief, flat or rubbly areas; 1 = low (<30 cm high) and sparse relief; 2 = low but widespread relief; 3 = widespread moderately complex (30–60 cm high) relief; 4 = widespread very complex (60–100 cm high) relief with numerous fissures and caves; 5 = exceptionally complex (>1 m high) relief with numerous caves and over- hangs.
Hard coral (HC)	Percent cover (%) of live scleractinian corals, identified to genera from point-intercept transects.
Macroalgae (MA)	Collective term used for seaweeds and other benthic marine algae >10 mm in height. Percent cover (%) of all macroalgae quantified from point-intercept transects. All macroalgae identified to genera.
Epilithic algal matrix (EAM)	Collective term for epilithic algal communities (i.e. turf forming filamentous algae) and non-living component (i.e. detritus, sediment) ≤ 10 mm in height. Percent cover (%) of EAM quantified from point-intercept transects.

Appendix D Supplementary Material for Chapter Six

D1. Qualitative coding

1. Environmental justice (framework driven coding) - **dimensions, subjects, criteria**

2. Theories around normative evaluations (theory driven coding) – **recursivity, change, fluidity, evaluations** (more abstract)

3. Broader themes of concern (data driven coding) - **caveats, tradeoffs, recurrent concerns**

Coding approach

1. Iterative coding across layers (using explanations + definitions below)

2. Reflect and generate analytic codes linking framework, theory and data generated codes **(recurrent themes, links, cohesive codes etc.)**

3. Re-code against new codes

Table S17. Coding themes around Environmental justice frameworks

BROAD THEME	SPECIFIC THEME - definition		NOTES (what to look for)
DIMENSIONS	1. Distribution – of costs and benefits 2. Procedure/ participation – in decision-making 3. Recognition	Descriptive (what/ how) Ideal (normative) Fair or unfair?	1. Rights, benefits, costs, (methods, pressure, technology, size, timing) 2. Practices, regularities 3. Legitimacy, respect, gap between 1. and 2. (a. and b.) [link to 2.]
CRITERIA	Equality Need Merit Deservedness Other? [link to 3.]	Why? (for above)	Explanations of why or why not something is fair, or caveats, tradeoffs
SUBJECTS	Individuals (ages, gender, clans) Groups Community (or outsiders) Generations Non-human organisms Nature	For whom or what?	Specific reference to a group, characteristic, scale, relationship

Table S18. Coding themes around normative judgements and evaluations (theory generated themes)

BROAD THEME	SPECIFIC THEME - definition	
NORMATIVE EVALUATIONS JUDGEMENTS		Claims about should, shouldn't, good, bad, good life, correct way of being, correct relationships; Trade-offs; Justifications of behaviour or views; Thoughts about what others do compared to what is right/ what I do; Thick and thin moral principles
RECURSIVITY	'Professed values' 'Values in use'	Descriptions of change, or 'curtailed' expectations/ judgements, gap between professed/ ideal version, and fieldnotes Resignation
VALUES	Collective relational values: cultural identity social cohesion social responsibility Individual relational values: individual identity stewardship	place is important to who we are as a group being in nature allows people to connect to each other caring for nature is important for the welfare of others a place can be important to a person's identity, such as a farmer's identity being tightly linked to the land respecting and preserving nature as 'the right thing to do' or to help somebody live a good life. Gap between ideals and practice on the ground "think of values as 'sedimented' valuations that have become attitudes or dispositions, which we come to regard as justified" (Sayer) Loaded terms to do with good and bad (see also normative

Table S19. Broader themes (data driven coding from first round)

BROAD THEME	SPECIFIC THEME - definition	NOTES links to S17 and S18
Values	Suspension/ clash with other values Aligned with other, broader values (especially Church)	Values
Entities beyond agency + control	Unfairness around challenge/ luck of fishing - overfishing	Justifications
Personal + community qualities (thick and thin moral principles?)	Maturity and understanding Individual family's responsibility, obedience Working together Working hard/ effort Respect, legitimacy, leadership oscillation between reactive and pro-active governance Masculinity, strength Fitness Sharing and reciprocity	Criteria and subject [1] Good life [2]
Fairness themes	Needs-based fairness Unfairness of technology, diving at night, catch-22 Enjoyment, wellbeing Providing alternatives	Criteria [1] Distribution [1] Normative judgements [2], capabilities [1] Responsibility (distribution of) [1]
Changes	Lifestyle, attitude changes Youth-elder relationships	Recursivity [2] Subjects [1]

Appendix E Disaggregating Ecosystem Service Values and Priorities by Wealth, Age, and Education

***Jacqueline D. Lau[1], Christina C. Hicks[2], Georgina G. Gurney[1], Joshua E. Cinner[1]**

[1]Australian Research Council Centre of Excellence for Coral Reef Studies, James Cook University, Townsville, QLD 4811 Australia

[2] Lancaster Environment Centre, Lancaster University, Lancaster, LA5 9PT, UK

* Jacqueline Lau, Australian Research Council Centre of Excellence for Coral Reef Studies, 21 James Cook University, QLD 4811 Australia
Email: jacqueline.lau@my.jcu.edu.au
Ph: +61 403990738

Abstract

Ecosystem services support the livelihoods and wellbeing of millions of people in developing countries. However, the benefits from ecosystem services are rarely, if ever, distributed equally within communities. Little work has examined whether and how socio-economic characteristics (e.g. age, poverty, education) are related to how people value and prioritize ecosystem services. We interviewed 372 people connected to coral reef fisheries in 28 communities across four countries in the western Indian Ocean. Each fisher ranked the importance of nine ecosystem service benefits, and then rated which services they most desired an improvement in quantity or quality. We disaggregated their responses to see whether age, poverty, or years of formal schooling influence how fishers rank and prioritize coral reef ecosystem services. Overall, we found little empirical evidence of strong differences between groups. However, the wealthiest fishers did prioritize improvements in habitat ecosystem services and recreational benefits more than other fishers. Our findings emphasize that people directly dependent on coral reef fisheries for their livelihood hold mostly similar values and priorities for ecosystem services. However, poverty influences whether fishers prioritize improvements in supporting ecosystem services associated with environmental care, in this case habitat benefits. Making the differences and similarities between the importance of and priorities for ecosystem services explicit can help decision-makers to target and frame management to be more socially inclusive and equitable and therefore, more effective.

1. Introduction

Ecosystem service research has made much progress toward conceptualizing and valuing nature's benefits to people. People need nature's benefits to live healthy, fulfilling lives with fresh water, clean air, and nutritious food (MEA, 2005). Yet until the 1990s, these benefits were often undervalued or completely missing from policy (Costanza et al., 1997). Natural capital and ecosystem services thinking emerged to remedy this oversight by explicitly accounting for nature's benefits to people (Daily, 1997). Since the 1990s, ecosystem services research has grown exponentially (Gómez-Baggethun et al., 2010; van den Belt and Stevens, 2016). More recently, a range of institutions and programmes have emerged, aiming to contribute to poverty alleviation and enhance human wellbeing by drawing on ecosystem services approaches and research. For instance, the Millennium Ecosystem Assessment (MA, 2005), Ecosystem Services for Poverty Alleviation (ESPA), and the International Panel for Biodiversity and Ecosystem Services (IPBES) all focus on improving and safeguarding human wellbeing. This agenda is particularly crucial in developing countries, where people often directly depend on ecosystem services for their sustenance and livelihoods.

Although research has examined the myriad ways that ecosystem services benefits are linked to human wellbeing and poverty alleviation (MEA, 2005), the links are not straightforward and remain poorly understood (Fish et al., 2016; Fisher et al., 2013, 2014; Howe et al., 2014). In particular, understanding whether and how ecosystem services benefits to wellbeing differ among different social subgroups remains nascent (Daw et al., 2011). Populations, communities, and societies are socially diverse – i.e. made up of different groups, with varying identities, values, and experiences. This diversity impacts who benefits from ecosystem services, and influences what is considered fair in ecosystem service distribution and governance (Berbés-Blázquez et al., 2016; Daw et al., 2011; Sikor and Baggio, 2014). Large-scale, aggregated ecosystem service studies – the norm in ecosystem services research (Wieland et al., 2016) – are unlikely to reflect the values of poorer or more marginalized people (Brooks et al., 2014), or to capture differences across social groups (Daw et al., 2011). Indeed, management based on aggregated studies may have unintended consequences on poverty alleviation, leading to inequitable socio-economic impacts that may further marginalize certain groups' interests (Adams, 2014; Berbés-Blázquez et al., 2016; Daw et al., 2011).

To date, research on social differentiation and ecosystem services has been growing but limited. Most studies addressing social differentiation have been single case studies (Orenstein and Groner, 2014; Lakerveld et al. 2015, although see Sodhi et al. 2010). Studies have differentiated by: livelihood type (e.g. Brooks et al., 2014; Caceres et al., 2015); beneficiary group (Milcu et al., 2015); rural vs urban residents (Orenstein and Groner, 2014); citizenship (Orenstein and Groner, 2014); socio-cultural groups (Lakerveld et al., 2015; Sagie et al., 2013); socio-economic status (Dawson and Martin, 2015; Sodhi et al., 2010); length of residency or location (Dawson and Martin, 2015; Sodhi et al., 2010); and socio-ethnic group (Dawson and Martin, 2015). Studies contrast perceptions of ecosystem services (Caceres et al., 2015; Orenstein and Groner, 2014; Sodhi et al., 2010), needs and benefits (Lakerveld et al., 2015; Milcu et al., 2015), and access (Lakerveld et al., 2015).

Many of these studies have found that people both benefit from and perceive ecosystem services differently. For example, in a valuation of wetland ecosystem services in Asia, government officials and business owners (i.e. decision makers) estimated wetland fisheries to have very little overall monetary value. However, for the livelihoods of poor fishermen and women dependent on the wetland ecosystem services these fisheries benefits were crucial (Brooks et al., 2014). In Argentina, subsistence farmers perceived many cultural ecosystem services benefits from the land, while large farmers perceived none (Caceres et al., 2015). In addition, work investigating urban and rural residents of the Arajun valley in Jordan and Israel has shown that perceptions of ecosystem services can be defined by political border and residential characteristics (Orenstein and Groner, 2014).

Work on the social dimensions of ecosystem services has been predominantly in terrestrial systems. Marine and coral reef ecosystem services remain under-researched from a wellbeing and human dimensions perspective (Rivero and Villasante, 2016), and ecosystem services work on poverty alleviation more broadly has tended to focus on cultivated and forested land (Suich et al., 2015). In line with this trend, most studies addressing social differentiation and ecosystem services are in terrestrial systems (although see Daw et al., 2011). Attention to social differentiation and marine and coastal ecosystem services is crucial not only because empirical research remains nascent, but also because much fisheries policy and research has historically been based on Malthusian narratives of overfishing (Finkbeiner et al., 2017) technical fixes that rarely include marginalized stakeholders (Degnbol et al., 2006). While often taken as an homogeneous stakeholder group, fisherfolk have diverse perspectives and experiences (Béné,

2003; Eder, 2005), and poverty in fisheries is rooted in complex social and institutional processes (Finkbeiner et al., 2017; Nayak et al., 2014).

Previous studies in the western Indian Ocean have shown that certain socio-economic factors meditate the benefits people perceive from ecosystem services (Hicks et al., 2014). More specifically, social relationships and institutions shape who can access ecosystem service benefits. Hicks et al. (2015) also found a great deal of variability within the ecosystem services that fishers prioritized for improvement. Here, we extend this work to understand how, and whether, wealth, age, and level of formal schooling shape differences. Specifically, we ask whether disaggregating by subgroups might illuminate logical stakeholder groups across scales, and whether we could identify the sorts of socio-economic characteristics that may shape variation in fishers' ecosystem services priorities. This study thus extends and deepens work on the role of socio-economic characteristics in shaping variability across ecosystem services priorities and importance.

We hypothesize that those who draw their livelihoods from coral reef fisheries directly (i.e. fishers, fish workers, and fish traders) may hold different priorities for ecosystem services depending on other socio-economic aspects of their identities. Here, we explore whether disaggregating the importance of and priorities for coral reef ecosystem services is a useful avenue for understanding fisherfolks' similarity beyond solely fishery-related provisioning services. More specifically, we examined how fishers' socioeconomic characteristics (including age, years of formal schooling, and material wealth) are related to: i) the relative importance they place on ecosystem services; and ii) their priorities for improvement in the quality and/or quantity of ecosystem services across 28 communities in four countries in the western Indian Ocean.

1.1 Background and Study Sites

Countries in the western Indian Ocean are heavily reliant on marine and coastal ecosystem services. The region has a history of cultures and livelihoods based around fishing, maritime trade, and marine resource use, and a vision of 'people prospering from a healthy Western Indian Ocean' underpins key regional policies aimed at sustainable development (Obdura et al., 2017, p. 5). More specifically, coral reef fisheries are extremely important to many coastal communities throughout the region (Cinner and Bodin, 2010), but are highly vulnerable to global environmental change (J Cinner et al., 2012). Coastal communities across the western Indian Ocean lack many of the resources necessary to adapt to losses of key coral reef ecosystem

services. Our study draws on interviews conducted in 28 communities western Indian Ocean, from Kenya, Madagascar, Seychelles, and Tanzania. These communities were broadly representative of the region's rural fishing communities. Each face similar challenges of environmental stressors and lack of resources and represent different types of reef management.

2. Methods

2.1 Sampling

This study is drawn from data gathered as part of a larger project on coral reef ecosystem services in the western Indian Ocean (Hicks et al., 2015; Hicks and Cinner, 2014). We surveyed a total of 372 fishers, fish workers, and fish traders (hereafter referred to collectively as fishers) from 28 coastal communities across Madagascar, Tanzania, Kenya, and the Seychelles. Respondents were randomly selected across gear types, residence, and age from fishers, fish traders, and fish factory workers registered with local fisher organizations or the fisheries department (i.e. a stratified random sampling approach). We interviewed between 7 and 32 fishers per community, which represents 20-40% of all fishers. Respondents were mostly men, although we interviewed some women working as fish traders in Madagascar.

2.2 Coral Reef Ecosystem Services

To identify coral reef ecosystem service benefits in the western Indian Ocean, we held five focus groups with managers and scientists. We use the definition of ecosystem services as 'the functions and processes of ecosystems that benefit humans, directly or indirectly'(Costanza et al., 2017). From these discussions, we wrote short descriptions and selected photographs to represent each ecosystem service visually. We then refined and crosschecked the list, descriptions, and photographs with fishers in 30 focus groups across the four countries. The resulting nine ecosystem services were fishery, materials, education, bequest, culture, recreation, habitat, coastal protection, and sanitation (Table 9-1). The descriptions of these ecosystem service benefits were kept broad to fit with different cultural contexts.

Ecosystem Service	Description
Fishery	The benefit we gain from the fish we catch and sell.
Materials	The benefit we gain from materials we can use such as mangrove poles, shells or corals.
Habitat	The benefits we gain from having a healthy coral reef habitat.
Coastal protection	The benefit we gain from having the reef buffer the force of the waves.
Sanitation	The benefit we gain from using the sea to wash and clean, knowing that when we come back tomorrow the waters will be clear again.
Recreation	The benefits we gain from being able to relax and enjoy the marine environment or having others come and enjoy it in this way.
Bequest	The benefits we gain from knowing we will have healthy reefs that we can pass on to our children so that they can benefit from all the benefits that we do today.
Education	The benefits we gain from the knowledge we have from the time we and our elders have spent in the marine environment.
Cultural	The benefits we gain from having cultural connections to the marine environment.

Table 9-1. Descriptions of ecosystem services derived from focus groups.

Our study measured i) the relative importance of an ecosystem service to people's lives and ii) people's priorities for improving the quality or quantity of different services. To calculate the relative importance, we asked respondents to rank the nine ecosystem services in order of importance to their lives (Hicks et al., 2015). To elicit the priorities for improvement in ecosystem services, we asked respondents to distribute 20 counters across the ecosystem services, based on where they would most like to see an improvement in quality or quantity. Examples of improvement may include a healthier reef (habitat), more productive fishing trips (fishery), or better coastal protection (coastal protection). After pilot testing this approach, we found that respondents put more thought into their distribution when working with fewer counters. Therefore, we provided respondents with only five counter at a time. Once a respondent had laid down their first five counters, we then provided them with the next five, and repeated this until they had distributed all 20 counters. We then weighted each round, to reflect that the first five matches held more weight than successive rounds (see Hicks et al., 2015). These weighted scores were then normalized to create continuous data that reflected an estimate of priorities for ecosystem services' improvement.

2.3 Socio-economic characteristics

We examined four socio-economic characteristics including two indicators of wealth, years of formal schooling, and age. We measured relative wealth (Pollnac and Crawford, 2000) based on the presence of household items and facilities (such as a mobile phone, electricity); the types of household structures (e.g. materials used for flooring, walls, and roofs) and fortnightly expenditure. We used a principle component analysis with varimax rotation to incorporate these variables into a wealth indicator explaining 59% of variance, hereafter referred to as relative wealth (see Table 3 in supplementary material). We calculated the second wealth indicator

(fisheries asset wealth) based respondent's investment in fishing gear on a scale of 1 to 4, with 1 being the lowest, and 4 the highest. Fishers were given a score according to whether they owned the following types of gear (ordered from least expensive to most expensive); spear gun, line, trap, and net (see Table 3 in supplementary material). We used these two wealth indicators because one represents a more general material style of life measurement, while the other is related to direct investment in reef fisheries. We hypothesized that groups within each of the two wealth indicators might differ in the rating and ranking because the indicators are not correlated. We also asked respondents' age (in years), and years of formal schooling. We then calculated the quartiles of each socio-economic characteristic (Table 2) and used each quartile as a categorical variable in our analysis.

Socio-economic indicators	Q1	Q2	Q3	Q4
Age (years)	<29	29-37	37-46	>46
Education (years)	<4	4-7	7-8	>8

Table 9-2. Years of age and formal education binned as quartiles.

Note: Q1 = 1st quartile. N = 93 per quartile.

2.4 Analysis

We used ordinal mixed effects regression models for each of the nine ecosystem services to test whether differences existed between quartiles for the relative importance of ecosystem services (ranked). For each model, a priori we specified country and community as random effects to account for the nested structure of the data (i.e. individuals nested in community, nested in country). We also identified and removed variables that failed the proportional odds assumptions, and re-fit models without them. We then used the Akaike information criteria values (AIC) to select the best model fit, and chose the most parsimonious model in each case. We compared this model with a null model with country and community specified as random effects. In the cases where the null model was the best fit we discontinued analysis. For the remaining models, we identified significant relationships and conducted post-hoc tests using least-squares means comparisons for multiple groups with Tukey contrasts between quartiles.

To analyse the priorities for improvement in ecosystem services, we fit a series of linear mixed effects models (LMMs). Again, we fit models with community and country specified as a priori random effects, and then dropped variables to determine the most parsimonious model. None of the variables suffered from multi-collinearity, the variance inflation factors were less than 5 in each model (supplementary material). As above, where the null model proved as good or a better

fit, we discontinued analysis. For the remaining models, we identified predictor variables with significant effects and conducted multiple comparisons of means post-hoc tests using Tukey contrasts between quartiles. For each LMM model we checked for assumptions of normality and homogeneity.

3. Results

Overall, we found few significant differences between how social subgroups rank the relative importance of and prioritize improvements in ecosystem services in the western Indian Ocean (Fig. 1, Table 3, Table 4). As expected, our 372 reef-dependant respondents generally ranked fishery benefits as both important and a high priority for improvement. Knowledge benefits and habitat benefits were also ranked highly, and prioritized for improvement overall. The differences we did find mostly fell across these three highly ranked and highly prioritized ecosystem services, and were between relative wealth and age groups. There were no significant differences between how people with different levels of formal education ranked and rated ecosystem services. In addition, the only difference between fisheries asset wealth groups was that the wealthy group (Q3) prioritised improving recreational benefits more than the poorest group (Q1, $p=0.007$).

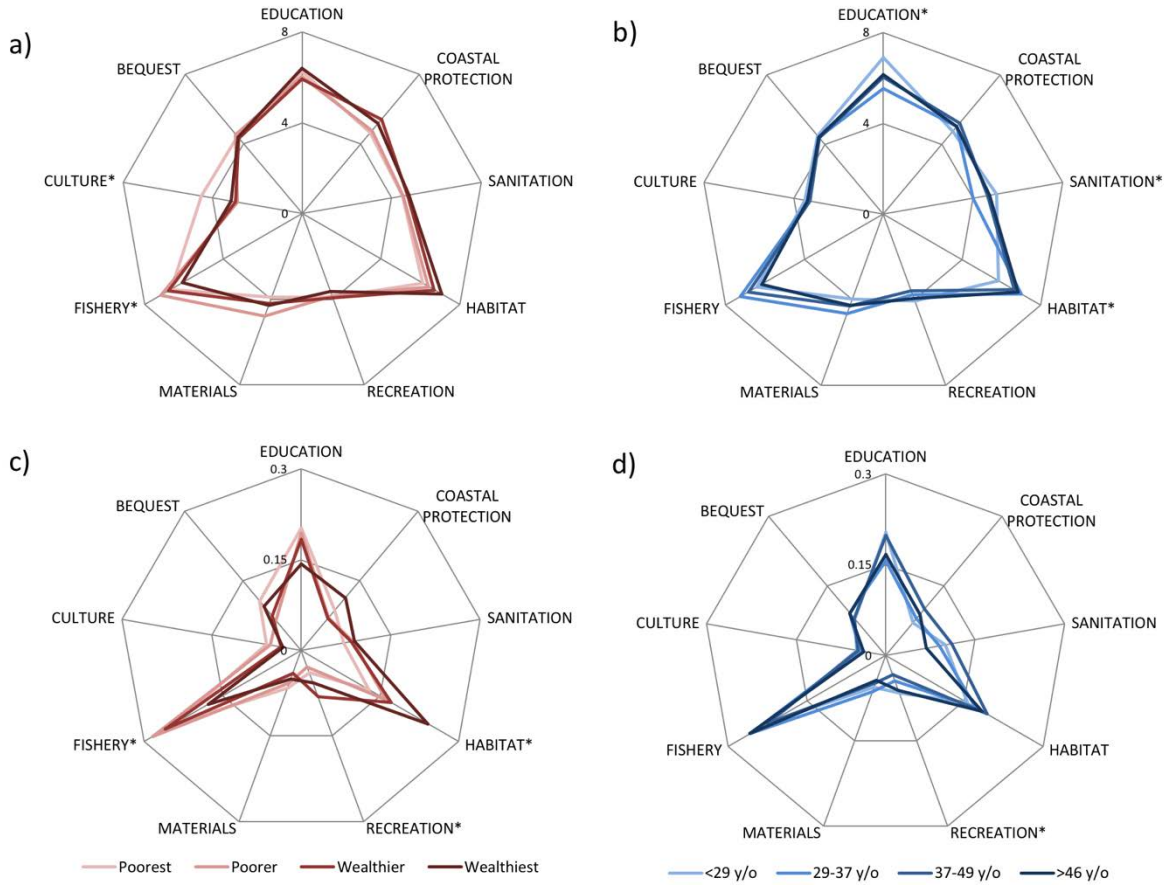


Figure 9-1. Mean ranked relative importance of ecosystem services for groups in the western Indian Ocean.

Note: A score of 9 indicates the highest rank, with a) relative wealth quartiles and b) age quartiles. Mean priorities for improvement in ecosystem services for groups with c) relative wealth quartiles and d) age quartiles. Significant differences between groups are denoted *. Note that years of formal schooling and fisheries asset wealth are not depicted here because they have no or very few significant differences.

3.1 Wealth

Most of the differences in rankings and ratings of ecosystem services fell across relative wealth groups. We found that fishers in the poor group (Q2) ranked fishery benefits higher than those in the wealthiest group (Q4), and this was also the case for their priorities for improvement (Fig. 1, Table 3) Coral reef habitat provides shelter and food for fish, and is therefore a key supporting ecosystem service for reef fisheries. We found that fishers consistently ranked habitat benefits as highly important, but that desire to improve habitat functions may be influenced by relative levels of wealth. The wealthiest fishers (Q4) prioritized improvements in habitat benefits more than all other fishers (Fig.1, Table 3).

We also found several differences between how different wealth groups ranked cultural ecosystem services; recreation, and culture. The poorest fishers (Q1) ranked cultural benefits as

more important than those slightly wealthier fishers in the poor group (Q2). In contrast, wealthier fishers prioritized an improvement in recreational benefits. We defined recreational services as 'the benefits we gain from being able to relax and enjoy the marine environment or having others come and enjoy it in this way'. Thus, recreation benefits include enjoying the reef oneself, or drawing one's livelihood from others' recreation, e.g. through tourism. The wealthy group (Q3) prioritized an improvement in recreational benefits more than the poor group (Q2).

		Differences between quartiles		
	Ecosystem Service	Higher	Lower	P value
Relative Importance (rank)	Fishery	Q2	Q4	0.001
	Culture	Q1	Q2	0.016
Priority for Improvement (rate)	Fishery	Q2	Q4	0.024
	Habitat	Q4	Q1	<0.001
		Q4	Q2	0.009
		Q4	Q3	0.024
	Recreation	Q3	Q2	0.028

Table 9-3. Differences between rank and rate scores between wealth groups.

Note: Based on material style of life scores for household items. Legend. Q1: poorest; Q2: poor; Q3: wealthy; Q4: wealthiest.

3.2 Age

As with wealth, there were few differences between age and people's ranking and rating of ecosystem services. Overall, fishers of all ages overwhelmingly ranked fishery benefits as most important, and as a key priority for improvement. Of the few differences across age groups, most fell between those in the younger groups, rather than young fishers and old fishers (Fig. 1, Table). The fishers under 29 years old (Q1) considered education benefits more important and habitat benefits less important compared to those slightly older, between 29 and 37 years old (Q2). Fishers under 29 years old (Q1) also prioritized improvement in education benefits more than the fishers between 29 and 37 (Q2) years old, and prioritized improvement in recreational benefits more than fisher between 37 and 49 (Q3) (Table). We found no significant differences in the relative importance of education and habitat services between the youngest and oldest groups. On no occasion were the relative importance of ecosystem services nor priorities for improvement within the oldest group (above 49, Q4) significantly different from other age groups.

		Differences between quartiles		
	Ecosystem Service	Higher	Lower	P value
Relative Importance (rank)	Education	Q1	Q2	0.0061
	Habitat	Q2	Q1	0.0154
	Sanitation	Q1	Q2	0.0015
Priority for Improvement (rate)	Recreation	Q1	Q3	0.0359

Table 9-4. Differences in rank and rate scores between age groups.

Note: Legend: Q1: < 29; Q2: 29-37; Q3: 37-49; Q4: >49.

4. Discussion

Approaching conservation and resource management equitably is not only morally imperative, but also crucial for conservation or management success. Equitable environmental management requires decision-makers to identify and navigate trade-offs between the priorities of different social groups or stakeholders (McShane et al., 2011; Reyers et al., 2009). Thus, identifying how different people value and prioritize ecosystem services is a crucial step for equitable and successful ecosystem service-based approaches (Daw et al., 2015; Sikor et al., 2014). However, much conservation practice and ecosystem services research presumes that stakeholder groups are homogenous, easily recognizable and simply need to be categorized (Leach et al., 1997; Reed, 2008). In fisheries, non-major stakeholders' interests are often left out altogether (Degnbol et al., 2006). We focused solely on priorities of fishers, and those with fisheries related livelihoods, to better understand social differentiation. While we hypothesized that there would be differences between how fishers with different socio-economic characteristics ranked and rated ecosystem services, we found, instead, many similarities in what ecosystem services are important and prioritised. We found only 12 significant differences across fishers in the western Indian Ocean region. The three ecosystem services most consistently highly ranked and prioritized fall across three ecosystem service categories: provisioning (fishery), supporting (habitat), and education (culture). This finding suggests that fishers in general do recognize and prioritize both direct and indirect ecosystem services. We begin by exploring these similarities and their implications, before turning to the differences we did find between socio-economic subgroups, and finally turn to key considerations for future work in ecosystem services.

4.1 Similarities in ranking and rating

Our results emphasize that there are many similarities in the way fishers across the region rank and prioritize ecosystem services. There are several possible reasons for these similarities. Firstly, fishers across the western Indian Ocean likely interact with coral reef ecosystem services regularly and in a similar way. Our respondents are broadly representative of the regions' rural coastal communities, and all engage with coral reef fisheries as a key livelihood. The way fishers interact with ecosystem services is also likely different to other stakeholders, for instance, tourist operators or small-business owners. However, we were unable to capture some key dimensions of

the social difference within the fisher group that may have highlighted more differences. We identified socio-economic characteristics a priori and therefore our findings could not capture potential differences across, for instance, gender, and ethnicity. Gender, for instance, shapes ecosystem services preferences (Villamor and van Noordwijk, 2016) but because our respondents were mostly male we could not disaggregate by gender. Secondly, our ecosystem services themselves were necessarily broad to make analysis comparable across the region. At a local case-study level, preference and perceptions of ecosystem services are complex and can differ down to the minutiae of species (Díaz et al., 2011). While our more general ecosystem services were necessary for examining an entire region, were established using a range of participatory methods, and were tailored to each context, this broadness may have obscured differences across, for instance, species.

These broad similarities in ranking and rating of ecosystem services that we identified can provide insights for decision-makers. For instance, our findings emphasize knowledge is a uniformly highly-valued cultural ecosystem service among fishers of different wealth groups and ages in the western Indian Ocean. The importance fishers place on environmental knowledge may reflect a strong sense of social identity often documented in small-scale fisheries, which is a crucial aspect of subjective wellbeing (Britton and Coulthard, 2013; Coulthard et al., 2011). We found no differences between years of formal education, and the perceived value of ecological knowledge. Fishers who had completed more years of formal schooling did not value or prioritize the benefits of experiential and inherited ecological knowledge differently than those with little or no formal education. This re-emphasizes work that suggests that ecological knowledge is fostered more through experience than through formal education (Reyers et al., 2009). Our findings therefore add weight to calls to better integrate local and traditional environmental knowledge into fisheries management broadly (Hind, 2015; Johannes et al., 2000), and in the western Indian Ocean specifically (Gaspare et al., 2015; Katikiro et al., 2015; Moshy and Bryceson, 2016).

4.2 Differences and the poverty-fishery nexus

Our findings around poverty and ecosystem services both challenge and support dominant narratives around poverty and fisheries. Overfishing and environmental degradation in fisheries has historically been framed in Malthusian terms of self-interested individuals with concern only for the instrumental values of fisheries and a desire for increasing production at the cost of sustainability (Finkbeiner et al., 2017). Poor fishers are seen as lacking alternative choices and therefore caught in the bind of declining catches, leading them to degrade the fishery in order to

maintain their income (Pauly, 1990). In addition, studies of fisheries and poverty at times assume that small-scale fishers are trapped in an inescapable poverty cycle (Béné, 2003). Our findings speak to directly to these arguments because the fishers in our sample are relatively poor compared to those with different livelihoods in the region. Indeed, Cinner (2010) found that in Kenya, fishers had lower levels of material wealth compared to non-fishers.

Our study adds weight to evidence challenging the Malthusian framing of fishers and overfishing. Specifically, we found that all fishers in our sample, regardless of relative wealth, do perceive in-direct benefits from habitat function and ecological knowledge to be important to their lives. And, importantly, the relatively wealthier individuals in our sample prioritized the need to improve habitat function. Therefore, on one hand, our results broadly challenge the notion that all small-scale fishers are trapped in cycles of poverty causing overexploitation (Béné, 2003) and cannot or do not prioritize sustainability. However, on the other hand, our results suggest that poverty does make a difference to the ecosystem services that fishers prioritize improvements in.

Our findings reflect and support the argument that the ability to prioritize enhancing in-direct benefits from the environment may be a luxury. Despite uniformity in what fishers consider important, the poorest then do not or cannot prioritize improvement in habitat services (Martinez-Alier, 2014). Large-scale analysis of environmental concern has suggested that environmental care is a ‘luxury’, based on post-materialist values only held by the well-off (Dunlap and York, 2008). Greater affluence within a fisheries livelihood may play a role in whether people prioritize improving habitat services. In Kenya and Tanzania, Cinner (2010) found that, when faced with a declining fishery, poorer fishers were much more likely to use destructive fishing gears that could damage sensitive marine habitats. This link between wealth and priorities around improving habitat matter for management because when people do not hold priorities for improvement (i.e. where their rating is low), they are unlikely to engage in management actions targeting these ecosystem services. This may be because they are unable to, or are, in fact, unconcerned, which may be broadly linked to levels of awareness, knowledge, and apathy.

Across age groups, the only differences in ecosystem service importance and priorities were in rankings of education, sanitation, and habitat ecosystem services, and in priorities for improving recreational services. This is a surprising result because, rather than a stark gap between the values and priorities of the oldest versus the youngest fishers, the most differences were between the two younger groups (i.e. those younger than 29, and those between 29 and 37). At face value, this finding suggests that incorporating younger fishers’ interests around ecosystems services into

decision-making will be straightforward because their priorities align with those of older fishers who tend to be in greater positions of power and have greater legitimacy in decision-making (Colfer, 2011). Nonetheless, it is possible that rather than the importance of and priorities for changing ecosystems services, differences in opinion, and hence conflicts about fisheries and coral reef governance between older and younger generations may occur across aspects we did not capture, such as changing cultural identities across generations (Zurba and Trimble, 2014).

Finally, we found wealthier fishers did prioritize an improvement in recreational benefits, slightly more than poor fishers. This result likely reflects that wealthier fishers have more flexibility, an openness to change, and perhaps the desire to engage in alternative livelihoods such as tourism (Hicks et al., 2015). More broadly, however, the relatively low priorities that fishers gave to recreational ecosystem services suggests that they are either unable to benefit much from the industry or do not desire to participate in it. The ability to engage with and benefit from the tourism industry likely requires certain skill sets that local fishers do not have. Our results highlight the relative disconnect between fishers and fish traders, and the tourism industry. Improving recreational ecosystem service benefits is therefore unlikely to alleviate poverty in the poorest fishers in the short term, as they are likely unable, or perhaps lack the desire to, engage with the tourism industry. Our analysis is therefore able to illuminate where alternative livelihoods may be inappropriate for various reasons. Tourism, based on recreational ecosystem services, is a key industry in the western Indian Ocean. Yet, tourism, as a strategy for reducing environmental vulnerability through economic development, may not only have negative social impacts (Diedrich and Aswani, 2016), but may actually not be accessible or desired by fishers highly vulnerable to environmental change. It is striking that recreational benefits were not valued or prioritized more by fishers, given the importance of tourism in the region. In the western Indian Ocean, coastal tourism generates around US$10.4 billion annually, almost 10 times the revenue from the entire fishery and aquaculture sector (Obdura et al., 2017).

4.3 Implications and future work

Disaggregating ecosystem services across social sub-groups within fishers in the western Indian Ocean can extend and deepen debates around the nexus between poverty and small-scale fisheries. Specifically, separating the ranking and rating exercise can highlight what is important and where change is actively wanted. A simple example of this is fresh water. While highly important to people’s lives and wellbeing, and increase in fresh water is not likely to vastly

improve people's lives. Water would be highly ranked, but not highly rated. Thus, identifying differences in priorities for change is like estimating an ecosystem services' marginal value for fishers, i.e. where an increase in quality or quantity would most contribute to people's wellbeing. Thus, ecosystem services that are both highly ranked and rated should be a priority for decision-makers. In our case, fishery is consistently highly important and highly prioritized, whereas habitat is consistently highly important but only the wealthiest actively prioritize its improvement. Alongside perceptions of the costs and benefits of conservation strategies to people's livelihoods (Bennett, 2016; Gurney et al., 2014), socially differentiated data on ecosystem services can provide evidence for designing appropriate conservation and management strategies but also, crucially, framing these strategies to different socio-economic groups. For example, in the western Indian Ocean, ecosystem-based conservation and management targeting habitat and ecosystem function (Pikitch et al., 2004) may resonate more with wealthier fishers.

Future work should include important socio-economic characteristics including gender, ethnicity, and class. Understanding differences at a local level will likely require concurrent qualitative methods to undercover why people hold priorities, how these priorities intersect with their resource needs, and how resources are accessed in different contexts (Fisher et al., 2015; Daw et al., 2017). Our study emphasizes the need for continued re-engagement with methods for selecting and understanding stakeholders and their priorities. Rather than assuming, for instance, that all small-scale fishers are stuck in poverty traps, our findings re-affirmed that there are different levels of wealth within fisheries, and that this difference is reflected in the priorities people have for improving habitat function.

Disaggregating the social dimensions of ecosystem services is just one aspect of making ecosystem service-based research and management more equitable. Tackling and understanding issues of elite capture and power (see Blaikie, 2006) in ecosystem service based approaches (e.g. payments for ecosystem services) will require deeper engagement with the justices and injustices of ecosystem services in specific contexts (Jax et al., 2013; Sikor, 2013). A key step towards justice is highlighting diverse priorities, plural perceptions, and worldviews around ecosystem services so that decisions-makers might make more environmentally-just decisions (Diaz et al. 2016). This attention to social differentiation is likewise crucial in fisheries, where political disempowerment is a key aspect of poverty and marginalization (Béné, 2003). Identifying what ecosystem services are important and where people desire an improvement is key to equitable policy and decision-making around poverty alleviation and conservation (Campbell et al., 2010).

5. Conclusion

As key global ecosystem services are lost, environmental management has a moral and environmental imperative to embrace and include multiple perspectives (Adams, 2016). Investigating how socio-economic groups value and prioritize ecosystem services differently is a key step towards understanding what matters to whom and to interrogating dominant narratives around the fisheries and poverty. Assessing and disaggregating both the importance of ecosystem services, but also priorities for improvement is a useful tool for gaining a broader sense of what different and diverse fishers (or another stakeholder group) might want and what they may have in common. For instance, in the western Indian Ocean, ecosystem-based management that emphasizes protecting habitat may resonate more with certain groups, in this case wealthier fishers, whereas poorer fishers might be more inclined to support strategies aimed at increasing fisheries benefits. Our work concurrently supports the idea that poorer fishers may be unable to prioritize in-direct ecosystem services, but highlights that this is not because they do not perceive these services to be important. Ecosystem service-based research needs to look beyond simplistic understandings of difference, and to interrogate pre-defined stakeholder groups to move towards social and environmental justice.

References

Adams, W.M., 2016. Do you speak Lion? Science (80-.). 17, 626–629. doi:10.1126/science.aaf8056

Adams, W.M., 2014. The value of valuing nature. Science (80-.). 346, 549–552.

Béné, C., 2003. When Fishery Rhymes with Poverty: A First Step Beyond the Old Paradigm on Poverty in Small-Scale Fisheries. World Dev. 31, 949–975. doi:http://dx.doi.org/10.1016/S0305-750X(03)00045-7

Bennett, N.J., 2016. Use of perceptions to improve conservation and environmental management. Conserv. Biol. 0, 1–5. doi:10.1007/s13398-014-0173-7.2

Berbés-Blázquez, M., González, J.A., Pascual, U., 2016. Towards an ecosystem services approach that addresses social power relations. Curr. Opin. Environ. Sustain. 19, 134–143. doi:10.1016/j.cosust.2016.02.003

Blaikie, P., 2006. Is Small Really Beautiful? Community-based Natural Resource Management in Malawi and Botswana. World Dev. 34, 1942–1957. doi:http://dx.doi.org/10.1016/j.worlddev.2005.11.023

Britton, E., Coulthard, S., 2013. Assessing the social wellbeing of Northern Ireland's fishing society using a three-dimensional approach. Mar. Policy 37, 28–36. doi:10.1016/j.marpol.2012.04.011

Brooks, E.G.E., Smith, K.G., Holland, R.A., Poppy, G.M., Eigenbrod, F., 2014. Effects of methodology and stakeholder disaggregation on ecosystem service valuation. Ecol. Soc. 19.

Caceres, D.M., Tapella, E., Quetier, F., Diaz, S., 2015. The social value of biodiversity and ecosystem services from the perspectives of different social actors. Ecol. Soc. 20. doi:10.5751/ES-07297-200162

Campbell, B.M., Sayer, J.A., Walker, B., 2010. Navigating trade-offs: Working for conservation and development outcomes. Ecol. Soc. 15, 2. doi:16

Cinner, J., McClanahan, T., Graham, N., Daw, T., Maina, J., Stead, S.M.M., Wamukota, A., Brown, K., Bodin, Ö., 2012. Vulnerability of coastal communities to key impacts of climate change on coral reef fisheries. Glob. Environ. Chang. 22, 12–20. doi:10.1016/j.gloenvcha.2011.09.018

Cinner, J.E., 2010. Poverty and the use of destructive fishing gear near east African marine protected areas. Environ. Conserv. 36, 321–326. doi:10.1017/S0376892910000123

Cinner, J.E., Bodin, Ö., 2010. Livelihood diversification in tropical coastal communities: A network-based approach to analyzing "livelihood landscapes." PLoS One 5. doi:10.1371/journal.pone.0011999

Cinner, J.E., McClanahan, T.R., Wamukota, A., 2010. Differences in livelihoods, socioeconomic characteristics, and knowledge about the sea between fishers and non-fishers living near and far from marine parks on the Kenyan coast. Mar. Policy 34, 22–28. doi:10.1016/j.marpol.2009.04.003

Colfer, C.J.P., 2011. Marginalized forest peoples' perceptions of the legitimacy of governance:

An exploration. World Dev. 39, 2147–2164. doi:10.1016/j.worlddev.2011.04.012

Costanza, R., Arge, R., Groot, R. De, Farberk, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R. V, Paruelo, J., Raskin, R.G., Suttonkk, P., van den Belt, M., 1997. The value of the world's ecosystem services and natural capital. Nature 387, 253–260. doi:10.1038/387253a0

Costanza, R., de Groot, R., Braat, L., Kubiszewski, I., Fioramonti, L., Sutton, P., Farber, S., Grasso, M., 2017. Twenty years of ecosystem services: How far have we come and how far do we still need to go? Ecosyst. Serv. 28, 1–16. doi:10.1016/j.ecoser.2017.09.008

Coulthard, S., Johnson, D., McGregor, J., 2011. Poverty, Sustainability and Human Wellbeing: A social wellbeing approach to the global fisheries crisis. Glob. Environ. Chang. 453–463.

Daily, G., 1997. Nature's Services: Societal Dependence On Natural Ecosystems. Island Press, Washington.

Daw, T., Brown, K., Rosendo, S., Pomeroy, R., 2011. Applying the ecosystem services concept to poverty alleviation: the need to disaggregate human well-being. Environ. Conserv. 34, 370–379.

Daw, T.M., Coulthard, S., Cheung, W.W.L., Brown, K., Abunge, C., Galafassi, D., Peterson, G.D., McClanahan, T.R., Omukoto, J.O., Munyi, L., 2015. Evaluating taboo trade-offs in ecosystems services and human well-being. Proc. Natl. Acad. Sci. 201414900. doi:10.1073/pnas.1414900112

Dawson, N., Martin, A., 2015. Assessing the contribution of ecosystem services to human wellbeing: A disaggregated study in western Rwanda. Ecol. Econ. 117, 62–72. doi:10.1016/j.ecolecon.2015.06.018

Degnbol, P., Gislason, H., Hanna, S., Jentoft, S., Raakjær Nielsen, J., Sverdrup-Jensen, S., Clyde Wilson, D., 2006. Painting the floor with a hammer: Technical fixes in fisheries management. Mar. Policy 30, 534–543. doi:10.1016/j.marpol.2005.07.002

Díaz, S., Quétier, F., Cáceres, D.M., Trainor, S.F., Pérez-Harguindeguy, N., Bret-Harte, M.S., Finegan, B., Peña-Claros, M., Poorter, L., 2011. Linking functional diversity and social actor strategies in a framework for interdisciplinary analysis of nature's benefits to society. Proc. Natl. Acad. Sci. U. S. A. 108, 895–902. doi:10.1073/pnas.1017993108

Diedrich, A., Aswani, S., 2016. Exploring the potential impacts of tourism development on social and ecological change in the Solomon Islands. Ambio 45, 808–818. doi:10.1007/s13280-016-0781-x

Dunlap, R.E., York, R., 2008. The Globalization of Environmental Concern and the Limits of the Postmaterialist Values Explanation : Evidence from Four Multinational Surveys 49, 529–563. doi:10.1111/j.1533-8525.2008.00127.x

Eder, J.F., 2005. Coastal resource management and social differences in Philippine fishing communities. Hum. Ecol. 33, 147–169. doi:10.1007/s10745-005-2430-Z

Finkbeiner, E.M., Bennett, N.J., Frawley, T.H., Mason, J.G., Briscoe, D.K., Brooks, C.M., Ng, C.A., Ourens, R., Seto, K., Switzer Swanson, S., Urteaga, J., Crowder, L.B., 2017. Reconstructing overfishing: Moving beyond Malthus for effective and equitable solutions. Fish Fish. 1–12. doi:10.1111/faf.12245

Fish, R., Church, A., Winter, M., 2016. Conceptualising cultural ecosystem services: a novel framework for research and critical engagement. Ecosyst. Serv. 1–10. doi:10.1016/j.ecoser.2016.09.002

Fisher, J.A., Patenaude, G., Giri, K., Lewis, K., Meir, P., Pinho, P., Rounsevell, M., Williams, M., 2014. Understanding the relationships between ecosystem services and poverty alleviation: A conceptual framework. Ecosyst. Serv. 34–45.

Fisher, J. a., Patenaude, G., Meir, P., Nightingale, A.J., Rounsevell, M.D. a, Williams, M., Woodhouse, I.H., 2013. Strengthening conceptual foundations: Analysing frameworks for ecosystem services and poverty alleviation research. Glob. Environ. Chang. 23, 1098–1111. doi:10.1016/j.gloenvcha.2013.04.002

Gaspare, L., Bryceson, I., Kulindwa, K., 2015. Complementarity of fishers' traditional ecological knowledge and conventional science: Contributions to the management of groupers (Epinephelinae) fisheries around Mafia Island, Tanzania. Ocean Coast. Manag. 114, 88–101. doi:10.1016/j.ocecoaman.2015.06.011

Gómez-Baggethun, E., de Groot, R., Lomas, P.L., Montes, C., 2010. The history of ecosystem services in economic theory and practice: From early notions to markets and payment schemes. Ecol. Econ. 69, 1209–1218. doi:10.1016/j.ecolecon.2009.11.007

Gurney, G.G., Cinner, J., Ban, N.C., Pressey, R.L., Pollnac, R., Campbell, S.J., Tasidjawa, S., Setiawan, F., 2014. Poverty and protected areas: An evaluation of a marine integrated conservation and development project in Indonesia. Glob. Environ. Chang. 26, 98–107. doi:10.1016/j.gloenvcha.2014.04.003

Hicks, C.C., Cinner, J.E., 2014. Social, institutional, and knowledge mechanisms mediate diverse ecosystem service benefits from coral reefs. Proc. Natl. Acad. Sci. 111, 17791–17796. doi:10.1073/pnas.1413473111

Hicks, C.C., Cinner, J.E., Stoeckl, N., McClanahan, T.R., 2015. Linking ecosystem services and human-values theory. Conserv. Biol. 29, 1471–1480. doi:10.1111/cobi.12550

Hind, E.J., 2015. A review of the past, the present, and the future of fishers' knowledge research: a challenge to established fisheries science. ICES J. Mar. Sci. 72, 341–358. doi:10.1093/icesjms/fsu169

Howe, C., Suich, H., Vira, B., Mace, G., 2014. Creating win-wins from trade-offs? Ecosystem services for human well-being: A meta-analysis of ecosystem service trade-offs and synergies in the real world. Glob. Environ. Chang. 28, 263–275. doi:10.1016/j.gloenvcha.2014.07.005

Jax, K., Barton, D.N., Chan, K.M.A., de Groot, R., Doyle, U., Eser, U., Görg, C., Gómez-Baggethun, E., Griewald, Y., Haber, W., Haines-Young, R., Heink, U., Jahn, T., Joosten, H., Kerschbaumer, L., Korn, H., Luck, G.W., Matzdorf, B., Muraca, B., Neßhöver, C., Norton, B., Ott, K., Potschin, M., Rauschmayer, F., von Haaren, C., Wichmann, S., 2013. Ecosystem services and ethics. Ecol. Econ. 93, 260–268. doi:10.1016/j.ecolecon.2013.06.008

Johannes, R.E., Freeman, M.M.R., Hamilton, R.J., 2000. Ignore fishers' knowledge and miss the boat. Fish Fish. 1, 257–271. doi:10.1111/j.1467-2979.2000.00019.x

Katikiro, R., Ashoka Deepananda, K.H.M., Macusi, E., 2015. Interplay between perceived changes in fishery and social structures in Tanzanian coastal fishing communities. Fish. Res. 164, 249–253. doi:10.1016/j.fishres.2014.12.009

Lakerveld, R.P., Lele, S., Crane, T.A., Fortuin, K.P.J., Springate-Baginski, O., 2015. The social distribution of provisioning forest ecosystem services: Evidence and insights from Odisha, India. Ecosyst. Serv. 14, 56–66. doi:10.1016/j.ecoser.2015.04.001

Leach, M., Mearns, R., Scoones, I., 1997. Environmental entitlements: a framework for understanding the institutional dynamics of environmental change. IDS Discuss. Pap. 359, 1–39.

MA (Millenium Ecosystem Assessment), 2005. Ecosystems and human well-being: synthesis. Island Press, Washington, D.C.

Martinez-Alier, J., 2014. The environmentalism of the poor. Geoforum 54, 239–241. doi:10.1016/j.geoforum.2013.04.019

McShane, T.O., Hirsch, P.D., Trung, T.C., Songorwa, A.N., Kinzig, A., Monteferri, B., Mutekanga, D., Thang, H. Van, Dammert, J.L., Pulgar-Vidal, M., Welch-Devine, M., Peter Brosius, J., Coppolillo, P., O'Connor, S., 2011. Hard choices: Making trade-offs between biodiversity conservation and human well-being. Biol. Conserv. 144, 966–972. doi:10.1016/j.biocon.2010.04.038

Milcu, A.I., Leventon, J., Hanspach, J., Fischer, J., 2015. Disaggregated contributions of ecosystem services to human well-being in low-intensity farmland. Reg. Environ. Chang. 117–163. doi:10.1007/s10113-016-0926-2

Moshy, V.H., Bryceson, I., 2016. Seeing Through Fishers' Lenses. SAGE Open 6, 215824401664171. doi:10.1177/2158244016641716

Nayak, P.K., Oliveira, L.E., Berkes, F., 2014. Resource degradation, marginalization, and poverty

in small-scale fisheries: Threats to social-ecological resilience in India and Brazil. Ecol. Soc. 19. doi:10.5751/ES-06656-190273

Obdura, D., Smits, M., Chaudhry, T., McPhillips, J., Beal, D., Astier, C., Gamblin, P., Tanzer, J., Burgener, V., Owen, S., Gonzales, A., 2017. Reviving the Western Indian Ocean Economy: Actions for a Sustainable Future. WWF International, Gland, Switzerland.

Orenstein, D.E., Groner, E., 2014. In the eye of the stakeholder: Changes in perceptions of ecosystem services across an international border. Ecosyst. Serv. 8, 185–196. doi:10.1016/j.ecoser.2014.04.004

Pauly, D., 1990. On Malthusian Overfishing. Naga, ICLARM Q. 13, 3–4.

Pikitch, E.K., Santora, C., Babcock, E.A., Bakun, A., Bonfil, R., Conover, D.O., Dayton, P., Doukakis, P., Fluharty, D., Heneman, B., Houde, E.D., Link, J., 2004. Ecosystem-Based Fishery Management. Science (80-.). 305, 346–347.

Pollnac, R., Crawford., B., 2000. Assessing behavioural aspects of coastal resource use. Narragansett, RI.

Reed, M.S., 2008. Stakeholder participation for environmental management: A literature review. Biol. Conserv. 141, 2417–2431. doi:10.1016/j.biocon.2008.07.014

Reyers, B., O'Farrell, P.J., Cowling, R.M., Egoh, B.N., le Maitre, D.C., Vlok, J.H.J., 2009. Ecosystem services, land-cover change, and stakeholders: Finding a sustainable foothold for a semiarid biodiversity hotspot. Ecol. Soc. 14, 38.

Rivero, S., Villasante, S., 2016. What are the research priorities for marine ecosystem services? Mar. Policy 66, 104–113. doi:10.1016/j.marpol.2016.01.020

Sagie, H., Morris, A., Rofè, Y., Orenstein, D.E., Groner, E., 2013. Cross-cultural perceptions of ecosystem services: A social inquiry on both sides of the Israeli-Jordanian border of the Southern Arava Valley Desert. J. Arid Environ. 97, 38–48. doi:10.1016/j.jaridenv.2013.05.007

Sikor, T., 2013. The Justices and Injustices of Ecosystem Services. Routledge, London and New York.

Sikor, T., Baggio, J.A., 2014. Can Smallholders Engage in Tree Plantations? An Entitlements Analysis from Vietnam. World Dev. 64, S101–S112. doi:10.1016/j.worlddev.2014.03.010

Sikor, T., Martin, A., Fisher, J., He, J., 2014. Toward an Empirical Analysis of Justice in Ecosystem Governance. Conserv. Lett. 7, 524–532. doi:10.1111/conl.12142

Sodhi, N.S., Lee, T.M., Sekercioglu, C.H., Webb, E.L., Prawiradilaga, D.M., Lohman, D.J., Pierce, N.E., Diesmos, A.C., Rao, M., Ehrlich, P.R., 2010. Local people value environmental services provided by forested parks. Biodivers. Conserv. 19, 1175–1188. doi:10.1007/s10531-009-9745-9

Suich, H., Howe, C., Mace, G., 2015. Ecosystem services and poverty alleviation: A review of the empirical links. Ecosyst. Serv. 12, 137–147. doi:10.1016/j.ecoser.2015.02.005

van den Belt, M., Stevens, S.M., 2016. Transformative agenda , or lost in the translation? A review of top-cited articles in the first four years of Ecosystem Services. Ecosyst. Serv. 22, 60–72. doi:10.1016/j.ecoser.2016.09.006

Villamor, G.B., van Noordwijk, M., 2016. Gender specific land-use decisions and implications for ecosystem services in semi-matrilineal Sumatra. Glob. Environ. Chang. 39, 69–80. doi:10.1016/j.gloenvcha.2016.04.007

Zurba, M., Trimble, M., 2014. Youth as the inheritors of collaboration: Crises and factors that influence participation of the next generation in natural resource management. Environ. Sci. Policy 42, 78–87. doi:10.1016/j.envsci.2014.05.009