Understanding and integrating socioeconomic factors into the design and management of marine protected areas

PhD thesis submitted by

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Contents

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Abstract

Marine protected areas (MPAs) are a key strategy employed worldwide to mitigate biodiversity loss and maintain marine ecosystem services. However, the efficacy of MPAs in achieving biological and socioeconomic goals is highly variable; a significant factor impeding their success is a lack of consideration and understanding of associated human systems. This is particularly true for MPAs designed under Systematic Conservation Planning (SCP), currently the foremost paradigm employed in the design of protected areas. Despite a flurry of activity in the SCP literature advocating the need to better understand and incorporate socioeconomic factors into design and management of protected areas, in practice, socioeconomic factors continue to be oversimplified and treated as secondary to biological factors. Given the ongoing expansion of MPAs globally, there is a pressing need to better understand and incorporate socioeconomic factors into design and management.

The overarching goal of my thesis is to improve our understanding of critical socioeconomic factors relevant to MPAs, and to provide guidance on how this knowledge can be incorporated into MPA design and management. I set out to achieve this goal through three research objectives, which are to:

1. Investigate the socioeconomic impacts of MPAs, and whether these vary according to social subgroup
2. Identify socioeconomic factors related to individual participation of local people in MPA management
3. Test alternative approaches to incorporating socioeconomic factors into spatial prioritisation of MPAs under a SCP approach.

The first objective of my thesis seeks to contribute to building the evidence base for the socioeconomic impacts of protected areas, which is currently weak, particularly in relation to whether impacts differ according to social subgroups. I address this objective by assessing the short-, medium- and long-term impacts of a MPA project on three key domains of poverty (i.e. security, opportunity, and empowerment) over fifteen years (chapter 2), including whether impacts differed by social subgroup (chapter 3). The studied MPA project was designed to achieve the dual goals of conservation and poverty alleviation, and was implemented over five years in four villages in North Sulawesi, Indonesia. Using social data from villages with and without MPAs, I found in chapter 2 that positive impacts spanned all three poverty domains, but appeared to occur mostly during the implementation period and subsided when external funding was withdrawn. These findings question the efficiency of the short-term approach taken in many international donor-assisted MPA projects, which are often designed with the expectation that management activities will be sustained and related benefits will continue to accumulate after external support is terminated.

In chapter 3, I assessed whether the socioeconomic impacts of the MPA project examined in chapter 2 differed according to social subgroups defined by age, gender, and religion. I found little empirical evidence that impacts on five indicators of poverty differed according to social subgroups. Environmental knowledge was the only indicator for which I found heterogeneous impacts; over the medium and long terms, younger people and Muslims showed greater improvements compared to older people and Christians, respectively. My findings elucidate some of the pathways through which socioeconomic impacts of MPAs may occur, and hence, may be used to improve targeting of management activities in the study region. Further, the research sheds light on the potential for heterogeneous socioeconomic impacts of protected areas, which is of critical importance given that social inequity can create conflict and impede poverty reduction, thus jeopardising biological and socioeconomic objectives of protected areas.

The second objective of my thesis seeks to contribute to our limited understanding of the factors affecting human behaviour associated with use and management of natural resources. I address this objective in chapter 4 by assessing how individual- and community-scale socioeconomic factors are related to individuals' participation in the management of 13 community-based MPAs in North Sulawesi and Bali, Indonesia. I take an interdisciplinary approach to the latter and draw from literature on human behaviour from social psychology, political science, and behavioural economics. I found three key factors that were related to participation of local people: subjective norms, structural elements of social capital, and nested institutions. There was also suggestive evidence that participation was related to people's cooperative behavioural disposition, which I elicited using a public goods game. My findings highlight the importance of considering multiple-scale interventions other than those designed to appeal to self-interested concerns, such as regulations and material incentives, which are typically employed to encourage participation of local people in management of natural resources.

The third objective of my thesis seeks to address the existing lack of a rigorous evaluation of how the design of protected areas can be affected by treating socioeconomic factors as costs or objectives in spatial prioritisation following a SCP approach. I address this objective in chapter 5 by assessing how treating socioeconomic considerations as costs or objectives, and stakeholders (i.e. fishers) as a single or multiple groups, affect MPA design in terms of trade-offs between biodiversity, livelihood and social equity objectives. I found that the achievement of fisheries objectives and equity tended to trade-off concavely with increasing biodiversity objectives, indicating that it is possible to achieve low to mid-range biodiversity objectives with relatively small losses to fisheries and equity. Importantly, the extent of trade-offs depended on the method employed for incorporating socioeconomic data, and were least severe when objectives were set for each stakeholder group explicitly.

My thesis contributes to SCP theory and practice by elucidating key socioeconomic factors relevant to protected areas and how they can be incorporated into the design and management of MPAs. My results demonstrate the importance of conceptually and theoretically broadening the way socioeconomic factors are considered in SCP, in both the spatial and non-spatial components of planning. Better understanding and incorporation of socioeconomic considerations in design and management of protected areas will help ensure this conservation tool contributes to human well-being and increase the likelihood of gaining local stakeholders' support, on which conservation success is predicated.

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Outputs related to thesis

Peer-reviewed papers

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Papers in review

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[1] Chapter 5
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Chapter 1
General Introduction

1 General Introduction

Coastal and marine ecosystems are becoming increasingly degraded worldwide (Myers and Worm 2003, Sala and Knowlton 2006, McCauley et al. 2015), and given the present momentum of human population growth, resource use and the imminent threat of climate change, this degradation is set to accelerate (Halpern et al. 2008). The resulting alterations to ecosystem structure and function (Salomon et al. 2008) threaten marine biodiversity (Sala and Knowlton 2006, Rands et al. 2010), and the provision of a wealth of ecosystem goods and services (e.g. coastal protection, food provisioning, water quality), on which hundreds of millions of people rely (MEA 2005).

1.1 Marine protected areas

Marine protected areas (MPAs) are commonly employed worldwide as a principal tool to mitigate biodiversity loss and degradation of marine ecosystems, and are increasingly advocated as a means to improve the well-being of associated human communities (Lubchenco et al. 2003, Fox et al. 2012b). A MPA is defined as "any area of intertidal or subtidal terrain, together with its overlaying water and associated flora, fauna, historical and cultural features, which has been reserved by law or other effective means to protect part or all of the enclosed environment" (Kelleher and Kenchington 1992). MPAs are an important element of ecosystem-based approaches to marine management (Sala and Knowlton 2006, Leslie and McLeod 2007), and are suggested to contribute to biodiversity conservation by protecting species and habitats within their boundaries (e.g. Claudet et al. 2008), restoring the structure of ecological communities (e.g. Micheli et al. 2004), and maintaining ecosystem function (e.g. Babcock et al. 2010). A growing body of empirical evidence suggests that MPAs can also contribute to fisheries in surrounding waters through spillover of adult and larval fish (e.g. Almany et al. 2009, Harrison et al. 2012). Thus, these tools are increasingly employed to contribute to socioeconomic objectives, primarily those related to sustaining fisheries, such as maintaining livelihoods and food security for coastal communities (e.g. CTI-CFF 2009). MPAs may also be intended to provide other socioeconomic benefits such as strengthening property rights, providing economic opportunities through tourism, and protecting against environmental hazards (Gaines et al. 2010, Burke et al. 2011).

Given accelerating marine degradation and the potential benefits conferred by MPAs, extensive establishment of MPAs is mandated under several international agreements, which are reflected in government policies, both nationally (e.g. Douvere et al. 2007) and locally (e.g. Lipsett-Moore et al. 2010). Of particular influence is the Aichi Biodiversity Target 11, outlined in the Strategic Plan to halt biodiversity loss adopted by the Convention on Biological Diversity (CBD), which mandates that at least 10% of coastal and marine area be conserved within MPAs by 2020 (CBD 2010). Since the 192 State Parties of the CBD ratified the Aichi Biodiversity Targets in 2010, the coverage of MPAs has

increased rapidly, and is likely to continue to rise (Edgar et al. 2014). Currently, MPAs cover 8.4% of all marine waters within national jurisdiction, and an additional 2.2 million km^2 will need to be designated as MPAs to reach the 10% target (Juffe-Bignoli et al. 2014).

1.2 Systematic Conservation Planning

Systematic Conservation Planning (SCP) is currently the foremost paradigm under which protected areas are designed (Kukkala and Moilanen 2013). The approach is increasingly employed in relation to marine spatial planning (Leslie 2005), and applied to MPAs in both developed (e.g. the Mediterranean Sea; Micheli et al. 2013) and developing country contexts (e.g. the Gulf of California; Álvarez-Romero et al. 2013). SCP provides a framework for guiding the spatial allocation of conservation actions to meet explicit quantitative conservation objectives (Margules and Pressey 2000, Pressey and Bottrill 2009). The framework is intended to outline the main stages of designing, implementing, and managing protected areas in 11 stages (Figure 1.1). A key component of SCP is stage 9 (hereafter 'spatial prioritisation stage'), which essentially involves using spatial prioritisation tools (i.e. computer algorithms) – such as Marxan (Ball et al. 2009), C-Plan (Pressey et al. 2009), and Zonation (Moilanen et al. 2005) – populated with biological, and ideally socioeconomic data, to identify priority areas for management based on maximising achievement of biodiversity objectives whilst minimising costs to people (Margules and Pressey 2000).

1. Scoping and costing the planning process
2. Identifying and involving stakeholders
3. Describing the context for conservation areas
4. Identifying conservation goals
5. Collecting data on socioeconomic variables and threats
6. Collecting data on biodiversity and other natural features
7. Setting conservation objectives
8. Reviewing current achievement of objectives
9. Selecting additional conservation areas
10. Applying conservation actions to selected areas
11. Maintaining and monitoring areas

Figure 1.1 Systematic conservation planning framework. The framework outlines the main components of conservation planning in 11 stages; adapted from Pressey and Bottrill (2009).

The SCP approach to designing and implementing protected areas offers a number of advantages aside from guiding efficient investment in conservation areas. Applied to the design of protected area networks at regional or larger scales, this approach can incorporate associations between different individual conservation areas (Pressey et al. 2013), including complementarity (Margules and Pressey 2000) and connectivity (Beger et al. 2010). Thus, designing protected areas using SCP principles and tools increases the likelihood of adequately representing biodiversity (Pressey et al. 1993), and maintaining biological connectivity, which is critical for preserving life cycles and enabling of recovery after disturbances (Hughes et al. 2003, Almany et al. 2009). Other important advantages of the SCP approach are that the framework guides decisions in a transparent and repeatable fashion (Pressey and Bottrill 2009), and can facilitate the investigation of spatial options for conservation actions (Green et al. 2009).

1.3 The limited success of MPAs

While there is relatively little robust evidence of impacts of conservation interventions, including MPAs (Ferraro and Pattanayak 2006 , Bottrill et al. 2014), existing studies suggest that MPAs have generally been fairly unsuccessful in meeting their biodiversity and socioeconomic objectives (e.g. Francour et al. 2001, Guidetti et al. 2008, Green et al. 2011). Impact is the positive or negative difference that a treatment (e.g. a MPA) makes relative to the scenario of no treatment (e.g. no MPA; Ferraro and Hanauer 2014a). The number of MPAs considered failures far outnumbers successes worldwide (Burke et al. 2011, Rife et al. 2013). For example, a recent global study of MPAs found that their performance in terms of recovery of fish biomass relative to fished sites, a central objective of MPAs, was poor (Edgar et al. 2014). Likewise, a review of whether MPAs achieved five common socioeconomic objectives (i.e. to improve food security, resource control, livelihoods, community organisation, and income), found a significant positive effect only in relation to food security (Mascia et al. 2010).

A number of factors contribute to the limited success of MPAs. For example, ecosystems within MPAs can be affected by threats that originate outside MPA boundaries, including: (1) pollution and sedimentation from land-based activities, such as coastal development and agriculture (Cicin-Sain and Belfiore 2005, Álvarez-Romero et al. 2011); and (2) stressors induced by climate change, such as storms and bleaching of coral reefs (Donner et al. 2005, Hoegh-Guldberg et al. 2007). Another factor limiting the success of MPAs is that design and regulations (e.g. in relation to size, location, restricted activities) can be inadequate to prevent threats within MPA borders (Burke et al. 2011). However, the foremost factor constraining the success of MPAs is a lack of management effectiveness, whereby management activities are not undertaken and MPA rules are not complied with or enforced (Pollnac et al. 2010, Campbell et al. 2012, Edgar et al. 2014), rendering many MPAs effectively ‘paper parks’

(Horigue et al. 2012, Rife et al. 2013). For example, a global study of over 900 coral-reef MPAs found that less than 10% were fully implemented or complied with (Mora et al. 2006).

In the context of SCP, limited MPA success relates primarily to the paucity of protected area designs that have been successfully implemented (Cabeza and Moilanen 2001, Hviding 2006, Knight et al. 2008). This “implementation crisis" (Knight et al. 2006a) is thought to have arisen primarily because of the focus of SCP on the spatial prioritisation stage of planning (Pierce et al. 2005), in particular the technical aspects (e.g. optimisation algorithms) and theoretical principles for identifying priority areas for biodiversity conservation (e.g. complementarity, representation). Critical to improving the uptake of protected area designs is better understanding and consideration of the factors that influence on-ground implementation and management, which are predominantly social, economic, and political, rather than ecological (Cowling and Wilhelm-Rechman 2007, Polasky 2008, Ban et al. 2013).

1.4 The role of socioeconomic factors related to MPAs

Impeding the implementation, management effectiveness, and ultimately the success of MPAs, is inadequate understanding and incorporation of socioeconomic factors in MPA design and management (Christie 2004, Knight et al. 2008, Polasky 2008). MPAs are intrinsically socioeconomic phenomena; that is, they are a product of human decision-making; their ultimate purpose is to modify human activities, and their success is contingent on human behaviour. Thus, integral to achieving objectives for biodiversity, let alone those related to people’s needs and aspirations, is enlisting the support of communities who are affected by the establishment and management of MPAs (e.g. compliance with regulations; Walmsley and White 2003, Chaigneau and Daw 2015). The local support required for sustainable MPA management in many developing countries often includes local stakeholders undertaking management (e.g. monitoring, enforcement), at least in part, themselves (hereafter ‘participation’). The reasons for the importance of community involvement in designing and managing MPAs include: coastal people’s livelihoods and many aspects of their way of life often being closely related to coastal and marine ecosystems (e.g. Johannes 2002); devolved governance of natural resources (Berkes 2010); and weak government institutions without resources for widespread management and enforcement (e.g. Siry 2011).

Given the importance of enlisting the support of local stakeholders for MPAs, designing and managing MPAs to achieve biodiversity and socioeconomic objectives requires a thorough understanding of the factors that influence support (Allegretti et al. 2012, Chaigneau and Daw 2015). One such factor is stakeholders’ perceptions of how MPAs impact them; while this is a likely determinant of support, a myriad of factors that operate at multiple scales can influence stakeholders’ support for MPA management (Pollnac et al. 2010, Dalton et al. 2012, Chaigneau and Daw 2015). For example, the social-ecological systems framework (Ostrom 2007, 2009) suggests that behaviour in relation to use and management of natural resources (e.g. participation) is affected by different

elements of the social-ecological system, including those related to the resource system (e.g. the fishery), resource units (e.g. fish), actors (e.g. fishers), and the governance system.

Therefore, understanding the socioeconomic factors related to MPAs, in particular the determinants of stakeholders' support for management and how MPAs affect people, is critical to designing and managing MPAs that align with stakeholders' needs and aspirations. Contextually appropriate MPAs that reflect socioeconomic and political realities, and that contribute to human well-being, are more likely to engender support, thus aiding implementation, management effectiveness, and ultimately, achievement of MPA objectives.

1.5 Socioeconomic factors in Systematic Conservation Planning

Given that the limited implementation and success of both terrestrial and marine protected areas has been attributed largely to insufficient consideration of socioeconomic factors, over the last decade there has been a flurry of activity in the SCP literature advocating the need to better incorporate these factors into design and management, and providing suggestions on how to do so (e.g. Knight et al. 2006b, Polasky 2008, Ban et al. 2009a). Pressey and Bottrill (2009) extended the stages of the SCP planning framework from the original ecology-centric six (Margules and Pressey 2000), to include five new stages intended to facilitate better consideration of the social, economic, and political context in which conservation occurs. Other notable contributions include: Knight et al.'s (2006a) operational model for implementing conservation, which emphasised the importance of participatory planning processes and engaging local stakeholders; and Ban et al.'s (2013) approach for linking the SCP framework to Ostrom's (2009) social-ecological systems framework.

However, this theoretical evolution in SCP has not been mirrored in practice; socioeconomic factors continue to be oversimplified and treated as secondary to biological factors (Ban et al. 2013). This is particularly true in the spatial prioritisation of protected areas (Wilson et al. 2009), and given that this stage is such an important part of SCP (Margules and Pressey 2000), this simplification tends to permeate the whole planning process. Stages 1 to 8 of the SCP framework (Figure 1.1) are essentially concerned with laying the ground for stage 9, the spatial prioritisation stage (Pressey and Bottrill 2009). Thus, the way human systems are conceived in the spatial prioritisation stage shapes how they are considered throughout the planning process; for example, in regards to identifying and involving stakeholders (stage 2), collecting of socioeconomic data (stage 5), and setting objectives (stage 7).

Four key limitations of how socioeconomic factors are treated in the spatial prioritisation stage of SCP are: (1) socioeconomic factors tend to be treated as costs to be minimised whilst meeting biodiversity objectives; (2) minimising costs is often assumed to maximise social support for protected areas; (3) data used to represent socioeconomic factors tends to relate to the material or monetary benefits of

ecosystems; and (4) stakeholders tend to be represented as a single group. Following, I summarise each of these four limitations and crucial related knowledge gaps, particularly in relation to MPAs:

1. **Socioeconomic factors tend to be treated as costs to be minimised whilst meeting biodiversity objectives**. Given that SCP emerged from the natural sciences, socioeconomic factors (usually conceived as human use of resources) tend to be thought of as costs to conservation initiatives focused primarily on achieving biodiversity goals (Ban and Klein 2009). Thus, the basis of all the commonly-used spatial prioritisation tools – such as Marxan (Ball et al. 2009), C-Plan (Pressey et al. 2009) and Zonation (Moilanen et al. 2005) – is to minimise a single index of cost whilst maximising achievement of biodiversity objectives. However, treating socioeconomic factors as costs is not ideal in terms of gaining stakeholders' support for management. This approach does not facilitate planning for both biodiversity and socioeconomic objectives, thus hindering the likelihood of achieving win-win outcomes between multiple competing objectives. Further, engaging stakeholders through requesting them to identify what they want to give up for conservation (i.e. positioning stakeholders as antagonists to conservation), rather than what their objectives are, is less likely to result in positive participatory decision-making. Recently, an alternative spatial prioritisation tool (Marxan with Zones; Watts et al. 2009) has been developed that can facilitate design based simultaneously on biodiversity and socioeconomic objectives. However, to date, no study has provided a rigorous comparison of protected area designs produced using methods that treat socioeconomic data as costs or objectives in spatial prioritisation.

2. **Minimising costs is often assumed to maximise social support for protected areas.** The assumption underpinning the approach of treating socioeconomic factors as costs is that minimising total cost to stakeholders will generate the most socially-acceptable designs (e.g. Fernandes et al. 2005), thus fostering stakeholders' support. However, such simplification of the determinants of people's attitudes and behaviour towards protected areas is often inadequate. This minimum-cost assumption is based on rational choice theory, which suggests that humans seek to maximise their utility by using a cost-benefit approach to make decisions (Coleman 1990). Economic models of human behaviour based on rational choice theory have long been applied to use and management of natural resources (St John et al. 2010); an example is Hardin's (1968) seminal work on "The Tragedy of the Commons". Although stakeholders' perceptions of the costs and benefits of MPA management are likely to be important in determining their support for MPAs, humans are not *Homo economicus* (Persky 1995); it is increasingly recognised that behaviour is influenced by a wider range of factors beyond economic self-interest, such as other-regarding preferences, and compliance to social norms (Gintis 2000, Fehr et al. 2002). The range and relative role of these factors in regards to behaviour associated with

use and management of natural resources remains poorly understood (St John et al. 2010, Milner-Gulland 2012, Cowling 2014). This applies to behaviour associated with MPAs, particularly participation in management, which a number of authors (e.g. Christie 2004, NOAA 2005) have flagged as critically in need of research.

3. **Data used to represent socioeconomic factors tend to relate to extractive uses of ecosystems.** When socioeconomic factors are used to reflect costs in spatial prioritisation, these are often represented by data reflecting extractive uses of ecosystems, such that minimising costs relates to minimising forgone extractive opportunities arising from protected areas (i.e. opportunity cost; Naidoo et al. 2006, Ban and Klein 2009). For example, data commonly used in marine spatial prioritisation as surrogates for opportunity costs include extent of protected areas (Beck and Odaya 2001, Stewart et al. 2003), density of fishing boats (Sala et al. 2002), and number of fishers (Weeks et al. 2010). Thus, the cost or impact of protected areas on people tends to be considered only in relation to extractive uses in spatial prioritisation. However, protected areas have the potential to have both positive and negative impacts on the entire range of benefits people derive directly and indirectly from ecosystems, such as spiritual and recreational benefits (MEA 2005). In the context of developing countries it is thus critical to consider how MPAs affect multiple dimensions of poverty. Following Sens's (1976) criticism of such definitions of poverty, there has been a consensus in the theoretical literature on the multidimensional nature of poverty. However, poverty still tends to be considered only in terms of a single dimension, most often based solely on material and monetary assets, in natural resource management and conservation. Thus, critical to designing and managing protected areas that align with stakeholders' needs (hence increasing the likelihood of enlisting stakeholders' support), is considering the impacts of protected areas on multiple dimensions of human well-being, rather than just considering potential impacts on extractive uses. The need to consider multiple dimensions of However, few studies have examined the causal effects of protected areas on people (Ferraro et al. 2011, Miteva et al. 2012), so the evidence base for the socioeconomic impacts of both marine and terrestrial protected areas is weak (Mascia et al. 2010, Carneiro 2011, Pullin et al. 2013).

4. **Stakeholders tend to be represented as a single group.** Given that only a single index of cost can be considered in commonly-used tools for spatial prioritisation, data used to represent cost are generally intended to reflect the collective benefit that all stakeholders' derive from ecosystems (Ban and Klein 2009). In these cases, minimising cost relates to minimising impacts of protected areas on stakeholders as an aggregate. However, this collective treatment of the potential impacts of protected areas disregards the potential for impacts to vary across stakeholder groups. Benefits derived from ecosystems are likely to differ (e.g. in magnitude or

spatial distribution) according to social subgroups defined by factors such as gender, age, religion, and occupation (Hicks and Cinner 2014). Likewise, priorities for resource use and management, and capacities and powers to defend those priorities, are likely to vary by social subgroups (Adhikari et al. 2004). The tendency to disregard the heterogeneity of stakeholder groups is common in conservation literature and practice (Agrawal and Gibson 1999, Leach et al. 1999, Waylen et al. 2013). Failing to recognise heterogeneity could result in inequitable impacts of protected areas on human well-being, which in turn could result in conflict (Christie 2004), lowering the likelihood of gaining stakeholders' support for management, and jeopardising conservation objectives (Persha and Andersson 2014). Thus, understanding how protected areas can differentially affect people according to social subgroup is critical to designing and managing them to promote social equity. Although the potential for inequitable impacts of protected areas is commonly discussed in the literature (Christie 2004, Béné et al. 2009), the evidence base for whether the socioeconomic impacts of marine or terrestrial protected areas differ according to social subgroup, is particularly weak (Fox et al. 2012a, Milner-Gulland et al. 2014).

This simplified treatment of human systems in the spatial prioritisation stage, and ultimately, much of the SCP process, inhibits the implementation and success of protected areas. Conceptually and theoretically broadening the way socioeconomic factors are considered in SCP will ensure more meaningful participatory planning processes, increasing the likelihood of gaining stakeholders' support (Pomeroy and Douvere 2008, Dalton et al. 2012). Given the planned expansion of both marine and terrestrial protected areas globally (e.g. CBD 2010), there is a pressing need to better understand socioeconomic factors relevant to protected areas (including those related to the knowledge gaps highlighted above), and how to better incorporate these factors into the design and management of protected areas.

1.6 Thesis goal and objectives

The overarching goal of my thesis is to improve our understanding of critical socioeconomic factors related to MPAs, and to provide guidance on how this knowledge can be incorporated into MPA design and management. I set out to achieve this goal through three research objectives, which address the knowledge gaps related to the above-listed four key limitations of how socioeconomic factors are treated in SCP. The three objectives are to:

1. Investigate the socioeconomic impacts of MPAs, and whether these vary according to social subgroup.
2. Identify socioeconomic factors related to individual participation of local people in MPA management.
3. Test alternative approaches to incorporating socioeconomic factors into spatial prioritisation of MPAs under a SCP approach.

1.7 Study regions

I address my thesis goal and objectives in relation to the establishment of MPAs for managing coral-reef social-ecological systems in the Indo-Pacific region, specifically Fiji and Indonesia (see the relevant chapters for maps of the study areas). My thesis goal and objectives are particularly pertinent in this context for three important reasons described below.

First, effective management of coral reefs in the Indo-Pacific is critical because reefs in this region are of high natural and socioeconomic value, and are currently facing immense threats. Coral reefs are one of the most biodiverse marine ecosystems, and those in the Coral Triangle region, which has Indonesia at its centre, boast particularly high species richness (Roberts et al. 2002, Green and Mous 2008). In addition, millions of people in this region are highly dependent on the goods and services provided by coral reefs – such as fisheries, coastal protection, and tourism – for their food security, livelihoods, and well-being (White 2008, Foale et al. 2013). However, these natural and socioeconomic values are at risk because of increasing degradation of coral reefs due to a myriad of stressors, including climate change, poor water quality, and destructive- and over-fishing (Burke et al. 2012). Local-scale stressors have intensified over the last decade, driven in part by rapid population growth, emerging markets, and increasing coastal development (Hughes et al. 2003, Berkes et al. 2006, Burke et al. 2012). Given this high exposure to threats and dependence of a large proportion of the population on coral reefs, both Indonesia and Fiji have been identified as two of nine countries in the world that are most vulnerable to the effects of coral reef decline (Burke et al. 2011).

Second, the number of MPAs being established to manage coral reef systems in the Indo-Pacific is rising rapidly (Horigue et al. 2012, White et al. 2014), and SCP is increasingly employed in their design and management (Weeks et al. 2014b). This is particularly true in regards to Indonesia and the rest of the Coral Triangle region, which was the focus of the Coral Triangle Initiative, an unprecedented multilateral partnership between six countries to improve management of the region's coastal and marine resources. The Coral Triangle Initiative was launched in 2009 with funding of more than U.S. $500 million committed from donors including the United States Agency for International Development (USAID) and the Global Environment Facility (CTI-CFF 2009). An important objective of the Coral Triangle Initiative is to establish MPA networks throughout the region.

Third, achieving biological and socioeconomic success of MPAs in the Indo-Pacific region rests heavily on gaining local stakeholders' participation in MPA management. This is in part because many coastal people's identity, culture, and way of life in the region are intimately related to coral-reef systems (Johannes 2002, Whittingham et al. 2003). Further, natural resource management often lies effectively with local institutions due to decentralised and devolved governance systems, and weak government institutions that lack the resources necessary to establish and enforce wide-spread

natural resource management (White 2008, Mills et al. 2010). In Indonesia, coastal-zone governance was decentralised to local and provincial governments under the Autonomy Act (Law 22/1999), the Financial Distribution Act (Law 25/1999), and their revisions (Law 32 and 33/ 3004). The Coastal Zone and Small Islands Management Act (Law 7/2007) further supports devolved coastal management and provides a framework for coordination of coastal planning and management (Siry 2011). In Fiji, customary law (i.e. community-level governance systems) remains the primary mechanism for managing natural resources (Govan 2009), with traditional subsistence fishing rights of customary owners being recognised by the Fiji Fisheries Act (Clarke and Jupiter 2010).

In sum, more nuanced understanding and incorporation of socioeconomic factors in MPA design and management is particularly critical in the context of coral reef management in the Indo-Pacific because: MPAs are increasingly being employed as a key strategy to mitigate accelerating reef decline; the establishment of MPAs in this region is mandated under several international agreements; and the success of this management tool in maintaining the high natural and socioeconomic value of coral reefs in this region relies heavily on gaining local stakeholders' participation in MPA management.

1.8 Thesis structure

I pursue the three objectives of my thesis through four data-based research chapters, which are presented in this thesis as a series of manuscripts formatted for publication in peer-reviewed journals. Thus, my thesis consists of six chapters (Figure 1.2), including this general introduction (chapter 1) and general discussion (chapter 6).

Chapters 2 to 4 relate to the first two objectives of my thesis, and contribute to better understanding of the socioeconomic factors relevant to MPAs, providing recommendations for their incorporation into MPA design and management. I apply some of the lessons learnt in chapters 2-4 to the design of MPA networks in chapter 5, which addresses my third objective. The data-based chapters of my thesis (chapters 2-5) have been submitted for publication to international journals: chapter 2 is published in *Global Environmental Change*; chapter 5 is in press in *Conservation Biology*; and chapters 3 and 4 are currently in review, in *Philosophical Transactions of the Royal Society B,* and *Environmental Science & Policy*, respectively.

Chapter 1 (this chapter) provides the rationale for the goal and objectives of my thesis. In this chapter, I highlight the critical need to better understand and incorporate socioeconomic factors into MPA design and management, particularly in relation to SCP. Further, I outline four key limitations of how socioeconomic factors are treated in spatial prioritisation under SCP, and crucial related knowledge gaps, particularly in relation to MPAs.

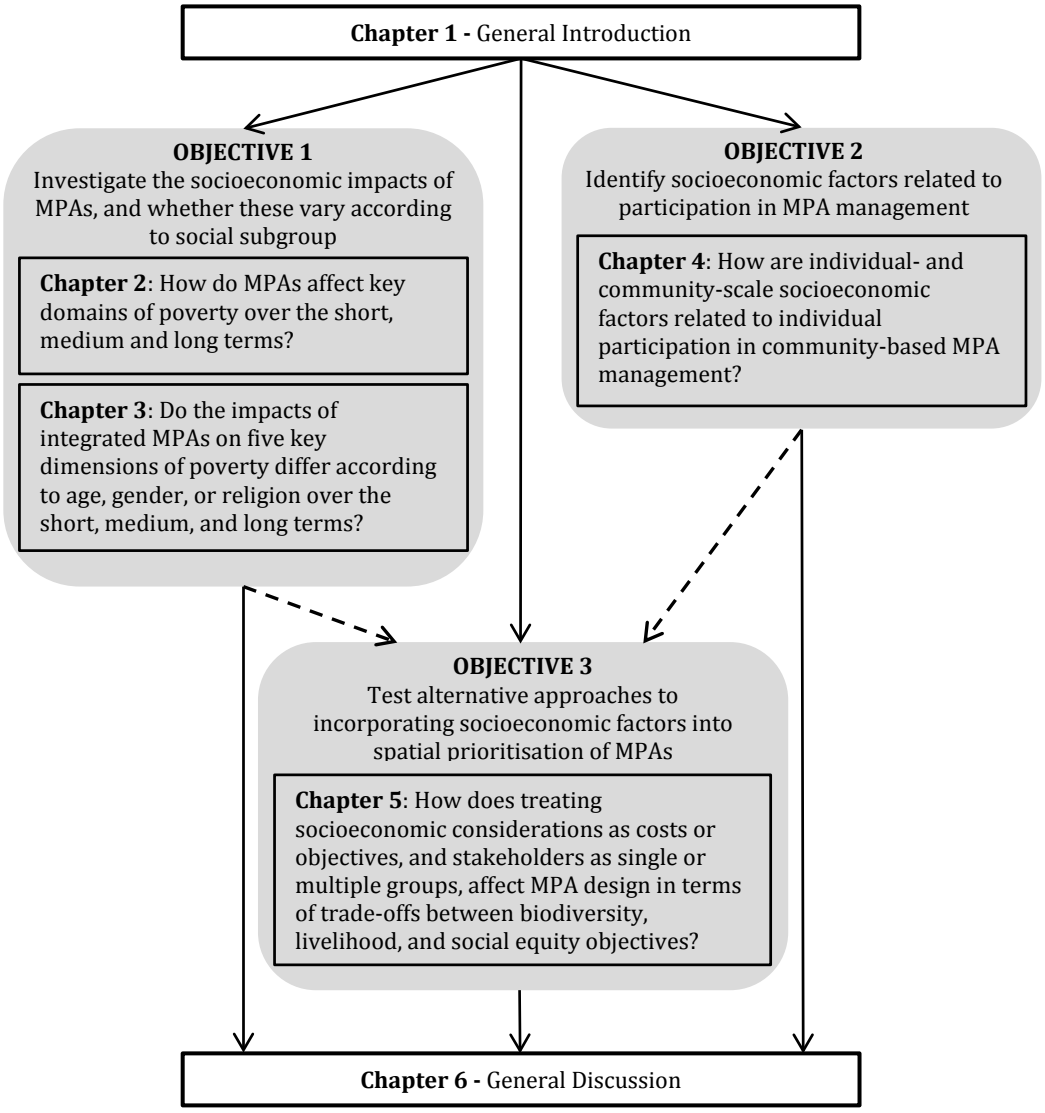


Figure 1.2 Thesis structure. Diagram shows the research question that I ask in each of the four data-based research chapters (chapters 2-5). The dashed arrows indicate that lessons learnt in chapters 2-4 were applied to chapter 5.

Chapter 2 addresses, in part, Objective 1. In this chapter I ask "how do MPAs affect key domains of poverty over the short, medium and long terms?" To address this question I examine the impacts of an integrated conservation and development MPA project in North Sulawesi, Indonesia, three, five and fifteen years after it was implemented. I use longitudinal socioeconomic data from villages with and without MPAs to evaluate whether the MPA project contributed to alleviating three key domains of poverty (empowerment, security, and opportunity). The results of chapter 2 provide insights into the impacts of MPAs on multiple dimensions of human well-being. Thus, this chapter helps address the weak evidence base for socioeconomic impacts of protected areas, which is a crucial knowledge gap related to the third above-listed limitation of how socioeconomic factors are treated in spatial prioritisation under SCP.

Chapter 3 further addresses Objective 1. In this chapter I ask "do the impacts of MPAs on five dimensions of poverty differ according to age, gender, or religion over the short, medium, and long terms?" To address this question I employ the same MPA case study as in chapter 2. I focus on five indicators of poverty that I found were significantly impacted by MPAs in chapter 2, and assess whether these impacts differ according to social subgroups defined by age, gender, and religion. Thus, the results of chapter 3 contribute to building our limited knowledge of the potential for socioeconomic impacts of protected areas to differ by social subgroup, which is an important knowledge gap associated with the fourth above-listed limitation of how socioeconomic factors are treated in spatial prioritisation under SCP.

Chapter 4 addresses Objective 2. In this chapter I ask "how are individual- and community-scale socioeconomic factors related to individuals' participation in community-based MPA management?" To address this question, I examine local stakeholders' participation in 13 community-based MPAs in North Sulawesi and Bali, Indonesia. I take an interdisciplinary approach to investigating socioeconomic factors related to participation, and draw from literature on human behaviour from political science, social psychology, and behavioural economics. The results of this chapter 4 provide insights into the determinants of stakeholders' participation in MPA management. Thus, this chapter contributes to addressing our poor understanding of the factors affecting human behaviour associated with use and management of natural resources, which is a key knowledge gap associated with the second above-listed limitation of how socioeconomic factors are treated in spatial prioritisation under SCP.

Chapter 5 addresses Objective 3. In this chapter I ask "how does treating socioeconomic considerations as costs or objectives, and treating stakeholders as a single or multiple groups, affect MPA design in terms of trade-offs between biodiversity, livelihood and social equity objectives?" I address this question by testing alternative approaches for incorporating socioeconomic factors into the spatial prioritisation of a system of MPAs in the Kubulau District, Fiji. The stakeholders that I consider in this analysis are fishers, who can be divided into multiple groups according to the type of fishing gear that they employ. I assess social equity in terms of catch losses among fisher groups employing different fishing gears. Thus, in this chapter I draw on some of the lessons learnt in chapters 2-4 that are relevant to how socioeconomic factors are typically treated in spatial prioritisation under SPC. Given that chapter 3 highlights the need to recognise the heterogeneity of stakeholder groups to ensure equitable impacts of MPAs, I examine how treating stakeholders as a single group or multiple groups can affect the design of MPA systems. Further, given that chapter 4 highlights that gaining stakeholders' support for MPA management does not rest solely on minimising cost to stakeholders, I incorporate social equity, an alternative potential determinant of stakeholders' support, into spatial prioritisation. Chapter 5 provides a rigorous comparison of protected area designs produced using methods that treat socioeconomic data as costs or objectives in spatial prioritisation,

and thus addresses the knowledge gap associated with the first above-listed limitation of how socioeconomic factors are treated in spatial prioritisation under SCP. Further, by providing novel methods for incorporating multiple groups in spatial prioritisation, this chapter also helps address the fourth above-listed limitation.

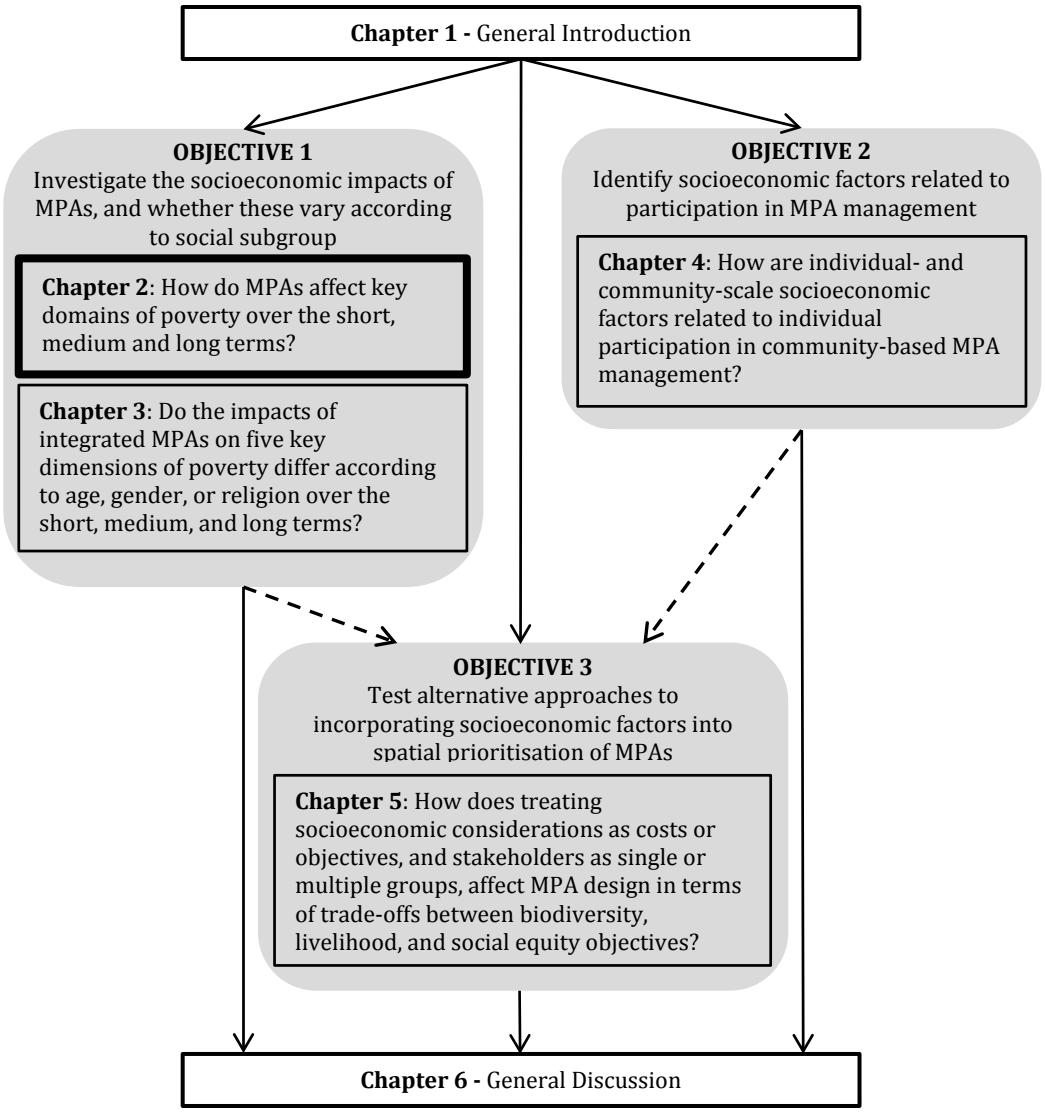
Chapter 6 provides a description of how my data-based research chapters (chapters 2 to 5) addressed the three objectives of my thesis, including the main contributions to theory and practice. Further, I discuss the contributions of my thesis to overcoming the four key limitations of how socioeconomic factors are treated in SCP, and highlight some shortcomings of my work and opportunities for further research.

Chapter 2

Socioeconomic impacts of MPAs

2 Socioeconomic impacts of MPAs

In chapter 2, I investigate the impacts of MPAs on multiple dimensions of poverty. This chapter contributes to addressing the weak evidence base for socioeconomic impacts of protected areas, which is an important knowledge gap associated with the third limitation of how socioeconomic factors are treated in SCP listed in chapter 1; this is, that data used to represent socioeconomic factors tend to relate only to extractive uses of ecosystems. Chapter 2 is published in *Global Environmental Change*[5]. I developed the research question for this chapter, analysed data, and wrote the chapter. I designed, coordinated and conducted data collection (with research assistants) for the fourth sampling period (2012). Cinner, Ban, and Pressey provided advice in the development of the research question and design of data collection, and assisted with structuring and editing the manuscript. Pollnac designed, coordinated and conducted data collection (with research assistants) for the first three sampling periods (1997, 2000, 2002), and assisted with editing the manuscript. Campbell, Tasidjawa, and Setiawan assisted with coordinating and conducting data collection in 2012, and contributed to editing the manuscript.



[5]Gurney, G., J. Cinner, N. Ban, R. Pressey, R. Pollnac, S. Campbell, S. Tasidjawa, and F. Setiawan. 2014. Poverty and protected areas: an evaluation of a marine integrated conservation and development project in Indonesia. Global Environmental Change 26:98-107.

2 Socioeconomic impacts of MPAs

2.1 Abstract

Protected areas are currently the primary strategy employed worldwide to maintain ecosystem services and mitigate biodiversity loss. Despite the prevalence and planned expansion of protected areas, the impact of this conservation tool on human communities remains hotly contested in conservation policy. The social impacts of protected areas are poorly understood largely because previous evaluations have tended to focus on one or very few outcomes, and few have had the data required to assess causal effects (i.e. longitudinal data for protected and control sites). Here, I evaluated the short-, medium- and long-term impacts of MPAs that were specifically designed to achieve the dual goals of conservation and poverty alleviation (hereafter 'integrated MPAs'), on three key domains of poverty (security, opportunity and empowerment) in eight villages in North Sulawesi, Indonesia. Using social data for villages with and without integrated MPAs from pre-, mid-, and post-the five-year implementation period of the integrated MPAs, I found that the integrated MPAs appeared to contribute to poverty alleviation. Positive impacts spanned all three poverty domains, but within each domain the magnitude of the effects and timescales over which they manifested were mixed. Importantly, positive impacts appeared to occur mostly during the implementation period, after which integrated MPA activities all but ceased and reductions in poverty did not continue to accrue. This finding questions the efficiency of the short-term approach taken in many international donor-assisted protected area projects that integrate development and conservation, which are often designed with the expectation that management activities will be sustained and related benefits will continue to accumulate after external support is terminated.

2.2 Introduction

It is widely recognised that there is a global biodiversity crisis, and environmental degradation is expected to accelerate with profoundly changing socioeconomic (e.g. human population growth, economic development and urbanisation) and climatic conditions (Thomas et al. 2004, Halpern et al. 2008, Rinawati et al. 2013). Protected areas are commonly employed worldwide as a principal tool for maintaining biodiversity and key ecosystems services (MEA 2005). While protected areas as a management strategy for nature conservation has a long history, the prevailing top-down protectionist paradigm was replaced in the 1980s by an approach that was, at least in principle, more sensitive to the rights and needs of local people (Campbell et al. 2010). This shift took place in part because of concern about the disproportionate costs of conservation imposed on poor communities in developing countries, especially given the geographic juxtaposition of biological wealth and human poverty (Sunderlin et al. 2005). Further, there was growing recognition of the importance of gaining local communities' support for protected areas to achieve conservation goals, particularly in developing

countries where resources for enforcement are scarce. The dual goals of conservation and poverty alleviation have since underpinned conservation philosophy and practice in most developing countries (Pelser 2013). This approach to protected areas continues to be implemented under a number of guises, including community-based conservation, co-management, and integrated conservation and development.

Despite the paradigm shift toward including poverty reduction as a goal of many protected areas, few evaluations of protected areas have assessed the social impacts of protected areas, instead focusing on the biological domain (Fox et al. 2012a, Miteva et al. 2012). Reviews of social impacts of protected areas (e.g. Agrawal and Redford 2006, Mascia et al. 2010, Carneiro 2011) have found mixed evidence. For example, economic impacts of protected areas – one of the most commonly assessed impacts – have been found to be both positive (e.g. Andam et al. 2010) and negative (e.g. Maliao and Polohan 2008), and there are too few case studies from which to extract explanations and generalisations. Thus the social impacts of protected areas remain poorly understood (Mascia et al. 2010, Ferraro et al. 2011). Previous social impact evaluations have tended to suffer from two broad shortcomings: first, studies often examined one or very few impacts of protected areas (Agrawal and Redford 2006, Mascia et al. 2010); and second, few evaluations have had the requisite data to assess causal effects of protected areas (Andam et al. 2010).

The first shortcoming of existing social impact evaluations of protected areas – the focus on one or very few outcomes – has led to very narrow definitions of costs or benefits of conservation (Agrawal and Redford 2006, Coad et al. 2008, Carneiro 2011). For example, evaluations in developing countries have often measured poverty based solely on material and monetary assets (Pelser et al. 2013). Following Sen's (1976) criticism of this narrow definition of poverty, there has been a consensus in the theoretical literature on a multidimensional definition of poverty (Agrawal and Redford 2006). The World Bank's strategy for poverty alleviation is based on such a definition, whereby poverty is due to a lack of opportunity, empowerment, and security (World Bank, 2001). However, monetary-based poverty indices continue to be used in many protected area assessments (e.g. Andam et al. 2010, Ferraro et al. 2011).

The second barrier to advancing knowledge of the social impacts of protected areas is the dearth of data required to assess causal effects (Miteva et al. 2012). This is despite increasing interest in social monitoring of conservation projects, for example SocMon for coral reefs (Bunce et al. 2000). The few existing empirical impact evaluations have tended to rely on comparisons of outcomes in: (1) sites with and without protected areas for a single time period (e.g. Tobey and Torell 2006, de Sherbinin 2008); or (2) protected area sites before and after the intervention was implemented (e.g. Gjertsen 2005, Leisher et al. 2012b). These two approaches rely on assumptions that are rarely met: that there was no difference between control and protected area sites prior to the intervention; and that there

were no concurrent macro-changes that would affect outcomes (Gertler et al. 2011). Subsequently, there have been repeated calls for evaluations to use longitudinal data for protected and control sites to avoid the need for these assumptions (Ferraro and Pattanayak 2006 , Pullin et al. 2013). Further, given that the outcomes of protected areas can be related to the duration of their implementation (Russ and Alcala 2004, Baral et al. 2007), longitudinal analysis using multiple points in time, including ex-post assessment, is crucial for a comprehensive understanding of social impacts. The few social impact evaluations that have used longitudinal data for control and project sites exist only for terrestrial sites in Bolivia (Canavire-Bacarreza and Hanauer 2012), and for Thailand and Costa Rica, where a number of studies have used country-wide data sets (e.g. Andam et al. 2010, Ferraro et al. 2011). However, these studies adopted a narrow definition of poverty with monetary-based indices, and only assessed impacts over one time period.

Given the prevalence and planned expansion of protected areas – the target set by the Convention of Biological Diversity is to protect 10% of marine and 17% of terrestrial areas by 2020 (CBD 2010) – understanding their social impact is of crucial policy importance, and is increasingly advocated as a priority topic of research (Sutherland et al. 2009). To address gaps in understanding of the social impacts of protected areas, I examine the impact of MPAs – designed to achieve the dual goals of conservation and poverty alleviation (hereafter 'integrated MPAs') – on poverty of associated villages in North Sulawesi, Indonesia. Using data from pre-, mid-, and post-implementation for villages with and without MPAs, I ask "how do integrated MPAs affect key domains of poverty over the short, medium and long term?"

2.3 Methods

Integrated MPAs in North Sulawesi

The Coastal Resources Management Project (CRMP; locally known as *Proyek Pesisir*) implemented integrated MPAs (all < 14 ha) from1997 to 2002 in 4 villages in North Sulawesi, Indonesia (Figure 2.1). The project was jointly run by USAID and Indonesia's National Development Planning Agency (BAPPENAS), and cost over US$ 1.4 million (Pollnac et al. 2003). Integrated MPA plans were developed through a participatory planning process lasting two years, after which they were formally adopted by village ordinance. Notably, the village ordinances relating to the prosecution of poachers were not supported by any district or higher governance level legislation. Various development activities were simultaneously carried out under the CRMP, including improving access to drinking water, livelihood training and environmental education. After the withdrawal of external support in 2002, the villages continued to manage their MPAs to varying extents; currently MPA rules are not enforced in any of the villages and only the MPAs in the villages of Blongko and Talise are still marked with buoys.

Sampling

I studied the four villages in North Sulawesi (hereafter 'MPA villages') pre-, mid-, and post-implementation of the integrated MPAs (1997, 2000, 2002, respectively; Pollnac et al., 2003), and in 2012 (i.e. ten years after the withdrawal of external support). To estimate the counterfactual outcomes, I concurrently studied four control villages (Figure 2.1). These were selected to match key attributes of MPA villages that were likely to affect outcomes of the integrated MPAs, such as aspects of poverty and use of marine resources, including distance to markets, population size, and fisheries dependence. I used household surveys (see Appendix 4 for survey) to gather quantitative data of several indicators of poverty, followed by semi-structured interviews with key informants (see Appendix 5 for survey guide), including heads of village, members of MPA groups, and traditional leaders. The two kinds of data were intended to triangulate results and aid my understanding of the possible causal mechanisms behind changes in poverty indicators.

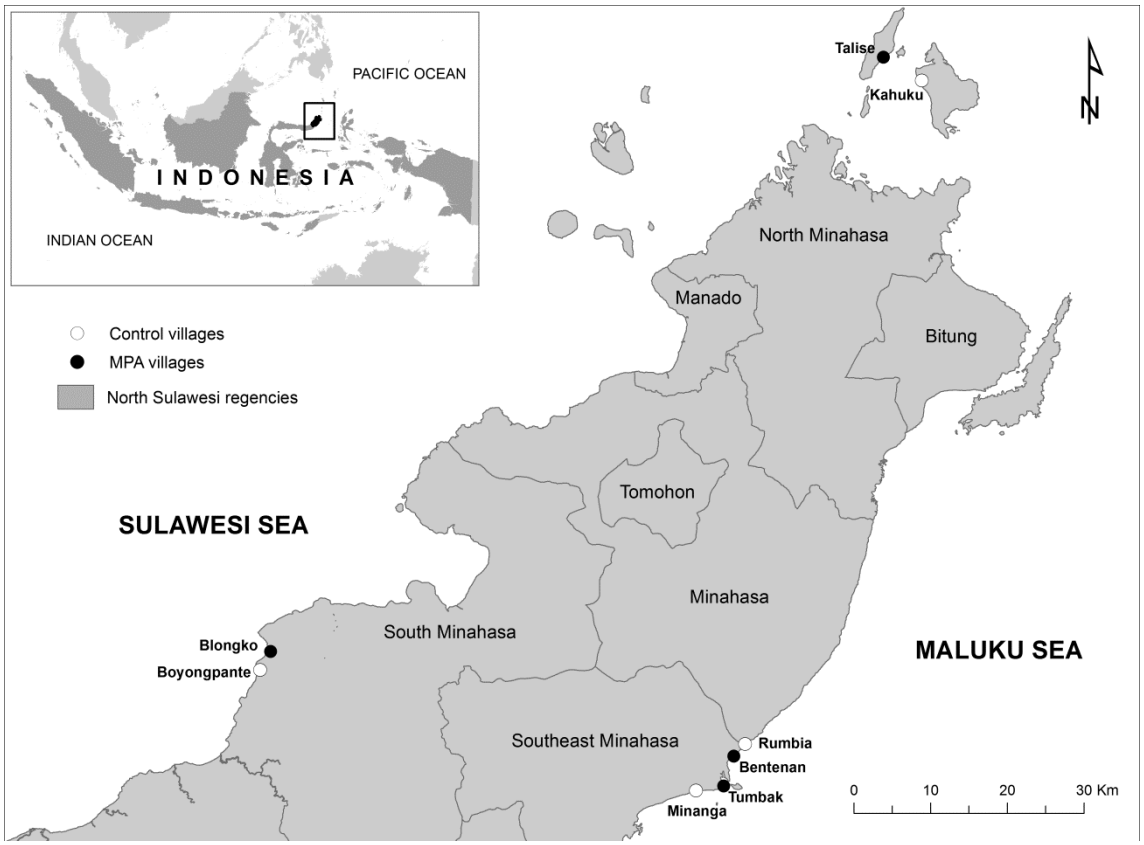


Figure 2.1 Location of villages with integrated MPAs and without integrated MPAs in the province of North Sulawesi, Indonesia.

Households within villages were systematically sampled, whereby a sampling fraction of every *i*th household (e.g. 2nd, 3rd, 4th) was determined by dividing the total village population by the sample size (Henry 1990, de Vaus 1991). This sampling strategy ensured that the sample was random, but also geographically representative. I surveyed over 2,000 respondents during the entire study. At each

village at each point in time, the number of surveys conducted per village ranged from 40 to 140, depending on the population of the village and available time at each site.

Poverty indicators

To develop a framework for assessing the impact of integrated MPAs on poverty, I drew on the World Bank's multidimensional definition of poverty (World Bank 2001) and its applications to examining the relationship between natural resource management and poverty (e.g. Scherl et al. 2004, Leisher et al. 2012a, van Beukering et al. 2013). The framework is composed of three domains of poverty: security, opportunity, and empowerment (Table 2.1). The premise of the framework is that poverty alleviation requires: (1) enhancement of security against adverse shocks to the social-ecological system; (2) promotion of material opportunities, including financial and human assets; and (3) empowerment of stakeholders to shape decisions that affect their lives (World Bank 2001). The three poverty domains and their respective components are complementary and interconnected; consequently affecting a component of poverty in one domain will affect underlying causes of poverty addressed in the other two domains (World Bank 2001). Components of this framework contain themes addressed in parallel literatures, for example the premise of the security domain reflects key concepts embedded in social resilience (Adger 2000). Likewise, the opportunities domain reflects important components of the Sustainable Livelihoods Framework (Scoones 1998). The three domains of poverty can be represented by ten components, operationalised in this study by context-specific indicators tailored to assess the impact of the integrated MPAs on poverty alleviation (Table 2.1). These indicators are not intended to represent all facets of each component or domain of poverty. Rather, the indicators I used measure some aspects of poverty that could be affected by the integrated MPAs. Indicators concerning respondents' perceptions of the state of various aspects of their surrounding environment were assessed using a 15-point scale to allow for fine ordinal judgments. To operationalise the scale, I used a visual self-anchoring ladder-like diagram, a technique developed by Cantril (1965), which has been used previously in studies of natural resource management (e.g. Pomeroy et al. 1996, Maliao and Polohan 2008). The 15 steps represented a continuum of scenarios from the worst to best for that indicator. Some of the poverty indicators were assessed at each of the four sampling periods, whereas others were assessed only in the most recent two or three sampling periods (Appendix 1, Table A1.1).

Table 2.1 Framework for assessing the impact of MPA management on poverty. The framework is based on the World Bank's strategy for poverty alleviation (World Bank 2001) and its applications to examining the relationship between natural resource management and poverty (e.g. Scherl et al. 2004).

Poverty domains and components	Indicator	Description
Security		
Livelihood diversity	Average number of different occupations	Total number of different occupations in the household divided by the number of household members
Resource dependence	Fisheries dependence	Whether fishing is the primary livelihood for the household
Conflict	Frequency of illegal fishing[a]	Perception of indicator based on a 15-point scale
Well-being	Present well-being	Present household well-being reported as worse, same or better than five years ago
	Future well-being	Expectation of household well-being in five years being better or worse than present well-being
Opportunity		
Financial capital	Wealth (material style of life)	Principal component score based on the type of wall, floor, roof and window, and the presence or absence of a toilet, lounge suite, display cabinet and modern stove (further details Appendix 1, Table A1.2)
Human capital	Environmental knowledge	Score based on responses to eight statements concerning the relationship between coastal resources and human activities (further details Appendix 1, Text A1.1)
Natural capital	Condition of local marine environment	Perception of indicator based on a 15-point scale
	Fish catch from local area	Perception of indicator based on a 15-point scale
Empowerment		
Resource access	Marine resource control	Perception of indicator based on a 15-point scale
Influence in community	Ability to influence community affairs	Perception of indicator based on a 15-point scale
Governance mechanism	Prosecution of fishing in the MPA	Perception of indicator based on a 15-point scale
	Local government support for MPA	Perception of indicator based on a 15-point scale
	Enforcement of fishing laws	Perception of indicator based on a 15-point scale

a 'Illegal fishing' refers to all fishing practices (including bombing and cyanide fishing) that are banned under national law in Indonesia.

Data analyses

To assess whether integrated MPAs significantly affected the poverty indicators (Table 2.1), I drew on the difference-in-differences method (Gertler et al. 2011), a quasi-experimental technique from the econometrics literature on impact evaluation. The difference-in-differences method compares changes in outcomes over time between impact and control groups, and thus accounts for bias due to: (1) initial difference between groups, and (2) changes that are a result of broader-scale trends (Gertler et al. 2011). The design involved testing the effect of two explanatory variables – time and presence of integrated MPAs – on each of the poverty indicators (our response variables). A significant interaction between the two explanatory variables would indicate that the integrated MPAs had an effect, such that changes in the poverty indicator over time differed significantly between MPA villages and control villages. Conversely, a non-significant interaction and a significant effect of integrated MPAs would indicate that the control and MPA villages differed significantly but the presence of integrated MPAs did not affect that difference.

I tested for interaction effects between time and integrated MPAs over different time periods for each of the poverty indicators individually. For poverty indicators for which I had baseline (i.e. pre-MPA) data (Appendix 1, Table A1.1), I tested for interaction effects for three time periods: 1997-2000, 1997- 2002 and 1997- 2012, representing the short-, medium- and long-term impacts of the integrated MPAs, respectively. For indicators without baseline data (Appendix 1, Table A1.1), I tested for interaction effects between each sampling event: 2000-2002 and 2002-2012. I tested for interaction effects using statistical models appropriate for the respective types of data. For present well-being (ordered categorical data) I used a proportional odds model, while for fisheries dependence and future well-being (dichotomous categorical data) I used a generalised linear mixed model with a binomial distribution. For all other indicators (continuous data) I used a general linear mixed model. The relevant assumptions were tested for each of the statistical models (e.g. normality and homogeneity of variances for linear mixed models). For two indicators – prosecution of fishing in the MPA and local government support for MPA – I tested for the effect of time but not the interaction effect because these indicators were only relevant in MPA villages. Village was set a priori as a random factor for all of the analyses because of the hierarchical nature of the data (i.e. respondents were nested in villages).

For indicators that were significantly affected by the integrated MPAs over at least one time period, I used standardised effect sizes to compare changes in poverty indicators between MPA and control villages, which allowed me to compare across indicators based on different measures. I used Cohen's *d* effect statistic with a bias correction for all continuous poverty indicators analysed using general linear mixed models, and odds ratios for the remaining categorical indicators. Confidence intervals were calculated using percentile bootstrapping (1,000 replications) to account for non-independence of the data arising from repeated sampling within each village. For indicators without baseline data, I

used t-tests to compare the indicator values from MPA and control villages for the earliest year for which I had data. All analyses were conducted using R software (version 2.15.1).

2.4 Results

My results indicate that the integrated MPAs significantly affected all three poverty domains (Table 2.2), but effects differed between indicators in terms of the magnitude and timescales over which they manifested (Figure 2.2).

Table 2.2 Summary of results of analyses testing for an interaction between presence of integrated MPA management and time (i.e. a significant effect of integrated MPA management) for each poverty indicator over multiple time periods. Bolded values are significant at $\alpha = 0.05$.

Poverty domains and components	**Indicator**	***p* value (management x time interaction)**		
		time period		
		1997-2000	*1997-2002*	*1997-2012*
Security				
Livelihood diversity	Average number of different occupations	**0.0461**	**0.0001**	**<0.0001**
Resource dependence	Fisheries dependence	**0.0009**	**6.63×10^{-6}**	**0.0010**
Conflict	Frequency of illegal fishing			0.2182[b]
Well-being	Present well-being	**0.0002**	**4.32×10^{-11}**	**1.94×10^{-6}**
	Future well-being	0.5420	0.5080	0.7800
Opportunity				
Financial capital	Wealth	**0.0136**	**0.0002**	**0.0137**
Human capital	Environmental knowledge	**0.0003**	**0.0435**	**0.0013**
			2000-2002	*2002-2012*
Natural capital	Condition of local marine environment			**0.0049**
	Fish catch from local area		0.5658	**0.0041**
Empowerment				
Resources access	Marine resource control		0.2060	**0.0103**
Influence in community	Ability to influence community affairs		0.5508	0.1034
Governance mechanism	Prosecution of fishing in the MPA			0.1651[a]
	Local government support for MPA			**0.0005**[a]
	Enforcement of fishing laws			**0.0027**

a p value relates to the effect of time not to the interaction between integrated-MPA management and time because data for control villages were not available for these indicators.
b Interaction between presence of integrated-MPA management and time was tested for 2002-2012 for the indicator frequency of illegal fishing.

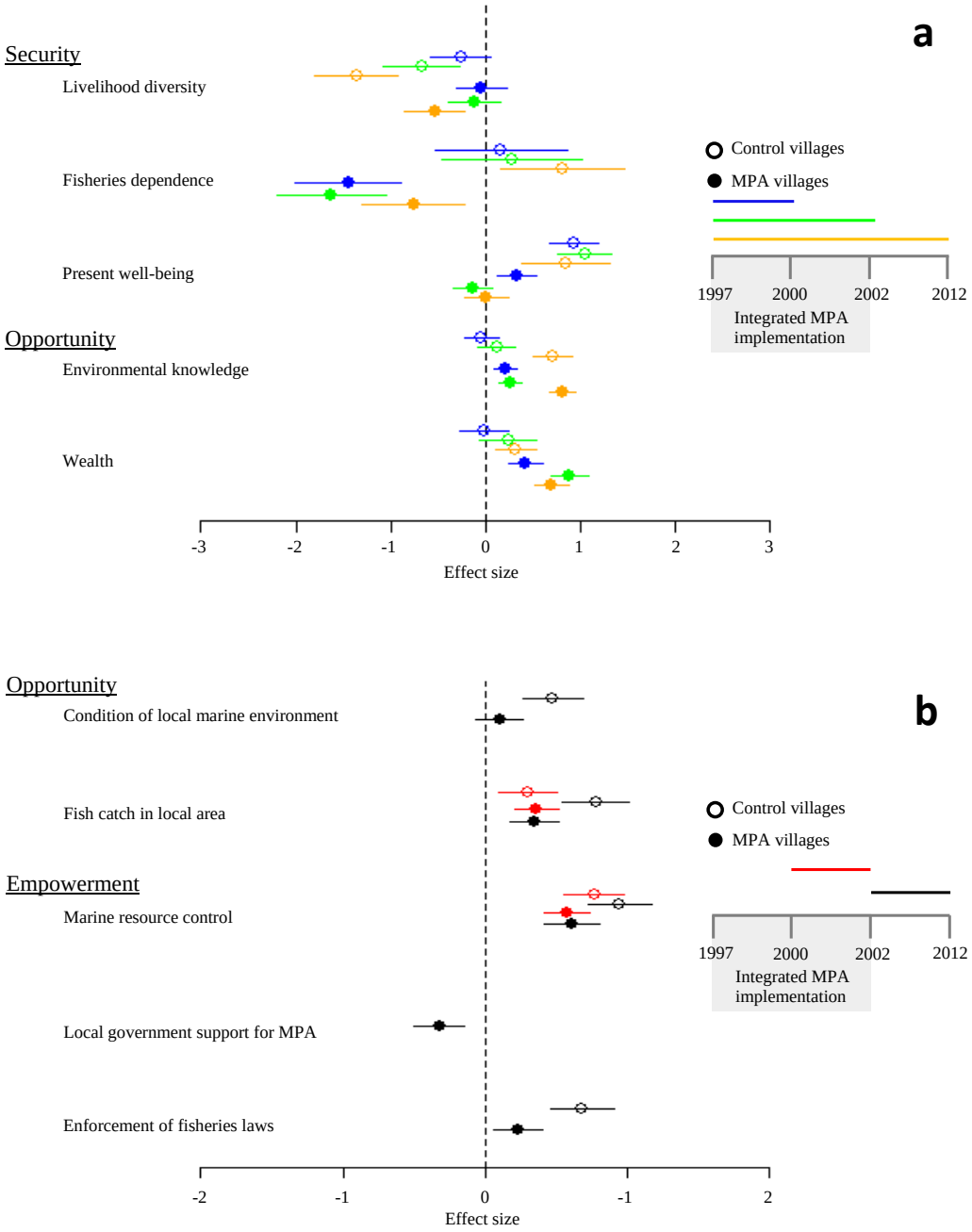


Figure 2.2 Changes in poverty indicators under the poverty domains of security, opportunity and empowerment. Poverty indicators in (a) were assessed during 1997-2000 (blue line), 1997-2002 (green line) and 1997-2012 (yellow line), and those in (b) were assessed during 2000-2002 (red line) and 2002-2012 (black line). Changes in poverty indicators in villages with integrated MPAs (closed circles) and without MPAs (open circles) are indicated by effect sizes and bootstrapped 95% confidence intervals. Effect sizes for fisheries dependence and present well-being were calculated using odds ratios, and are represented here on a logarithmic scale. The effect statistic used to calculate the effect size for the other indicators was Cohen's *d* with a bias correction.

Security domain

Changes in security during 1997-2012 differed between indicators, suggesting integrated MPAs can have a mixed effect on this poverty domain (Figure 2.2a). Fisheries dependence was reduced by integrated MPAs; households in MPA villages were 80% more likely to undertake an activity other than fishing as their primary livelihood in 2002, compared to 1997, while control villages showed little change. Although fisheries dependence increased in both control and MPA villages post-implementation, fisheries dependence did not return to baseline levels in MPA villages (Figure 2.2a). Livelihood diversity decreased for both MPA and control villages during the experimental period, but the decrease was greatest for control villages, indicating that integrated MPAs dampened the decrease in livelihood diversity. Perception of present well-being was negatively affected by integrated MPAs. While households in MPA villages were 39% more likely to rate their well-being in a higher category in 2000 than in 1997, households in control villages were 153% more likely to rate their well-being more highly in 2000. Further, while perceived well-being in MPA villages decreased after the first three years of integrated MPA implementation and did not return to the level in 2000, well-being in control villages showed little change. Lastly, perceived future well-being and frequency of illegal fishing were not significantly affected by the integrated MPAs over any time periods (Table 2.2).

Opportunity domain

Opportunity increased for MPA villages but did not change significantly, or increased by a lesser extent, for control villages during integrated MPA implementation (i.e. 1997 – 2002), indicating that integrated MPAs positively affected opportunity (Figure 2.2). During integrated MPA implementation, wealth, environmental knowledge, and fish catch increased for both control and MPA villages, although the increase was significantly greater for MPA villages. However, post-implementation (i.e. 2002-2012) changes in opportunity indicators in MPA villages either matched that of the control villages (e.g. environmental knowledge; Figure 2.2a), were less than those in the control villages (e.g. natural capital indicators; Figure 2.2b), or were partially reversed after gains in opportunity in MPA villages prior to 2002 (e.g. wealth; Figure 2.2a).

Empowerment domain

The effect of the integrated MPAs on the domain of empowerment differed between indicators. Perceived ability to influence community affairs appeared not to be affected by the integrated MPAs, and perceived prosecution of fishing in the MPA did not change significantly over time in the MPA villages. For indicators that were significantly affected by integrated MPAs, the general effect in control and MPA villages was uniform across all indicators, except local government support for MPAs. Empowerment increased for both MPA and control villages from mid-implementation (i.e. 2000) until 2012, but these increases were significantly larger for control villages than MPA villages

post-implementation (post-2002; Figure 2.2b). These results indicate that integrated MPAs had a negative effect on empowerment over the period analysed. However, empowerment could have increased in MPA villages during the initial years of implementation for which I lack data. This possibility is supported by data from the beginning of the periods analysed. Resource control and ability to influence community affairs were significantly higher for MPA than control villages in 2000, as was enforcement of fisheries laws in 2002 (Figure 2.3).

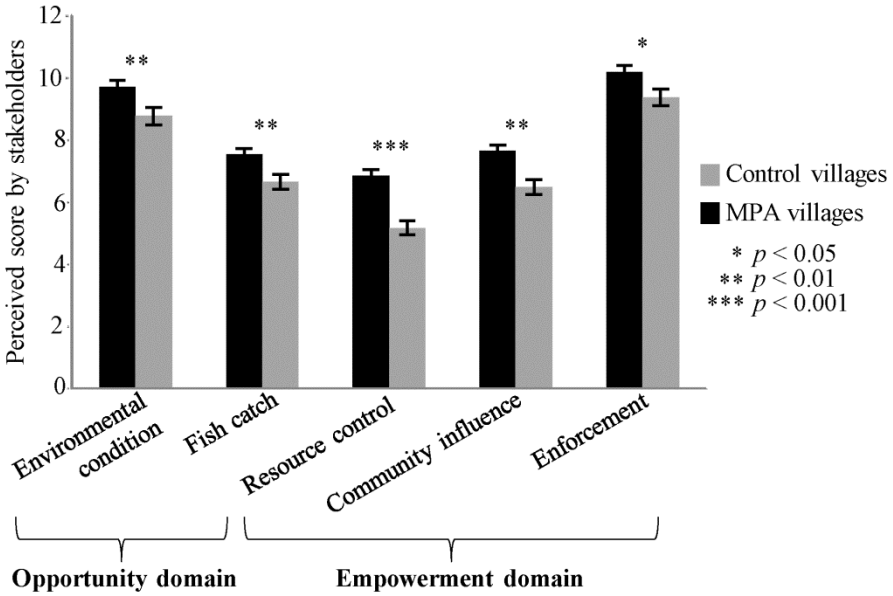


Figure 2.3 Mean perceived scores of a subset of poverty indicators under the poverty domains of opportunity and empowerment. Scores are for villages with integrated MPAs (black) and without integrated MPAs (grey) in 2002 (for enforcement and environmental condition) and 2000 (for resource control, community influence and fish catch). For all five indicators, the mean perceived score for MPA villages was significantly greater than for control villages (significance level indicated by asterisks). Error bars show standard errors of the mean.

2.5 Discussion

Although protected areas are currently the dominant approach to mitigating biodiversity loss and environmental degradation, their effect on associated human communities remains poorly understood, and is intensely debated in conservation policy (Agrawal and Redford 2006, Andam et al. 2010). Using data from pre-, mid-, and post-implementation of integrated MPAs for villages with and without MPAs in North Sulawesi, I found that the integrated MPAs appeared to contribute to reducing the three key domains of poverty (security, opportunity and empowerment) during the implementation period, but these improvements tended not to continue to accrue after external support was withdrawn. The magnitude of the effects and timescale over which they manifested were mixed, but positive impacts spanned all poverty domains. I first discuss the temporal trends in impacts of the integrated MPAs on poverty, and then explore the impacts on each of the poverty domains.

Temporal trends in effects of integrated MPAs on poverty

Many conservation and development projects funded by multilateral development banks and international donors, such as the integrated MPAs in North Sulawesi, are designed with the expectation that outcomes will be achieved within the implementation period and that management activities will persist and related outcomes will continue to accrue after external support is withdrawn (Olsen and Christie 2000). A key finding from my study is that the integrated MPAs did appear to contribute to poverty alleviation, but these improvements occurred mostly during the implementation period and did not continue to accumulate after the large injection of funds and external expertise had been terminated. During the decade after implementation finished, management activities all but ceased and changes in poverty indicators in MPA villages either matched those of the control villages (e.g. environmental knowledge), were less than those of the control villages (e.g. empowerment indicators), or gains in poverty alleviation in MPA villages which occurred prior to 2002 were partially lost (e.g. fisheries dependence and wealth). Previous studies in the Philippines have also found that community-based fisheries management projects had positive social impacts within the implementation periods (e.g. Baticados and Agbayani 2000), and that the activities of such projects are commonly not sustained after external support is terminated (e.g. Pomeroy and Carlos 1997).

One likely reason for the lack of sustainability of projects, such as the integrated MPAs, is their short funding cycles (typically three to five years; Bottrill et al. 2011, Keppel et al. 2012), which do not reflect the time necessary to develop the attitudinal, behavioural, and socioeconomic changes required for stakeholders to continue undertaking conservation activities unaided (Blom et al. 2010). Indeed, a study of a conservation and development project in Nepal found that the focus of the project progressed from development, through a transitional period of institutional strengthening, towards conservation (Baral et al. 2007). The authors suggested that at least a decade is required to build capacity for, and interest in conservation amongst local people. Institutional strengthening is also critical to long-term success because projects are often hindered by lack of local government interest or parochial village politics (e.g. Christie 2004, Webb et al. 2004). I also found that respondents' perceptions of local government support for MPAs decreased significantly post-implementation, which many respondents attributed to issues unrelated to the MPAs. For example, in the village of Blongko, the current head of the village does not support the MPA because the leader of the MPA group is his political rival.

My findings about the temporal trends of effects of integrated MPAs on poverty have important implications for future design and evaluation of conservation and development initiatives. These results suggest that the short-term approach taken in many international donor-assisted protected area projects can be adequate to reduce poverty, but only within the implementation period. Further, these findings highlight that short-term projects are insufficient to motivate sustained management activities

required for continual achievement of development and conservation outcomes after external support is withdrawn. Other studies have similarly suggested that longer project timeframes are necessary to sustain funding, build capacity, and gain broad-based support for management activities from both villagers and local governments (e.g. Olsen and Christie 2000, Keppel et al. 2012). Related literature in resource management suggests that gaining ongoing support from local governments will also require institutional strengthening, for example by fostering linkages with higher levels of governance (Ostrom 1990). Further, conservation projects that rely on community support, such as those in this study, should seek to strengthen or maintain the institutional design principles (Ostrom 1990; e.g. graduated sanctions, clearly defined boundaries) thought to facilitate collective action outcomes such as improved livelihoods and compliance in fisheries co-management (Cinner et al. 2012). The time required to achieve project sustainability will depend on the context, with some authors suggesting one to several decades (e.g. Torell et al. 2004, Baral et al. 2007), while others advise that indefinite commitment is needed in some sites (e.g. Christie et al. 2009).

My findings also emphasise the importance of carrying out evaluations at multiple points in time after projects are initiated, a recommendation which has been advocated by a number of authors (e.g. Baral et al. 2007, Miteva et al. 2012). In particular, ex-post assessments are critical because results from evaluations within the project implementation phase can be different from ex-post evaluations, as I found. Despite this need, a recent review of co-managed fisheries found that ex-post assessments are rare (Evans et al. 2011).

Security domain

The impact of the integrated MPAs on the poverty domain of security differed between indicators, with positive impacts on livelihood indicators and negative impacts on perceived well-being. The reduction in fisheries dependence in MPA villages during the implementation period was not completely sustained after 2002. Achieving permanent livelihood shifts is difficult, as found by other conservation and development projects (e.g. Weber et al. 2011), because livelihood behaviour is affected by a multitude of socio-cultural factors (OECD 2007), such as family traditions (Terkla et al. 1988) and occupational attachment and identity (Pollnac et al. 2001, Marshall 2010). Further, broader-scale trends, such as the decline in seaweed farming due to disease in North Sulawesi over the same period (Pollnac et al. 2003), probably contributed to increased fisheries dependence in both control and MPA villages. The integrated MPAs were associated with greater livelihood diversity, probably through alternative livelihood programs, but there was an overall decline over time in the number of livelihoods per household member in both control and MPA villages. This decrease in livelihood diversity probably reflects broader macro-economic trends whereby increasing development and wealth promotes livelihood specialisation (Cinner and Bodin 2010, Hill et al. 2012).

The negative changes in perceived well-being that I found in MPA villages were at odds with changes in other indicators of poverty, such as wealth, that were positively affected by the integrated MPAs. Previous studies have found that perceived well-being has been both positively and negatively affected by conservation projects, including protected areas (e.g. Gockel and Gray 2009) and co-management (e.g. Evans et al. 2011). Respondents' sense of well-being was likely influenced by other factors affected by the integrated MPAs, such as conflict, which has sometimes been found to increase under community-based fisheries management in developing countries (e.g. Clarke and Jupiter 2010, Evans et al. 2011). While I did not have quantitative data on conflict (apart from that potentially arising from illegal fishing), my key informants recalled a number of issues related to the integrated MPAs which led to conflict, such as the misuse of project funds and confusion over property rights. For example, the village of Talise has an ongoing dispute with a neighbouring village, Kinabohutan, regarding the location of the MPA. Poaching by Kinabohutan residents as a result of this dispute continues, and led to at least two violent interactions between villagers during the implementation period (Pollnac et al. 2003). Another significant source of conflict reported by respondents was that few poachers were punished; in the village of Blongko, members of the MPA group staged a demonstration about this governance failure by fishing together in the MPA. This lack of enforcement of MPA rules is likely to be partially due to the limited ability of villagers to pursue prosecution of poachers under the village ordinance pertaining to the integrated MPAs, because the ordinance is not supported by any district or higher governance level legislation relating to prosecution of poachers. Thus to reduce the likelihood of conflict related to MPA management, it is critical that projects such as the integrated MPAs foster appropriate governance mechanisms, including nested governance systems, graduated sanctions, and context-appropriate mechanisms to resolve conflict (Ostrom 1990).

The negative effect of the integrated MPAs on well-being could also be due to respondents' expectations of project outcomes that were not realised. For example, many respondents mentioned they were told that establishing MPAs would bring tourism business to their villages, but this had not occurred. Exaggerating the benefits of such projects to stakeholders – which appears often to be the case in regards to tourism potential (e.g. Magome et al. 2000, Fabricius et al. 2001) – is counterproductive because it can lead to disillusionment and distrust. Thus, it is imperative to the success of such projects that stakeholders have realistic expectations of outcomes and related benefits, a recommendation made also by a recent evaluation of a terrestrial conservation and development project (Pelser et al. 2013).

Opportunity domain

The integrated MPAs initially promoted important aspects of the opportunity poverty domain but impacts did not continue to accrue post-implementation. Improvement in environmental knowledge is a principal outcome expected from integrated conservation and development projects, and some

evaluations have detected such changes (e.g. Leisher et al. 2012b). Although I found that the integrated MPAs improved environmental knowledge during the implementation period, increases in knowledge after 2002 (i.e. post-implementation) were comparatively much larger for both MPA and control villages. This suggests that although the project achieved some success in improving environmental knowledge, broader-scale factors, such as regional media awareness campaigns or growing national awareness of environmental issues, were likely to be more important in influencing people's understanding of social-ecological systems.

Wealth was positively affected by the integrated MPAs during the implementation period, a finding consistent with some recent evaluations of protected areas (e.g. Andam et al. 2010, Sims 2010) and fisheries co-management (e.g. Evans et al. 2011). Increases in wealth could be due to a number of project activities aimed at improving livelihoods and living conditions in general, such as farm productivity training, revolving funds for fishing gear, and construction to prevent floods. Improvements in household wealth could also relate to increased fisheries yield, which was perceived to be greater in MPA villages than control villages midway through the project.

Empowerment domain

The poverty domain of empowerment increased for both MPA and control villages from mid-MPA implementation until 2012. Increases in empowerment in MPA villages were either the same or significantly less than for control villages, depending on time period and empowerment indicator. This indicates that the integrated MPAs either had no effect or negatively impacted different components of empowerment. The positive changes in empowerment in all villages probably reflect the Indonesia-wide devolution of power to local government since the passing of the decentralisation laws (Law No. 22 and 25) in 1999, and their revisions in 2004 and 2008. This shift in governance has provided opportunities for local villages to participate in decision-making processes about natural resources (Siry 2011).

Two plausible explanations exist for the apparent lack of a positive effect of the integrated MPAs on empowerment. First, it could be an artefact of my sampling method. I have data on this poverty domain only from mid-project implementation, but improvements in empowerment could have already occurred during the initial years of implementation. Indeed, the level of all empowerment indicators was higher for MPA than control villages in 2000/2002. This is expected because many of the management activities that should build empowerment occurred in the initial years of implementation (i.e. 1997-2000). These activities included facilitating land tenure and various village ordinances concerning, for example, MPAs and associated management groups – activities that many respondents and key informants mentioned as foremost benefits of the project. The second explanation is that integrated MPAs did inhibit overall feelings of empowerment for many villagers. This could be partly because villagers are largely unable to pursue prosecution of violators of the

integrated MPAs, given that the related village ordinance is not supported by any higher governance level legislation relating to prosecution of poachers. Further, although common property management, such as the integrated MPAs, is often associated with shifts in property rights and governance towards local stakeholders (Ostrom 1990), reallocation of power might not always be equitably distributed and might provide opportunities for local elites to control resources (Béné et al. 2009, Glaser et al. 2010). Indeed, reviews of MPAs (Maliao et al. 2009, Mascia et al. 2010) and co-managed fisheries (Evans et al. 2011) have found both negative and positive changes in perceptions of empowerment in associated communities.

Critiques and caveats

Existing evaluations of the impacts of protected areas on people have tended to suffer two broad limitations, which I have endeavoured to overcome. First, evaluations have tended not to assess the full suite of social impacts that conservation initiatives are likely to have, instead often evaluating only one or very few impacts (Agrawal and Redford 2006, Carneiro 2011). Although my evaluation included 14 indicators of three domains of poverty, I was unable to consider some important aspects of poverty that could potentially be impacted by protected areas, such as power dynamics, which could have explained the observed negative changes in perceived well-being. Likewise, the only indicator of the human capital component I operationalised was environmental knowledge, yet there are other aspects of human capital that could potentially be affected by the integrated MPAs, such as livelihood skills acquired from alternative livelihood training sessions. Further, while I represented natural capital under the opportunity domain using perception data, given that stakeholders' perceptions of ecological condition can differ from that gathered using biological monitoring (Daw et al. 2011), it would be preferable to have had both perception and biological data to represent this poverty component. Nevertheless, my study highlights the inadequacy of using a single indicator (e.g. monetary-based indices) to evaluate social impacts because the impacts of the integrated MPAs differed between indicators.

The second common limitation of existing evaluations of protected areas is that the appropriate data are often lacking to overcome two important forms of bias that impede attribution: (1) confounding factors correlated with project and outcomes; and (2) selection bias, whereby project units are selected on the basis of characteristics that also affect outcomes (Ferraro 2009). I sought to overcome these biases by using longitudinal data for MPA villages and control villages which were coarsely matched according to key attributes of the MPA villages likely to affect outcomes of the integrated MPAs. This approach relies on the parallel trends assumption (Gertler et al. 2011): this is, in the absence of management, changes in poverty in MPA villages would be parallel to those in control villages. While my coarse matching approach sought to meet this assumption, it might have been better fulfilled if I had used statistical matching techniques (which my data would not allow); such techniques require

matching project and control units based on characteristics assumed to affect project participation and outcomes (Gertler et al. 2011). However, in reality these characteristics are often not observable or quantifiable, and change over time. A randomised experimental design is optimal for undertaking impact evaluation, but this technique has yet to be used in conservation evaluation because it is seldom feasible or ethical to randomly allocate conservation interventions (Miteva et al. 2012).

2.6 Conclusion

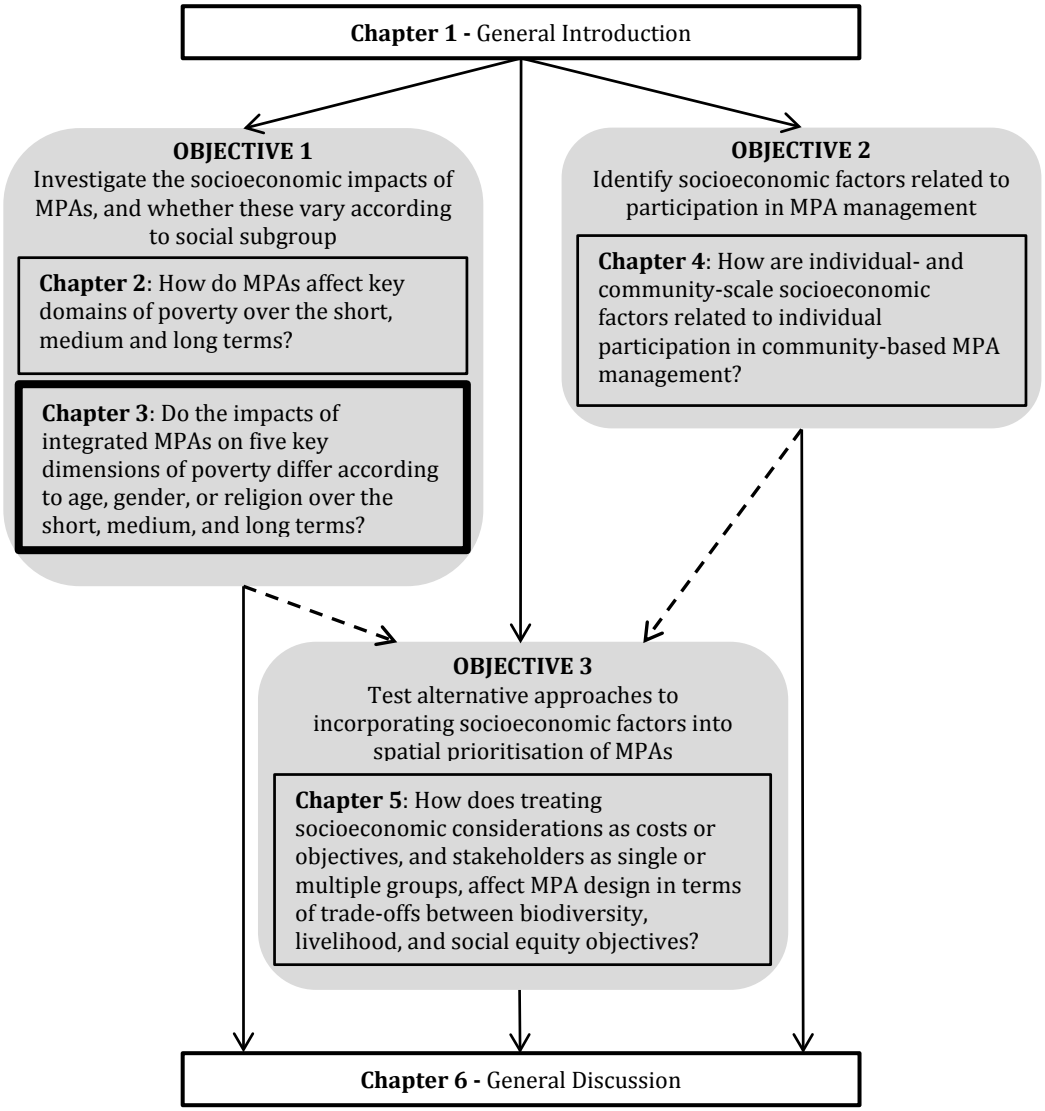
I provide empirical evidence that integrated MPAs can contribute to poverty alleviation. Within each poverty domain, the temporal persistence of effects was mixed, but positive impacts spanned all three domains. Many conservation and development projects, such as the integrated MPAs, are designed with the expectation that management activities will be sustained and related outcomes will continue to accumulate after external support is terminated (Olsen and Christie 2000). However, I found this was not the case. My results suggest that improvements occurred mostly during the five-year implementation period, after which management activities all but ceased and accumulation of outcomes did not continue. This finding questions the cost-effectiveness and efficiency of the short-term approach taken in many international donor-assisted protected area projects that integrate conservation and development (Bottrill et al. 2011, Keppel et al. 2012), and suggests that long-term conservation and development goals require long-term commitment from implementation agencies and donors. However, given that the effect of protected areas on people is likely to vary with project and context (Cinner et al. 2012), further studies such as mine are needed to understand how impacts of protected areas are likely to vary, and to learn to design projects to better achieve socioeconomic goals. Given the present dearth of research on the socioeconomic impacts of protected areas (Mascia et al. 2010, Ferraro et al. 2011), further research involving estimation of counterfactual outcomes is urgently needed. Additionally, my study highlights the importance of evaluating multiple outcomes at several points in time after projects are initiated (including ex-post assessments) because impacts are likely to vary over time and between poverty domains. Improving understanding of the social impacts of protected areas is of vital policy importance given that protected areas are one of the principal tools employed to mitigate the adverse effects of global environmental change, and that their prevalence and planned expansion requires vast investments of time and money. More importantly, as global protected area coverage increases, millions more people in developing countries will be affected. An understanding of the social impacts of protected areas is therefore crucial to designing projects that improve the well-being of people, and thus have a greater likelihood of achieving positive environmental outcomes.

Chapter 3

Heterogeneous socioeconomic impacts of MPAs

3 Heterogeneous socioeconomic impacts of MPAs

In chapter 3, I examine whether the socioeconomic impacts of MPAs differ according to social subgroup. This chapter contributes to improving our limited knowledge of the potential for heterogeneous socioeconomic impacts according to social subgroup, which is a key knowledge gap associated with the fourth limitation of how socioeconomic factors are treated in SCP listed in chapter 1; this is, that stakeholders tend to be represented as a single group. Chapter 3 is in review in *Philosophical Transactions of the Royal Society B*[6]. I developed the research question for this chapter, analysed data, and wrote the chapter. I designed, coordinated and conducted data collection (with research assistants) for the fourth sampling period (2012). Cinner and Pressey provided advice in the development of the research question and design of data collection, and assisted with structuring and editing the manuscript. Pollnac designed, coordinated and conducted data collection (with research assistants) for the first three sampling periods (i.e. 1997, 2000, 2002), and assisted with editing the manuscript.



[6]Gurney, G., R. Pressey, J. Cinner, and R. Pollnac. In review. Poverty and protected areas: evaluating a marine integrated conservation and development project for heterogeneous socioeconomic impacts. Invited submission to a special issue of the Philosophical Transactions of the Royal Society B.

3 Heterogeneous socioeconomic impacts of MPAs

3.1 Abstract

Despite the prevalence of protected areas, the evidence base for their impacts on people is weak and remains hotly contested in conservation policy. A key question in this debate is whether socioeconomic impacts vary according to social subgroup. Here, I assess whether the socioeconomic impacts of the integrated MPAs examined in chapter 2 differed according to age, gender or religion. Using data from pre-, mid-, and post-implementation of the integrated MPAs for control and project villages, I found little empirical evidence that impacts on five indicators of poverty differed according to social subgroup. Environmental knowledge was the only indicator for which I found heterogeneous impacts; over the medium and long terms, younger people and Muslims showed greater improvements compared to older people and Christians, respectively. My findings help elucidate the pathways through which the impacts of the integrated MPAs occurred, and may be used to improve targeting of management activities in the region. Given that social inequity can create conflict and impede poverty reduction, understanding how protected areas can differently affect people is critical to designing them to achieve socioeconomic and biological goals.

3.2 Introduction

An evidence-based approach to the designing and implementing conservation interventions is increasingly advocated as a means to improve their outcomes for both ecosystems and people (e.g. Pullin and Knight 2001, Ferraro and Pattanayak 2006). Evidence-based approaches involve reviewing the impacts of past management interventions and applying this knowledge to decision-making about future interventions. Despite enthusiasm to move beyond ‘conservation practice based on anecdote and myth’ (Sutherland et al. 2004), evidence-based conservation is severely impaired by a lack of knowledge, or evidence, of what conservation actions work, where they work, and why.

Most of the recent literature concerning evidence-based conservation and impact evaluation has focused on the biological realm (Fox et al. 2012a, Miteva et al. 2012), but understanding the impact of conservation interventions on associated human communities is central to designing interventions that are likely to meet biological objectives, let alone contribute to human well-being. Given the purpose of conservation interventions is generally to modify human behaviour, achieving biological gains rests largely on enlisting stakeholders’ support, which in turn is heavily influenced by their perceptions of the costs and benefits of management. Thus designing conservation interventions to benefit associated human communities is crucial for achieving success in biological terms. More importantly, managers have an ethical responsibility, at the very least, to ‘do no harm’ to stakeholders (CBD 2010). Given that people’s well-being is inextricably linked to their natural environment (MEA 2005) conservation

interventions have the potential to significantly impact people, both positively and negatively. For these reasons, the link between nature conservation and human well-being is increasingly emphasised in international policy (e.g. MEA 2005, CBD 2010) and reflected in conservation organisations' mandates and activities (Levine 2002, Bottrill et al. 2014). This integrated approach is implemented in a number of forms, including community-based conservation, co-management, and integrated conservation and development.

Despite its importance, the evidence base for socioeconomic impacts of protected areas, the cornerstone of many biodiversity interventions (MEA 2005), is weak (Miteva et al. 2012, Pullin et al. 2013). Reviews (e.g. Mascia et al. 2010, Bowler et al. 2011, Pullin et al. 2013) have found that studies concerning socioeconomic impacts of protected areas are dominated by qualitative case studies, and the few existing empirical studies tend not to focus on causal identification of impacts. Although qualitative studies are critical to understanding the impacts of protected areas on people (Homewood 2013), they must be accompanied by quantitative impact evaluation that can help untangle the effects of protected areas from the broader dynamics of the system (Clements et al. 2014). Confounding factors could include, for example, the typical non-random location of protected areas and macro-trends concurrent with establishment of protection (Gertler et al. 2011). Assessing causal effects requires estimation of the counterfactual (i.e. what would have happened in the absence of the intervention). Ideally, such an assessment would use longitudinal data from before and after an intervention for both control and intervention sites (Pullin et al. 2013). However, such data are very rare. For example, the review of Pullin et al. (2013) covering studies of the socioeconomic impacts of terrestrial protected areas, found only one study (Korhonen et al. 2004) that employed this evaluation design; similarly, to my knowledge, my study in chapter 2 is the first to use this kind of data to estimate the socioeconomic impacts of MPAs. Recently, a number of studies concerning the socioeconomic impacts of terrestrial protected areas have applied rigorous evaluation techniques to estimate the counterfactual (e.g. Andam et al. 2010, Sims 2010, Canavire-Bacarreza and Hanauer 2012). These studies have significantly advanced the evidence base for protected areas by providing relatively bias-free estimates of impacts. However, many of these studies adopted an aggregated approach to evaluation, focusing on net impacts determined via a single metric of poverty, over a single time period.

Empirical evidence of the heterogeneity of socioeconomic impacts of protected areas across space and time, and among dimensions of poverty and social subgroups is particularly weak, and has recently been highlighted as a research frontier (e.g. Fox et al. 2012a, Milner-Gulland et al. 2014). Understanding this heterogeneity is important for gaining a comprehensive picture of how protected areas affect people. More specifically, studies of heterogeneity can elucidate potential pathways through which impacts occur and highlight trade-offs that are likely to arise (e.g. among dimensions of poverty or social subgroups). In regards to temporal heterogeneity, although the impacts of

protected areas can be related to their duration of establishment (Russ and Alcala 2004, Baral et al. 2007), the few evaluations that use longitudinal data (Pullin et al. 2013) tend not to examine impacts over multiple time periods. As discussed in chapter 2, existing evaluations have also generally overlooked potential heterogeneity of impacts in relation to different dimensions of poverty, generally focussing on one or very few poverty metrics (Mascia et al. 2010, Carneiro 2011).

Understanding how protected areas can differently affect social subgroups is particularly critical because social inequity can create conflict (Christie 2004) and impede poverty reduction (Jones 2009), thus jeopardising social and biological goals (Persha and Andersson 2014). The prevailing approach of using aggregated data to assess mean impacts (Davies et al. 2013) can mask inequalities, and is likely due to the failure of much of conservation practice to adequately recognise and account for the heterogeneous social structure of communities (Agrawal and Gibson 1999, Waylen et al. 2013). Priorities for resource use and management, and capacities and powers to defend those priorities, are likely to differ according to social subgroups, defined by factors such as gender, age, ethnicity, religion, and occupation (Adhikari et al. 2004). Failing to recognise the heterogeneous nature of communities may thus result in inequitable distribution of costs and benefits. This may manifest as "elite capture", whereby local elites use their positions of power to protect and promote their interests at the expense of the marginalised (Béné et al. 2009). Although the potential for inequitable impacts of protected areas is commonly discussed in the literature (Christie 2004), empirical evidence is lacking. Existing literature relating to inequality and resource management often considers inequality as a driver of outcomes, rather than as an outcome of management (Persha and Andersson 2014). Meanwhile the literature on program evaluation has tended to focus on mean treatment effects (Ferraro and Hanauer 2011). To my knowledge, three studies employing impact evaluation techniques have assessed heterogeneity of socioeconomic impacts of (terrestrial) protected areas according to social subgroups, in relation to livelihood strategies (Clements and Milner-Gulland 2014), and level of poverty at the census tract scale (Ferraro and Hanauer 2011, Ferraro et al. 2011).

Given the planned expansion of protected areas (e.g. CBD 2010), there is a pressing need for further research on the socioeconomic impacts of protected areas to extend the depauperate evidence base. The current lack of evidence for how protected areas affect people, particularly in relation to heterogeneity of impacts, does little to resolve the polarised debate around whether protected areas benefit or negatively affect people (Homewood 2013); meanwhile, conservation policy decisions continue to be based on assumptions (Bottrill et al. 2014). To contribute to a sounder evidence base, I address the critical question of whether the socioeconomic impacts of protected areas vary according to social subgroup. Specifically, I provide empirical evidence of whether the socioeconomic impacts of the integrated MPAs examined in chapter 2 differed according to age, gender, or religion. Using data from pre-, mid-, and post-implementation for villages with and without MPAs, I ask "do the

impacts of integrated MPAs on five key dimensions of poverty differ according to age, gender, or religion over the short, medium, and long terms?"

3.3 Methods

Sampling and poverty indicators

I studied the same eight villages in North Sulawesi that I assessed in chapter 2 (see details of the integrated MPA project and sampling in chapter 2). I examined five indicators of poverty for heterogeneous impacts of the integrated MPAs; these were perceived well-being, environmental knowledge, wealth, fisheries dependence, and livelihood diversity (Table 2.1). I chose these indicators because they were found to be significantly affected by the integrated MPAs (chapter 2) and were measured at each of the four sampling times.

Social subgroups

The impacts of conservation and resource management are suggested to vary according to a range of social subgroups, including gender, religion, age, wealth, ethnicity, and occupation (Mascia and Claus 2009, Milner-Gulland et al. 2014). A key factor thought to influence the likelihood of heterogeneous impacts among social subgroups is whether participation in management activities and decision-making varies according to those subgroups (Agrawal and Gupta 2005, Torri 2013). Thus, I selected social subgroups based on the socioeconomic characteristics that Pollnac et al. (2003) found were related to participation in integrated MPA activities, namely, age, gender, and religion. I treated age as a dichotomous variable, whereby respondents were classed as 'younger' if their age was below the median age at baseline (33 years), and 'older' if it was 33 years and above. The most common religions in North Sulawesi are Christianity and Islam; all of my respondents described themselves as following one of these faiths.

Data analyses

To assess whether integrated MPAs significantly affected the poverty indicators, I followed the difference-in-difference method, which involves comparing changes in outcomes over time between impact and control groups (Gertler et al. 2011). The design involved testing for a significant interaction between three explanatory variables – time, presence of integrated MPAs and a social subgroup variable (either age, gender or religion) – on each of my poverty indicators (my response variables). A significant interaction between the three explanatory variables indicates that the effect of the integrated MPAs differed between the subgroup categories (e.g. between men and women). I tested for these three-way interaction effects over different time periods for each of the poverty indicators individually. The time periods assessed were 1997-2000, 1997-2002, and 1997- 2012, representing the short-, medium- and long-term impacts of the integrated MPAs, respectively. I used

only data from household heads for the models of fisheries dependence, wealth, and livelihood diversity, because these poverty indicators were measured at the household scale. My sample of female household heads was too small to examine whether the impacts on these poverty indicators differed between genders.

I tested for interaction effects using statistical models appropriate for the respective types of data. For perceived well-being and fisheries dependence (dichotomous categorical data) I used a generalised linear mixed model with a binomial distribution. For all other indicators (continuous data) I used a general linear mixed model. I set village a priori as a random factor to account for non-independence of data arising from repeated sampling within each village. I controlled for the subgroup variables that I was not testing for heterogeneous impacts using fixed factors; for example, for models testing for heterogeneous impacts according to gender (i.e. the three-way interaction included gender), I controlled for age and religion by specifying them as fixed factors. I used Bayesian estimation, with non-informative uniform priors, so the posterior estimates were informed by the data alone. I ran the Bayesian models with three parallel chains for 2,000,000 iterations, with a burn-in period of 500,000, and a thinning interval of 1,000, which generated 4,500 samples from the posterior distribution of each model parameter estimated. I used the parallel chains to check for convergence using the Gelman-Rubin diagnostic (Gelman and Rubin 1992). This test compares variance between and within several Markov chains run in parallel and with different initial points, and indicates convergence when the Gelman-Rubin diagnostic < 1.1. Chains were also observed to have mixed properly, which was also indicated by consistently low autocorrelation (< 0.2) between subsequent lags. The relevant assumptions were tested for each of the statistical models (e.g. normality and homogeneity of variances for linear mixed models).

I used standardised effect sizes to illustrate estimated differences between the changes in poverty indicators in the project and control villages within each social subgroup, which allowed me to compare across indicators based on different measures. I used Cohen's *d* effect statistic with a bias correction for all continuous poverty indicators analysed using general linear mixed models, and odds ratios for the remaining categorical indicators. All analyses were undertaken using R (3.02) and JAGS (3.4.0) statistics packages.

3.4 Results

I found little empirical evidence that the socioeconomic impacts of the integrated MPAs differed according to age, gender or religion, except in relation to environmental knowledge (Table 3.1, Figure 3.1).

My results suggest that the impact of the integrated MPAs on perceived well-being and environmental knowledge did not differ between men and women. Although it appeared that men's environmental

knowledge benefited more from the integrated MPAs than women's, and that the negative impact on women's perceived well-being was greater than for men's (Figure 3.1), I did not find strong evidence that impacts differed between genders (Table 3.1).

I did not find strong evidence that the impact of the integrated MPAs on the five dimensions of poverty differed by age, except in relation to environmental knowledge over the medium (i.e. 1997-2002) and long terms (i.e. 1997-2012; Table 3.1). My analysis suggests that younger people's environmental knowledge benefited from the integrated MPAs more than older people's (Figure 3.1). The impact of the integrated MPAs on household-scale indicators of poverty did not vary according to age of the head of household (Table 3.1); for both younger and older age groups, livelihood diversity and wealth were positively affected and fisheries dependence was negatively affected across the three time periods (Figure 3.1).

Differential impact of the integrated MPAs according to religion was not supported by strong evidence, except in relation to environmental knowledge over the medium and long terms (Table 3.1). The impact of the integrated MPAs on environmental knowledge was positive for both religious groups, although I found strong evidence that Muslims benefited more.

Table 3.1 Summary results of Bayesian hierarchical regressions that tested for an interaction between presence of integrated MPAs, time and social subgroup, for each poverty indicator over multiple time periods. Mean posterior estimates are bolded for interactions that are supported by strong evidence for an effect (i.e. where the 95% highest posterior density intervals does not intersect zero). Regressions included the social subgroup variables that I was not testing for heterogeneous effects as fixed factors; for example, for models testing for heterogeneous impacts according to gender (i.e. the three-way interaction included gender), I controlled for age and religion by specifying them as fixed factors.

Dimension of poverty	Social subgroup	Mean posterior estimates and 95% highest posterior density intervals for interactions between integrated MPAs, time and social subgroup		
		Time period		
		1997-2000	1997-2002	1997-2012
Perceived well-being				
	Gender	-0.02 (-1.01, 0.96)	-0.23 (-1.29, 0.81)	-0.07 (-1.13, 1.01)
	Age	-0.07 (-1.05, 0.87)	0.31 (-0.71, 1.35)	0.17 (-0.93, 1.26)
	Religion	0.67 (-0.65, 1.96)	-0.59 (-1.97, 0.74)	-0.26 (-1.64, 1.02)
Environmental knowledge				
	Gender	0.18 (-0.02, 0.39)	-0.09 (-0.31, 0.13)	-0.01 (-0.24, 0.22)
	Age	0.13 (-0.09, 0.33)	**0.27** (0.04, 0.49)	**0.25** (0.02, 0.52)
	Religion	0.22 (-0.05, 0.49)	**0.49** (0.21, 0.76)	**0.35** (0.07, 0.63)
Wealth				
	Age	0.27 (-0.36, 0.88)	0.31 (-0.35, 0.96)	0.29 (-0.38, 0.99)
	Religion	0.14 (-0.66, 0.94)	0.38 (-0.42, 1.17)	0.19 (-0.63, 0.99)
Fisheries dependence				
	Age	-0.09 (-1.44, 1.27)	0.07 (-1.38, 1.58)	-0.03 (-1.58, 1.47)
	Religion	-0.07 (-1.77, 1.79)	0.53 (-1.37, 2.50)	0.75 (-1.19, 2.65)
Livelihood diversity				
	Age	-0.02 (-0.96, 0.97)	0.11 (-0.97, 1.18)	-0.09 (-1.17, 1.03)
	Religion	0.47 (-0.78, 1.74)	1.18 (-0.12, 2.46)	0.99 (-0.32, 2.31)

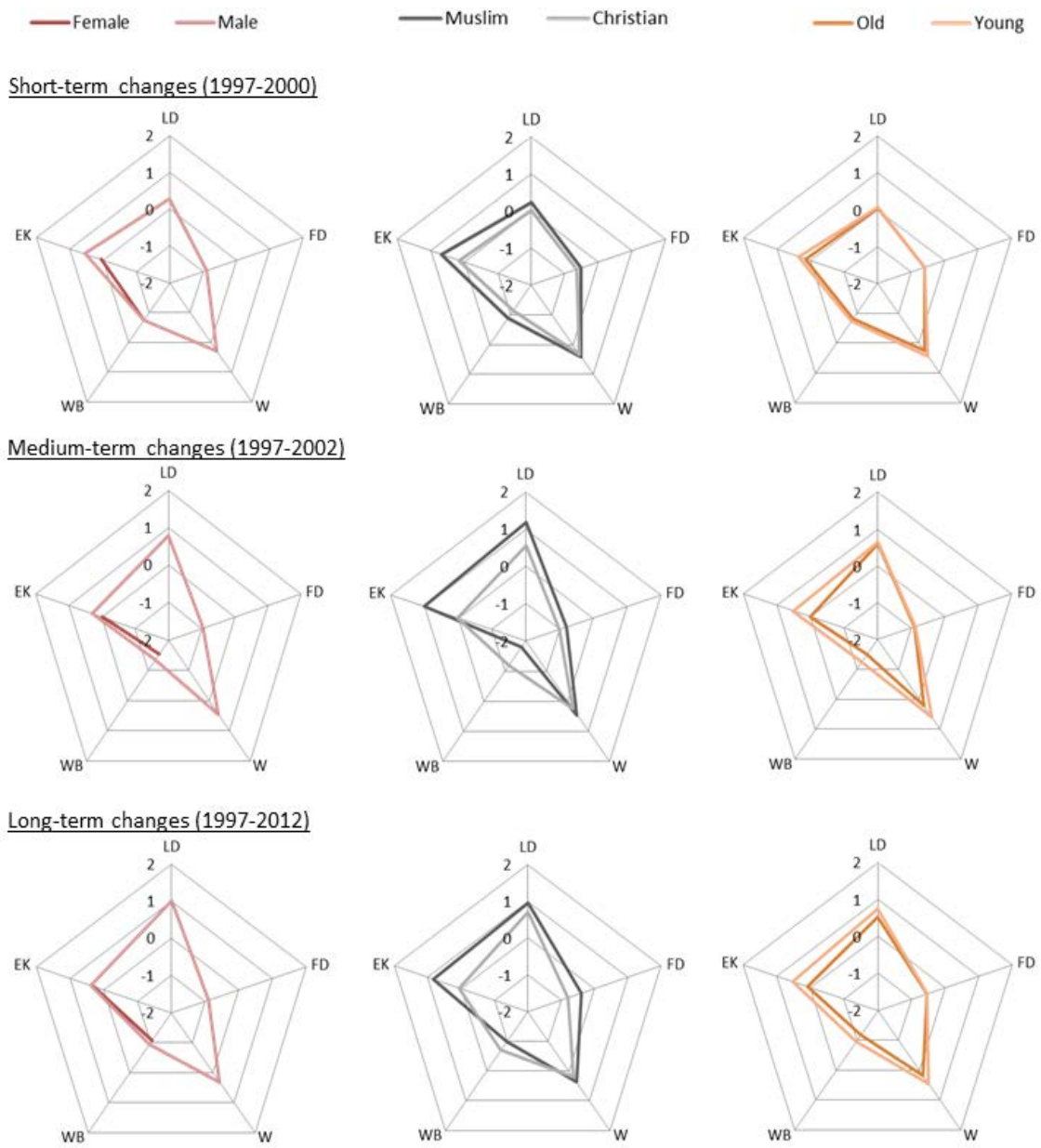


Figure 3.1 Estimated impacts over different time periods of the integrated MPAs on the five poverty indicators conditional on three social subgroups. The three social subgroups are defined by gender (red lines), religion (grey lines), and age (orange lines). The five axes of the spider diagram relate to the five poverty indicators as follows: LD = livelihood diversity, FD = fisheries dependence, W = wealth, WB =perceived well-being, and EK = environmental knowledge. Numbers on the rings of spider plots are effect sizes, which represent estimated differences between the change in poverty indicator in the project and control villages within each social subgroup. Effect sizes for fisheries dependence and perceived well-being were calculated using odds ratios, and are represented here on a logarithmic scale. The effect statistic used for the other indicators was Cohen's *d* with a bias correction. Sample of female household heads was too small to examine whether the impacts on fisheries dependence, wealth and livelihood diversity differed between genders (spider plots on left column). Age is represented here as a dichotomous variable, whereby respondents were classed as 'young' if their age was below the median value for age, and 'old' if their age was above the median value for age.

3.5 Discussion

Evidence-based policy decisions concerning the steadily increasing number of protected areas globally are inhibited by poor understanding of the impact of this conservation tool on associated human communities (Pullin et al. 2013, Milner-Gulland et al. 2014). A key aspect of this understanding is whether there is variation in the socioeconomic impacts of protected areas among different subgroups of the affected communities. Using data from pre-, mid-, and post-implementation of integrated MPAs for villages with and without MPAs in North Sulawesi, I found little empirical evidence that the impacts of the integrated MPAs on five dimensions of poverty differed according to age, gender, or religion. Environmental knowledge was the only indicator for which I found differential effects of the integrated MPAs; over the medium and long term, younger people and Muslims showed greater improvements compared to older people and Christians, respectively.

Differential impacts according to gender

I found no evidence that the impact of the integrated MPAs on perceived well-being and environmental knowledge differed along gender lines. I had expected the impacts of the integrated MPAs to differ by gender because participation in integrated MPA activities was considerably higher for men than for women; for example, 64% of the participants in the integrated MPA activities during 2000-2002 were men (Pollnac et al. 2003). Given that the negative impact of the integrated MPAs on perceived well-being was felt equally by both genders, it appears that these negative impacts were not related to individuals' participation. Dalton et al. (2012) also found that perceived impacts of MPAs were not related to participation in management but rather, the quality of the participatory process. As suggested in chapter 2, this negative impact could have arisen from conflict in relation to the project and unrealised expectations of project benefits, which are likely to act at the community scale. Although men made up the majority of participants in integrated-MPA activities overall, the proportion of men and women attending environmental education sessions was roughly equal (e.g. 51% of participants in environmental education during 2000-2002 were men; Pollnac et al. 2003). This is likely to explain the modest positive impact of the integrated MPAs on environmental knowledge for both genders.

The integrated MPAs could have differentially impacted men and women in respect to other dimensions of poverty for which I did not have data. This is likely because the majority of participants in integrated-MPA meetings, during which decisions about resource-use rules and management activities were made, were men (e.g. 71% of participants at meetings during 2000-2002 were men; Pollnac et al. 2003). Indeed many of my female respondents mentioned that they did not want to attend or speak up in integrated-MPA meetings because it was not their role to be involved in village decision-making, and that their male family members would represent the whole family. This was particularly the case in Muslim families, with women's roles tending to be more strictly defined to the

household sphere. Previous studies have highlighted how existing social norms defining women's behaviour and role have led to inequitable impacts of devolved resource management through women's interests not being adequately considered in male-dominated decision-making (e.g. Agarwal 2001). For example, resource restrictions can differentially affect livelihoods according to gender when women and men use different resources and these differences are not adequately considered in decision-making (e.g. Allendorf et al. 2006, Ogra 2008). My qualitative data suggest that such a situation occurred in the village of Blongko; female respondents mentioned that because they were not involved in decisions about placement of the MPA, access to the reef area used by women for gleaning was significantly restricted. To avoid potential inequitable impacts of resource management along gender lines, it is imperative that MPA projects, such as the one that I studied, initially conduct gender analyses to determine potential gendered use of resources, and identify existing norms regarding women's roles in decision-making. Even if women attend decision-making meetings, they may be unable or reluctant to make their concerns heard (Torri 2013), suggesting that their inclusion should be fostered through other means, such as women's groups or informal consultation.

Differential impacts by age

The impact of the integrated MPAs on the five dimensions of poverty did not differ by age, except in relation to environmental knowledge. Environmental knowledge of younger people showed large increases over the medium and long terms, compared to older people. Evaluations of environmental education associated with conservation projects in Malaysia (Ismail 2008) and Indonesia (Leisher et al. 2012b) also found that younger people were more likely to show positive changes in environmental knowledge and attitudes. Younger respondents are often more open to new knowledge and better able to absorb information provided by education activities (Jonsson 2005), perhaps in part because they have attended school more recently, and the education they received is more likely to align with that provided by the project. I also found differential impacts to environmental knowledge according to age over the long term (i.e. 1997-2012). Therefore, it appears that the positive impact on younger respondents' environmental knowledge during the implementation period (i.e. over the medium term) puts them in better stead to respond to and benefit from broader-scale factors that were responsible for increases in environmental knowledge in project and control villages after the project finished in 2002, as discussed in chapter 2.

I found no evidence that the impact of the integrated MPAs on household-scale indicators of poverty differed according to age of the head of household. Thus it appears that the livelihoods of households headed by younger or older people were equally affected by restrictions to fishing areas and integrated-MPA programs aimed at improving livelihoods and living conditions. However, households are not homogeneous, and intra-household variability in poverty can occur according to age and gender (Homewood 2013). Resource management can contribute to intra-household inequity

if, for example, age influences how and which resources people use (Coad et al. 2008). Elderly people may be less mobile and thus less able to cope with changes in access to resources; indeed Cinner et al. (2009) found that age influenced fishers' decisions to exit the fishery. Thus, variability in impacts of the integrated MPAs according to age could have been masked due to my examination of these factors at the household scale, suggesting that future socioeconomic impact evaluations should use individuals as the unit of analysis.

Differential impacts by religion

The impact of the integrated MPAs on the five dimensions of poverty did not differ according to religion, except in relation to environmental knowledge. While environmental knowledge of both religious groups increased over the three time periods, Muslims' environmental knowledge benefited more from the integrated MPAs in the medium and long term. This is probably because Muslims were more likely to participate in integrated-MPA activities (Pollnac et al. 2003). A number of my key informants suggested that integrated-MPA trainings related to marine-resource use and management, in particular, were more often attended by Muslims. Studies have highlighted how religious beliefs concerning nature can affect resource use and management, and thus the potential socioeconomic impacts of protected areas (e.g. Bhagwat et al. 2011). For example, establishment of a strictly protected area in Mongolia adversely affected residents for whom the area was important for religious practices (Dudley et al. 2005). However, in my study, differential participation in and impacts of the integrated MPAs according to religion are likely because Muslims are more fisheries dependent than Christians, rather than due to differences in religious outlooks. Muslims tend to live directly on the shoreline and are more reliant on fishing and other marine livelihoods (e.g. seaweed farming) than Christians, who tend to live further inland and practice farming. Thus, it is likely that Muslims' environmental knowledge benefited more from the integrated MPAs because the trainings and education activities were more relevant to them than to Christians, leading to higher rates of participation. Further, given Muslims' lives are more related to the sea than Christians', they could have had greater existing knowledge of the marine environment, enabling them to better absorb the new information provided through the integrated-MPA activities.

The impact of the integrated MPAs on household-scale indicators of poverty did not differ by the religion of the head of household. Although Muslims participated more in integrated-MPA activities overall (Pollnac et al. 2003), I found no strong evidence they received more of the benefits related to wealth and livelihood diversity. This could be in part because many of the integrated-MPA activities were focused on generating village-level benefits, such as building dykes to prevent flooding. Further, many of the integrated-MPA activities that were not focused on the marine environment, which my qualitative data suggests were less often attended by Muslims, were directly focused on strengthening livelihoods (e.g. facilitating land tenure and improving farming productivity). In contrast, activities

related to the marine environment, which made up the majority of the integrated-MPA activities, were more varied and included environmental education, MPA management training, and mangrove protection.

Critiques and caveats

The robustness of my results depends in part upon the extent to which my analyses addressed potential sources of bias. Two common forms of bias that affect impact evaluations are: (1) confounding factors correlated with the project and that affect outcomes; and (2) systematic differences between project and control units (aside from the project) that affect outcomes (Ferraro 2009). Most existing evaluations of socioeconomic impact are highly susceptible to these forms of bias because they tend to rely on comparisons of outcomes inside and outside protected areas for a single time period (e.g. Tobey and Torell 2006, de Sherbinin 2008), or track outcomes in protected area sites over time (e.g. Gjertsen 2005, Leisher et al. 2012b). The difference-in-difference design, which I used, is more robust to these forms of bias, because using data from project and control units over time accounts for time-invariant observable and unobservable factors that affect outcomes (Gertler et al. 2011). However, if the impact of these factors varies over time, they can undermine the underpinning assumption of difference-in-difference designs: the untestable parallel trends assumption, that in the absence of the project, changes in outcomes in project and control units are the same (Gertler et al. 2011).

The parallel trends assumption is likely to hold in my analysis in regards to bias associated with time-varying confounding factors. Given the spatial distribution of the control and project villages in four districts, it is unlikely that only MPA or the control villages were systematically affected by major factors affecting poverty status in North Sulawesi, such as the decimation of seaweed farming due to disease during the implementation period (Pollnac et al. 2003) or changes to political jurisdiction, with the division of the Minahasa regency in 2003. I sought to overcome bias associated with systematic differences between project and control sites at both the village and individual scale. I selected my control villages based on key factors that influence poverty status in North Sulawesi, the most important being fisheries dependence and distance to markets and roads. At the individual scale, my regression design controlled for age, gender and religion, characteristics thought to influence poverty and participation in the integrated MPAs. Other individual-scale factors that could have influenced poverty and participation in the integrated MPAs and have had a time-varying impact include baseline wealth, education, and fisheries dependence. In the case of fisheries dependence, given it was correlated with religion, controlling for baseline fisheries dependence would have helped to isolate the impact of religion. However, I was not able to explicitly control for these other factors that could have influenced poverty and participation in integrated MPAs in my regression because individual-scale panel data (i.e. surveying the same person over time) were not collected, and I could

not condition on post-baseline estimates of these factors because they were influenced by the integrated MPAs.

Regarding the robustness of my results, it is important to consider the precision of my estimates. Although my sample contained over 2,000 respondents, I had a low sample size at the village scale, and my analysis involved segmenting my data according to subgroups. Further, given my post hoc analysis of randomly-sampled data, my statistical design is unbalanced (i.e. different sample sizes for each combination of subgroup, time and project category). Low sample size can result in lack of precision, which can give rise to type I errors (finding an impact when there was in fact no impact) and type II errors (not finding an impact when there was in fact an impact). The width of the Bayesian 95% highest posterior density intervals indicates the precision of my estimates, with wider intervals indicating less precision. The highest posterior density intervals are fairly narrow for the three-way interactions for which I found an effect (i.e. does not intersect zero), indicating against the likelihood of a type I error. To increase precision in future impact evaluations of heterogeneous impacts, sampling should be designed to ensure adequate sample sizes through power analysis and stratified sampling.

3.6 Conclusion

My study is one of the first to provide empirical evidence of whether the socioeconomic impacts of protected areas vary according to social subgroups. I found little empirical evidence that the impacts of the integrated MPAs on five dimensions of poverty differed by gender, age, or religion, except in relation to environmental knowledge. My findings help elucidate some of the pathways through which the socioeconomic impacts of the integrated MPAs occurred, and may be used to improve targeting of management activities in the region. Given that the socioeconomic impacts of protected areas are likely to vary with project and context (Cinner et al. 2012), only through the accumulation of studies such as mine can we understand the heterogeneous impacts of protected areas, and learn to design projects to achieve social equity, and positive socioeconomic impacts more broadly. The current weak evidence base for the socioeconomic impacts of protected areas, particularly in relation to heterogeneous impacts according to social subgroups, demands further research in how protected areas affect people. To strengthen future evaluations of heterogeneous socioeconomic impacts of protected areas, monitoring should be designed for evaluation of heterogeneous impacts from the offset, rather than post hoc analyses such as mine. Such an approach could include collection of individual-scale panel data and targeted analyses, involving identifying appropriate subgroups for analysis through assessing the access mechanisms (e.g. social and institutional) that operate in that context to determine who benefits or is negatively affected by protected areas. Building the evidence base of potential differential impacts of protected areas according to social subgroup is critical given

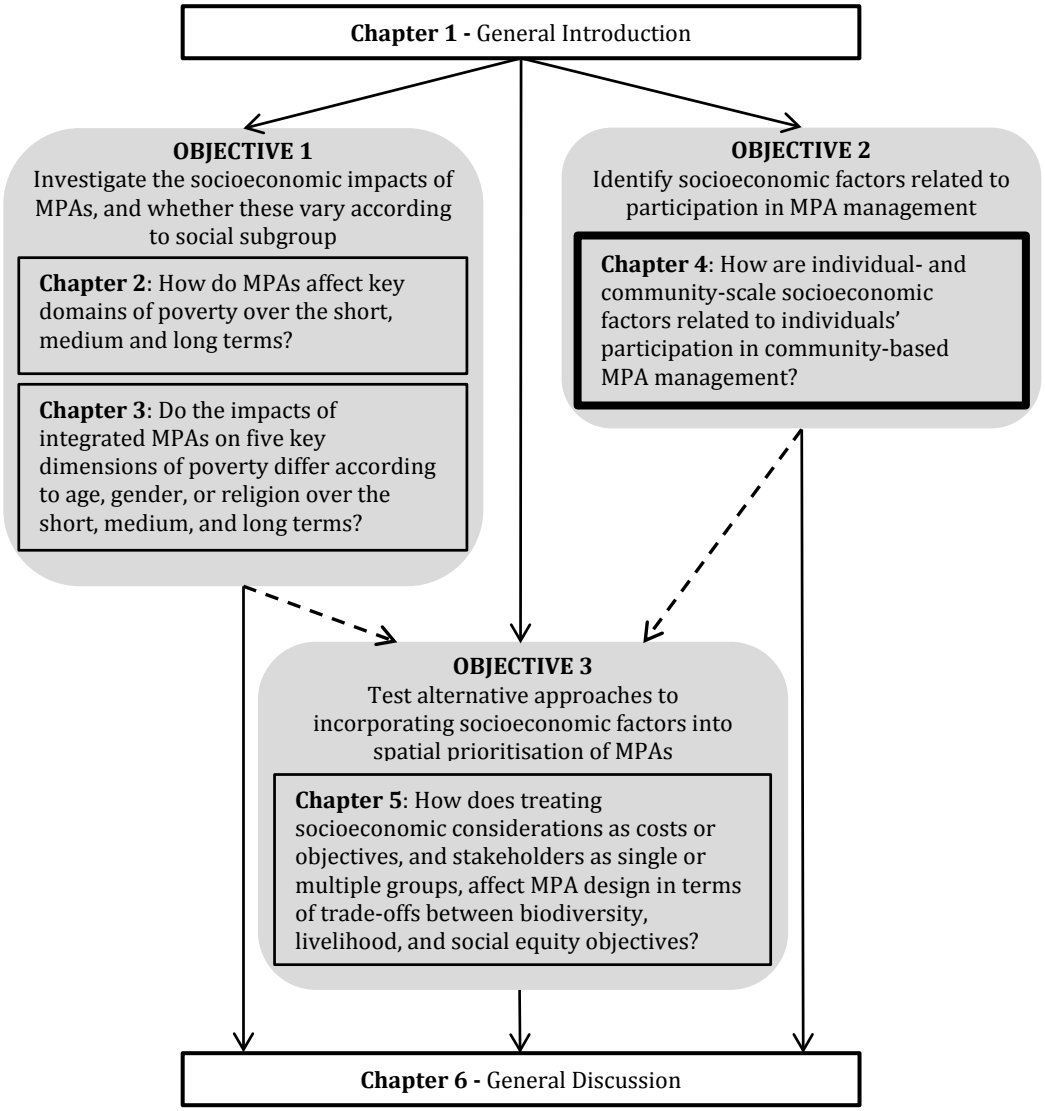
that social inequity can lead to conflict (Christie 2004) and impede poverty reduction (Jones 2009), thus jeopardising social and biological goals (Persha and Andersson 2014).

Chapter 4

Participation in community-based management of MPAs

4 Participation in community-based management of MPAs

In chapter 4, I examine how individual- and community-scale socioeconomic factors are related to individuals' participation in community-based MPA management. This chapter helps address our limited understanding of the factors affecting human behaviour associated with use and management of nature resources, which is a critical knowledge gap associated with the second limitation of how socioeconomic factors are treated in SCP listed in chapter 1; this is, that minimising costs is often assumed to maximise social support for protected areas. Chapter 4 is in review in *Environmental Science & Policy*[7]. I developed the research question for this chapter, designed, coordinated and conducted data collection (with research assistants), analysed data, and wrote the chapter. Cinner, Sartin, Ban and Pressey provided advice in the development of the research question and design of data collection, and assisted with structuring and editing the manuscript. Marshall provided advice on design of data collection, and assisted with editing of the manuscript. Prabuning assisted with coordinating and conducting data collection, and assisted with editing the manuscript.



[7]Gurney, G., J. Cinner, J. Sartin, N. Ban, R. Pressey, N. Marshall, and D. Prabuning. In review. Participation in devolved commons management: multiple-scale socioeconomic factors related to individual's participation in community-based management of marine protected areas in Indonesia. Environmental Science & Policy.

4 Participation in community-based management of MPAs

4.1 Abstract

Management of common-pool natural resources is commonly implemented under institutional models promoting devolved decision-making, such as co-management and community-based conservation. Although participation of local people is critical to the success of devolved commons management, few studies have empirically investigated how individuals' participation is related to socioeconomic factors that operate at multiple scales. Here, I evaluated how individual- and community-scale factors were related to participation in management of community-based MPAs in Indonesia. In addressing this aim, I drew on multiple bodies of literature on human behaviour from economics and social science, including the social-ecological systems framework from the literature on common-pool resources, the theory of planned behaviour from social psychology, and public goods games from behavioural economics. I found three key factors related to participation of local people: subjective norms, structural elements of social capital, and nested institutions. There was also suggestive evidence that participation was related to people's cooperative behavioural disposition, which I elicited using a public goods game. My findings highlight the importance of considering multiple-scale mechanisms other than those designed to appeal to self-interested concerns, such as regulations and material incentives, which are typically employed in devolved commons management to encourage participation of local people. Increased understanding of the factors related to participation could facilitate better targeting of investments aimed at encouraging cooperative management.

4.2 Introduction

During the 1990s, decentralisation reforms in many developing countries led to management of common-pool natural resources being widely implemented under institutional models promoting devolved decision-making and participation of local people, such as co-management and community-based conservation (Berkes 2010). These decentralisation reforms were in response to the poor performance of centralised management and involved the transfer of decision-making and financial responsibilities from a central authority to lower levels of government (Brugere 2006). Due to increasing recognition of local people's rights and ability to manage their local environment, decentralisation was often accompanied by devolution, the transfer of management rights and responsibilities to local non-governmental institutions, usually user groups, which have discretionary decision-making power (Jentoft et al. 1998, Berkes 2010). Devolved management of common-pool resources (hereafter 'devolved commons management') is now part of the discourse and practice of many governments (e.g. Chile; Gelcich et al. 2010) and non-government organisations (e.g. World Bank; Mansuri and Rao 2004). However, the success of devolved commons management in achieving

positive biological and socioeconomic impacts is highly variable (Brooks et al. 2012, Cinner et al. 2012).

Devolved commons management is underpinned by participation of local people (Berkes 2010), with the extent of participation shown repeatedly to be critical to achieving positive impacts (Pagdee et al. 2006, Brooks et al. 2012). For example, a study of devolved forest management in six countries found that local participation was related to improved biological and livelihood outcomes (Persha et al. 2011). Participation of local people, especially those who will be affected by management, is often viewed as an important mechanism to provide incentives to people to use their resources sustainably, because it improves perceived legitimacy of rules, and ensures that management is likely to better reflect the needs and preferences of local people (Larson and Soto 2008, Persha et al. 2011). Indeed, participation has been shown to improve knowledge and attitude towards community-based management of marine and terrestrial resources (Brooks et al. 2012). In addition, incorporating local knowledge of the social-ecological system through participation is thought to increase the effectiveness of management (Ostrom et al. 1993).

However, our understanding of the factors influencing local people's individual decisions relating to participation in devolved commons management is limited (Zanetell and Knuth 2004, Larson and Soto 2008, Tesfaye et al. 2012). Much of the existing empirical literature on decentralised and devolved approaches to commons management focuses on why outcomes are variable, and use local government administration or local communities as the unit of analysis (Andersson and Ostrom 2008, Chaigneau and Daw 2015). For example, studies have examined the factors influencing municipal governments to undertake management of common-pool resources (e.g. Larson 2002, Andersson 2003, 2006), and how management outcomes are related to biological and socioeconomic characteristics of local communities (e.g. Pollnac et al. 2001, Varughese and Ostrom 2001, Agrawal and Chhatre 2006). However, understanding participation of local people in devolved commons management also requires complementary analyses that use individuals as the unit of analysis. It must be noted that there is a considerable body of related literature that uses individuals as the unit of analysis to examine private landholder's decisions to adopt conservation practices (e.g. Pannell et al. 2006, Marshall 2009). However, landholders' management of private property generates largely private benefits, as opposed to management of common property, which is less excludable and generates largely public benefits.

Communities are heterogeneous social structures; individuals within communities have different interests and characteristics that will influence whether they will perform a particular behaviour (Agrawal and Gibson 1999, Botchway 2000), such as participating in devolved commons management. Analyses that use individuals as the unit of analysis allow examination of these important individual-scale factors that influence a person's behaviour. However, individuals'

behaviours are also shaped by the characteristics of the larger-scale context in which they are embedded (Altman et al. 1984, Ostrom 2007). Further, in the context of devolved commons management, it is useful to explicitly consider contextual factors (e.g. characteristics of the government system) because they represent potential levers for management. Thus, understanding what motivates individuals' decisions to participate in devolved commons management requires consideration of multiple-scale factors that reflect the nested hierarchical structure of the social-ecological system in which human behaviour is situated (Ostrom and Janssen 2004).

Empirical studies of environmental management behaviour, including the few on participation of local people in devolved commons management, tend to focus solely on the influence of individual-scale factors (Dolisca et al. 2009, Qin and Flint 2010). Individual-scale factors that have been found to be important in these studies include wealth (e.g. Agrawal and Gupta 2005), gender (e.g. Baral and Heinen 2007), and resource dependence (e.g. Dalton et al. 2012, Smith et al. 2012). While the importance of context is often recognised in studies of participation in devolved commons management and is described qualitatively, inclusion of multiple-scale characteristics in quantitative analyses is rare (but see Atmiş et al. 2007 and Dolisca et al. 2009). However, considering all of the potential influencing factors in a single analysis offers the advantage of providing insights into the relative magnitude and importance of those variables (Goldthorpe 1997, Agrawal and Chhatre 2006).

Given the prevalence of devolved commons management and the importance of participation of local people for success, understanding the factors influencing participation is of crucial scientific and policy importance. To this end, I examine the factors related to individual participation of local people in management of MPAs, a primary tool employed in devolved management of marine common-pool resources. Of the few studies that have quantitatively assessed how individual's participation is related to socioeconomic factors, to my knowledge this study is the first to do so in regards to factors that operate at multiple scales in a marine context. Using data from 13 MPAs in Indonesia, I ask "how are community- and individual-scale factors related to individual participation of local people in community-based MPA management?"

Conceptual approach

I take an interdisciplinary approach to investigating the factors related to local participation in devolved commons management by drawing on multiple bodies of empirical and theoretical literature on human behaviour developed in economics and social science; specifically I employ the social-ecological systems framework (Ostrom 2007) from the literature on common-pool resources, the theory of planned behaviour (Ajzen 1991) from social psychology, and public goods games (e.g. Aswani et al. 2013) from behavioural economics.

The social-ecological systems framework, which arose from the literature on common-pool resources and stems from political science, focuses on how commons-related behaviour and social-ecological outcomes are shaped, with a particular focus on the role of institutions, both formal (e.g. laws) and informal (e.g. norms; Ostrom 1990, Poteete et al. 2010). The multitier framework depicts elements of the social-ecological system operating at multiple scales that are thought to influence outcomes in situations involving common-pool resources (Ostrom 2007). Four core subsystems are described: the resource system (e.g. forest); resource units (e.g. trees); actors (e.g. resource users); and the governance system. The 'action situation', around which the framework is orientated, details actors' interactions or behaviour, and social-ecological outcomes. Each of these subsystems is composed of second-tier variables that may be drawn upon to assess specific social-ecological outcomes and behaviours, such as participation in management. Given the framework emphasis on the hierarchical structures of the social-ecological system in which behaviour is situated, I employ it to structure my analysis and draw on the second-tier variables to guide my choice of factors to examine. However, given a number of the second-tier variables describing the actor subsystem are at the community scale (e.g. number of actors), there is room to add individual-scale variables to the framework. Indeed, the second-tier variables are particularly salient to studying the conditions that facilitate communities (rather than individuals) to sustainably harvest and manage common-pool resources (Basurto et al. 2013), and are based on the existing literature on common-pool resources, which tends to use communities as the unit of analysis (Chaigneau and Daw 2015). In this literature there are a small number of studies that have empirically examined individuals' participation in devolved commons management (e.g. Agrawal and Gupta 2005), but these have focused on terrestrial resources. Therefore, to further investigate the cognitive facets of the actor system, I draw on social psychology and behavioural economics.

The theory of planned behaviour is the most commonly applied behaviour model in social psychology (St John et al. 2010), providing guidance on individuals' cognitive decision-making processes. It suggests that the likelihood of an individual behaving in a certain way can be predicted from his or her attitudes, subjective norms, and perceived control towards that behaviour. Attitudes are people's perceptions of the positive and negative consequences to them of undertaking a specific behaviour, while subjective norms are perceived societal expectations to undertake a behaviour. The third construct of the theory of planned behaviour, perceptions of control towards the behaviour, refers to the people's beliefs about whether they have the skills or resources necessary to undertake the behaviour. Given that reviews have found that the theory generally explains behaviour incompletely (e.g. Sutton 1998, Armitage and Conner 2001), numerous authors have suggested additional factors be added to it, including both cognitive and contextual considerations (St John et al. 2010). Recently, there have been calls to increase the relatively few applications of this theory to conservation-related behaviour (St John et al. 2013). Further, a number of studies have highlighted the need for studies on

the relationship between attitudes, beliefs, and behaviour in relation to MPAs in particular (NOAA 2005, Pomeroy et al. 2005).

Public goods games are one of a number of experimental games that are used in behavioural economics to investigate human behaviour. These games have had some application to social dilemmas (i.e. situations where group outcomes conflict with individual interests) associated with common-pool resources (e.g. Ostrom et al. 1994, Castillo et al. 2011). Given that cooperation is central to understanding behaviour in a social dilemma (Poteete et al. 2010), I assess individuals' cooperative behavioural disposition using a public goods game. MPA management is in principle a public good because it is non-rivalrous (i.e. it affects people whether or not they participate), and non-excludable (i.e. participation generally does not preclude further participation); thus a public goods game can reflect the social dilemma related to MPA management. Recently, experimental economic games have begun to be played in the field rather than in laboratories, catalysing interest in whether gaming and real-world (external) behaviour is consistent (St John et al. 2013). To date, studies that have used games to study commons-related behaviour have tended to apply them to harvesting (e.g. Prediger et al. 2011, Gelcich et al. 2013), which requires a common-pool resource game, rather than participation in management (but see Rustagi et al. 2010, Aswani et al. 2013). Further, very few studies have assessed the external validity of games in the context of common-pool resources (Vollan and Ostrom 2010, Anderies et al. 2011); to my knowledge, my study is the first to do so in relation to a public goods game applied to management of marine common-pool resources. Using a public goods game not only allows me to assess people's cooperative behavioural disposition, but to test the game's external validity, providing insights into whether MPA management is considered a social dilemma in relation to a public good.

4.3 Methods

Study sites and sampling

I studied 13 coastal communities on the islands of Sulawesi and Bali, Indonesia (Figure 4.1). As described in chapter 1, governance of Indonesia's coastal zone was decentralised to local and provincial governments under several regulations that support devolved coastal management and provide a framework for coordination of coastal planning and management. The studied communities were selected primarily because each manages a small community-based MPA, and the variation in level of participation within and between communities was known to be sufficient to address my research question. The MPAs were established with support from external institutions, primarily non-government organisations (NGOs). Support from these organisations presently differs between communities.

I collected data from 264 respondents using surveys (see Appendix 4 for survey) and an experimental economic game. Respondents were randomly selected from a list of MPA-management participants that I compiled based on information given by key marine-resource users and leaders in government and MPA management. Those included on the list had to have participated in management within the past two years. All of my respondents were men because women tended not to be involved in MPA management. To aid understanding of the drivers of local participation and to triangulate results, I also conducted semi-structured interviews with key informants (see Appendix 5 for survey guide), including leaders in government, religion, and MPA management.

I developed a conceptual framework for assessing the multiple-scale factors related to participation of local people in MPA management by drawing primarily on the theory of planned behaviour and the social-ecological systems framework (Table 4.1). I operationalised my conceptual framework, which includes the key elements from the theory of planned behaviour and the governance and actor subsystems from the social-ecological systems framework, with 14 individual- and 5 community-scale factors expected to influence participation (Table 4.1). I did not include the two resource subsystems from the social-ecological systems framework, because the resource system (i.e. coral reef) and the resource units (i.e. reef fish) were the same for all communities in my study. While the social-ecological systems framework identifies a large number of second-tier variables that could potentially affect commons-related behaviour, it is not intended that scholars use the entire suite; as noted by Ostrom (2010) “there is no way that one can analyse the entire spaghetti plate of variables that have been identified”. Therefore, I selected my variables based on their likely relevance to the context, identified through my knowledge of the area (and that of my collaborators) and existing literature on common-pool resources and MPA management. In particular, the variables that I assessed for the governance subsystem were informed by Ostrom’s (1990) eight design principles for devolved commons management. Further, to guide my choice of cognitive facets of the actor subsystem, I drew on the behavioural theory of human action (Poteete et al. 2010), which emphasises the importance of trust, reciprocity, and cooperation for explaining behaviour in a social dilemma.

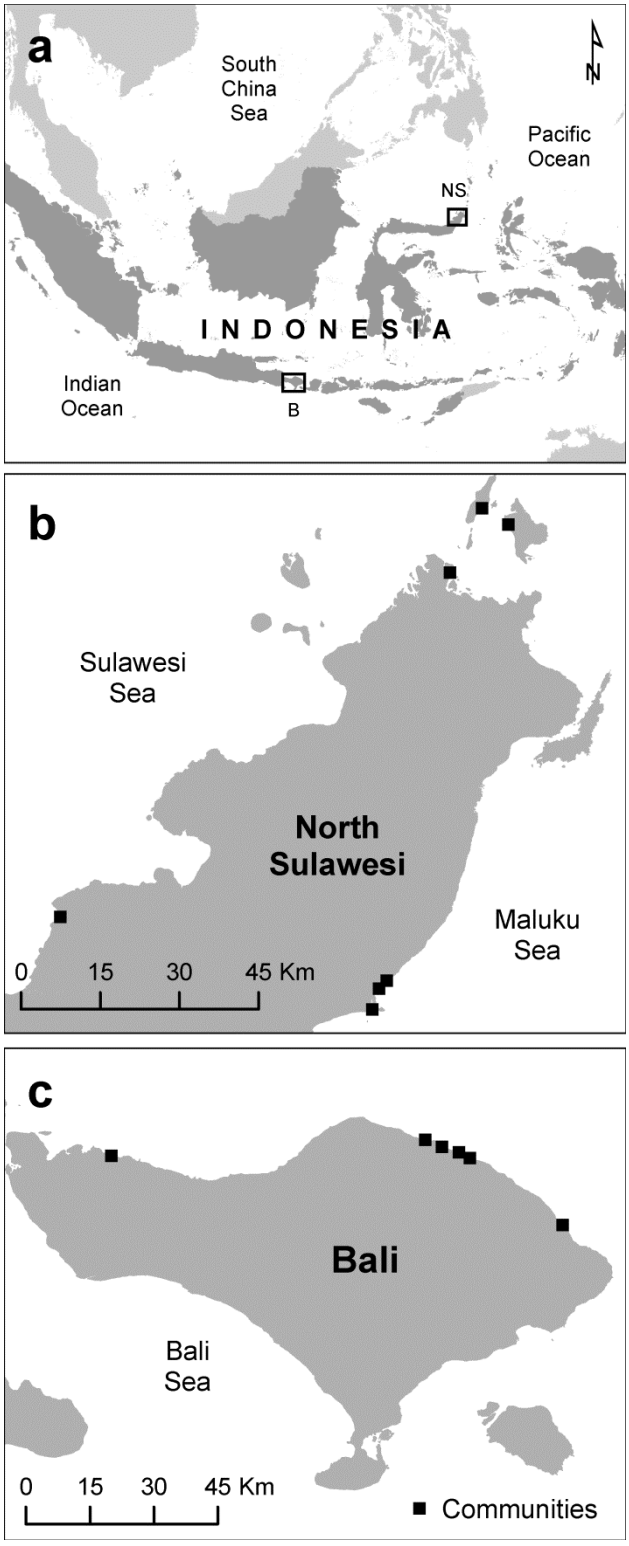


Figure 4.1 Locations of study communities with small community-based MPAs in North Sulawesi and Bali, Indonesia. (a) General location of the two study regions in Indonesia; (b) the seven studied coastal communities in North Sulawesi; and (c) the six studied coastal communities in Bali.

Table 4.1 Descriptions of the dependent variable (participation in MPA management) and covariates (individual- and community-scale factors) thought to be related to participation. Shaded covariates are community-scale factors; others are at the individual scale.

	Variable	Description
Theory of planned behaviour		
Attitudes		
	Perceived benefit of participation in MPA management	4-point scale reflecting perceived benefit of participating in MPA management
Subjective norms		
	Perceived societal expectation to participate in MPA management	Additive index of level of perceived encouragement to participate in MPA management from friends and family, community heads and religious leaders (4-point scale for each of the three groups of people)
Behavioural control		
	Perceived barriers to participating in MPA management	Number of perceived barriers to participating in MPA management
Social-ecological systems framework		
Interactions		
	Participation in MPA management	Additive score of three facets of participation: (1) level of decision-making in relation to MPA management (3-point score); (2) number of management activities participated in (e.g. participating in training, attending MPA meetings, monitoring for illegal fishers); and (3) frequency of participation (number of times during previous six months). Variables were converted into z-scores prior to summing, allowing equal weighting.
Governance subsystem		
Operational rules	Nested institutions	Whether the MPA management group was assisted by external institutions regularly (i.e. > 2 times/year)
	Graduated sanctions	Whether sanctions increase with multiple offences
	Clearly defined boundaries	Whether there is clear delineation of the MPA
Actor subsystem		
Number of users	Population	Number of people living in the community
History of use	Age of MPA management group	Number of years since the MPA management group was established
Leadership/ entrepreneurship	Trust in leader	Additive index of level of trust in government, religious and MPA leaders (5-point scale for each of the three groups of people)
Knowledge of social-ecological systems	Environmental knowledge	Additive score based on responses to eight statements concerning the relationship between coastal resources and human activities (2-point scale for each statement; Appendix 1, Text A1.1)
Importance of resource	Fisheries dependence	Whether fishing is the primary livelihood for the respondent

Table 4.1 continued from previous page

	Variable	Description
Social-ecological systems framework		
Socioeconomic attributes of users	Wealth	Principal component score based on the type of wall, floor, and window, and the presence or absence of a fan, piped water, refrigerator, satellite dish, television and modern stove (Appendix 2, Table A2.1)
	Education	Number of years of formal education
	Age	Age in number of years
Norms/social capital	Trust in community	5-point scale reflecting level of trust in other community members
	Reciprocity	3-point scale from giving and receiving favours from other community members (0 = neither gives or receives favours, 1 = gives or receives favours, 2= gives and receives favours)
	Involvement in community groups	Number of community groups (other than the MPA management group) that the respondent is involved in
	Involvement in decision-making	3-point scale reflecting level of involvement in general (i.e. not related to MPA management) decision-making in the community (not involved, passive, active)
	Cooperative behavioural disposition	8-point scale reflecting contribution in public goods game

To capture the multidimensional nature of individuals' participation in MPA management, my dependent variable was a composite score of three key facets of participation: (1) level of decision-making in MPA management (Appendix 2, Table A2.2); (2) number of management activities (e.g. participating in training, attending MPA meetings, monitoring for illegal fishers) the respondent participated in (Appendix 2, Table A2.3); and (3) frequency of participation (i.e. number of times during the previous six months; Appendix 2, Table A2.4).

To elucidate cooperative behavioural disposition, I used a one-shot public goods game, which essentially involved giving participants a sum of money that they could either keep or invest fully or partly in a public good, with their payoff at the end of the game depending on the actions of the players in their group (Appendix 2, Text A2.1).

Data analyses

To assess how factors were related to participation of local people in MPA management, I used a Bayesian hierarchical model implemented as a linear mixed model, in which community was set a priori as a random factor to account for non-independence of data arising from repeated sampling

within each community. Prior to the Bayesian analysis, covariates were checked for collinearity by calculating correlation coefficients and variance inflation factors (VIF; Logan 2010). Pearson correlations were calculated between numeric variables, polyserial correlations between numeric and ordinal variables, and polychoric correlations between ordinal variables. For pairs of covariates that had a correlation coefficient > 0.6, I removed the covariates which had the highest VIF. Subsequently I also removed covariates that had a VIF > 3. The covariates removed were graduated sanctions, clear boundaries and age of organisation. Subsequently, all covariates were retained in my model, because I intended to assess the relative influence of various factors in influencing people's likelihood to participate in management, rather than derive a predictive model. I used non-informative uniform priors for all parameters because I did not have a priori information about parameter distributions, so the posterior estimates were informed by the data alone. The model was run for 2,000,000 iterations, with a burn-in period of 1,000,000 and a thinning interval of 1,000, which generated 1,000 samples from the posterior distribution of each model parameter estimated. I ran three parallel chains to check for convergence using the Gelman-Rubin diagnostic (Gelman and Rubin 1992). Chains were also observed to have mixed properly, which was also indicated by consistently low autocorrelation (< 0.2) between subsequent lags. All analyses were undertaken using R (3.02) and JAGS (3.4.0) statistics packages.

4.4 Results

The level of participation in MPA management differed between communities (Figure 4.2A), with inter-community variation accounting for 42% of the total variance. Communities in Bali tended to have higher levels of participation than those in Sulawesi, although there was variation within regions.

There was strong evidence (i.e. where a parameter's 95% highest posterior density intervals does not intersect zero) for the role of both individual- and community-scale factors in individuals' participation in MPA management (Figure 4.2B). At the individual scale, participation was more extensive if perceived expectation to participate from family, friends, and local religious and government leaders (i.e. subjective norms) was high. Two elements of social capital, namely membership in community organisations and involvement in decision-making, were also related to participation in MPA management. My analysis suggests that only those who nominated their involvement in decision-making as active, not passive, participated more extensively. At the community scale, participation was more extensive if the MPA management group was supported by external institutions (nested institutions). For two of the covariates, namely age and cooperative behavioural disposition, there was suggestive evidence of an effect (i.e. where 80% to 94% of the posterior distribution was positive or negative). The results suggest that participation was more extensive when people were older and were more cooperative, as indexed by the public goods game.

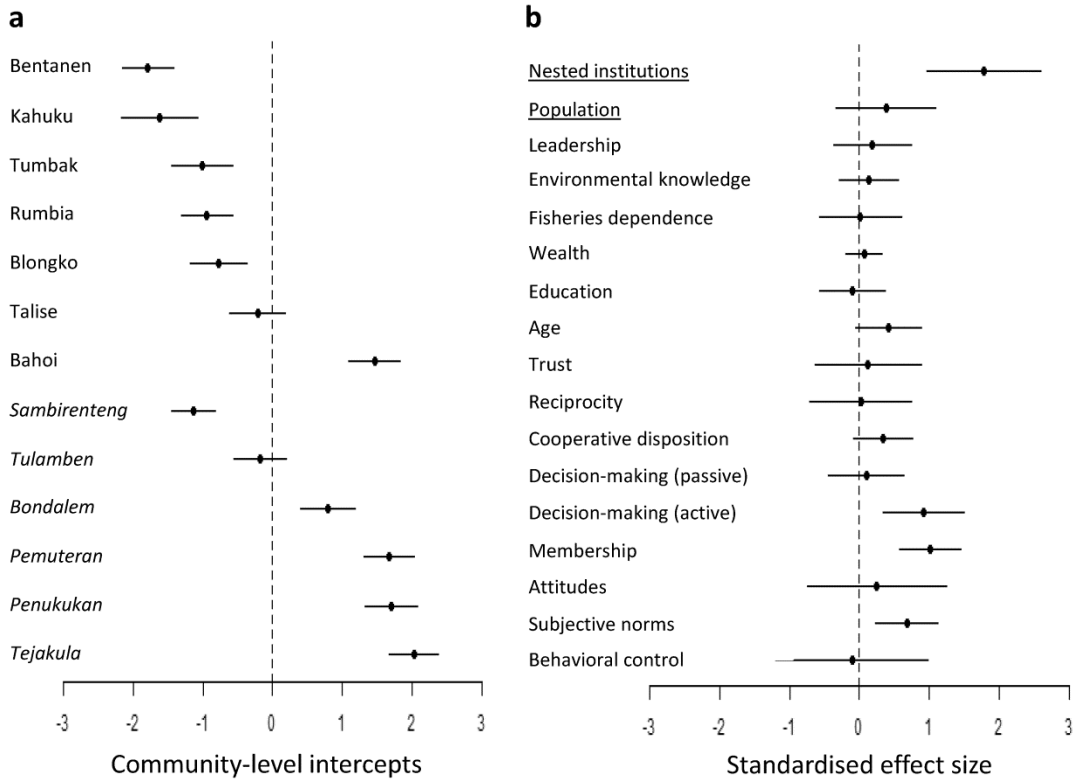


Figure 4.2 Variation in participation between communities, and relationship of multiple-scale covariates with participation. Mean posterior estimates (dots) and 95% highest posterior density intervals (lines) for community-level intercepts (a) and multiple-scale covariates (b) from Bayesian hierarchical model of participation in MPA management. Communities that are italicised in (a) were located in Bali, the other communities were located in North Sulawesi. Covariates that are underlined in (b) are at the community scale, the other covariates are at the individual scale. Note that three covariates (i.e. age of organisation, clearly defined boundaries, and graduated sanctions) were removed prior to the final analysis because they were collinear with other community-level covariates (i.e. nested institution and population) and had higher variance inflation factors.

4.5 Discussion

Although devolved commons management is employed globally, we have limited understanding of the factors related to local people's participation behaviour, a crucial element for success. To this end, I assessed how multiple-scale factors were related to individuals' participation in MPA management. The key factors related to participation in my analysis were: subjective norms, a component of the theory of planned behaviour; and nested institutions and two elements of social capital, which are components of the social-ecological systems framework. There was also suggestive evidence that participation was related to age and cooperative behavioural disposition, which I elicited using a public goods game from behavioural economics.

Subjective norms

People's perception of societal expectation (i.e. subjective norms) in regards to participation in MPA management was an important factor driving their participation behaviour; those that perceived encouragement to participate from peers and community leaders were more likely to participate. Although less attention has been given to subjective norms than to attitudes in the conservation literature (St John et al. 2010), previous studies have highlighted the importance of subjective norms in determining behaviour in relation to natural resource management, such as abiding to boating speed limits in conservation areas (Aipanjiguly et al. 2003) and involvement in planting trees (Zubair and Garforth 2006).

Subjective norms were important in my study likely because of strong motivations to comply with the expectations of families and community leaders. Indonesian society is orientated around family and is hierarchical, with respect shown to those with age, position, and status. Indeed, Ajzen (1991) specifies that motivation to comply is an important component of subjective norms. However, I did not include a measure of individuals' motivation to comply with social norms in my quantitative analysis because I was not confident about measuring it reliably using my survey instruments.

In those communities where perceived societal expectation to participate in MPA management was high, NGOs worked closely with government and religious leaders to gain their support. For example, in several communities with the most participation, located in Bali, NGOs have strong links with the local Balinese Hindu religious leaders. The MPA opening ceremonies in these communities included a religious blessing, and the local Balinese Hindu religious leaders actively promoted the MPAs, even through local radio. Given nature is revered in Balinese Hinduism, many existing religious norms in Bali are likely to be conducive to natural resource management. Thus, my study highlights the importance of identifying and working within existing norms and institutions. This approach, paired with close involvement of influential people within communities in designing devolved commons management, could increase the legitimacy of management and facilitate participation.

Social capital

Two elements of social capital, namely membership in community organisations and active decision-making, were positively associated with individuals' participation in MPA management. These elements represent structural components of social capital suggested to facilitate the cognitive components (e.g. shared norms, trust, and reciprocity) through providing a venue for repeated interactions and reinforcement of norms (Uphoff 1993). Social capital is suggested to be critical to the success of devolved commons management (Pretty 2003), such as co-management of fisheries (Grafton 2005), because it lowers the transaction costs of working together, thus increasing the likelihood of participation.

Given that, apart from subjective norms, the cognitive elements of social capital were neither collinear with structural social capital nor related to participation, other mechanisms could be shaping the relationship between structural social capital and participation. One alternative explanation is elite control, whereby local political and social elites are better equipped and positioned to participate in management (Dasgupta and Beard 2007). Indeed, I found that only people who were involved actively in decision-making (likely the political and social elites) were more extensively involved in management. This possible elite control could have led to elite capture of benefits, to which devolved commons management is vulnerable (Béné et al. 2009, Fabinyi et al. 2010). Thus, my results suggest that organisations facilitating devolved commons management should actively promote representative community participation, for example, by providing explicit opportunities for non-elites to be involved in decision-making and building their skills required for those positions.

Nested institutions

Participation of local people in MPA management was more extensive if institutions were nested, specifically if their associated MPA management group received external support from NGOs and communicated frequently with them. The important role of nested governance institutions is widely recognised, especially since Ostrom (1990) specified nested institutions as one of the key eight institutional design principles for successful devolved commons management. While this principle is often interpreted as referring to vertical linkages with government institutions, my study supports the wider interpretation that includes linkages with other external institutions such as NGOs, academia and other community groups (e.g. Cox et al. 2010, Cinner et al. 2012). These non-government institutions often assist and are involved with "appropriation, provision, monitoring, enforcement, conflict resolution, and governance activities" (Ostrom 1990), as specified in the design principle relating to nested intuitions. For example, support provided by the NGOs in my study sites was tailored to the needs of the communities and included: (1) providing scientific, legislative, and other information; (2) training in monitoring, ecotourism, and writing grant applications; and (3) facilitating dialog with government, local businesses, and other communities, including for collaboration, monitoring and conflict resolution. These benefits came with little material support from NGOs. Although all the MPAs that I studied were established with external support, the communities with the least participation were not considered nested institutions because they had little or no ongoing contact with external organisations. These results suggest ongoing external support is critical to local participation and the success of devolved commons management, and thus question the short-term approach often taken in internationally-funded devolved commons management (Keppel et al. 2012).

Cooperation

There was suggestive evidence that individuals' participation was positively related to cooperative behavioural disposition, as indexed by the public goods game. There are two potential reasons why

this factor was not more strongly related to participation. First, behaviour in the game could have lacked external validity. Economic games are necessarily highly simplified models of real-world decision-making, allowing disaggregation of the social-ecological system into manageable components for analysis. Results from the few studies of the external validity of economic games are mixed (Anderies et al. 2011), with some finding correspondence between gaming and real-world behaviour (e.g. Rustagi et al. 2010) and others not (e.g. Gurven and Winking 2008).

The second potential explanation for the lack of a strong relationship between cooperation and participation is that participation in MPA management might not be considered primarily as a social dilemma associated with a pure public good (which was reflected in the public goods game). This is because MPA management might have produced private benefits that dominated over public benefits, which would have rendered management an impure public good. Impure public goods are not completely non-rivalrous and non-excludable (Perrings and Gadgil 2003). These private benefits, essentially externally-provided incentives, might have precluded pro-social motivations (Bouma et al. 2008). Examples of material private benefits that arose through MPA management in some communities include boat engines, and agricultural and building equipment. Although material incentives are commonly employed in devolved commons management to encourage participation (d'Adda 2011), they can be counterproductive, lowering pro-social behaviour and raising expectations of externally-driven participation instead of encouraging voluntary collective action (Vollan 2008).

Critiques and caveats

An important limitation of my study is that I considered self-reported rather than observed participation in MPA management. Although research on human behaviour often relies on self-reporting, discrepancies between self-reported and observed behaviour can occur (Armitage and Conner 2001). Although I cannot assess potential discrepancies in my study, my qualitative data on the frequency and type of MPA management activities in each community correspond with self-reported participation. Another shortcoming of my study is that the small sample of 13 communities limited my ability to explore the effects of factors at the community scale. My analysis indicated that community-scale factors were important in explaining participation; the variance partition coefficient, which represents the percentage of variance explained by clustering of individuals (e.g. within communities) with a specific combination of covariates (Goldstein et al. 2002) was 0.42 for the intercept-only model (i.e. model that does not include covariates). This means that 42% of the total variation in participation (my dependent variable) was due to community-scale characteristics. However, the addition of the two community-scale covariates (nested institutions and population) reduced the variance partition coefficient to 0.07. Given that there was strong evidence of an effect of nested institutions, the reduction in the variance partition coefficient suggests that nested institutions explained most of the variability in participation that was due to community-scale characteristics.

Nevertheless, other community-scale characteristics that may have been related to participation that I was not able to examine, include activities undertaken by the NGO and who initiated management. The importance of community-scale characteristics in my study suggests that a key area of future research is to better explore the relationship between community-scale factors and participation, which requires greater sampling effort at the community scale.

4.6 Conclusion

The key role of subjective norms and social capital in my study highlights the importance of considering multiple-scale mechanisms other than those designed to appeal to self-interested concerns, such as regulations and material incentives, which are typically employed in devolved commons management to encourage participation (d'Adda 2011). Further, my study suggests that ongoing external support is critical to local participation, questioning the short-term approach often taken in internationally-funded initiatives promoting devolved commons management. Given the prevalence of devolved institutional approaches to management of natural resources, further research on the constraints and drivers of participation is crucial for policy. The knowledge gained could facilitate better targeting of investments aimed at encouraging cooperative management, ultimately improving the likelihood of devolved commons management contributing positively to the well-being of both people and the ecosystems on which they depend.

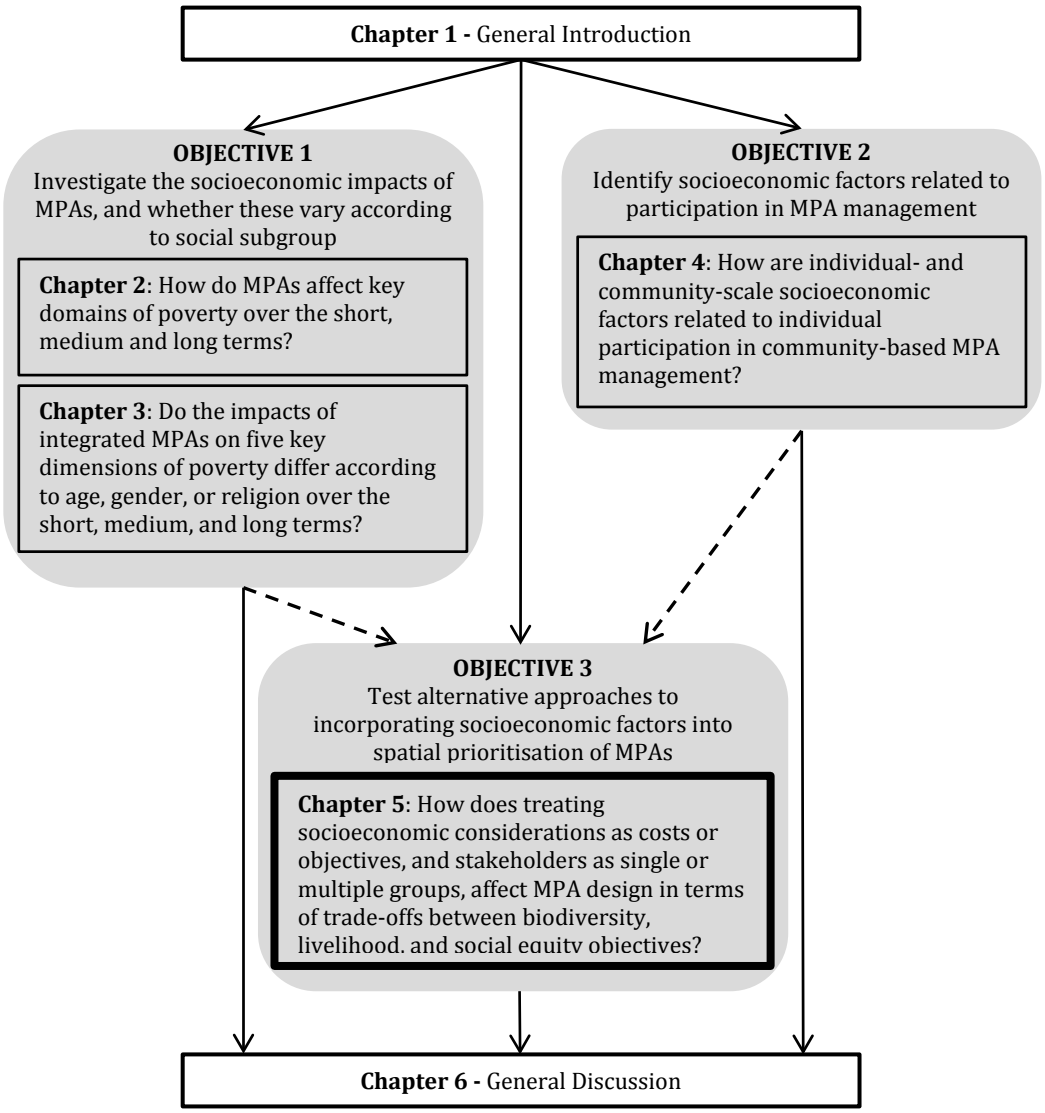
Chapter 5

Testing approaches to incorporating socioeconomic factors into spatial prioritisation of MPAs

5 Testing approaches to incorporating socioeconomic factors into spatial prioritisation of MPAs

In chapter 5, I assess how treating socioeconomic considerations as costs or objectives, and stakeholders as a single group or multiple groups, in spatial prioritisation affects resulting MPA design in terms of trade-offs between biodiversity, livelihood and social equity objectives. In this chapter I draw on some of the lessons learnt in chapters 2 to 4 that are relevant to how socioeconomic factors are typically treated in spatial prioritisation under SPC. Given that chapter 3 highlighted the need to recognise the heterogeneity of stakeholder groups to ensure equitable impacts of MPAs, I examine how treating stakeholders as a single group or multiple groups affects MPAs designs. Further, given that chapter 4 highlighted that gaining stakeholders' support for MPA management does not rest solely on minimising cost to stakeholders, I incorporate social equity, an alternative potential determinant of stakeholders' support, into spatial prioritisation. Chapter 5 addresses the existing lack of a rigorous evaluation of treating socioeconomic data as costs or objectives in spatial prioritisation, which is an important knowledge gap associated with the first limitation of how socioeconomic factors are treated in SCP listed in chapter 1; this is, that socioeconomic factors tend to be treated as costs to be minimised whilst meeting biodiversity objectives. Further, chapter 5 provides novel methods for incorporating multiple groups in spatial prioritisation, thus contributing to addressing the fourth limitation of how socioeconomic factors are treated in SCP listed in chapter 1; this is, that stakeholders tend to be represented as a single group. Chapter 5 is in press in *Conservation Biology*[8]. I developed the research question for this chapter, conducted the analysis, and wrote the chapter. Pressey, Ban, Álvarez-Romero provided advice on development of the research question, and assisted with structuring and editing the manuscript. Jupiter collected fisheries data. Álvarez-Romero and Adams assisted with data processing. Jupiter and Adams assisted with editing the manuscript.

[8]Gurney, G., R. Pressey, N. Ban, J. Álvarez-Romero, S. Jupiter, and V. Adams. 2015. Efficient and equitable design of marine protected areas in Fiji through inclusion of stakeholder-specific objectives in conservation planning. Conservation Biology. In Press.


Chapter 1 - General Introduction
OBJECTIVE 1
Investigate the socioeconomic impacts of MPAs, and whether these vary according to social subgroup
Chapter 2: How do MPAs affect key domains of poverty over the short, medium and long terms?
Chapter 3: Do the impacts of integrated MPAs on five key dimensions of poverty differ according to age, gender, or religion over the short, medium, and long terms?
OBJECTIVE 2
Identify socioeconomic factors related to participation in MPA management
Chapter 4: How are individual- and community-scale socioeconomic factors related to individual participation in community-based MPA management?
OBJECTIVE 3
Test alternative approaches to incorporating socioeconomic factors into spatial prioritisation of MPAs
Chapter 5: How does treating socioeconomic considerations as costs or objectives, and stakeholders as single or multiple groups, affect MPA design in terms of trade-offs between biodiversity, livelihood, and social equity objectives?
Chapter 6 - General Discussion

5 Testing approaches to incorporating socioeconomic factors into spatial prioritisation of MPAs

5.1 Abstract

The efficacy of protected areas varies, partly because socioeconomic factors are not sufficiently or adequately considered in planning and management. Although integrating socioeconomic factors into systematic conservation planning is increasingly advocated, research is needed to progress from recognition of these factors to incorporating them effectively in spatial prioritisation of protected areas. I evaluated two key aspects of incorporating socioeconomic factors into spatial prioritisation: whether socioeconomic factors are treated as costs or objectives, and whether stakeholders are treated as a single group or multiple groups. Using as a case study the design of a system of no-take MPAs in Kubulau, Fiji, I assessed how these aspects affected the configuration of MPAs in terms of trade-offs between biodiversity objectives, fisheries objectives, and equity in catch losses among fisher stakeholder groups. I found that the achievement of fisheries objectives and equity tended to trade-off concavely with increasing biodiversity objectives, indicating that it is possible to achieve low to mid-range biodiversity objectives with relatively small losses to fisheries and equity. Importantly, the extent of trade-offs depended on the method employed for incorporating socioeconomic data, and were least severe when objectives were set for each fisher stakeholder group explicitly. I show that using different methods for incorporating socioeconomic factors that require similar data and expertise can result in plans with very different impacts on local stakeholders.

5.2 Introduction

Protected areas are a principal tool employed globally to help mitigate the current biodiversity crisis and accelerating environmental degradation. Extensive establishment of protected areas is mandated under several international agreements (e.g. CBD 2010), which are reflected in government policy at national (Douvere et al. 2007) and local scales (Lipsett-Moore et al. 2010). However, the efficacy of protected areas is variable (Green et al. 2011). A key factor suggested to contribute to this lack of success is insufficient consideration of socioeconomic factors in planning and management (Christie 2004, Ban et al. 2013). Consideration of socioeconomic factors is critical for achieving social benefits from conservation and engendering stakeholders' support for management.

The importance of including socioeconomic factors in SCP (Margules and Pressey 2000) is increasingly advocated (e.g. Polasky 2008, Ban et al. 2013). Consequently the original biocentric framework of SCP has been modified to better recognise socioeconomic factors to aid implementation of plans (Pressey and Bottrill 2009). However, this theoretical evolution has not been mirrored in practice, and socioeconomic factors continue to be considered as secondary to biological factors in

SCP, particularly in spatial prioritisation of protected areas using optimisation algorithms. Thus, development and assessment of techniques for explicitly incorporating socioeconomic considerations into prioritisation are still limited (Ban et al. 2013). Two key aspects of how socioeconomic data can be incorporated are whether socioeconomic factors are treated as costs or objectives, and whether stakeholders are treated as a single group or multiple groups.

Whether socioeconomic factors are treated as costs or objectives is important for determining how human factors are considered in spatial prioritisation. In the field of SCP, socioeconomic factors were originally conceived as costs to conservation organisations focused solely on achieving biodiversity benefits. Thus the predominant approach has been to treat socioeconomic factors as costs (hereafter 'costs approach') in spatial prioritisation tools (e.g. Marxan, C-Plan, Zonation), whereby a single index of cost is minimised whilst meeting biodiversity objectives (Ban and Klein 2009). The assumption underpinning this approach is that minimising total costs to stakeholders will generate the most socially-acceptable plans (e.g. Fernandes et al. 2005). Given that only a single index of cost can be minimised, approaches to dealing with multiple costs include post hoc analysis of solutions from prioritisations using different types of costs (e.g. Cameron et al. 2008) and combining costs to form a single index (e.g. Green et al. 2009). A disadvantage of post hoc analyses is that no solutions consider all costs simultaneously. Single-index approaches amalgamate disparate socioeconomic data which often have different measurement units (e.g. dollars and area), thus adding subjectivity when determining the relative importance of different costs (Naidoo and Ricketts 2006). An alternative recent approach is treating socioeconomic considerations as objectives in spatial prioritisation (hereafter 'objectives approach'), facilitating design of plans based simultaneously on biodiversity and socioeconomic objectives (e.g. Klein et al. 2010, Grantham et al. 2013). Multiple socioeconomic objectives can be set under this approach (e.g. for different stakeholder groups). An objectives approach is not underpinned by the assumption that minimising total socioeconomic cost provides the most socially-acceptable plans. Rather, it can facilitate more nuanced treatment of socioeconomic data, allowing consideration of more complex and realistic determinants of social acceptability of plans. Further, this approach allows planning for multiple competing objectives simultaneously, potentially increasing the likelihood of achieving win-win outcomes. Importantly, engaging stakeholders through requesting them to identify their objectives for human uses, rather than which areas should remain available for use (i.e. positioning stakeholders as antagonists to conservation) is likely to result in more positive participatory decision making. However, existing studies do not provide a rigorous comparison of treating socioeconomic data as costs or objectives. The few studies that have used an objectives approach have focused on its utility to design MPAs based on multiple management zones (but see Weeks et al. 2010).

Regardless of whether socioeconomic data are analysed as costs or objectives, stakeholders can be considered as a single group or multiple groups. Typically, stakeholders are treated as a single group

either by using a surrogate measure to represent impacts on all stakeholder groups collectively (e.g. population density; Ban et al. 2009b), or by considering only one stakeholder group (e.g. commercial fishers; Richardson et al. 2006). However, the assumption underpinning these approaches – that there is no spatial variation between costs to different stakeholder groups – is rarely met; consequently such plans are likely to have inequitable impacts (Adams et al. 2010). A handful of studies have considered costs to multiple stakeholder groups under a costs approach (e.g. Klein et al. 2008, Adams et al. 2010) or an objectives approach (e.g. Klein et al. 2010, Weeks et al. 2010). Studies that used a costs approach aggregated costs to each stakeholder group in the prioritisation analysis and assessed impacts to each group post hoc, whereas studies that used an objectives approach minimised costs to each stakeholder group explicitly in prioritisation. However, there are no previous studies that treat stakeholders as a single group or multiple groups using both a costs and objectives approach. Further, those studies that assessed amalgamating costs into a single index (i.e. Klein et al. 2008, Adams et al. 2010) did not compare alternative methods for integrating costs, instead comparing plans using cost data based on a single stakeholder group to those produced using a normalised sum of costs (Klein et al. 2008) or a sum of raw costs (Adams et al. 2010) across groups.

Research on incorporating socioeconomic factors into spatial prioritisation is limited (Ban et al. 2013) partly because of SCP's focus on efficiency, which is motivated by the assumption that minimising cost will generate the most socially-acceptable plans. However, it is increasingly recognised that such simplification of the determinants of social acceptability is often inadequate (Adams et al. 2010), and other important determinants of social acceptability, such as equity, have begun to be incorporated in SCP (e.g. Klein et al. 2010). Although inequitable impacts of conservation can cause conflict between stakeholders and thus impede management (Christie 2004), there is little theory to guide incorporation of equity into SCP (Halpern et al. 2013). Halpern et al.'s (2013) simulation analysis of the relationship between efficiency, equity, and conservation provides the most rigorous assessment of equity following a SCP approach to date. However, research has yet to address how different techniques for incorporating socioeconomic data into prioritisation tools that are commonly employed by managers affect prioritisation outputs in terms of the relationship between equity, biodiversity conservation, and efficiency.

Systematic Conservation Planning is increasingly being employed globally to design MPAs (Leslie 2005, Álvarez-Romero et al. 2011, Micheli et al. 2013), including in areas where people rely heavily on marine resources for subsistence and income, such as the Coral Triangle and South Pacific (Weeks et al. 2014a). It is in these areas that the need for more nuanced incorporation of socioeconomic factors into spatial prioritisation is particularly acute. To this end, I evaluate alternative approaches for integrating socioeconomic factors into spatial prioritisation of MPAs, using as a case study the design of a system of no-take MPAs (hereafter 'MPAs') in the Kubulau District, Fiji. Specifically, I address two key research gaps regarding how socioeconomic factors are treated in SCP, and thus ask 'how

does treating socioeconomic considerations as costs or objectives, and treating fisher stakeholders as a single group or multiple groups affect the resulting MPAs in terms of spatial configuration, and trade-offs between biodiversity objectives, fisheries objectives, and equity in catch losses among fisher stakeholder groups?'

5.3 Methods

Planning region

I used the Kubulau District on the island of Vanua Levu in the Republic of Fiji (Figure 5.1) as a case study because detailed spatial data on fisheries and habitats were available. My planning region covered Kubulau's 260 km^2 traditional fisheries management area (Jupiter and Egli 2011).

The ten villages within Kubulau are highly dependent on fisheries for subsistence and income, and the main types of fishing gear (hereafter 'gear') employed are speargun, hand line, gill net, Hawaiian sling, and trolling (Cakacaka et al. 2010). In 2005, the District's villages established a system of marine reserves and adapted its design in 2012 (Weeks and Jupiter 2013). The existence of these reserves did not influence my analysis because my intention was not to modify current management in the region; rather, I aimed to further understanding of the use of socioeconomic data in spatial prioritisation tools in the design of protected areas more generally. I used uniform hexagonal planning units of 0.06 km^2; this size matched the resolution of my data, and was comparable to the smallest marine reserve in Kubulau (Weeks and Jupiter 2013).

Data

A habitat map of Kubulau's marine area was derived from the Millennium Coral Reef Mapping Project (Andréfouët et al. 2006), which identified nine geomorphic habitat classes (Figure 5.1). Species-specific data were not available across the study region. Spatially-explicit catch data, recorded from 180 fishing trips from fishers in four of the ten villages in Kubulau between May 2008 and June 2009, were used to calculate catch per unit effort (CPUE; in kilograms $person^{-1}$ $hour^{-1}$; Cakacaka et al. 2010). Fishers were asked to indicate the locations of their fishing areas on a map by drawing polygons or points, which were digitised (Adams et al. 2011). Locations identified as points were converted to polygons with an area equivalent to the mean of the area of hand-drawn polygons reported for the same combination of transport and gear. Where polygons overlapped for the same gear type, I calculated the mean CPUE value to create a single layer for each gear. CPUE data were not available for the remaining six villages, and too many assumptions would have been required for extrapolation. However, to explore the potential effect of incomplete CPUE data I assessed spatial similarity between the original CPUE data layer (that included the four villages) and four CPUE layers that excluded CPUE data from one village at a time. I calculated Pearson correlation

coefficients, and found that CPUE layers for which data from one village were excluded were highly correlated to the original CPUE layer (Appendix 3, Table A3.1).

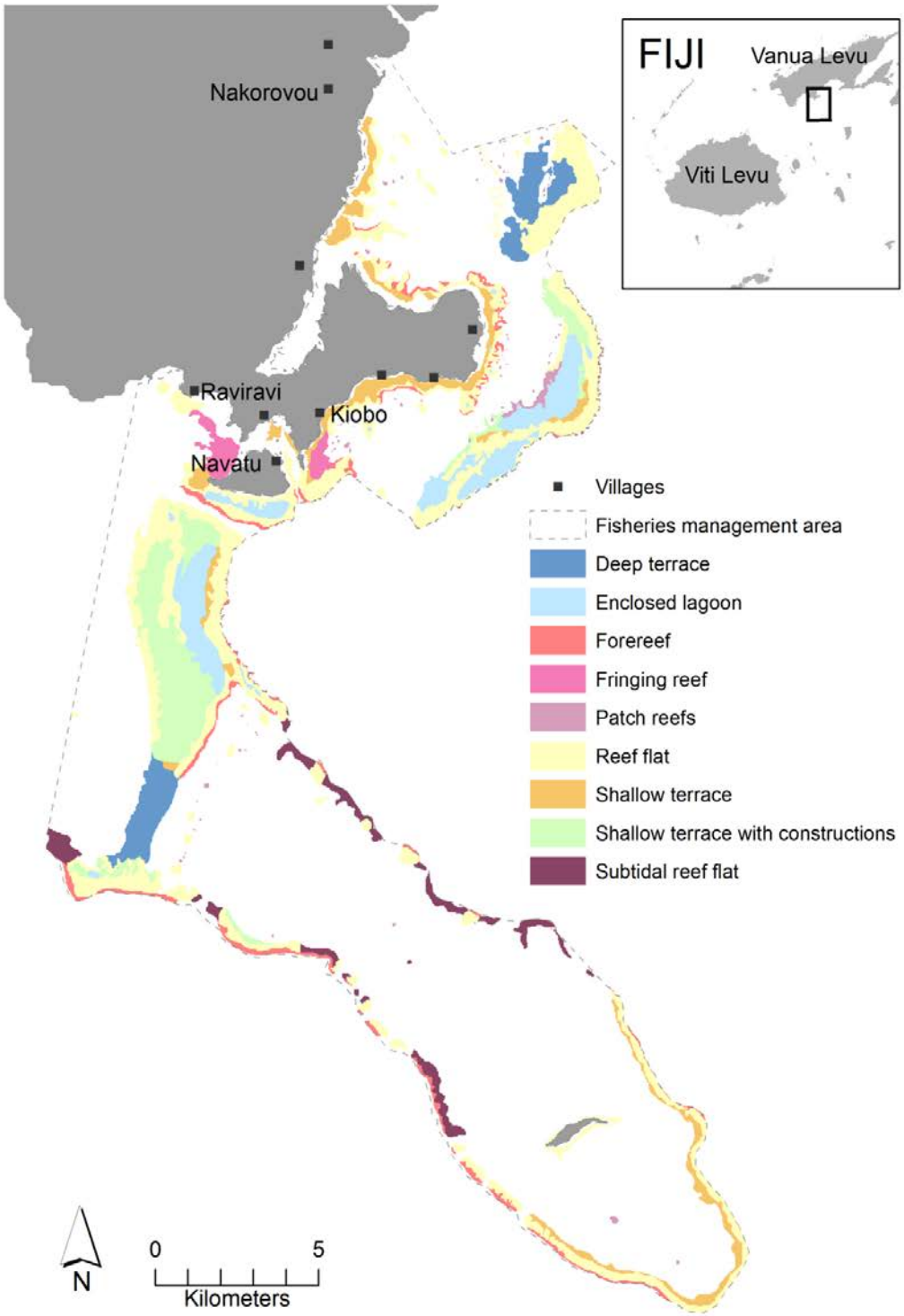


Figure 5.1 Kubulau District, located in Vanua Levu, Fiji. The traditional fisheries management area used as my planning region is demarcated (dashed line). Villages for which CPUE data were collected are labelled. Habitat geomorphic classes are from the Millennium Coral Reef Mapping Project (Andréfouët et al. 2006).

Design of MPAs

I examined four scenarios for integrating socioeconomic considerations into spatial prioritisation of MPAs. These were combinations of treating socioeconomic data as costs or objectives, and considering fisher stakeholders as a single group or multiple groups according to gear employed (Figure 5.2). To allow comparisons between scenarios, all analyses had two zones: MPAs and an open zone where fishing with all gears was possible. The biodiversity objectives for all four scenarios were to ensure minimum levels of representation of the nine habitats in the MPA zone. I used equal-representation objectives so that I could vary the biodiversity objectives of each of the habitats equally in increments of 10% (between 10% and 90%), allowing me to examine trade-offs between biodiversity and fisheries objectives.

		TREATMENT OF SOCIOECONOMIC DATA	
		COSTS	OBJECTIVES
TREATMENT OF STAKEHOLDERS	SINGLE GROUP	Cost_single: CPUE of all six gears summed to obtain a single value of CPUE per planning unit. Summed CPUE data used in prioritization analyses as a cost to be minimized whilst achieving biodiversity objectives.	Objective_single: CPUE of all six gears summed to obtain a single value of CPUE per planning unit. Prioritization analyses set to maintain a minimum of 90% of summed CPUE outside of MPAs whilst simultaneously achieving biodiversity objectives.
	MULTIPLE GROUPS	Cost_multiple: The relative importance of each planning unit for each gear was calculated by normalising to the maximum CPUE value for that gear; these values were summed to obtain a single value of CPUE for each planning unit, effectively weighting gears equally. Summed CPUE were treated as a cost to be minimized whilst achieving biodiversity objectives.	Objective_multiple: CPUE of each of the six gears was treated separately. Prioritization analyses set to maintain a minimum of 90% of each gear's CPUE outside of MPAs whilst simultaneously achieving biodiversity objectives.

Figure 5.2 The four scenarios investigated for integrating socioeconomic considerations into spatial prioritisation.

Costs approach

For the two scenarios where socioeconomic data were treated as costs (i.e. Cost_single, Cost_multiple; Figure 5.2; Appendix 3, Text A3.1), I used Marxan (Ball et al. 2009) to identify potential configurations of MPAs that achieved biodiversity objectives. Marxan uses a simulated annealing algorithm to generate multiple solutions of MPAs that minimise the total cost of selected planning units subject to the constraint that all biodiversity objectives are met (Appendix 3, Text A3.2).

Objectives approach

For the two scenarios where socioeconomic data were treated as objectives (i.e. Objective_single, Objective_multiple; Figure 5.2), I used Marxan with Zones (Watts et al. 2009), to identify potential MPAs. Marxan with Zones solves essentially the same problem as Marxan, to achieve objectives for a minimum cost, but multiple management zones can be employed, and users can specify the costs and contributions of each zone to alternative objectives (Appendix 3, Text A3.2). Although I specified only two zones (MPAs and open), Marxan with Zones allowed me to set objectives for CPUE in the open zone (i.e. fisheries objectives). Therefore, the design of MPAs was based on achieving biodiversity and fisheries objectives simultaneously. For both objectives scenarios, the cost associated with achieving the biodiversity objectives in the no-take zone was the total area of planning units, and no cost was associated with achieving the fisheries objectives.

The fisheries objective for Objective_single was to maintain a minimum of 90% of total CPUE in the open zone. Based on advice by my collaborators, I considered this objective was realistic and potentially socially acceptable, and would ensure that fishers retained access to their most productive fishing grounds. However, defining this objective in real-world planning requires thorough socioeconomic analyses and consultation with fishers. The fisheries objective for Objective_multiple was to retain a minimum of 90% of each gear's CPUE in the open zone. The feature penalty factor (fpf) was first set to ensure that the 90% fisheries objectives were achieved (with the same fpf for each gear in Objective_multiple). If this objective was achievable without compromising the biodiversity objectives, it was increased as far as possible without affecting biodiversity objectives to ensure the maximum percentage of CPUE remained in the open zone. All gears had the same fisheries objective in the Objective_multiple scenario. If the 90% fisheries objective compromised the biodiversity objectives, the fpf for each biodiversity objective was increased to ensure all habitats were represented at the required level. Therefore, if both the biodiversity and fisheries objectives could not be met, the fisheries objectives suffered the shortfall.

Analysis of configurations of MPAs

I compared scenarios in terms of raw CPUE retained outside MPAs, either in terms of CPUE by gear type or total CPUE. To assess equity, I used the inverse of the Gini coefficient of inequality (Gini 1921), calculated as (1-Gini), which ranges from 0 (maximal inequity) to 1 (perfect equity). I assessed equity in terms of the percentage of retained CPUE (i.e. outside MPAs) per gear. To compare the spatial configuration of solutions between scenarios I assessed the selection frequency of planning units under each objective level for each scenario using two methods: Spearman rank correlations and non-parametric multidimensional scaling (MDS). Spearman rank correlations were calculated between all combinations of biodiversity objectives and scenarios. To visualise the differences

between scenarios I created an MDS ordination based on a Bray-Curtis similarity matrix of selection frequencies.

5.4 Results

Although biodiversity objectives tended to trade-off nonlinearly (concavely) with the extent to which CPUE could be retained outside MPAs for all scenarios, the level of the biodiversity objective at which fisheries objectives were compromised differed between scenarios (Figure 5.3).

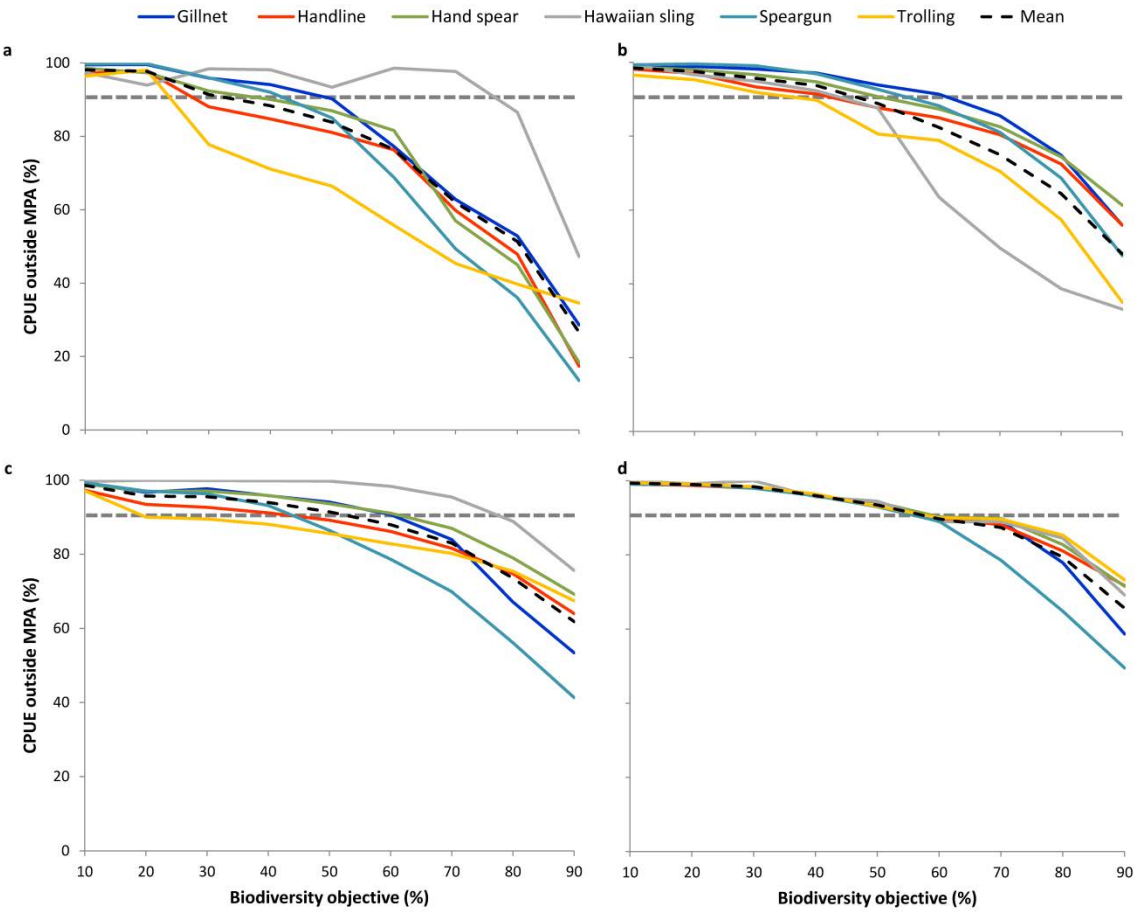


Figure 5.3 Trade-offs between achieving biodiversity and fisheries objectives for each gear for the four scenarios for integrating socioeconomic factors into spatial prioritisation. The four scenarios are: Cost_single (a); Objective_single (b); Cost_multiple (c); and Objective_multiple (d). The results presented are means of solutions from 100 replicate runs of each biodiversity objective under each scenario. The horizontal grey dotted line marks the fisheries objective of maintaining 90% of CPUE in the open zone.

Concave trade-off curves indicate that low and moderate biodiversity objectives can be achieved with relatively small losses of CPUE, and that the loss of CPUE accelerates as biodiversity objectives increase. Trade-offs between biodiversity and fisheries objectives were most direct (linear) under Cost_single (Figure 5.3a), and least so under Objective_multiple (Figure 5.3d). Thus, the fisheries objective of maintaining a minimum of 90% of each gear's CPUE in the open zone was achieved

under Objective_multiple for biodiversity objectives up to 60% (Figure 5.3d). However, under all other scenarios, the maximum biodiversity objective at which CPUE for any of the gears fell below 90% in the open zone was 20%, 30% and 40% under Cost_single, Objective_single, and Cost_multiple, respectively.

Although trade-offs between biodiversity and fisheries objectives for all gears were roughly concave, the shape of the curves differed between gears within scenarios, particularly when stakeholders were treated as a single group. For example, under Cost_single, the percentage of CPUE retained in the open zone for Hawaiian sling did not drop below 90% until the biodiversity objective exceeded 70%, in contrast to trolling, for which the 90% objective was achieved only for biodiversity objectives less than 30% (Figure 5.3a).

Equity among gear stakeholder groups in terms of retained CPUE also tended to trade-off concavely with biodiversity objectives in all scenarios (Figure 5.4). The impact of MPAs on fisheries was most equitable under the Objective_multiple scenario, in which fisheries objectives were set explicitly for each gear, followed by Cost_multiple. The impact was least equitable under Cost_single. Importantly, increases in equity under scenarios in which stakeholders were considered as multiple groups were not accompanied by decreases in relative efficiency, in terms of area or CPUE retained outside MPAs (Figure 5.5).

Under all scenarios, as expected, the area and total CPUE retained outside MPAs decreased as biodiversity objectives increased. Retained area traded-off approximately linearly with biodiversity under all scenarios (Figure 5.5a). In contrast, trade-off curves between retained total CPUE and biodiversity were concave, and differed between the costs and objectives approaches (Figure 5.5b). When socioeconomic data were treated as costs, considering stakeholders as multiple groups by gear type resulted in more efficient MPAs, but when data were treated as objectives the difference was negligible. Further, MPAs were more efficient when data were treated as objectives rather than costs, particularly at biodiversity objectives greater than 50%; above this objective level, retained total CPUE under Cost_single was 20-67% less than under Objective_single and Objective multiple, and 12-64% less than under Cost_multiple.

There was clear similarity in spatial configurations of MPAs, represented by selection frequencies, between the two objectives scenarios and between the two costs scenarios (Appendix 3, Figure A3.1, A3.2). However, as biodiversity objectives increased, MPAs under the Cost_single scenario diverged from those under the Cost_multiple scenario, and were more similar to those in the objectives scenarios.

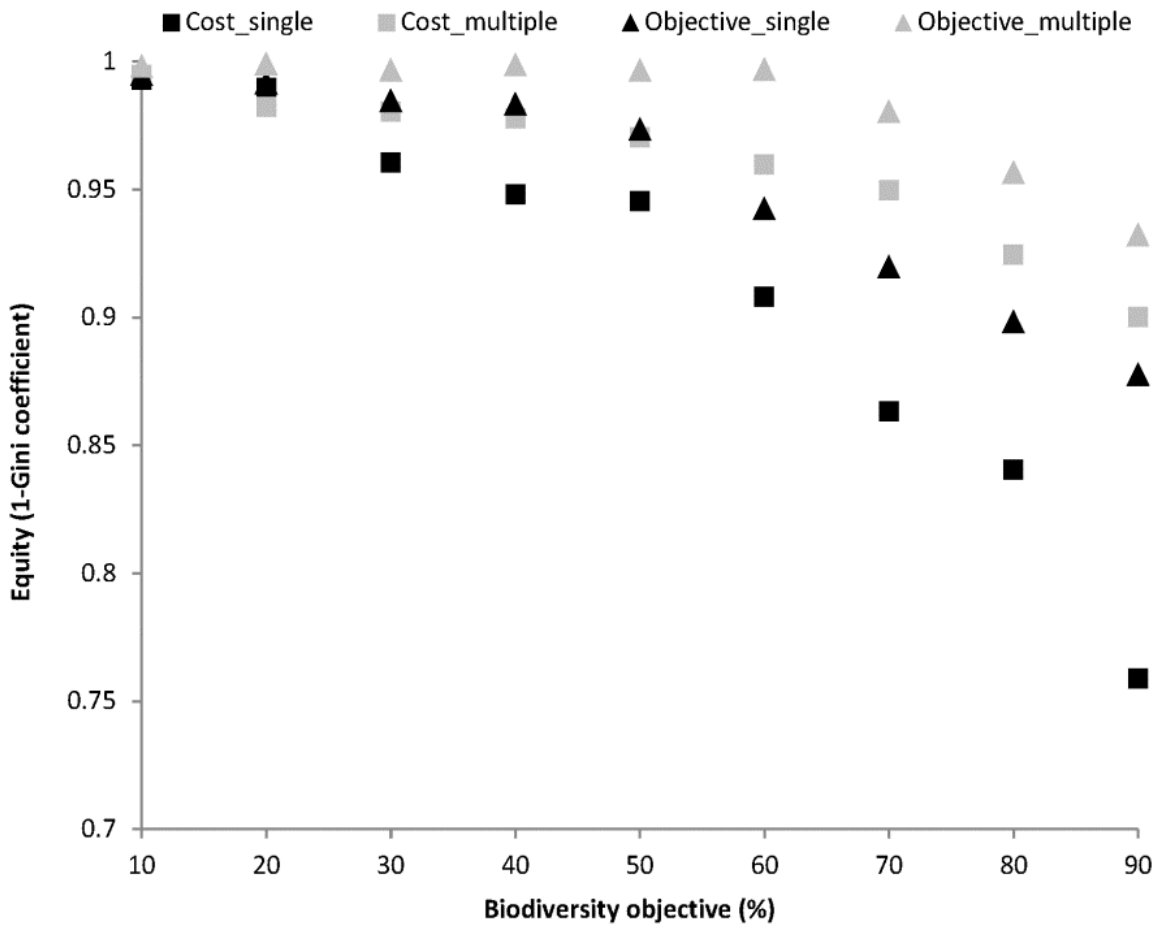


Figure 5.4 Trade-offs between achieving biodiversity objectives and equity of retained CPUE (i.e. CPUE outside MPAs) between gears for the four scenarios. Equity is measured using the inverse of the Gini coefficient, which ranges from a value of 0 (maximum inequality) to 1(perfect equality). The results presented are means of solutions from 100 replicate runs of each biodiversity objective under each scenario.

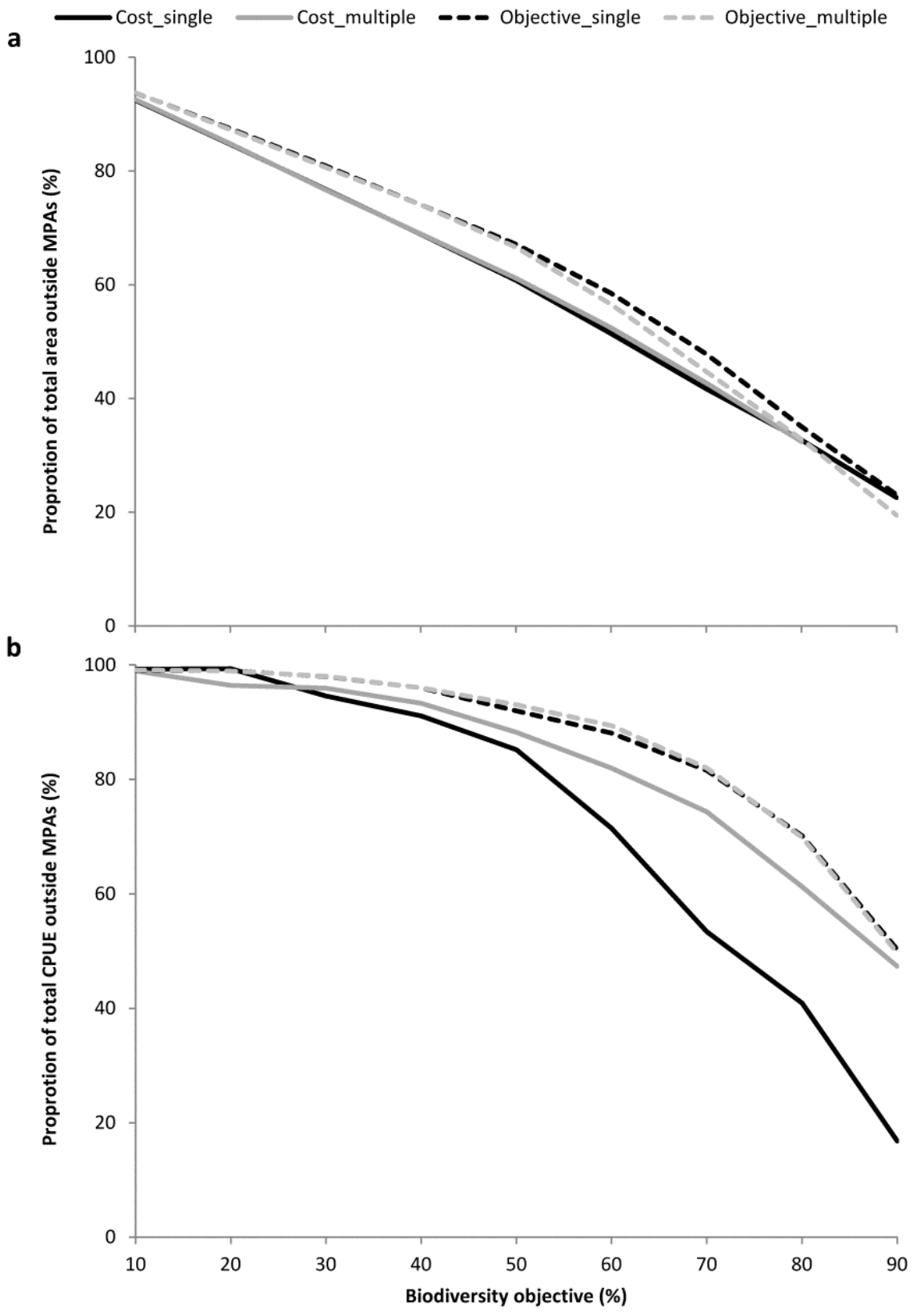


Figure 5.5 Trade-offs between achieving biodiversity objectives and retaining total area of planning region and total CPUE outside MPAs. Proportion of total area of planning region (a) and CPUE for all gears (b) retained outside MPAs for different biodiversity objectives for each of the four scenarios. The results presented are means of solutions from 100 replicate runs of each scenario.

5.5 Discussion

Given that an important factor contributing to the lack of success of protected areas is insufficient consideration of socioeconomic factors in planning and management (Ban et al. 2013), there is a pressing need to advance techniques for better integrating these into SCP. My analysis of key methods for integrating socioeconomic factors into prioritisation found major differences in MPAs produced by alternative methods in terms of trade-offs between biodiversity objectives, fisheries objectives, and social equity. For my case study in Fiji, setting stakeholder-specific objectives produced MPAs with the least severe trade-offs between biodiversity and fisheries objectives, and that were most equitable in terms of lost catch potential between gears.

Trade-offs between fisheries and biodiversity objectives

Biodiversity objectives tended to trade-off concavely with retention of CPUE outside MPAs. Concave trade-off curves between biodiversity and socioeconomic objectives have been found in studies following a costs approach to spatial prioritisation (Hamel et al. 2013), and those that have set stakeholder-specific objectives in a framework of multiple-zone management (e.g. Klein et al. 2010, Grantham et al. 2013). Concave trade-off curves indicate that it is possible to achieve low- to mid-range biodiversity objectives with relatively small losses of CPUE.

Concave trade-off curves occur when: (1) biodiversity and socioeconomic features are poorly correlated (Naidoo et al. 2006); (2) socioeconomic variables are skewed toward low values; or (3) higher socioeconomic values are spatially concentrated. In these cases, low biodiversity objectives can be achieved by selecting planning units with little or no socioeconomic value but, as biodiversity objectives increase, areas of high socioeconomic value must be selected. All three data characteristics applied to my case study. Contributing factors were the concentration of CPUE in inshore waters (Adams et al. 2011) and the presence of MPAs in 45% of Kubulau's traditional fisheries management area, which tended to displace fishing to unprotected areas. Another contributing factor is underestimation of CPUE because data were collected from only four of the ten villages in Kubulau. Obtaining data from the remaining six villages in the region would be critically important if the approach outlined in this paper was undertaken to inform marine spatial planning in Kubulau. Plans produced using data from a subset of the ten villages, such as mine, could result in inequitable loss of fishing grounds, particularly for those villages for which no CPUE data is available.

Trade-offs between biodiversity and fisheries objectives were most severe under the common approach of considering socioeconomic data as costs and stakeholders as a single group. Thus it is important to consider alternative methods to integrating socioeconomic data into spatial prioritisation to avoid unnecessarily hard trade-offs between competing objectives, thereby reducing conflicts that often arise from protected areas impinging on human uses (Redpath et al. 2013). My results suggest

that treating socioeconomic data as objectives rather than costs, and stakeholders as multiple groups rather than as a single group, could ease such trade-offs. In cases where information is available only for one socioeconomic value, an objectives rather than a costs approach could facilitate win-win outcomes.

Equity of MPAs

Treating all gear users as a single group produced MPAs with inequitable loss of CPUE because gears that had CPUE values of the highest magnitude dominated the prioritisation, displacing MPAs to areas important for other gears. Similarly, Adams et al. (2010) found that summing the economic value of multiple land uses to form a single cost layer resulted in protected areas that least impacted uses with highest economic value, displacing opportunity costs toward stakeholders involved in lower-value uses. Conversely, treating stakeholders as multiple groups, either by summing normalised CPUE values across gears or by setting gear-specific objectives, resulted in more equitable MPAs. Normalising CPUE values ensured that CPUE per gear type was more equally weighted in the prioritisation than under the scenarios when stakeholders were considered as a single group. However, given the variation in raw CPUE values between gears, normalising did not result in exact equal weighting of gears. Gears that had a smaller range in raw CPUE values (e.g. Hawaiian sling) lost a lower proportion of CPUE than other gears because the magnitude of most of their normalised values was higher. Thus setting gear-specific objectives produced the most equitable solution. This finding is consistent with previous studies (e.g. Klein et al. 2010, Weeks et al. 2010), who found that setting stakeholders-specific objectives led to more equitable MPAs than under the typical approach of treating stakeholders as a single group.

While it has been assumed that increased equity will result in less efficient conservation (Pascual et al. 2010), I found that increased equity in retained CPUE between gears did not come at a cost to efficiency in terms of total area of MPAs or CPUE available for extractive use. For any given biodiversity objective, MPAs produced using gear-specific objectives were most equitable and, compared to other scenarios, tended to be equally efficient in terms of area and more efficient in terms of retained CPUE. Previous results have been inconsistent in this regard. Klein et al. (2010) found that MPAs produced under an objectives approach were both more equitable and efficient than those produced under a costs approach, while Weeks et al. (2010) found that more equitable MPAs under an objectives approach were less efficient. Differences in findings are likely due to factors such as spatial variability and correlation between different socioeconomic objectives, resolution of data and/or whether multiple management zones are employed. Given the range of factors that can affect the relationship between equity, efficiency and biodiversity, a scenario-analysis approach can be useful in determining how the relationship manifests in a given planning context, rather than assuming that incorporating equity will necessarily compromise achievement of other conservation objectives

(Pascual et al. 2010). Such assumptions are likely to have been barriers to incorporating equity in past planning.

Practical applications

Recognising the diversity of stakeholders and setting objectives for human uses in parallel with those for biodiversity is likely to be well received by stakeholders. Given that most land- and sea-scapes are subject to multiple human uses (Sanderson et al. 2002), an objectives approach to prioritisation in which multiple competing objectives can be planned for simultaneously increases the relevance of plans to a wider variety of people. Coupled with trade-off analysis, an objectives approach provides transparency through making the losses and gains to different uses and planning objectives explicit. Although trade-off analyses are uncommon in SCP (Ban and Klein 2009), and in conservation in general (White et al. 2012), such an approach is useful for identifying multiple potential locations for protected areas. It thus provides the flexibility required to produce outcomes likely to be acceptable to the stakeholders involved. Importantly, as I have shown, the expertise and data required to undertake an objectives approach are not substantially different from the typical costs approach.

Increasing emphasis on generating socioeconomic benefits from conservation, and on the critical importance of gaining stakeholder support for achieving conservation (Chaigneau and Daw 2015), has recently catalysed more nuanced incorporation of socioeconomic considerations in SCP. It is clear that the prevailing preoccupation with efficiency (Kukkala and Moilanen 2013) is insufficient in many contexts. Stakeholders' preferences for management will be determined by their socioeconomic, biophysical, and cultural context (Ban et al. 2013). For my comparative evaluation of approaches to prioritisation, I assumed that equity in retained CPUE between gears (as a proxy for equity in impact) was a desirable management outcome for local fishers. However, given that most Kubulau households use multiple gears and share catch within and among households (S. Jupiter, pers. comm.), maximising the total village catch as a whole might take priority over equitable impact. Alternatively, if fish are sold rather than consumed, equity in retained economic value could be more appropriate. Given that plans produced using different metrics of equity could vary (Halpern et al 2013), it is important to identify the metric of equity that is most relevant to stakeholders to ensure plans are most likely to reflect their preferences. Further, I did not consider that equity in retained CPUE does not necessarily translate to equity in impact. The impact to fishers of losing fishing ground is mediated by factors that dictate their response, such as spatial and occupational mobility (Cinner et al. 2009). For example, fishers using motorised boats have the most spatial mobility and thus are least vulnerable to implementation of MPAs. Therefore, achieving equal impact amongst gears may require different objectives for each fisher gear group, reflecting the constraints of their response to lost fishing grounds.

Further, while I only considered equity in terms of lost CPUE by gear type, achieving socially equitable solutions requires consideration of other factors that demarcate fishers into different stakeholder groups. For example, real-world planning in this context should consider which villages fishers reside in to avoid inequitable impacts among villages. Indeed a case study of marine planning in the Philippines found that not considering local tenure in prioritisation produced plans that were infeasible because some villages' entire inshore fishing grounds were designated as no-take areas (Weeks et al. 2010). Given the complexity of deciphering the potential socioeconomic impacts of management actions, it is critical to engage with stakeholders throughout the planning process, including identifying stakeholders' objectives and potential responses to management actions. If stakeholders' preferences are misrepresented, subsequent protected areas might not win support and might not be effective. Further, given detailed socioeconomic data tend to be limited and their collection requires large investments of time and money, involving stakeholders in the design of data-collection strategies and instruments may allow for more targeted data collection.

5.6 Conclusion

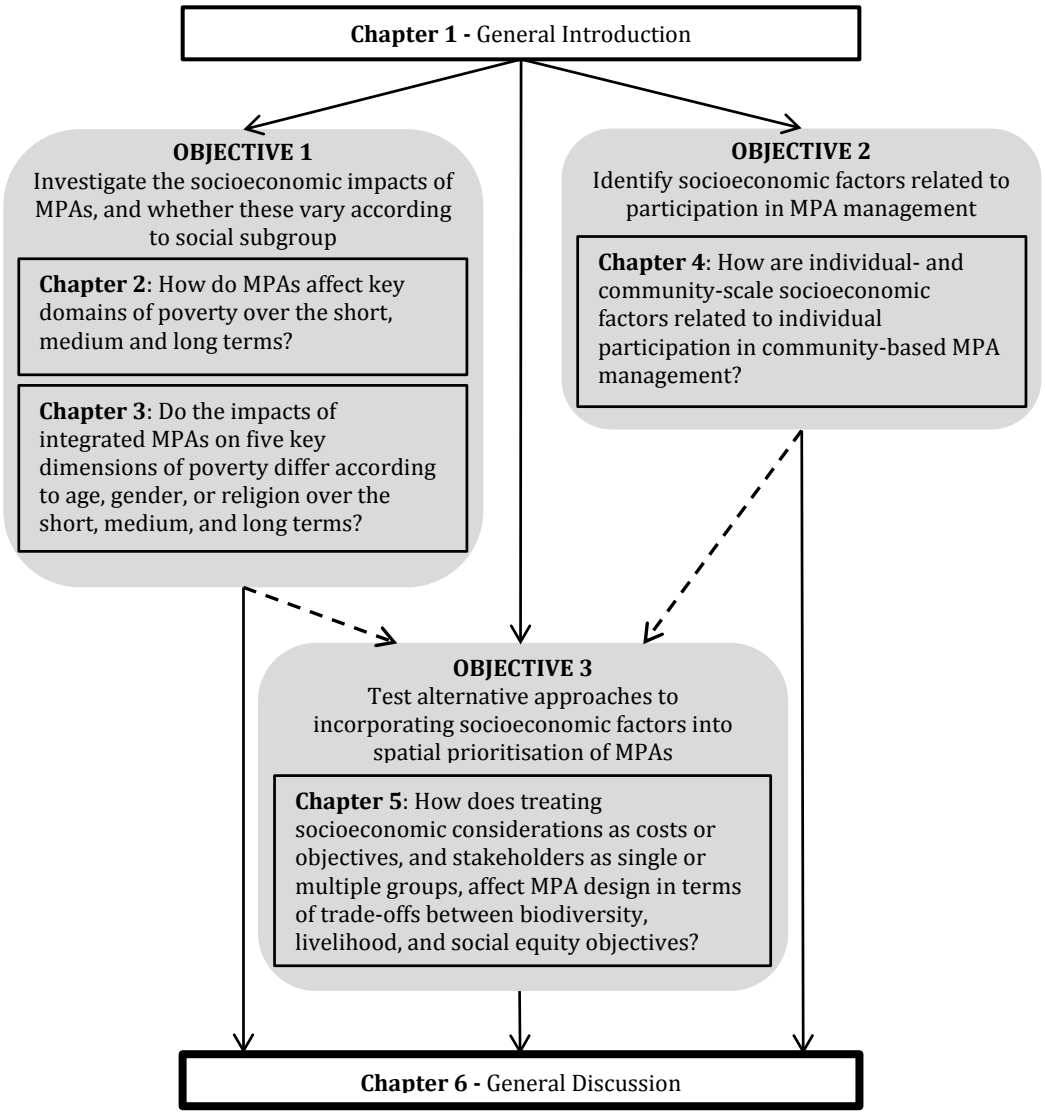
My analysis of key methods for integrating socioeconomic factors into prioritisation found major differences in MPAs produced by alternative methods in terms of trade-offs between biodiversity objectives, fisheries objectives, and social equity. While the type and extent of trade-offs between competing objectives will vary with context, my results suggests that treating socioeconomic data as objectives and stakeholders as multiple groups could minimise impacts to local stakeholders, at least in regions with similar data characteristics to my case study. In my case study, employing stakeholder-specific objectives facilitated more nuanced approaches to integrating socioeconomic considerations into spatial prioritisation; my approach requires similar data and expertise to typical methods of treating socioeconomic data as costs and stakeholders as a single group. Although plans produced through spatial prioritisation will always need modifying prior to implementation, the more detailed the incorporation of socioeconomic factors, the less likely plans will need to be significantly altered and biodiversity objectives potentially compromised (Weeks et al. 2010). Further, better incorporation of socioeconomic factors will increase the likelihood of achieving social benefits from protected areas and gaining stakeholders' support, on which conservation success is predicated. Given the planned expansion of protected areas globally, better approaches to incorporating human dimensions into spatial prioritisation are of critical importance.

Chapter 6

General Discussion

6 General Discussion

In chapter 6, I describe how my data-based research chapters (chapters 2 -5) addressed the three objectives of my thesis, including the principal contributions of the research to theory and practice. I also discuss the contributions of my thesis to overcoming the four key limitations of how socioeconomic factors are treated in SCP, and highlight some shortcomings of my work, and directions for future research.



6 General Discussion

Marine protected areas (MPAs) are a key strategy employed worldwide to mitigate biodiversity loss and maintain marine ecosystem services (Lubchenco et al. 2003, Fox et al. 2012b). SCP is currently the foremost paradigm under which protected areas are designed (Kukkala and Moilanen 2013). However, the efficacy of MPAs in achieving biological and socioeconomic goals is highly variable (Burke et al. 2011, Rife et al. 2013); a significant factor limiting their success is a lack of consideration and understanding of associated human systems (Christie 2004, Polasky 2008). Given the ongoing expansion of MPAs globally (e.g. CBD 2010), there is a pressing need to better understand and incorporate socioeconomic factors into MPA planning and management.

The goal of my thesis was to improve understanding of critical socioeconomic factors related to MPAs, and to provide guidance on how this knowledge can be incorporated into MPA design and management. To achieve this goal, I developed three objectives that address critical knowledge gaps related to the four key limitations of how socioeconomic factors are treated in SCP described in chapter 1. Following, I describe how my data-based research chapters (chapters 2-5) addressed the three objectives of my thesis, and outline the main contributions of the research in these chapters to theory and practice. Finally, I discuss the contributions of my thesis to overcoming the four key limitations of how socioeconomic factors are treated in SCP, and highlight some shortcomings of my work, and opportunities for further research.

6.1 Achievement of thesis objectives

Objective 1. Investigate the socioeconomic impacts of MPAs, and whether these vary according to social subgroup

I addressed this objective by assessing the short-, medium-, and long-term impacts of a MPA project on three key domains of poverty over fifteen years (chapter 2), including whether impacts differed by social subgroup (chapter 3). The MPA project appeared to contribute to poverty alleviation, with positive impacts spanning all three poverty domains but with variation in the magnitude of the effects and timescales over which they manifested. Importantly, positive impacts appeared to occur mostly during the implementation period, after which integrated MPA activities all but ceased and reductions in poverty did not continue to accrue. I found little empirical evidence that impacts on five indicators of poverty differed according to social subgroups defined by age, gender, or religion. Environmental knowledge was the only indicator for which I found heterogeneous impacts; over the medium and long terms, younger people and Muslims showed greater improvements compared to older people and Christians, respectively.

To my knowledge, this is only the second study (the other [Korhonen et al. 2004] being focused on terrestrial management) to assess the socioeconomic impacts of protected areas using longitudinal data from before and after an intervention for both control and intervention sites. Such data are critical for robust estimates of the impacts of protected areas (Pullin et al. 2013). Given that the evidence base for the socioeconomic impacts of protected areas is currently weak (Mascia et al. 2010, Pullin et al. 2013), particularly in terms of whether impacts are heterogeneous according to social subgroups (Fox et al. 2012a, Milner-Gulland et al. 2014), my research constitutes a significant and novel contribution to the literature on protected areas.

This research provides some of the first robust estimates of the socioeconomic impacts of protected areas, and thus, has important implications for management. Importantly, this research questions the efficacy and efficiency of the short-term approach taken in many international donor-assisted protected area projects in developing countries (Bottrill et al. 2011, Keppel et al. 2012), which assume that management activities will be sustained and related benefits will continue to accumulate after external support is terminated. Chapter 2, in particular, highlights the inadequacy of the common approach in conservation practice of considering one or very few indicators (usually material) of poverty (Agrawal and Redford 2006, Coad et al. 2008); pointing to the importance of considering the impacts of protected areas on multiple dimensions of poverty (or human well-being). Chapter 3 elucidates some of the pathways through which socioeconomic impacts of protected areas may occur in the study region, and hence, may improve targeting of management activities. More broadly, the research highlights the importance of considering the potential for heterogeneous impacts of protected areas, and provides guidance on how to design evaluations of heterogeneous impacts according to social subgroup.

Objective 2. Identify socioeconomic factors related to individual participation of local people in MPA management

I addressed this objective in chapter 4 by assessing how individual- and community-scale socioeconomic factors were related to individuals' participation in the management of 13 community-based MPAs in North Sulawesi and Bali, Indonesia. I took an interdisciplinary approach, drawing from literature on human behaviour from political science, social psychology and behavioural economics. I found three key factors that were related to participation of local people: subjective norms, structural elements of social capital, and nested institutions. Participation was more extensive if: (1) people perceived social pressure to participate (i.e. subjective norms); (2) people were active in community organisations and decision-making (i.e. social capital); and (3) MPA management groups received external support (i.e. nested institutions). There was also suggestive evidence that participation was related to people's cooperative behavioural disposition, which I elicited using a public goods game.

This research advances the literature on devolved common-pool natural resource management because, to my knowledge, it is the first study to quantitatively assess how individuals' participation in marine resource management is related to socioeconomic factors that operate at multiple scales. Further, I took a novel approach to this research, integrating theory and methods from literature on human behaviour from multiple disciplines that previously have not been considered together. More specifically, this research is an important contribution to the emerging area of research on behavioural economics on the external validity of experimental economic games, with this study being the first to assess the external validity of a public goods game applied to management of marine commons.

The results of this research have important implications for devolved commons management. My findings highlight the importance of considering interventions other than those designed to appeal to self-interest, such as regulations and material incentives, which are typically employed in devolved commons management to encourage participation (d'Adda 2011). These alternative approaches may operate at multiple scales to influence participation; an example of such approaches highlighted in my research was explicitly aligning management with existing norms and institutions, and closely involving influential people within communities. In addition, my research demonstrates the importance of ongoing external support for fostering local stakeholders' participation in management, echoing the findings of chapters 2 and 3.

Objective 3. Test alternative approaches to incorporating socioeconomic factors into spatial prioritisation of MPAs under a SCP approach

I addressed objective 3 in chapter 5 by evaluating two key aspects of incorporating socioeconomic factors into spatial prioritisation: whether socioeconomic factors are treated as costs or objectives, and whether stakeholders are treated as a single group or as multiple groups. Using the design of a system of MPAs in Fiji as a case study, I examined how these aspects affected the configuration of MPAs in terms of trade-offs between biodiversity objectives, fisheries objectives, and equity in catch losses among fisher stakeholder groups. I found that the achievement of fisheries objectives and equity tended to trade-off concavely with increasing biodiversity objectives, indicating that it is possible to achieve low to mid-range biodiversity objectives with relatively small losses to fisheries and equity. Importantly, the extent of trade-offs depended on the method employed for incorporating socioeconomic data, and were least severe when objectives were set for each fisher stakeholder group explicitly.

This research is the first robust evaluation of treating socioeconomic factors as costs or objectives in spatial prioritisation under a SCP approach. Given that treating socioeconomic factors as costs is a common practice in SCP, my evaluation is a significant contribution to the field, and helps resolve the debate on whether treating socioeconomic factors as costs or objectives produce similar designs. Further, this research advances understanding of the relationship between achieving efficiency and

equity in spatial prioritisation. While it is commonly assumed in conservation that achieving equity will compromise efficiency (Pascual et al. 2010), my research suggests that this is not always the case in spatial prioritisation of protected areas.

The key management implication of this research is that using different methods for incorporating socioeconomic factors that require similar data and expertise can result in plans with very different impacts on local stakeholders. While the type and extent of trade-offs between competing objectives will likely vary with context, my results suggest that plans produced under the typical approach of treating socioeconomic factors as costs and stakeholders as a single group could result in unnecessarily hard trade-offs between competing objectives.

6.2 Thesis contributions and opportunities for future research

Although the importance of considering socioeconomic factors in SCP is increasingly advocated (e.g. Polasky 2008, Ban et al. 2013), in practice, socioeconomic factors continue to be oversimplified and treated as secondary to biological factors. Four key limitations of how socioeconomic factors are treated in SCP are:

1. Socioeconomic factors tend to be treated as costs to be minimised whilst meeting biodiversity objectives.
2. Minimising costs is often assumed to maximise social support for protected areas.
3. Data used to represent socioeconomic factors tend to relate to extractive uses of ecosystems.
4. Stakeholders tend to be represented as a single group.

The three objectives of my thesis were related to critical knowledge gaps associated with these four limitations. Following, I describe how my research contributes to addressing the knowledge gaps, and highlight some of the shortcomings of my work, and further avenues of research that are required to overcome the four limitations.

Limitation 1. Socioeconomic factors tend to be treated as costs to be minimised whilst meeting biodiversity objectives

My research in chapter 5 contributes to addressing this limitation because it is the first rigorous comparison of treating socioeconomic factors as costs or objectives in spatial prioritisation under a SCP approach. My evaluation showed major differences in MPA designs produced using socioeconomic factors as costs versus objectives, namely in terms of the magnitude of trade-offs between biodiversity objectives, fisheries objectives, and social equity.

A shortcoming of this research is that I assumed rather than elicited stakeholders' objectives. Therefore, an important area of further research is finding ways to directly ascertain stakeholders' goals and translate them into quantitative objectives for spatial prioritisation. Given that treating socioeconomic factors as costs is the predominant approach in prioritisation, stakeholders' preferences have generally been accounted for in SCP after prioritisation through the modification of plans. For example, MPA designs for the Great Barrier Reef Marine Park changed significantly after accounting for stakeholders' preferences (Pressey et al. 2013). However, this post hoc alteration of plans is likely to compromise biodiversity objectives (Weeks et al. 2010). Thus, directly eliciting and incorporating stakeholders' goals into spatial prioritisation using an objectives approach, which has not been attempted to date, offers a promising direction for research.

Including quantitative socioeconomic objectives in spatial prioritisation opens many avenues of research, in both the elicitation and prioritisation components of the process. To elicit stakeholders' management objectives, planners can draw on numerous social science methods and tools (Ban et al. 2013), including multi-criteria analysis (e.g. Kiker et al. 2005, Giove et al. 2009), deliberative democratic methods (e.g. Smith 2003, Carpini et al. 2004), and collaborative mapping (e.g. Elwood 2006, Ban et al. 2008). Some potential areas of research in the spatial prioritisation stage of including quantitative socioeconomic objectives in SCP include the use of trade-off analysis, which is not commonly employed in SCP (Ban and Klein 2009) or conservation in general (White et al. 2012). For example, future studies could further examine the trade-offs that I assessed (i.e. between biodiversity, livelihood, and social equity objectives), in terms of how they change in different contexts, or with the inclusion of zoning for multiple types of management (e.g. Klein et al. 2010).

Limitation 2. Minimising costs is often assumed to maximise social support for protected areas

My research in chapter 4 contributes to overcoming this limitation by demonstrating that stakeholders' participation in management, an important element of social support towards protected areas, is influenced by factors other than narrow economic self-interest. My investigation of the individual- and community-scale factors related to individuals' participation in MPA management showed that participation was related to nested institutions, subjective norms, and structural elements of social capital.

A key opportunity to extend my research in participation lies in examining the potential for heterogeneity in socioeconomic factors related to participation, across: (1) space; (2) time; and (3) social subgroup. First, while the complete set of socioeconomic factors that affect participation will differ by context, repeating studies such as mine in different social-ecological systems may allow for the identification of common associations between socioeconomic factors and participation. For example, Ostrom (1990) identified eight principles common to successful management of common-pool natural resources through examining hundreds of cases of commons management. Second,

examining how participation and the socioeconomic factors affecting it vary over time enables a more nuanced understanding, and better allows assertions of causality rather than simple correlation, which is afforded by the "snapshot" approach that I took. Third, examining whether the socioeconomic factors related to participation differ among social subgroups or among stakeholders with different levels of participation may allow for better targeting of management actions aimed at fostering participation.

Overcoming the limitation of assuming that minimising cost will maximise social support towards protected areas requires research on how to incorporate alternative determinants of social support into SCP. To this end, in chapter 5 I provided a novel approach for how equity, one such alternative determinant, can be incorporated into spatial prioritisation. An emerging approach to integrating determinants of social support into spatial prioritisation is to map factors that are indicative of the feasibility of conservation action (Knight et al. 2010). Given that most of these studies of 'conservation opportunity' have mapped private landholders' capacity to engage in conservation activities (often focusing on willingness to sell land; e.g. Guerrero et al. 2010, Curran et al. 2011, Knight et al. 2011), opportunities remain to map other elements related to social support, such as those affecting participation in management of commons.

While some factors affecting social support may be amenable to quantification and mapping, other factors, such as norms of cooperation or reciprocity, may be distinctly non-spatial and cannot be readily incorporated into spatial prioritisation software (Ban et al. 2013). Such factors can be integrated into the non-spatial aspects of SCP. For example, understanding of such factors can be used to design incentives schemes aimed at encouraging participation and support for management (e.g. Travers et al. 2011); a promising area of research in this vein is investigating how pro-environmental and pro-social behaviour is influenced by the design of incentive schemes, for example in relation to whether incentives are applied at the individual or community scale. Further, critical non-spatial factors affecting social support for protected areas are stakeholders' perceptions of design and management processes, including how they are involved, how information is shared, and whether the process is fair and transparent (Knight et al. 2006a, Dalton et al. 2012). Therefore, another area for future research is identifying the important elements influencing positive perceptions of design and management (e.g. Dalton 2005), including which tools for engaging stakeholders (e.g. focus groups, public meetings, seeking submissions of public comments) are likely to be most effective in different contexts.

Limitation 3. Data used to represent socioeconomic factors tend to relate to extractive uses of ecosystems

My research in chapter 2 contributes to overcoming this limitation by demonstrating that MPAs may impact multiple dimensions of human well-being, highlighting the inadequacy of the predominant

approach in SCP of only considering impacts to extractive uses of ecosystems. My evaluation of the impacts of a MPA project on 14 diverse indicators of poverty found a significant impact on 10 indicators across three key domains of poverty.

An important opportunity to extend my research on the socioeconomic impacts of protected areas is to identify the mechanisms through which protected areas affect poverty. Knowledge of the mechanisms behind impacts of protected areas on poverty allows more nuanced design of these conservation tools to foster mechanisms that alleviate poverty and mitigate the negative effects of mechanisms (Ferraro and Hanauer 2014a). Such mechanisms are diverse; for example, the positive effect of the integrated MPAs on wealth found in chapter 2 could have been due to a number of mechanisms including: (1) increased fishing yield associated with the MPA; (2) alternative livelihoods programs; or (3) increased number of outsiders visiting the MPA villages due to the project, and spending money on groceries, meals and accommodation. Further, these mechanisms can differ by social subgroup, as suggested in chapter 3. To date, studies focusing on mechanisms are very rare in the conservation literature (but see Ferraro and Hanauer 2014b).

Overcoming this limitation of considering only how protected areas affect extractive uses of ecosystems requires complementary research on eliciting and incorporating the diverse benefits that people derive from ecosystems into spatial prioritisation. Considering the entire range of benefits that stakeholders derive directly and indirectly from ecosystems (MEA 2005) during protected area design will help ensure that these conservation tools align with stakeholders' needs. Understanding these benefits should also include how they may vary temporally (e.g. Dalton et al. 2010). To spatially describe the benefits that stakeholders derive from ecosystems, planners can use tools such as collaborative mapping (e.g. Elwood 2006, Ban et al. 2008) or cognitive mapping (e.g. Kitchin 1994, Delisle et al. 2009). Although planners are increasingly using these tools to map ecosystem benefits and social values (e.g. Alessa et al. 2008, Raymond et al. 2009, Bryan et al. 2011), very few studies have incorporated these social factors into spatial prioritisation (but see Whitehead et al. 2014). One potential approach to the latter area of research is using non-market valuation methods (e.g. stated preference techniques such as contingent valuation or choice modelling; e.g. Spash 2008, Adams et al. 2014) to enable comparative representation of different kinds of values in prioritisation.

Limitation 4. Stakeholders tend to be represented as a single group

My research in chapter 3 contributes to overcoming this limitation by providing insights into whether the impacts of MPAs on people can vary by social subgroup. I found little empirical evidence that MPA impacts on five indicators of poverty differed according to social subgroups defined by age, gender and religion. Although environmental knowledge was the only indicator for which my quantitative data indicated heterogeneous impacts, my qualitative data suggest that there may have been other differential MPA impacts according to social subgroup. I further contributed to

overcoming this limitation that stakeholders tend to be represented as a single group in SCP through my research in chapter 5, in which I provided methods for treating stakeholders as multiple groups in spatial prioritisation.

A shortcoming of my research in chapter 3 and chapter 5 is that I did not explicitly examine which subdivisions of stakeholder groups are most relevant to achieving equity. Given that the purpose of my research in chapter 5 was to test methods for incorporating socioeconomic considerations into spatial prioritisation, I assumed rather than elicited that the most important factor to account for to achieve equity in lost CPUE was the type of gear employed. The subgroups I examined in chapter 3 were chosen based on the assumption that extent of participation is significantly related to benefits received from management; I divided stakeholders according to age, gender, and religion because these factors were found to be related to participation (Pollnac et al. 2003). Future research could identify the most appropriate factors to disaggregate stakeholders by explicitly assessing which groups are likely to benefit or be negatively affected by protected areas. Daw et al. (2011) identify two key pathways through which ecosystem services can differentially contribute to poverty alleviation according to social subgroups: (1) different individuals benefit from and rely on different ecosystem services; and (2) individuals' benefits from an ecosystem service depend on a range of access mechanisms, including social relationships, institutions, and capabilities. For example, Hicks and Cinner (2014) found that social, institutional, and knowledge access mechanisms determined perceived ecosystem benefits. These ideas can be applied to the socioeconomic impacts of protected areas, both proactively, through incorporating subgroups into spatial prioritisation, and retrospectively, through impact evaluation.

The subdivisions of stakeholder groups that are most relevant to achieving equity will likely depend on which aspects of equity are considered. For example, Brown and Corbera (2003) distinguished three key elements of equity that should be considered in payments for environmental services programs: equity in access, equity in decision-making, and equity in benefits. Thus, future research could assess which social subgroups are most important to account for to achieve equity in relation to different aspects of designing and managing protected areas.

6.3 Conclusion

My thesis contributes to SCP theory and practice by elucidating principal socioeconomic factors related to protected areas and how they can be incorporated into the design and management of protected areas. I contributed to filling knowledge gaps that critically need addressing to overcome four key limitations of how socioeconomic factors are treated in spatial prioritisation, and ultimately much of the SCP process. My results demonstrate the importance of conceptually and theoretically broadening the way socioeconomic factors are considered in SCP, in both the spatial and non-spatial components of planning. Better understanding and incorporation of socioeconomic considerations in

protected area design and management will help ensure these conservation tools contribute to human well-being and increase the likelihood of gaining local stakeholders' support, on which conservation success is predicated.

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Appendices

Appendix 1. Chapter 2 Supplementary materials

Table A1.1 Years that data were collected for each poverty indicator.

Poverty domains and components	Indicator	Years that data were collected
Security		
Livelihood diversity	Average number of different occupations	1997, 2000, 2002, 2012
Resource dependence	Fisheries dependence	1997, 2000, 2002, 2012
Social cohesion	Frequency of illegal fishing	2002, 2012
Well-being	Present well-being	1997, 2000, 2002, 2012
	Future well-being	1997, 2000, 2002, 2012
Opportunity		
Financial capital	Wealth (material style of life)	1997, 2000, 2002, 2012
Human capital	Environmental knowledge	1997, 2000, 2002, 2012
Natural capital	Condition of local marine environment	2002, 2012
	Fish catch from local area	2000, 2002, 2012
Empowerment		
Resources access	Marine resource control	2000, 2002, 2012
Community participation	Ability to influence community affairs	2000, 2002, 2012
Governance mechanism	Prosecution of illegal fishing	2002, 2012
	Local government support for MPA	2002, 2012
	Enforcement of fishing laws	2002, 2012

Table A1.2 Factor loadings for the first principal component of eight material items that were reduced to a single index of material style of life using principal component analysis. This component accounted for 46% of the total variance.

Material item	Factor loading
Wall (bamboo)	-0.80
Floor (dirt, wood)	-0.74
Roof (coconut fronds, wood)	-0.71
Window (no window, wood)	-0.77
Indoor toilet	0.53
Lounge suite	0.64
Display cabinet	0.65
Modern stove	0.50

Text A1.1

Environmental knowledge was estimated through respondents' evaluation based on a seven-point Likert scale of the following eight statements concerning the relationship between coastal resources and human activities. Respondents were given a score of one for every statement which they responded with an accurate (i.e. conservation orientated) belief.

Statements regarding the relationship between coastal resources and human activities

1. Human activities do not influence the number of fish in the ocean.

2. Unless mangroves are protected we will not have any small fish to catch.

3. We have to take care of the land and the sea or it will not provide for us in the future.

4. If we throw our garbage on the beach, the ocean takes it away and it causes no harm.

5. We do not have to worry about the air and the sea, God will take care of it for us.

6. If our community works together we will be able to protect our resources.

7. Fishing would be better if we cleared the coral where the fish hide from us.

8. There are so many fish in the ocean that no matter how many we catch, there will always be enough for our needs.

Appendix 2. Chapter 4 Supplementary materials

Table A2.1 Factor loadings for the first principal component of nine material items that were reduced to a single index of material style of life using principal component analysis. This component accounted for 44% of the total variance.

Material item	Factor loading
Wall (concrete)	0.53
Floor (tile)	0.51
Window (glass)	0.62
Piped water	0.61
Fan	0.57
Refrigerator	0.57
Satellite dish	0.53
TV	0.60
Modern stove	0.51

Table A2.2 Level of decision making relating to MPA management.

	Number of respondents		
	Not involved	Passively involved	Actively involved
Level of decision making in relation to MPA management	66	82	116

Table A2.3 Number of MPA management activities respondents participated in.

	Number of respondents								
	1	2	3	4	5	6	7	8	9
Number of management activities participated in	91	16	20	23	32	19	35	25	3

Table A2.4 Frequency of participation in MPA management activities in last six months.

	Number of respondents			
	0	1-5	6-20	>20
Frequency of participation in management activities in last six months	120	83	42	19

Text A2.1

The public goods game

Participants were randomly paired and the games were played in groups of two. The players did not know the identity of their paired player or their contribution because players' decisions about how much to contribute to the public good were made privately. Each of the two players received seven bills of 10,000 Indonesian Rupiah (IDR), which was equivalent of a day's wage. The players then

decided whether and how many of the seven bills of 10,000 IDR they would contribute to the public good. The total amount of money in the public good from both players was increased by 50% and distributed equally between the two players irrespective of their individual contributions. Therefore the payoff for player *i* was

$$\text{Payoff}_i = 70{,}000 - g_i + \frac{\left(1.5 \sum_{j=1}^{2} g_j\right)}{2}$$

where g_i is the contribution from player *i* to the public good, and g_j is the contribution from each player *j*. The game results in a social dilemma. Players together would be best off if they contributed their entire 70,000 IDR to the public good. However each player's payoff is maximised by contributing nothing to the public good independent of the other player's contribution because the return for a player contributing 10,000 IDR is 7,500 IDR. For example, if both players contributed their entire endowment, they would both receive 105,000 IDR and together their payoff would be 210,000 IDR. However, if one player free-rides and contributes nothing to the public good, while the other player contributes 70,000 IDR, the free-rider earns 122,500 IDR, while the other player receives 52,500 IDR, and their collective payment is 175,000 IDR.

Experimental procedure

Players were gathered in community halls or schools for the public goods game sessions. My chief research assistant and I delivered instructions to the entire group in Bahasa Indonesia, the official language of Indonesia. The game instructions were followed by a fixed set of examples which were illustrated by the lead author, chief research assistant, and volunteers from amongst the players. The instructions and examples were consistent between public goods games sessions in each of the communities because they were explained using a detailed script and the same chief research assistant. Players were allowed to ask questions during the instructions and the examples. Questions were answered directly by the lead author or the answer was translated by the chief research assistant.

After the instructions and examples, each player was called individually into a separate room where they made their decisions about how much to contribute to the public good. Prior to playing the game they were asked six questions to test their understanding of the game. If the player got one or more of the questions wrong they were not allowed to play the game and were given a 20,000 IDR show-up payment. If the player answered all the questions correctly they were given seven bills of 10,000 IDR and asked how much they would like to contribute to the public good. Once the player had made the decisions they left the community hall or school. At all times two research assistants remained with the players waiting to play the game to ensure they did not discuss the game or communicate with those who had already played.

Appendix 3. Chapter 5 Supplementary materials

Table A3.1 Pearson correlation coefficients between CPUE data layers that included data from four villages and data layers that excluded data from one of the four villages at a time.

	Village that was excluded			
	Raviravi	**Nakorovu**	**Kiobo**	**Navatu**
Summed CPUE	0.981	0.972	0.818	0.706
Gillnet	0.995	0.909	0.485	1
Handline	0.946	0.971	0.976	0.418
Handspear	0.603	0.987	0.989	1
Hawaiian	0	1	1	1
Speargun	0.981	0.983	0.882	0.616
Trolling	1	0.475	0.888	1

Text A3.1

Cost scenarios

For the scenarios Cost_single and Cost_multiple, the cost of each planning unit was based on CPUE. For Cost_single, the total cost of each planning unit ($CPUE_{single}$) was the sum of CPUE for all gear types:

$$CPUE_{single} = \sum_{f=1}^{Nf} CPUE_{if} \quad (1)$$

where $CPUE_{if}$ is the CPUE in planning unit *i* for gear type *f*, and *Nf* is the number of gear types. For Cost_multiple, the total cost for each planning unit ($CPUE_{multiple}$) was based on the relative importance of each planning unit for each gear type:

$$CPUE_{multiple} = \sum_{f=1}^{Nf} \frac{CPUE_{if}}{CPUE_{mf}} \quad (2)$$

where $CPUE_{mf}$ is the maximum CPUE value for gear type *f* in the planning region.

Text A3.2

Spatial prioritization tools

Marxan uses a simulated annealing algorithm to generate multiple protected area solutions that aim to minimize cost of selected planning units subject to the constraint that all biodiversity objectives are met (Ball et al. 2009):

Minimise

$$\sum_{i=1}^{Np} x_i c_i + b \sum_{i1=1}^{Np} * \sum_{i2=1}^{Np} x_{i1} * (1 - x_{i2}) * cv_{i1i2}) \quad (3)$$

subject to the constraint that all biodiversity objectives are met

$$\sum_{i=1}^{Np} x_i a_{ij} \geq t_j \,, \ \forall\, j \quad (4)$$

and

$$x_i \in \{0,1\}, \ \forall\, i \quad (5)$$

where a_{ij} is the occurrence level of feature j in planning unit i, c_i is the cost of planning unit i, Np is the number of planning units, and t_j is the objective level for feature j. The control variable x_i has value 1 for planning units selected to be placed in a protected area and value 0 for planning units not selected. The parameter cv_{i1i2} reflects the cost associated with having planning unit $i1$ selected and planning unit $i2$ not selected. The parameter b, is the boundary length modifier (BLM), a user-defined variable that controls the importance of minimizing the total boundary length of the selected areas.

Marxan with Zones solves essentially the same problem as Marxan, to achieve objectives for a minimum cost, but multiple management zones can be employed, and users can specify the costs and contributions of each zone to alternative objectives (Watts et al. 2009):

Minimise

$$\sum_{i=1}^{Np} * \sum_{k=1}^{Nz} x_{ik} c_{ik} + b \sum_{i1=1}^{Np} * \sum_{i2=1}^{Np} * \sum_{k1=1}^{Nz} * \sum_{k2=1}^{Nz} cv_{i1,i2,k1,k2} x_{i1,k1}\, x_{i2k2} \quad (6)$$

subject to

$$\sum_{i=1}^{Np} * \sum_{k=1}^{Nz} x_{ij} ca_{jk} a_{ij} \geq t1_j \ \forall\, j \quad (7)$$

and subject to

$$\sum_{i=1}^{Np} a_{ij}\, x_{ik} \ \geq \ t2_{jk} \ \forall\, j \text{ and } \forall\, k \quad (8)$$

and

$$x_{ik} \in \{0,1\}, \ \forall \ i \quad (9)$$

and

$$\sum_{k=1}^{Nz} x_{ik} = 1 \ \forall \ i \quad (10)$$

Equation (6) represents the costs for a configuration of planning units where each planning unit is allocated to one of the total number of zones, *Nz*. The control variable x_{ik} has value 1 for planning units selected to be placed in zone *k* and a value 0 if planning unit *i* is not allocated to zone *k*, but each planning unit must only be in a single zone. The parameter c_{ik} is the cost of placing each planning unit *i* in zone *k*. Equation (10) specifies that each planning unit must only be in a single zone. The second term of equation (6) represents the connectivity cost of a configuration of planning units in particular zones, the connectivity matrix records the cost of connections between planning units *i*1 and *i*2 if *i*1 is in zone *k*1 and *i*2 is in zone *k*2. In equation (7) a_{ij} is a matrix of features which outlines the amount of each feature *j* in each planning unit *i*, the parameter t_{ij} is objective level for each feature *j*, ca_{jk} is the contribution of each zone *k* to achieving each feature's objective. The parameter $t2_{jk}$ in equation (8) is the amount of each feature *j* that is targeted for a particular zone *k*.

For each objective under each of the four scenarios I used the method of Stewart and Possingham (2005) to select a BLM that resulted in achievement of a level of compactness between protected areas that did not excessively increase cost. I applied 100 replicate runs to each objective level for each of the four scenarios.

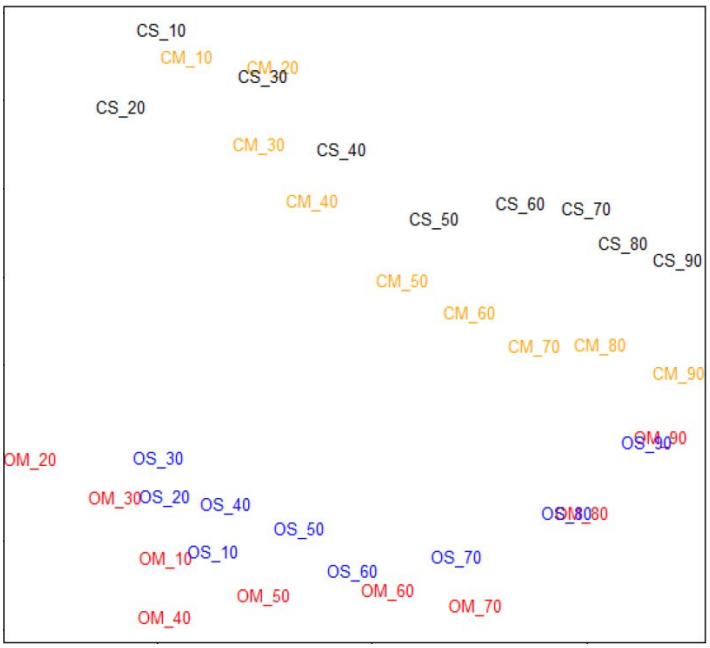

Figure A3.1 MDS ordination of MPAs with different biodiversity objectives under each of the four scenarios: Cost_single (CS; black), Objective_single (OS; blue), Cost_multiple (CM; yellow) and Objective_multiple (OM; red). Ordination is based on a Bray-Curtis similarity matrix of selection frequencies for each planning unit over 100 replicate runs for each biodiversity objective under each scenario. 2D stress = 0.05.

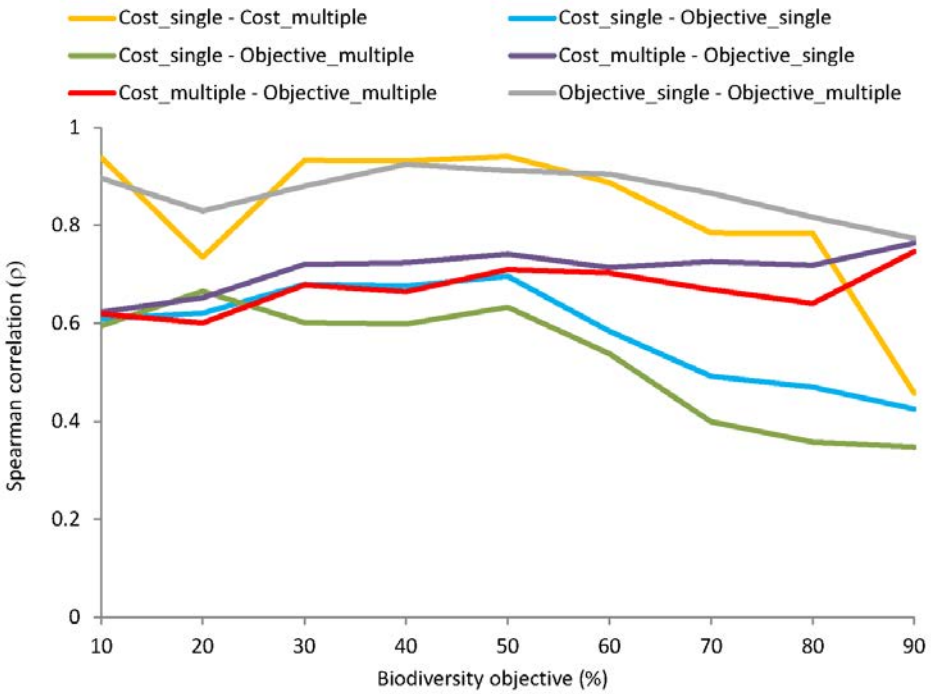

Figure A3.2 Spearman rank correlations between selection frequencies of planning units between each of the four scenarios (Cost_single, Objective_single, Cost_multiple, Objective_multiple) under different biodiversity objectives. The results presented are means of solutions from 100 replicate runs of each biodiversity objective under each scenario.

Appendix 4. Household survey

Survey number

Date_____
Village (Desa/Dusun)_____
Interviewer_____

This interview is for a study by James Cook University in Australia, and it is about trying to understand fishing and management of fishing in Indonesia. Helping us with this survey is voluntary. If you do not want to take part or do not want to answer any questions, there is no penalty. Also, there are no right or wrong answers. The information that you give us is confidential, we will not tell anybody what you told us. This interview should take approximately 40 minutes. Do you have any questions? Are you happy to continue with the interview?

DEMOGRPAHIC INFORMATION

1. Gender

Male	Female

2. Where were you born? (*Tick only one column*)

This village	This subdistrict	This district	This province	This island	Other island

3. How many years have you lived in this village?

4. How many currently people live in your house? (*Including person being interviewed and child is under 17 years and they are a household if they share food)*

Adult male	Adult female	Male children	Female children

5. What jobs do you that bring in food or money to your house? What is your first, second and third job? What do other people in your house do that bring in food or money to your house? (*Tick activities that respondent does, then write the number of people who undertake different activities in the household, then rank the importance of the household activities).*

ACTIVITY		# according to level of importance RESPONDENT	# of people	Rank of Importance WHOLE HOUSE
Fishing				
Gleaning				
Seaweed farming				
Milkfish fry collection				
Buy and sell	Fish			
	Milkfish fry			
	Seaweed			
	Other			
Fish processing				
Other processing				
Farming				
Salaried Employment				
Tourism				
Informal Economic Activities				
Other				

If fishing,

6. In general, what percentage of your fish catch do you sell?

MARINE MANAGEMENT

I would now like to ask you some questions about the sea, fishing and managing fishing.

7. What is the condition of the coral and fish near this village?

Very bad	Bad	Neither	Good	Very good	Don't know

8. How is the fishing around this village compared to 5 years ago?

Decreasing	Same	Increasing	Don't know

9. Are there places around here where fishing is restricted, for example all fishing is not allowed, fishing with some gears is not allowed, or where only some people are allowed to fish?

Yes	No

What do you call this management/rule?

10.(a) Can you please explain further what is allowed and what is not allowed in the MPA? (*First don't read options and tick the activities mentioned in the first column, then ask them about the rules they don't mention and if yes put in second column. Then ask if agree or not.*

(b) Which of these rules do you agree with?

Description	Tick rule mentioned without prompting	Tick rule that were participated in	Agree? (y/n)
All kinds of fishing disallowed (no-take)			
a. bombs			
b. poison			
c. net			
Some people restricted (describe)			
Other (describe)			

INDIVIDUAL INVOLVMENT IN MPA MANAGEMENT

11. Currently, are you involved in decisions about marine resource use (e.g. fishing, gleaning) or managing marine resources (e.g. fish, mangroves or coral)? For example, have you been to any meetings about marine resources use (e.g. fishing, gleaning) or marine resources (e.g. fish, mangroves or coral)? If yes, how? *(Interviewer to decide level of involvement, active =if talks at meetings, does MPA activities etc; passive=if attends meetings but does not talk)*

No	Active	Passive

Description of involvement:

12. Over the last few months have you participated in any MPA activities/MPA management? What are they? *(First don't read options and tick the activities mentioned in the first column, then ask them about the activities they didn't mention and if they say that they have done those activities then tick in the second column.)*

MPA activities	Tick activities mentioned without prompting	Tick activities that were participated in
MPA group meetings		
Unofficial meetings about MPA without MPA group		
Socialisation/visiting		
Watching for illegal fishers		
Maintaining boundaries of MPA		
Training		
Checking fish and coral condition		
Environmental clean-up near MPA		
Other		

13. In general, how many times have you participated in these MPA activities in the past 6 months?

14. In general, how much time did you spend doing management in the last 2 weeks?

15. In this village, who encourages you to spend time doing MPA activities (for example, friends, family, community leaders?

16. How much do these people encourage you to spend time doing MPA activities? (*Read out options a-c)*

	Discourage	Not discourage or encourage	Little encouragement	Strong encouragement
a. Family and friends				
b. Village government leaders (Hukum tua and PALA (depala lingkungan/dusun)				
c. Religious and social village leaders (adat, pendeta, iman etc)				

17. Are there any barriers preventing you from participating (more) in MPA activities? What makes it difficult for you to participate more in MPA activities? *(Don't read options but tick if respondent mentions problem or write in 'other')*

Not enough time	Don't have right skills or equipment	Don't agree with what is allowed and not allowed	Not enough money
Other people don't participate	Other	No one asked me to	No invitation

PERCEPTIONS OF MPAS

18. In general, is the MPA good or bad for this village?

Very bad	Bad	Neither	Good	Very good	Don't know

19. What do you think are the benefits to the community from this MPA? (*Don't read options but tick if respondent mentions benefit or write in 'other')*

Improve fish catch	Improve coral/fish condition	Increase tourism	Pride/prestige for the village
Protect future generations	Excludes people from other villages	Stops bad gear	More money and benefits from NGO or government in future
Reduce conflict	Other		

20. In general, do you think that it is good or bad for you personally to be involved in MPA activities?

Very bad	Bad	Neither	Good	Very good	Don't know

21. What do you think are the benefits to you personally from being involved in MPA activities (*Don't read options but tick if respondent mentions benefit or write in 'other')*

Pride/prestige	Influence in the village	Will improve my fish catch
Other		

22. (a) In general, do you think that the MPA is good to bad for the government?

Very bad	Bad	Neither	Good	Very good	Don't know

22. (b) If yes, what do you think the benefits are for the government?

Conservation of fish and sea	Village pride	Tourism	Attention higher government
Money from LSM or higher government		More infrastructure from higher government or LSM	

23. Do you think there are any problems with this MPA? (*Don't read options but tick if respondent mentions problem or write in 'other')*

Don't know the rules	Outsiders breaking rules	Unfair	Increase conflict A. Within village B. Between villages

Too hard to enforce MPA	Bad for fishing	Don't agree with rules	No money or support to run MPA
Other			

ILLEGAL FISHING

Now I would like to ask you about people doing things that they are not allowed to do in the MPA.

24. Have you seen or heard of people from this village violating the rules of the MPA? *(If no, circle 'never', if yes, ask how often).* How often does this happen?

Daily	Weekly	Monthly	Less than monthly	Never

25. Have you seen or heard of people not from this village violating the rules of the MPA? *(If no, circle 'never', if yes, ask how often).* How often does this happen?

Daily	Weekly	Monthly	Less than monthly	Never

26. What would you do if you saw someone violating the rules of the MPA? *(Interviewer don't read options but tick the one of the following options which bests suits the response)*

- □ Nothing
- □ Talk to him and explain why he should not do it
- □ Report the incident to the sanctuary management committee
- □ Report the incident to the head of village
- □ Apprehend the violator and bring them to village head or police

KNOWLEDGE OF ENVIRONMENT

Thank you for that helpful information. I would now like to ask you some questions regarding your opinions about the environment. I am going to read you a series of statements. Please indicate to what extent you agree with each of the following statements. There is no right answer. Please note that the scale is slightly different for this one.

Interviewer please read statements exactly,and do not explain too much.

27.

(a). Human activities do not influence the number of fish in the ocean.

Strongly disagree	Disagree	Slightly disagree	Neither disagree or agree	Slightly agree	Agree	Strong agree

(b). Unless mangroves are protected we will not have any small fish to catch

Strongly disagree	Disagree	Slightly disagree	Neither disagree or agree	Slightly agree	Agree	Strong agree

(c). We have to take care of the land and the sea or it will not provide for us in the future

Strongly disagree	Disagree	Slightly disagree	Neither disagree or agree	Slightly agree	Agree	Strong agree

(d). If we throw our garbage on the beach, the ocean takes it away and it causes no harm.

Strongly disagree	Disagree	Slightly disagree	Neither disagree or agree	Slightly agree	Agree	Strong agree

(e). We do not have to worry about the air and the sea, God will take care of it for us.

Strongly disagree	Disagree	Slightly disagree	Neither disagree or agree	Slightly agree	Agree	Strong agree

(f). If our community works together we will be able to protect our resources.

Strongly disagree	Disagree	Slightly disagree	Neither disagree or agree	Slightly agree	Agree	Strong agree

(g). Fishing would be better if we cleared the coral where the fish hide from us.

Strongly disagree	Disagree	Slightly disagree	Neither disagree or agree	Slightly agree	Agree	Strong agree

(h). There are so many fish in the ocean that no matter how many we catch, there will always be enough for our needs.

Strongly disagree	Disagree	Slightly disagree	Neither disagree or agree	Slightly agree	Agree	Strong agree

TRUST

In every community some people get along with each other and trust each other, while other people do not. I would now like to talk to you about trust, and how much you trust different kinds of people.

28. In general, how much do you trust the following people? *(Read the options a-d)*

	Not at all	Distrust more people than trust	About half-half	Trust more people than distrust	Trust all

a. People in your village					
b. Village government leaders (Hukum tua and PALA (depala lingkungan/dusun)					
c. Religious and social village leaders (adat, pendeta, iman)					
d. MPA management group					

29. How many people in the village have you lent a small amount of money (no more than a household's weekly expenses-for example Arisan) to in the past 6 months?

30. How many people in the village have you lent your possessions (e.g. clothes, motorcycles, fishing or farming tools) to in the past 6 months?

31. In the past 6 months how many people from this village have helped you, including mapalus?

32. In the past 6 months how many people from this village have you helped, including mapalus?

VILLAGE INVOLVEMENT

Now I would like to ask you some questions about your involvement in village activities and your relationships with other people in the village:

33. How many village organisations are you involved in? Which organisations?

34. How many village events (other than meetings, e.g. weddings) have you attended in the last 6 months?

35. (a) If there is a decision made in your village, are you involved in that decision? If yes, how? *(Active=if talks at meetings, passive=if attends but does not talk)*

(b) Description of involvement:

No	Active	Passive

CRMP

Note: # denotes project village only and * denotes control village only

In terms of household well-being, are you better off or worse off or the same as 5 years ago?

Worse	Same	Better

Why? What factors/events/reasons have affected it?

Do you expect you standard of living to be better in 5 years?

Worse	Same	Better

Have you heard of Proyek Pesisir?

Yes	No

#Did you know that an ordinance was approved in your village establishing a village-based MPA?

Yes	No

#Did you participate in Proyek Pesisir activities?

Yes	No

If yes, which of the following activities and how frequently did you participate in them? *(Interviewer read options)*

ACTIVITY	FREQUENCY			
	Never	Rarely	Sometimes	Often
Development of MPA plan and village ordinance				
MPA management group				
Talking with extension officers				
Looking after MPA activities (i.e. buoys)				
Resolving problems about fishing (e.g. who can fish where with what gear)				
Environmental education				
Reef/fisheries monitoring				
Tourism development				

Livelihoods (jobs/occupations other than fishing)				
Proyek pesisir management group di desa				
Mangrove group				
Other non-marine activities				

#Are any of these activities still continuing?

#If yes, why do you/people in this village continue the activity? If no, why do they not continue activity?

#What was the most useful activity of *Proyek Pesisir*?

#In general, was Proyek Pesisir good or bad for this village?

Very bad	Bad	Neither	Good	Very good	Don't know

#Were there benefits of *Proyek Pesisir?* What were they?

#Where there problems with *Proyek Pesisir*? What were they?

* Do you know that an ordinance was approved in your neighbouring villages establishing a village-based MPA?

Yes	No

LADDER QUESTIONS

The following questions involve showing the respondent a ladder-like diagram with 15 steps. The respondent is told that the first step represents the worst possible situation and the highest step is best situation. The subject would then be asked where on this ladder (ruler, scale, whatever is appropriate for the subjects involved) the village is today.

a) Empowerment: Control over marine resources. STEP NUMBER___
The first step indicates a community where the people have no control over access to the community's coastal resources--anyone from anywhere is free to come and fish, gather shellfish, cultivate seaweed, etc. The highest step indicates a community where the people in the community have the right to control (e.g., develop rules) the use of the coastal resources of their community.

b) Empowerment: Ability to influence community affairs. STEP NUMBER___
The first step indicates a community where the people have no influence on community affairs. Things are changed even if community members disagree with the changes, and they have no influence on anything that happens. The highest step indicates a community where all community members can attend meetings, voice their wants and concerns, and influence what happens in the community through popular vote.

c) Benefit: Amount of traditionally harvested fish resource in the water. STEP NUMBER___
The first step indicates waters with none of the traditionally harvested fish. All the fish are gone. The highest step indicates waters where community members can easily catch all the fish they want.

d) Benefit: Resource health STEP NUMBER___
First step is coastal resources destroyed, Highest step is coastal resources healthy

e) Illegal fishing STEP NUMBER___
First step is illegal fishing happens all the time. Highest step is illegal fishing never occurs

f) Enforcement STEP NUMBER___
First step is no enforcement of fishing laws, no one ever arrested. Highest step is laws strictly enforced and people always arrested

g) Prosecution STEP NUMBER___
First step is people who break the rules are never caught or fined, Highest step step is Sanctuary violators are caught and fined/sanctioned,

h) Support from Local Government Leadership STEP NUMBER___
First step is government leadership above the village is apathetic with respect to the marine sanctuary. Highest step is government leadership above village is supportive and active with respect to the marine sanctuary.

MORE DEMOGRAPHIC QUESTIONS

36. How old are you?

37. What is the highest level of education you have obtained?

School level	Number of years complete
Elementary school	
Junior high school	
Senior high school	
Diploma	
University	

38. What is your ethnicity?

39. What is your religion?

40. Material style of life. (*Please circle the items present and leave blank those that are not present)*

a. Household items & facilities.

Cupboard	Electricity	Matched living room set	Modern stove

TV	VCR/DVD	Satellite dish	Refrigerator
Electric fan	Radio/cassette player	Piped water	Indoor toilet
Display cupboard	Wood or plastic chairs	Wooden benches	VIDEO GAME

b. Windows

Open	Wood shutters	Glass	Other

c. Roof material

Nipa (coconut)	Metal	Wood	Tile	Other

d. Floor material

Dirt/soil	Wood	Cement	Finished (tiles, etc.)	Other

e. Wall material

Bamboo/ thatch	Wood (plank)	Concrete	Other

Appendix 5. Key informant survey

Survey number

Date_____
Village (Desa/Dusun)_____
Interviewer_____

This interview is for a study by James Cook University in Australia, and it is about trying to understand fishing and management of fishing in Indonesia. Helping us with this survey is voluntary. If you do not want to take part or do not want to answer any questions, there is no penalty. Also, there are no right or wrong answers. The information that you give us is confidential, we will not tell anybody what you told us. This interview should take approximately 40 minutes. Do you have any questions? Are you happy to continue with the interview?

Position (*circle*): Village mayor MPA management group Social leader Elder Experienced fisher

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MPA MANAGEMENT

I am interested in knowing more about the management of marine resources in this village.

1. When was the MPA started?

2. Why was it started?

3. (a) What are the goals of the MPA?/what is the MPA supposed to achieve? Examples of goals = tourism, better fishing, better resource/coral condition, reduce conflict between people, ownership of resources etc.

(b) Do you think the MPA has been successful in achieving those goals?

4. In general, is the MPA good or bad for this village?

Very bad	Bad	Neither	Good	Very bad	Don't know

5. What do you think are the benefits to the community from this MPA?

6. In general, do you think that it is good or bad for you personally to be involved in MPA activities? Examples of MPA activities are cleaning up rubbish, watching for people breaking rules, being in the MPA group etc.

Very bad	Bad	Neither	Good	Very bad	Don't know

7. What do you think are the benefits to you of personally from being involved in MPA activities?

8. In general, do you think that the MPA is good to bad for the government?

Very bad	Bad	Neither	Good	Very bad	Don't know

If yes, what do you think the benefits are for the government?

9. Do you think there are any problems with this MPA?

MPA BOUNDARIES

10. Are there markers showing the boundaries of the MPA?

11. Do people in this village know where the boundaries are/is there ever any confusion about where the MPA is?

12. How do people know where the boundary of the MPA is?

MPA RULES

13. (a) What are the rules of the MPA? Are there places where people can't fish? Are some gears or species restricted?

(b) How often are the rules broken, daily, weekly, monthly, yearly or never?

(c) Who watches out for people breaking the rules and applies a punishment if they are?

(d) What is the penalty for breaking the rules? Are the penalties different for breaking different rules?

14. (a) Does the punishment or fine increase if someone breaks the same rule twice, three times or more?

(b) Do you have the ability/rights to make arrests of illegal fishers?

15. (a) Before the MPA, was there any traditional management of marine resources, i.e. of fishing?

If yes, describe.....

16. How is the MPA different from traditional management?

17. Is traditional management or MPA better?

18. Since the MPA started, have the rules of the MPA changed?

If yes, why did the rules change?

CONFLICT-NOT JUST ABOUT MPA

---

19. (a) Are there conflicts/problems about marine resources (for example arguments over ownership, the MPA, gear use)?

If yes,

(b) Who between?

(b) What is the conflict about?

(c) What is the intensity?

(d) How often does it happen?

20. Have these conflicts/ problems been resolved?

21. How are these conflicts/problems dealt with?

22. Do people in your village ever meet with people from other villages to talk about marine resource use, for example fishing, gleaning or MPAs?

23. What are the barriers to having a MPA in this village? What makes it difficult to do MPA activities in this village?

VILLAGE MARINE AREA-Not MPA

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24. (a) What is the approximate length of coastline under control of this village?

(b) Are the boundaries marked? If yes, what with?

(c) Is there ever any confusion with people from other villages over the where the boundaries of the village's waters are?

(d) Who is allowed to fish in village waters (i.e. people from other villages)?

(e) Is there ever any confusion about who is allowed to fish in village waters?

DISTANCE TO MARKET

---

25. (a) When people from this village sell fish, where does that fish go?

(b) How long does it take to travel there?

(c) Who takes to fish to the place where it is sold (e.g. trader)?

VILLAGE POLITICS

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26. How many political parties are there in this village which are supported?

27. How many political parties support the MPA?

28. How many times in the past year has the kepala desa called a meeting at which community members voted on an issue?

29. What percentage of people attend?

30. Please rank and list the 3 most frequently discussed topics at village meetings:

(please number 1,2, or 3 and add other categories if needed)

School	Village rules	Health	Land rights
Fishing rights	Water supply	Village work	MPA

31. Is the MPA in sight of the village?

32. Does a formal written MPA management plan/ordinance exist?

INVOLVEMENT IN MPA

33. How many people in this village are involved in the MPA activities?

34. What MPA/marine resource management activities do people do in this village?

35. Why do people get involved in MPA activities?

36. How many people are in the MPA group?

37. Who can join the MPA group? Who chooses who can join the management board?

38. Is there ever any confusion about who can join the MPA group (describe)?

39. Who makes the decisions about the rules of the MPA or the punishment for breaking the rules?

40. Who helps them make the decisions?

41. Does the MPA group have the power/is able to design and change MPA rules?

42. (a) Does anyone, including people not from this village, collect information about the condition of the environment (count fish/coral, look at what people catch)?

If yes,

(b) Who?

(c) How often?

(d) Who gets information?

PARTNERSHIPS WITH OUTSIDE ORGANISTATIONS

43. How much is the MPA supported by village government officials?

44. How much is the MPA supported by community leaders (e.g. adat, religious leaders)?

45. (a) Currently, who helps with the MPA from outside the village?

(b) What do they do (e.g. advice, idea, training, conflict resolution)?

(c) How often does the village have contact with these people (e.g. once a month/ year etc)?

46. Do you get funding for the MPA? Where from?

47. (a) How many outside organisations (for example, NGOs, government or universities) have been involved in marine resource management and research in this village over the last 20 years?

(b) What were they called?

(c) What did they do?

(d) What years where they involved?

DEMOGRAPHICS

48. Where were you born?

This village	This subdistrict	This district	This province	This island	Other island

49. How long have you lived in this village?

50. What is the highest level of education you have obtained?

School level	Number of years complete
Elementary school	
Junior high school	
Senior high school	
Diploma	
University	

51. What is your ethnicity?

52. What is your religion?

PROYEK PESISR

Have you heard of Proyek Pesisir?

#Did you participate in Proyek Pesisir activities?

#What was the most useful activity of *Proyek Pesisir*?

#Are any of these activities still continuing?

#If yes, why do you/people in this village continue the activity? If no, why do they not continue activity?

#In general, was Proyek Pesisir good or bad for this village?

#Were there benefits of *Proyek Pesisir?* What were they?

#Were the benefits for everybody? Did some people benefit more than other people?

#Where there problems with *Proyek Pesisir*? What were they?

*Do you know that an ordinance was approved in your neighbouring villages establishing a village-based MPA?

#Since Proyek Pesisir has bomb fishing in the waters near the village changed?

#Since Proyek Pesisir has coral mining in the waters near the village changed?