DOCTOR OF PHILOSOPHY

Exploring real and hypothetical impacts of community-based conservation interventions

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By

Amy Rose Lewis

Thesis for the degree of Doctor of Philosophy

2019

Title	Exploring real and hypothetical impacts of community-based conservation interventions
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Executive Summary

Community-based conservation projects have been promoted as a way of achieving both conservation and development goals. There is a growing literature surrounding the challenges of implementing such projects and achieving the outcomes sought, however questions remain including: To what extent do donors value community aspects of conservation projects? Does community conservation effectively build the capacity of participating communities? To what extent might interventions such as Payments for Ecosystem Services and promoting communication improve the ecological outcomes of such projects? In this thesis I attempt to answer these questions focusing on the case of community conservation conducted by Durrell Wildlife Conservation Trust in Madagascar. I use a combination of methods which rely on hypothetical scenarios (choice experiments and experimental games), and an evaluation of self-reported impacts measured using a Before-After-Control-Impact design.

Firstly, I conducted a discrete choice experiment with visitors to Durrell's Jersey Zoo to explore the impact of highlighting community involvement in a conservation project (rather than species or habitat aspects) on likely donations. Respondents showed the highest willingness to pay for projects that have local community involvement in management. By simultaneously conducting a revealed preference study through an experimental campaign asking for real donations, I attempted to validate the choice experiment findings. With the level of donation we requested, most respondents made a donation so I was not able to demonstrate an effect of campaign type on real donations. Secondly, I conducted a household survey in Northern-central Madagascar across nine communities around a lake where a community conservation project was planned, and eight around an otherwise similar lake with no planned conservation project. I used this to develop indicators of community capacity and found that the levels and changes in indicators differed, showing a requirement for capacity to be considered in multidimensional space. In the following Chapter I used these measures of community capacity to evaluate the impact of capacity building activities carried out over the first two years of a community-based conservation project aimed at preparing the first lake for the reintroduction of the world's rarest duck. For this evaluation I used a before-after-control-impact approach allowing a robust estimation of impact. I found no evidence of impact in composite scores of capitals, though I found evidence of the impact of the intervention on some indicators of social capital. My analysis also revealed some evidence of elite capture of training and resources. Finally, I used an experimental game played with community members in both conservation and non-conservation sites to explore the hypothetical impact of potential interventions to improve

ecosystem service provision by reducing pesticide use amongst farmers. I found that incentives in the form of subsidies increased co-operative behaviour and decreased the rate of non-cooperative behaviour. Enhancing communication did not increase the provision of ecosystem services across the game landscape, however it did increase cooperative behaviours between players. I argue that experimental games such as this have value beyond research and could be used as a tool for communities and conservation projects to explore the potential pros and cons of various interventions collaboratively.

Together these chapters provide helpful evidence to improve the marketing, evaluation and future design of community-based conservation projects, in Madagascar and elsewhere, which will ultimately contribute to maximising benefits for both people and wildlife.

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My thanks go to my supervisors; Julia P.G. Jones and James M. Gibbons at Bangor University and Richard P. Young at Durrell Wildlife Conservation Trust. Over the last three and a half years or so, they have provided amazing, sustained and constructive advice and guidance which helped to shape both my research and my writing. I also am grateful to the financial support provided by the Leverhulme Trust both for my scholarship and field work costs. Our collaboration with Professor Hery-Lisy at Mahajunga University was incredibly useful, and I hope that this paves the way for future collaborations between Bangor, Durrell and Mahajunga. The main case-study within this thesis was a Darwin initiative project in collaboration between multiple organisations; Durrell (Madagascar), Wildfowl and Wetlands Trust, Asity Madagascar, The Peregrine Fund, Le Ministère de L'Environnement et des Forêts (Government of Madagascar). My thanks go to all of the project partners that supported my work and provided helpful advice. I hope that they find the outcomes of the research useful.

This thesis would of course not been possible if not for the hundreds of people, both in the UK and Madagascar, that we have interviewed over the last few years (sometimes twice!) the time and energy they took to answer our surveys were invaluable. I am immensely grateful for the insights they have provided in further understanding the dimensions of community-based conservation projects. In Madagascar, we were given the best welcomes- Misaotra! My thanks go to all of the people that let us camp on their land over the three years of field work, and those that gave the team and food, shelter and water. Original translations of the Malagasy household survey were conducted by Rio Ridhish Heriniaina. The survey was also guided by discussions with Hanitra Rakotojaona, Herizo Andrianandrasana and Felix Razafindrajao.

The Durrell team in Madagascar really went above and beyond, from helping with physically getting to the site, to checking in on me and the team when we were camping out in the hills. To name some of that incredible team: Richard Lewis, Aina Ramamonjisoa, Lance Woolaver, Herizo Andrianandrasana, Bary Jean Rasolonjatovo, Floriot Randrianarimangason, Hanitra Rakotojaona as well as many others. Particular thanks to Felix Razafindrajao who I am so grateful for everything while I was in the field. In Jersey the field experiment could not have gone ahead without the help of the senior management team. My thanks also go to Donna Woodman, Kate Smallwood, Paddy Hammersley as well as the staff on the tills at Jersey Zoo.

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Lastly to family and friends who have given their love and support while I have been working on this thesis. For Rob and Finn.

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Glossary

AIC	Akaike Information Criterion
ASC	Alternative Specific Constant
BACI	Before-After-Control-Impact
BAU	Business as Usual
CBC	Community-Based Conservation
CBET	Community-Based Eco Tourism
CBNRM	Community-Based Natural Resource Management
CF	Community Forestry
CI	Confidence Interval
DCE	Discrete Choice Experiment
DWCT	Durrell Wildlife Conservation Trust
ES	Ecosystem service
GCF	Gestion Contractualisée des Forêts
GELOSE	Gestion Locale Sécurisée
GPS	Global Positioning System
IBC	Incentive based conservation
ICDP	Integrated Conservation and Development Project
IV	Instrumental Variable
KS	Kolmogorov-Smirnov
LME	Linear mixed effects model
MIXL	Mixed multinomial logit modelling
MPI	Multidimensional Poverty Index
NGO	Non-governmental Organisation
ODK	Open Data Kit
PCA	Principal Component Analysis
PES	Payments for Ecosystem Services
PMNR	Co-Management/ Participatory Management of Natural Resources
RCT	Randomised Control Trial
RDD	Regression Discontinuity Design
SE	Standard Error
VOI	Vondrona Olona Ifotony
WTP	Willingness to Pay
WWT	Wildfowl and Wetlands Trust

Authorship

All data chapters (Chapters 2-5) in this thesis have been prepared as manuscripts for peer reviewed publication. These are co-authored to reflect the role of my supervisors and collaborators. The references and supplementary material can be found at the end of this thesis.

Chapter 2: Lewis, A.R., Young, R.P., Gibbons, J.M., Jones, J.P.G. (2018) To what extent do potential conservation donors value community-aspects of conservation projects in low income countries? PLOS ONE, 13, 1-18, https://doi.org/10.1371/journal.pone.0192935

I designed the study with advice from Julia Jones (JJ), James Gibbons (JG) and Richard Young (RY). I was responsible for data collection with field assistants. I conducted the statistical analysis with advice from JG. I wrote the first version of the paper and all co-authors edited it.

Chapter 3: Lewis, A.R., Gibbons, J.M., Young, R.P., Razafindrajao, F. Razafindramavo, D., Jones, J.P.G. (Manuscript in preparation). Using a capitals based approach to investigate multidimensional aspects of capacity for community conservation in Madagascar.

I designed the study with advice from JJ, JG, RY and Felix Razafindrajao (FR). I was responsible for data collection with Danielysa Razafindramavo (DR) and field assistants. I conducted the statistical analysis with advice from JG. I wrote the first version of the paper and all co-authors edited it.

Chapter 4: Lewis, A.R., Gibbons, J.M., Young, R.P., Razafindrajao, F. Razafindramavo, D., Jones, J.P.G. (Manuscript in preparation). Measuring the impact of capacity building for community based conservation using a Before-After-Control-Impact.

I designed the study with advice from JJ, JG, RY and FR. I was responsible for data collection with DR and field assistants. I conducted the statistical analysis with advice from JG. I wrote the first version of the paper and all co-authors edited it.

Chapter 5: Lewis, A.R., Jones, J.P.G., Razafindrajao, F., Ramangatsimialona, L.A., Young, R.P., Gibbons, J.M. (Manuscript in preparation). Using an experimental game to explore stakeholder responses to wetland conservation interventions in Madagascar.

I designed the study with advice from JJ, JG, RY and FR. I was responsible for data collection with Luna Ramangatsimialona (LR) and field assistants. I conducted the statistical analysis with advice from JG. I wrote the first version of the paper and all co-authors edited it.

1. Introduction

1.1 Research Rationale

Fundamental to community-based conservation (CBC) projects is the attainment of multiple goals, which are broadly "natural resources protection by, for, and with the local community" (Berkes, 2007). This in effect makes monitoring and evaluations of CBC projects inherently difficult, covering academic disciplines including (to name a few); ecology, economics, psychology, development studies and sociology. Hence there are calls for interdisciplinary research to fill some of the gaps in CBC evidence (Sievanen, Campbell and Leslie, 2012). It is generally acknowledged that conservation decision making should be based on empirical evidence (Sutherland *et al.*, 2004; Ferraro and Pattanayak, 2006; Margoluis *et al.*, 2009; B. Fisher *et al.*, 2014). This is particularly apparent in the context of CBC interventions. CBC has grown hugely at a tool for conservation over the last 20 years, yet evidence of its effectiveness remains scarce (Nilsson *et al.*, 2016; Calfucura, 2018).

Robust impact evaluations, which can rigorously determine the effect of the intervention, are being increasingly used to build an evidence base of environmental and social impacts of environmental projects (Ferraro and Hanauer, 2014). However the challenges of randomly allocating interventions, limited ability to replicate, and cost can hamper evaluation attempts in real-life conservation projects (Baylis et al. 2016; Margoluis et al. 2009).

In addition to understanding the relative effectiveness of conservation projects, practitioners are increasingly turning to tools derived from economic disciplines to predict the potential impact of new conservation interventions. Tools such as discrete choice experiments and economic games place participants in hypothetical situations to determine behavioural responses to potential interventions. Fundamental critiques of these approaches include the reliance on hypothetical scenarios, and failure to validate the outcomes with independent data on real behaviour (Rakotonarivo, Schaafsma and Hockley, 2016).

In this thesis I aim to contribute to improving the design and implementation of CBC projects by using impact evaluation and experiments relying on hypothetical scenarios to address the following objectives.

Objective 1: To explore the extent to which potential donors to a wildlife conservation project in Madagascar value community aspects of a conservation intervention.

Key research questions (Chapter 2):

i) How do potential donors to conservation in Madagascar value the various attributes of a conservation project: species conservation, habitat protection, community involvement in management and provision of alternative livelihoods?
ii) Can a choice experiment attempting to measure willingness to pay for aspects of a conservation project be validated using respondent's behaviour in an experimental marketing campaign?

Objective 2: To evaluate the impact of capacity building interventions carried out as part of a community based conservation project on community capacity.

Key research questions (Chapter 3):

i) Can community capacity be quantified?
ii) How do elements of community capacity relate to one another and to poverty?

Key research questions (Chapter 4):

i) Does capacity building conducted as part of a community based conservation project have an impact on measures of community capacity?
ii) To what extent is there elite capture of the benefits of capacity building activities?

Objective 3 (Chapter 5): To explore the potential impacts of proposed wetland conservation interventions on behaviour of farmers and the provision of ecosystem services using a framed field experiment.

Key research questions:

i) Will introducing payments for ecosystem services increase ecosystem service provision and reduce pesticide use?
ii) Does communication amongst neighbouring farms increase ecosystem service provision and reduce pesticide use?
iii) Does behaviour in an experimental game reflect stated behaviour in household questionnaires?

1.2 Community-based conservation

1.2.1 The evolution of community-based conservation

Conservation historically aimed to minimise negative anthropogenic impacts on nature through a "parks and fines" or "fortress" approach to conservation (Sarmento and Reading, 2016). This approach largely excluded local people from protected areas (Holmes and Cavanagh, 2016). Such top down, externally imposed conservation approaches increasingly led to conflicts (Roe, 2008). For example in Uganda, after being resettled in a conservation area after eviction, residents killed wildlife to reduce its conservation value to prevent future eviction (Kideghesho, Røskaft and Kaltenborn, 2007) and in Kenya support for conservation parks were eroded due to increased crop raiding by elephants (Gadd, 2005). In the 1980s and 1990s conservation organizations increasingly recognised the failures of exclusionary conservation (Berkes, 2007; Lele *et al.*, 2010) and also began to acknowledge the development needs of local people (Campbell and Vainio-Mattila, 2003). CBC grew out of this new perspective on conservation (Berkes, 2004; Calfucura, 2018)

1.2.2 The definitions of community-based conservation

There is a range of definitions of CBC (Horwich and Lyon, 2007). For example Campbell and Vainio-Mattila (2003) suggest that CBC projects typically have two broad objectives: "to enhance wildlife/biodiversity conservation and to provide incentives… for local people" but they emphasise that the mechanism by which the objectives are achieved is key; for example through local-level, voluntary, participatory or decentralized management. Brooks *et al*. (2013) suggest CBC projects typically "link conservation and development, engage communities as stakeholders, and devolve control over natural resources" (Brooks, Waylen and Mulder, 2013). We use the extended definition put forward by Berkes (2007) that suggests CBC should include "… natural resources protection by, for, and with the local community" while also considering the wider socio-political environment such as "institutional linkages".

1.2.3 Critiques of community-based conservation

There are multiple critiques of the CBC approach, the predominant one of which is the lack of systematic evidence with attributes causal factors to their success or failure (Berkes, 2004; Garcia and Lescuyer, 2008; Nilsson *et al.*, 2016). For instance there is dispute as to whether conservation projects lift people out of poverty rather than exacerbate it (Roe *et al.*, 2011). In many cases this will be context specific but the effect on poverty is critical to determine conservationist's ethical responsibility to do no harm (Barrett, Travis and Dasgupta, 2011;

Davies *et al.*, 2014). This lack of evidence on the social side of conservation projects has restricted opportunities to learn and improve CBC through adaptive management (Davies *et al.*, 2014).

Within CBC projects there is often an implicit assumption that there is a single, harmonious community unit in any given location (Cleaver, 1999; Brooks, Waylen and Mulder, 2013a). It is important to note that the concept of community can mean different things to different people: community groups vary by size, composition, social norms, and resource dependence (Agrawal and Gibson, 1999). Blaikie (2006) suggests that the community concept can be considered in three ways; "as a spatial unity, as a distinct social structure and as a set of shared norms". Not all of the concepts of community overlap, and may not map over the natural resource under management. For example jurisdictional boundaries may not overlap with a catchment or the habitats of threatened species (Scarlett and Boyd, 2015), yet this may be the level of functional organisation within a group of local stakeholders. Jurisdictional communities may not represent the complexities of networks of: social interaction; natural resource use and decision making, yet development activities often require clear administrative boundaries (Cleaver, 1999).

Fundamental concerns of the CBC approach include those raised by Brockington (2004) who suggests that the "principal of local support" where by conservation strategies will fail unless given the support of the local community, is redundant as the rural poor are relatively weak to resist conservation agendas. Other critiques include whether resources commercialisation in market-based approaches to CBC are compatible with conservation goals (Brooks, Waylen and Mulder, 2013). The devolution of power may even hamper project implementation where central governments are unwilling to concede power (Barrett and Arcese, 1995) or where devolution can risk elite capture of training and resources in community-based projects (Mrema, 2017). Redford and Sanderson (2000) suggest delinking objectives of conservation and development to serve them both better. Despite this, community based conservation approaches have been adopted by many large scale NGOs and are at the forefront of conservation approaches in low-income countries (Blaikie, 2006).

1.2.4 Key mechanisms of CBC projects

Multiple schemes have emerged to meet the growing demand for CBC projects including: Community-Based Natural Resource Management (CBNRM); Co-Management/ Participatory Management of Natural Resources (PMNR); Community-Based Eco Tourism (CBET);

Community Forestry (CF); Incentive Based Conservation (IBC) and Payments for Environmental Services (PES) amongst others (Barrow and Murphree, 1999; Kiss, 2004; Borrini and Jaireth, 2007; Gruber, 2010). Nilsson et al. (2016) identified that these CBC projects tend to use three key main mechanisms to engage communities in conservation activities: (i) providing economic value through conservation livelihoods; (ii) providing socio-economic benefits in return for conservation behaviour; (iii) providing communities' devolved authority over their natural resources. In practice, many CBC initiatives represent multiple approaches (Saberwal and Rangarajan, 2005).

i) Economic value through conservation livelihoods

This includes projects where alternative livelihoods are developed, either through the provision of equipment such as bee keeping or coffee seedlings or by developing eco-tourism (CBET) in the region (Kiss, 2004). The theory is that through economic substitution, the reliance on core natural resources is reduced (Salafsky, 2011). Despite their intentions, there have been several issues with these approaches: a lack of training and capacity to use the equipment or to develop alternative markets (Amulen *et al.*, 2017); continued exploitation of natural resources (Salafsky, 2011) and failure to prevent the incentive to resist external threats such as agricultural expansion (Kiss, 2004). In addition, those that benefit from the intervention are not necessarily the ones using the natural resources, making the project at risk of elite capture (Pascual *et al.*, 2010).

ii) Benefits for conservation behaviour

These projects provide a benefit (cash or development benefits) as a reward for pro-conservation behaviour (Wunder, 2007). These use a mechanism by which participants can reason that the benefits offset any losses from a prohibited behaviour (Nilsson *et al.*, 2016). For example, in return for adhering to forest law, participants in a programme in Peru were given energy efficient stoves, among other items (Cranford and Mourato, 2011). These schemes have been used to control invasive species (Pokorny and Krueger-Mangold, 2007), curtailing negative forest-use behaviours (Sommerville, Milner-Gulland and Jones, 2011) and increasing the population of vulnerable species (Caputo, Canestrelli and Boitani, 2005) amongst others.

The most widely acknowledged intervention in this category are PES schemes, which have received considerable attention over the last 2 decades (Chan *et al.*, 2017). However, there are

a number of drawbacks with the mechanism including: new negative externalities (such as soil erosion through the unintended promotion of eucalyptus planting) (Chan *et al.*, 2017); motivational crowding-out (Rode, Gómez-Baggethun and Krause, 2014) and the tendency to benefit only the elite members of the community (Pascual *et al.*, 2010).

iii) Devolved authority

Some community-based programmes such as co-management or participatory management projects devolve some level of authority over the natural resources to the control of the local community. Some evidence suggests increased conservation success when some level of control over natural resources was given to local communities (Adams and Hulme, 2001; Waylen *et al.*, 2010). These mechanisms can include the establishment of local institutions (Bajracharya, Furley and Newton, 2005), though devolved authority requires the building of community capacity to undertake management of natural resources (Chaskin, 2001; Wells *et al.*, 2004; Cavaye, 2008; Mizrahi, 2009). However there is limited quantitative evidence as to the effectiveness of the co-management approach (Whittle, Colgan and Rafferty, 2012; Nilsson *et al.*, 2016).

1.3 Impact evaluation in conservation

1.3.1 Calls for evidence in conservation

It is widely acknowledged that there should be an evidence-base to conservation decision-making to ensure lessons can be learnt from what works (or doesn't work) when delivering conservation interventions (Sutherland *et al.*, 2004; Ferraro and Pattanayak, 2006; Margoluis *et al.*, 2009; Fisher *et al.*, 2014). The pressure from funders for conservation projects to deliver on some aspect of CBC highlights the need to understand the impact of CBC projects (Calfucura, 2018). Yet there remains limited empirical evidence to suggest the relative effectiveness of different community-based interventions (Nilsson *et al.*, 2016).

Annually, billions of dollars are spent on community conservation projects around the world (Ferraro and Simpson, 2002; Brockington and Scholfield, 2010) yet conservation science has been slow to adopt robust methods to determine impact of interventions (Baylis *et al.*, 2016). In a systematic review of CBC projects Brooks, Waylen, and Mulder (2013) suggest that few "quantitative and comparative" studies on CBC interventions had been undertaken. In a review of Community Forest Management, Bowler and colleagues (2012) found that the vast majority of studies lacked the methodological quality to allow conclusions to be drawn(Margoluis et al., 2009; Bowler et al., 2012)(Margoluis et al., 2009; Bowler et al., 2012)(Margoluis et al., 2009; Bowler et al., 2012)(Margoluis et al., 2009; Bowler et al., 2012)(Margoluis et al., 2009; Bowler et al., 2012)(Margoluis et al., 2009; Bowler et al., 2012).

There are multiple challenges to adopting robust impact evaluations which allow for the credible constructions of a counterfactual scenario (Baylis *et al.*, 2016). For example CBC projects inherently have multiple goals and therefore multiple outcomes must be measured (Brooks, Waylen and Mulder, 2013). In addition, random allocation to an intervention is seldom possible, outcomes may spill over to areas not exposed to an intervention and there are many potentially confounding factors (Baylis *et al.*, 2016). Low adoption rates of robust methods may be due to short-term projects and restricted funding which limits the ability to collect baseline data on both the social as well as the biological elements of CBC projects (Ferraro and Pattanayak, 2006; Margoluis *et al.*, 2009).

1.4 Approaches to conservation impact evaluation

1.4.1 Definition of impact evaluation

Impact evaluation is more than simply "outcome monitoring" of a project or programme (White, 2010). To attribute causality, an understanding of what would have happened if the intervention had not taken place (the counterfactual) is needed (Ferraro and Hanauer, 2014). The impact of an intervention is the difference between the outcome of interest (Y), both with (Y_1) and without (Y_0) the intervention, while impact evaluation attempts to estimate the counterfactual (unobserved) value of Y_0 (White 2010; see Figure 1.1). Simply measuring before and after an intervention ignores what might have happened irrespective of an intervention, while only measuring post-intervention outcomes in an intervention and control site may differ in unobserved ways that may affect the outcome measure.

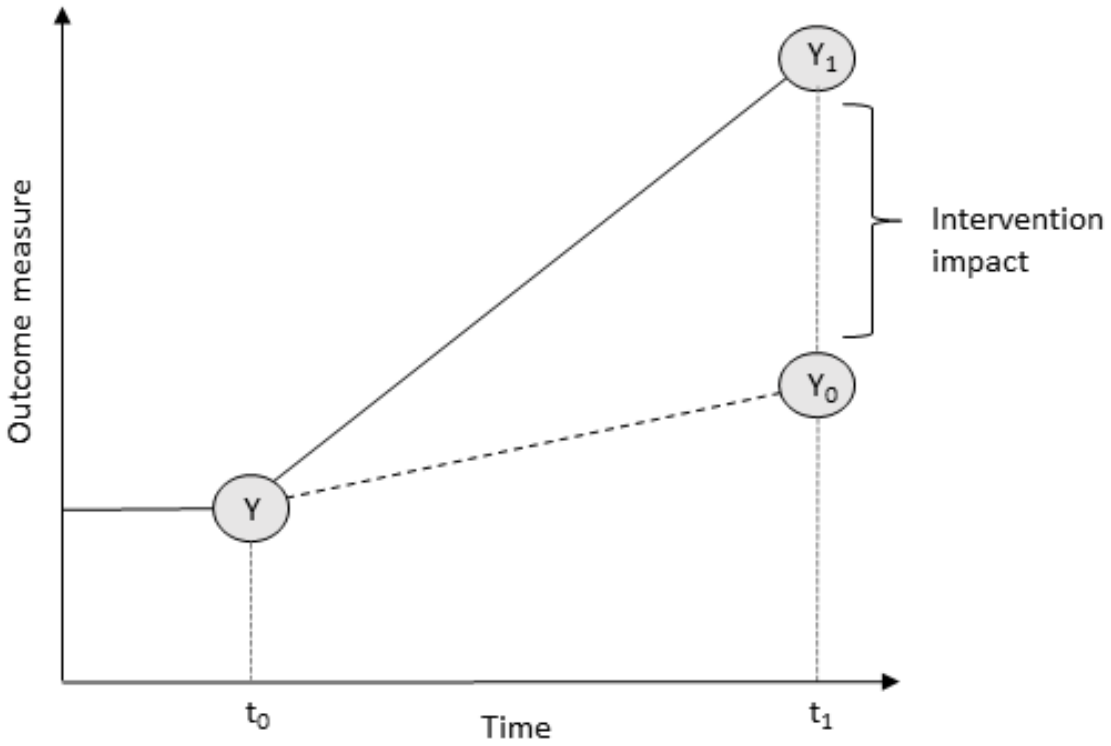


Figure 1.1 Diagram of an impact evaluation to estimate the impact of a conservation intervention (adapted from White and Raitzer 2017). If the intervention occurs at time t_0, impact evaluations measure outcome variable Y in the intervention site (Y_1) at time t_1. Impact evaluations then also attempt to estimate the unobserved value of Y as if the intervention had not occurred (Y_0) through establishing credible counterfactuals.

1.4.2 Estimating counterfactuals

There are multiple ways that researchers attempt to determine the counterfactual value of an impact measure. These include experimental, quasi-experimental and non-experimental designs. While non-experimental designs are often quicker or cheaper to implement, it becomes more difficult to determine causality due to unobserved confounding factors and may be exposed to subjective interpretations (Margoluis *et al.*, 2009; Baylis *et al.*, 2016). Both experimental and quasi-experimental designs have their own strengths and weaknesses. Impact evaluation in the real world requires a degree of responsiveness, the design must be matched to the "needs, constraints and opportunities" of the intervention in question (Rogers, 2009). Scholars have called for the use of multiple methods to determine causal impact: longitudinal experimental studies using controls combined with participatory assessments (Roe, Grieg-Gran and Mohammed, 2013; Woodhouse *et al.*, 2015; de Lange, Woodhouse and Milner-Gulland, 2016)

i) Experimental designs

The gold standard in quantitative impact evaluations is Randomised Control Trials (RCTs), considered to provide "best evidence" in determining causal effect of a treatment (Djulbegovic and Guyatt, 2017). RCTs require the random assignment of subjects (for example communities or households) to treated (experimental) and untreated (control) groups, and measurements are taken both before and after interventions (Margoluis *et al.*, 2009). Developed in medical research, RCTs are now part of established methods to determine impact of interventions in development projects (Cameron, Mishra and Brown, 2016) and are more recently being applied to establish the impact of conservation interventions (Asquith and Vargas, 2008). However, randomisation is not always practicable, where there is low replication and small sample sizes, as is common in the less well-funded conservation sector. For example an intervention to improve the condition of catchments would require interventions in multiple catchments, covering vast areas with potentially thousands of stakeholders (Baylis *et al.*, 2016).

ii) Quasi-experimental approaches

Quasi-experimental designs are similar to RCTs, but lack random treatment assignment. These designs are often used when experimental designs are not possible, for instance in the face of political, financial, ethical or practical constraints (Ferraro, 2009). Quasi-experimental experiments may include matched or generic control groups or where a generic control group is generated by comparing data to available data on the general population (Margoluis *et al.*,

2009). Multiple quasi-experimental approaches are used including: regression discontinuity; instrumental variables and difference in difference. The regression discontinuity design (RDD) is used in cases where those who receive treatment differ systematically from those who don't. The RDD approach assumes knowledge of the assignment "*rule*" and the design requires a specific cut-off point (van der Klaauw, 2008). The instrumental variable approach (IV) requires the identification of a variable which is correlated with the treatment, but is otherwise independent of treatment outcomes (Greenstone and Gayer, 2009). The Before-After-Control-Impact (BACI) approach uses matched controls and measurement both before and after the project, to allow comparisons of outcomes through difference-in-difference analysis (Smith, 2013). Control sites are selected to be as similar as possible to intervention sites, and difference-in-difference analysis controls for both observable and unobservable differences in characteristics of units (Wooldridge, 2001). Lack of data of baseline conditions is a common problem in conservation research (Macura et al. 2015; Clements & Milner-Gulland 2015; Rasolofoson et al. 2017). In the absence of a true BACI design, studies wanting to conduct the most robust impact evaluation possible may retrospectively match control sites to intervention sites, for example to determine the impact of long established interventions (Andrianandrasana, 2016). While a BACI design cannot overcome all challenges in impact evaluation; it is often seen as the best option when treatment sites cannot be chosen at random, as is the case of the majority of conservation interventions (Conner *et al.*, 2015; Baylis *et al.*, 2016).

iii) Non-experimental approaches

Often conservation projects operate in complex contexts and applying experimental or quasi-experimental designs are not practicable (Bamberger, Rugh, and Mabry 2006). Alternative approaches include theory, case-study or participatory based methods. These approaches have the potential to generate insights into project impacts that may be overlooked by more experimental approaches (Chambers, 2009). Theory-based methods such as causal link diagramming identifies breaks in the causal chain which can explain the impacts of an intervention (Rogers, 2009). Comparisons between case-studies of successful or unsuccessful interventions can highlight causal factors influencing project impacts (Woodhouse *et al.*, 2015). Participatory methods allow communities to systematically assess the changes themselves, either through focus group discussions or through reflexive counterfactuals which asks respondents what they would have done in the absence of the intervention (Kaufman, Ozawa and Shmueli, 2014).

1.5 Using behavioural experiments to explore potential conservation impacts

Policy makers and conservation practitioners are increasingly turning to predictive methods to determine potential impacts prior to any interventions taking place (List and Price, 2016). Combining evidence from both retrospective impact evaluations as well as prospective studies which use explicit counterfactual future scenarios can help decision makers better predict the future impact of interventions (Ferraro and Pressey, 2015). Balmford and Cowling (2006) wrote that "*conservation is primarily not about biology but about people and the choices they make*". Understanding future behaviour within conservation interventions ex ante may make more efficient uses of limited resources and can inform the design and evaluation of environmental policy (List and Price, 2016). These predictive tools do not only have research value, but can act as facilitation mechanisms for communities to explore pros and cons of various interventions collaboratively (Redpath *et al.*, 2018), which is central to the concept of community-based projects.

Following on from the taxonomy of experiments identified in Harrison and List (2004), Rode, Gómez-Baggethun, and Krause (2013) reviewed empirical studies that determine motivations and incentives required to participate in conservation programmes. The review identified multiple methods used to gain evidence for stakeholder behaviour in conservation programmes including; natural experiments to determine real impacts of policy interventions; and lab, natural and framed field experiments to determine hypothetical impacts. In economics, field experiments are those that "occur in the natural environment of the agent being observed and cannot be reasonably distinguished from the tasks the agent has entered the marketplace to complete" (List, 2008). Lab based studies have been criticised for often lacking participants who represent those who may be really affected by an intervention (Levitt and List, 2007; Velez, Stranlund and Murphy, 2009; Taylor, Morrison and Boyle, 2010; Johansson-Stenman and Svedsäter, 2012). Natural and framed field experiments have relative strengths and weaknesses including: relative resource intensity; ethical considerations and generalisability of results.

Natural field experiments

Survey-based methods have traditionally been a mainstay for eliciting preferences and predicting behavioural outcomes, but often lack external validity (Vossler, Doyon and Rondeau, 2012). A natural field experiment is one where the subjects naturally undertake an experimental task, and the subjects do not know that they are in an experiment (List and Price,

2016). In these experiments the "real world" setting can be manipulated, for instance where a farmer's choice between different agricultural practices may be manipulated by introducing different incentives (Rode, Gómez-Baggethun and Krause, 2015). Recently hypothetical choice experiments (which are traditionally lab-based stated preference experiments) have been combined with natural field experiments in the context of conservation and natural resources to validate stated preferences against real behavioural outcomes (Rakotonarivo, Schaafsma and Hockley, 2016). For example Kerr, Vardhan, and Jindal (2012) conducted both choice and natural field experiments to test the response of prosocial behaviour to incentives for environmental services in Mexico and Tanzania.

Framed field experiments

Recently, there has been an increase in the number of framed field experiments (as opposed to lab-based experiments) where the experiment involves local participants whose behavior it seeks to explore, and where the context more closely relates to real-life scenarios (Harrison and List, 2004; Anderies *et al.*, 2011). Framed field experiments such as experimental games represent an iterative "social dilemma" and have been used to explore behavior in the context of common pool resources or public goods. Within conservation research, experimental games have focused predominantly on resource extraction in the context of fisheries (Velez, Stranlund and Murphy, 2009; Travers *et al.*, 2011) or forests (Cardenas, 2004; Janssen *et al.*, 2013; Gatiso, Vollan and Nuppenau, 2015). Experimental games have also been used to test the effects of policy interventions on local people such as: the effect of payments on intrinsic motivations (Rode, Gómez-Baggethun and Krause, 2015; Moros, Vélez and Corbera, 2017); the effect of group-based payments (Salk, Lopez and Wong, 2017); the effect of self-monitoring on natural resource extraction (Marrocoli *et al.*, 2018) and the role of communication between stakeholders (Lopez and Villamayor-Tomas, 2017). As with other behavioral economic experiments questions arise about the external and internal validity of results, meaning that the results must be treated with caution (Jackson, 2012).

1.6 Community-based conservation in Madagascar

1.6.1 Biodiversity in Madagascar

Madagascar is one of the world's "hottest" hotspots for biodiversity (Myers et al. 2000). High levels of species diversity and endemism, alongside human threat make it a country of conservation priority (Goodman and Benstead, 2005). The endemism at higher taxonomic levels in plants and vertebrates make Madagascar particularly stand out (Myers *et al.*, 2000). From, insects to vertebrates, new species are continually being discovered on the island (Lees, 2016; Massifs *et al.*, 2016; Rakotoarison *et al.*, 2017). There has been an estimated 90% loss of natural habitat since human colonisation circa 2,000 years ago (Ganzhorn *et al.*, 2001; Goodman and Benstead, 2005). A recent study estimates that 37% of forest loss occurred between 1973 and 2014 with deforestation rates increasing progressively since 2005 (Vieilledent *et al.*, 2018). Throughout Madagascar there are ever increasing pressures on natural resources including: mineral extraction (Waeber *et al.*, 2015); land clearance for agriculture (known as Tavy; Brown et al, 2015); and exotic hardwood extraction (Schuurman and Lowry II, 2009).

1.6.2 Poverty in Madagascar

The Republic of Madagascar failed to achieve any of its 2015 Millennium Development Goals, which included the eradication of extreme poverty and hunger (MDG_1; Waeber et al. 2016). The global multidimensional poverty index (MPI) identified Madagascar as one of the countries with the highest levels of poverty (Alkire, Roche, *et al.*, 2015). Comparing data between 2008 and 2011 Madagascar showed a statistically significant increase in MPI, i.e. got poorer (Alkire and Housseini, 2014). The World Bank estimated in 2012 that around 77.6% of the population live below the international poverty line ($1.90, 2011ppp; World Bank 2018). The majority of shifting agricultural practices in Madagascar are predominantly for subsistence rice production (van Vliet *et al.*, 2012; Zaehringer *et al.*, 2016). In 2017 Transparency International ranked Madagascar 155/188 with its corruption index of 24 (100 being least corrupt; Transparency International, 2017).

1.6.3 CBC in Madagascar

In 2003, the government of Madagascar committed to tripling the protected area network in Madagascar and between 2003 and 2016 the number of protected areas quadrupled (Gardner *et al.*, 2018). Protected areas remain a backbone of Malagasy conservation policy (Desbureaux *et al.*, 2016) but CBC is also very important (Raik and Decker, 2007; Pollini *et al.*, 2014). In 1996 the Malagasy government passed a law to enable local management of natural resources through GELOSE[1] and GCF[2] agreements (Rasamoelina *et al.*, 2015). This lead to the establishment of local committees (known locally as Vondrona Olona Ifotony or VOI) to deliver natural resource management at the community level. Many of the country's new protected areas involve areas under community management (Gardner *et al.*, 2013). There are over 1,000 community forest management sites in Madagascar alone (Scales, 2014; Rasolofoson *et al.*, 2016). Gardner et al. (2018) identified that while challenges remain, the current protected area network has expanded to include: i) multiple-use management models; ii) shared governance arrangements between community associations and NGOs and; iii) emphasis on livelihood based approaches to management.

Madagascar has become one of the largest recipients of conservation funding among low income countries (Bare, Kauffman and Miller, 2015), it receives significant investment for both conservation and development activities (Waeber *et al.*, 2016). A range of conservation interventions are in operation in Madagascar including: threatened species protection (Rabearivony *et al.*, 2010); protecting habitats (Gardner, 2011); providing alternative livelihoods (Gardner *et al.*, 2013; Brimont and Karsenty, 2015); and involving the local community in management decisions (Pollini *et al.*, 2014).

[1] GELOSE: Gestion Locale Sécurisée (secured local management)
[2] GCF: Gestion Contractualisée des Forêts (contracted forest management)

1.7 Study context

1.7.1 The Madagascar pochard

The CBC project focused on within this thesis aimed to protect and restore the wetland for a population of the world's rarest duck. Previously thought extinct, a very small population of the Critically Endangered Madagascar pochard, *Aythya innotata* was re-discovered in a lake in the Bealanana wetlands-complex in Northern Madagascar. The wetlands are not ecologically suitable for the pochard, with low food availability leading to extremely low fledging rates and recruitment (Woolaver *et al.*, 2015). While protecting the remnant population, conservationists harvested three clutches of eggs to start a captive breeding programme for a future release into a more suitable lake.

In 2014 a team of multiple NGOs including: Durrell Wildlife Conservation Trust (Madagascar); Wildfowl and Wetlands Trust (WWT), Asity Madagascar, The Peregrine Fund, Le Ministère de L'Environnement et des Forêts (Government of Madagascar) received funding to host a community-based conservation project to ready the site for the reintroduction of *A. innotata* (Woolaver *et al.*, 2015). The project, funded by the UK government's Darwin Initiative, was initiated in 2014 to *"support local communities to create a successful, sustainable co-management system for the lake and its catchment"* (Darwin initiative application 2014). The project also aimed to *"establish sustainable management by communities, building their capacity to manage the wetland"* (Darwin initiative application 2014).

1.7.2 Study area

Lac Sofia, was one of multiple shortlisted lakes, deemed best suited to host a released flock of *A. innotata* (Woolaver *et al.*, 2015) (see Figure 1.2 for locations of both the control and intervention site). We selected the control site (Lac Antafiandakana) using the short-list of suitable lakes, while taking into consideration access. Both selected lakes are in the Sofia region in Northern Madagascar. The lakes belong to the Bealanana wetlands-complex in a mountainous region close to the tallest mountain in Madagascar. Lac Sofia was designated as a RAMSAR site (site number 2301) in June, 2017. Vehicular access is restricted for several months during the monsoon season and can effectively isolate the lakes. As such, the majority of the field work in Madagascar reported in this thesis was carried out on foot between 2015 and 2017 over a total of 9 months.

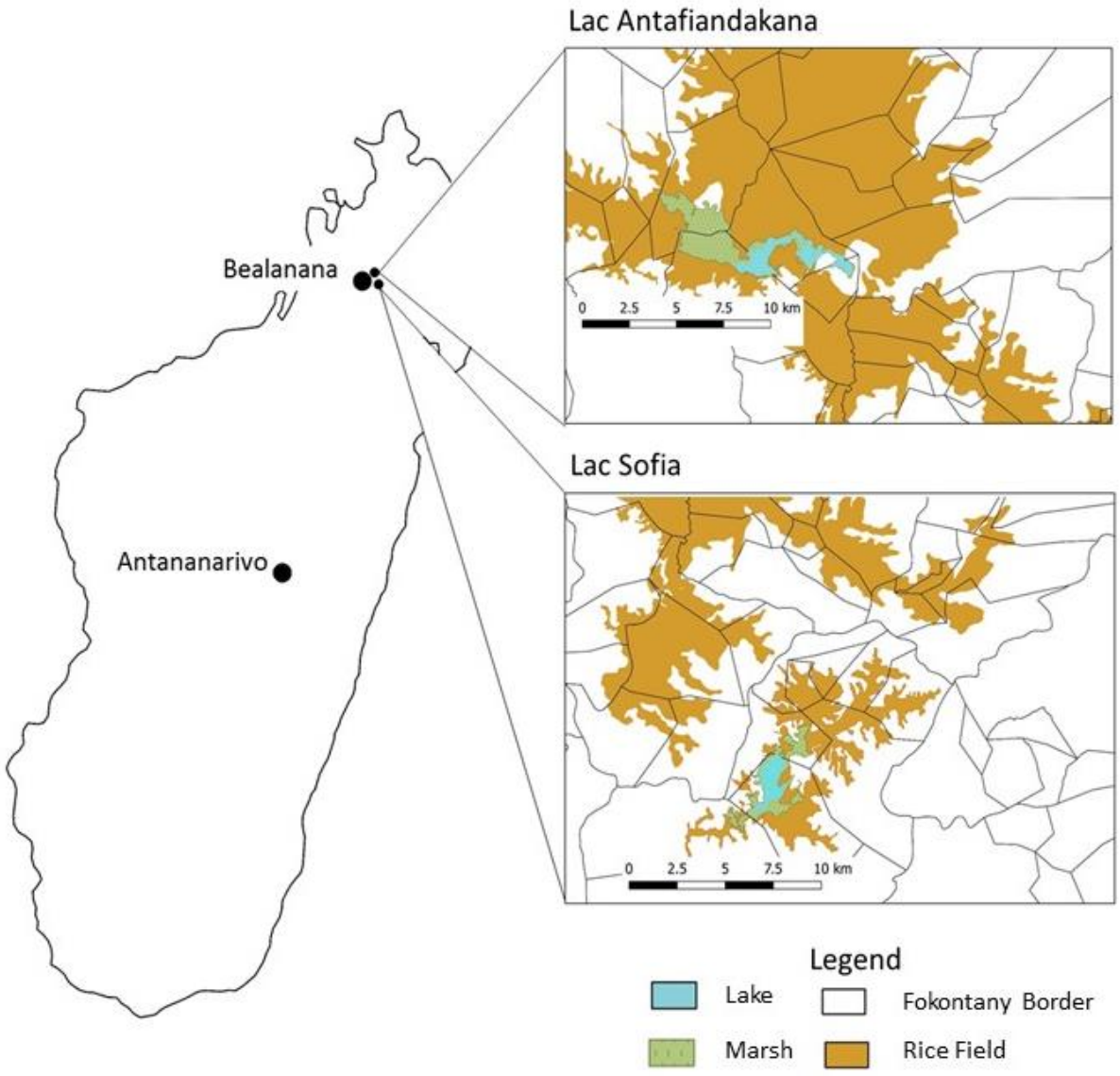


Figure 1.4. Map of Madagascar showing the two lake systems (Lac Sofia where the community conservation project was planned and Lac Antafiandakana which is an otherwise similar area but without a planned community conservation project). Households were sampled in the fokontany surrounding each lake in Chapters 3, 4 and 5.

Throughout this thesis we use the term fokontany (the lowest administrative unit in Madagascar) as synonymous with community. Although a fokontany may contain a number of small villages and hamlets, each fokontany has a defined leader (the president of the fokontany), defined boundaries and is the unit at which many community engagement activities occur in Madagascar (Cullman, 2015; Lammers *et al.*, 2017). The predominant ethnic group in the North-Central region is the Tsimihety people, translated as "those who cut their hair"

associated with a tradition associated with mourning. The regional dialect is Tsimihety which is distinct from Malagasy Offisialy (the national dialect).

In addition to field work in Madagascar, Chapter 2 in this thesis concerns potential oversees donors for Malagasy conservation. As such we conducted two months of research at Durrell Wildlife Conservation Trust's Zoo in Jersey, Channel Islands. Throughout the thesis I use "we" when describing methods as all fieldwork was carried out with research assistants (see acknowledgements) and to acknowledge the role of my supervisors and collaborators in analysis and interpretation.

1.7.3 Ethical standards

All research received ethical approval from Bangor University as described in detail in each chapter.

1.8 Thesis synopsis

In this thesis, I explore several ways to understand the impacts of a community-based conservation project in Madagascar. The overall aim is to create an evidence base for the best way to design, promote and evaluate future community based conservation projects that benefit both people and wildlife.

In Chapter 2, I explore the extent to which potential donors value community aspects of conservation projects. I use a discrete choice experiment as well as a real fundraising campaign to hypothetical willingness to pay to real donations for a community based conservation project in Madagascar. I find that, hypothetically, respondents preferred conservation projects that included local people in the decision making compared to exclusively wildlife-based actions. There was no significant difference in real donation amounts. Understanding the preferences of donors in high income countries is valuable for the marketing of future conservation campaigns.

In Chapter 3, I explore the role of community capacity building for co-management of natural resources. Many CBC projects seek to develop community capacity to yet the definition of it and the quantitative measurement remains scarce. I develop and refine a set of quantitative indicators to measure community capacity to undertake co-management of a CBC project in Madagascar. This is measured through the communities' assets of human, social, economic and organisational capitals. By understanding the strengths and weaknesses in community capacity we can develop capacity building initiatives to promote more successful conservation outcomes.

Chapter 4 uses this set of indicators as a basis to evaluate the impact of capacity-building initiatives. I use a before-after-control-impact (BACI) method over a 2 year period to evaluate the impact of capacity building in Madagascar. There was no evidence of impact in composite scores of capitals, though some specific indicators of social capital have improved over time, and there is some evidence of elite capture within the intervention site.

In Chapter 5 I use a tablet-based game with Malagasy farmers to mimic land-use decision making amongst multiple stakeholders in a wetland ecosystem context as cooperative behaviour is at the heart of CBC initiatives. The results show that while incentives can increase ecosystem service provision in the game landscape, peer pressure significantly improves the coordination of ecosystem services between stakeholders. Finally, in Chapter 6, I review the strengths and weaknesses of our research methods and the policy implications of the research.

Table 1.1 Summary of the data chapters and methods used within this thesis.

Chapter	Methodological approach	Data used	Data analysis
Chapter 2	Choice experiment with validation & questionnaire	Socio-economic data from questionnaire, Choice data from choice experiment, Zoo entrance data	Mixed multinomial logit modelling (MIXL)
Chapter 3	Key informant interviews & Household questionnaire	Socio-economic data & Likert based questions from questionnaire	Principal component analysis (PCA) & Linear modelling
Chapter 4	Household questionnaire[1] (Before-After-Control-Impact; BACI)	Socio-economic data & Likert based questions from questionnaire	Kolmogorov-Smirnov (KS) tests, Principal component analysis (PCA) & difference-in-difference analysis (linear mixed effects modelling; LME)
Chapter 5	Key informant interviews, Household questionnaire & Experimental game	Qualitative interviews, Socio-economic data from questionnaire & Netlogo choice outputs	Linear mixed effects modelling (LME)

[1]The same households were visited twice over a 2-year period, this chapter uses a subset of households from Chapter 3 that completed both surveys.

2. To what extent do potential conservation donors value community-aspects of conservation projects in low income countries?[3]

Abstract

There is a major gap in funding required for conservation, especially in low income countries. Given the significant contribution of taxpayers in industrialized countries to funding conservation overseas, and donations from membership organisation, understanding the preferences of ordinary people in a high income country for different attributes of conservation projects is valuable for future marketing of conservation. We conducted a discrete choice experiment with visitors to a UK zoo, while simultaneously conducting a revealed preference study through a real donation campaign on the same sample. Respondents showed the highest willingness to pay for projects that have local community involvement in management (95% confidence interval £9.82 to £15.83), and for improvement in threatened species populations (£2.97 - £13.87). Both of these were significantly larger than the willingness to pay for projects involving provision of alternative livelihoods, or improving the condition of conservation sites. Results of the simultaneous donation campaign showed that respondents were very willing to donate the suggested £1 or above donation (88% made a donation, n=1798); there was no effect of which of the two campaigns they were exposed to (threatened species management or community involvement in management). The small number of people who did not make a donation had a higher stated willingness to pay within the choice experiment, which may suggest hypothetical bias. Conservationists increasingly argue that conservation should include local communities in management (for both pragmatic and moral reasons). It is heartening that potential conservation donors seem to agree.

[3] Published as: Lewis, A.R., Young, R.P., Gibbons, J.M., Jones, J.P.G. (2018) To what extent do potential conservation donors value community-aspects of conservation projects in low income countries? PLOS ONE, 13, 1-18, https://doi.org/10.1371/journal.pone.0192935

2.1 Introduction

For the last few decades it has been widely recognised that conservation, while having national and global benefits, frequently brings local costs (Hirsch *et al.*, 2010; Pascual *et al.*, 2014). Given that areas of high biodiversity overlap with areas where poverty is widespread (Fisher and Christopher, 2007), it is increasingly argued that conservation should invest in human development alongside species and habitat based actions (Rands *et al.*, 2010; Fisher *et al.*, 2014; Li *et al.*, 2015). Delivering the dual goals of conservation and development has led to a mix of strategies to deliver conservation objectives; from strict protected areas (often with initiatives aimed at supporting local livelihoods) to community based conservation approaches which include local people in management (Salafsky and Wollenberg, 2000; Hughes and Flintan, 2001).

Though money is not the only barrier to achieving conservation outcomes, there is a major gap between expenditure and need, which is most extreme in the tropics (Balmford and Whitten, 2003). Every year the world spends around US$126 billion of official aid addressing global poverty and between US$8-16 billion addressing biodiversity loss (Adams *et al.*, 2004; Roe *et al.*, 2011), where there remains substantial unmet need (McCarthy *et al.*, 2012). Funding for biodiversity in low-income countries include: domestic budget allocations (~US$11 billion); multilateral and bilateral aid (~US$4 billion); and philanthropy (including charitable trusts and conservation NGO funding, ~US$0.5-1 billion) (Hein, Miller and de Groot, 2013). The philanthropic element of biodiversity funding therefore represents approximately between 3% and 12% of current estimates (Hein, Miller and de Groot, 2013) meaning public attitudes to what conservation projects should fund is important (Booth, Gaston and Armsworth, 2009). Understanding the preferences of donors for these different aspects of conservation projects such as involvement of local communities in management and decision making or providing alternative livelihoods, could help target and improve future marketing campaigns.

Various methods have been designed to measure the value people place on goods or services for which there is no current market (Christie *et al.*, 2012). Discrete choice experiments (referred to here as choice experiments) are a stated preference valuation technique where respondents are given a series of future scenarios and asked to make choices between them (Brouwer, 2000). From these choices one can analyse an individuals' preferences for the attributes that make up that scenario. Choice experiments are increasingly applied to questions important in conservation science. For example many studies have looked at the preference of potential donors for the management and protection of charismatic species (Morse-Jones *et al.*,

2012; Di Minin *et al.*, 2013; Zander *et al.*, 2014). However, these studies assume that individuals only value the outcome of a proposed intervention, not the structure by which it is implemented. Other studies have used stated preference techniques to value the preference local people place on the impact of different environmental management mechanisms on their communities and livelihoods (Hanley *et al.*, 2003; Kenter *et al.*, 2011; Rakotonarivo, Schaafsma and Hockley, 2016). A notable exception, however, is a recent paper that shows that potential foreign donors have preferences for distributive benefits of payments for ecosystem services to local people in Madagascar (Markova-Nenova and Wätzold, 2017).

Despite the wide use of choice experiments, they may be prone to hypothetical bias, as respondents do not have to support their choices with real commitments. Few choice experiments are able to validate their findings through external validation with a real market due to the difficulty in identifying a market valuing the same attributes (Hensher, 2010). A recent systematic review by Rakotonarivo et al (2016) identifies 11 non market valuation choice experiment studies, published between 2003 and 2016, that attempt to validate their results (Rakotonarivo, 2016). Often such studies are laboratory based and use undergraduate students and use a binding choice (where they are obliged to part with a good/ real money) if a choice within the experiment is selected (Taylor, Morrison and Boyle, 2010; Johansson-Stenman and Svedsäter, 2012). Only one study compared preferences made in a hypothetical choice with a revealed preference field study (Araña *et al.*, 2013).

We use a choice experiment to explore the extent to which potential donors to a conservation project in Madagascar (visitors to Jersey Zoo, headquarters of the Durrell Wildlife Conservation Trust) value the various aspects of a conservation intervention (threatened species populations, community involvement in management, the condition of sites of conservation concern and investing in the provision of alternative livelihoods). We explore the characteristics of donors with a stated higher willingness to pay, and preferences for the various aspects of the conservation project. We also attempted to validate the results of the choice experiments by conducting a revealed preference trial where those entering the zoo were asked to make a small donation to a conservation project in Madagascar (the advertising alternating between a focus on threatened species populations or community involvement in management). This paper therefore adds to the very limited literature comparing a hypothetical choice experiment with field observation of revealed preferences. It also increases our understanding

of the preferences of potential contributors to conservation projects among the general public; providing valuable marketing insights for conservation projects.

2.2 Methods

2.2.1 Case study

Bangor University Ethics Committee approved this research (CNS2015AL2). This study was carried out at Jersey Zoo, Chanel Islands, UK. Visitors to the zoo over the age of 18 were our target population. While it may be argued that zoo visitors have an above average interest in conservation, evidence suggests that zoos do reach a relatively representative cross section of society, and that the popularity of a zoo's collection is more indicative of visitor numbers than socio-demographic indicators (Whitworth *et al.*, 2012). We therefore suggest that this sample provides useful information on the preferences of the general public in the UK, and probably industrialized countries more broadly, who may donate to conservation initiatives.

Jersey Zoo is run by the Durrell Wildlife Conservation Trust (hereafter abbreviated to Durrell). Durrell has been active in Madagascar for 30 years where they have high profile community-based conservation programmes and Jersey Zoo has populations of many of their target species from Madagascar and contains an exhibit modelled on a field site (the Menabe dry forest). Durrell runs regular fund-raising campaigns through the zoo to support their field programmes. At the time of this research, Durrell was planning a new campaign to generate more donor funding for conservation projects in Madagascar. This provided us with the opportunity to measure both stated preferences (using a choice experiment) and compare with revealed preferences (as measured through voluntary donations at the zoo entrance; the details of the campaign were altered weekly in an experimental set up).

Madagascar is a biodiversity hotspot (Myers *et al.*, 2000) which has become one of the largest recipients of conservation funding among low income countries (Bare, Kauffman and Miller, 2015). Since its independence, Madagascar has benefited from several hundred million US dollars of support for environment programmes (Waeber *et al.*, 2016). A range of conservation approaches are in operation in Madagascar including threatened species protection (Rabearivony *et al.*, 2010), protecting habitats (Gardner, 2011), providing alternative livelihoods (Gardner *et al.*, 2013; Brimont and Karsenty, 2015), and involving the local community in the management of the project or intervention (Pollini *et al.*, 2014). Of course many interventions will involve more than one approach. In 2003, the government of Madagascar committed to tripling the protected area network in Madagascar. This remains a primary conservation mechanism in Madagascar (Desbureaux *et al.*, 2016) but there has also been a significant increase in the number of community based conservation projects in

Madagascar over the last 20 years (Pollini *et al.*, 2014), with over 1,000 community forest management sites alone (Scales, 2014; Rasolofoson *et al.*, 2016).

2.2.2 Choice experiment design

The design of the choice experiment is based on hypothetical future conservation projects. The choice task was framed as a selection between different conservation management options that would require a financial contribution if selected. These future scenarios are described in terms of their attributes which are represented by levels (See Table 2.1 and Figure 2.1). In order to reduce the complexity we selected five attributes (four conservation attributes and a payment attribute to allow valuation in monetary terms). Each of the conservation attributes had three levels representing the potential levels of conservation interventions; a business as usual (BAU) scenario, where no further conservation measures are implemented; a moderate intervention of management and a substantial management intervention. The four conservation attributes were selected based on the literature and in consultation with conservation practitioners and aim to reflect the range of approaches to conservation. We wanted to have an equal number of community orientated attributed and ecological orientated attributes to enable us to associate these attributes with the revealed preference campaigns. The payment vehicle was determined as a one-off donation to enable us to validate our results with the real donations, and it was decided to include £1 as one of the payment levels, to match the real suggested donation, though other studies suggest the payment vehicle could be increased taxation or an addition to a utility bill (Birol, Karousakis and Koundouri, 2006).

Table 2.1. Conservation management approaches Madagascar, their attributes and levels used in the choice experiment and the validation method used in revealed preference study.

Attribute	*Definition*	*Management levels*	*Validation method*
Threatened species populations	The extent to which the conservation project's focus is improving or maintaining populations of threatened species.	BAU: Population declines Low: Maintain current populations High: Population increases	Visitors were asked to make a £1 donation for a conservation project in Madagascar (focused on threatened species).
Community involvement in management	The extent to which local people are trained and empowered to protect their local environment.	BAU: In no communities Low: In few communities High: In many communities	Visitors were asked to make a £1 donation for a conservation project in Madagascar (involving local communities in management).
Site focus	The extent to which the conservation project improves or maintains the condition of conservation sites.	BAU: No conservation activity Low: Maintain the field sites High: Improve the field sites	None
Provision of alternative livelihoods	The extent to which the conservation project invests in supporting alternative livelihoods for local communities.	BAU: No investment Low: Limited investment High: Significant investment.	None
Donation (one off)	A one-off payment to support the project campaign.	£0, £1, £5, £20, £50	Real donation of £1 or more to either Marketing campaign

Note: Each attribute has three levels of conservation interventions including a business as usual scenario (BAU). Payment levels were determined in the pilot study.

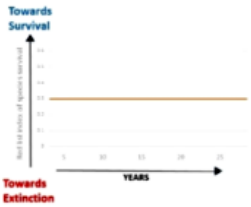
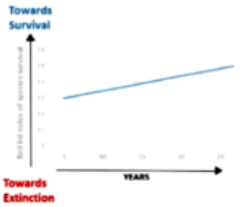
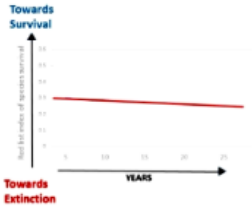
	Option A	Option B	None
Threatened species populations	 Maintain	 Improve	 Decline
Community involvement in management	 In many communities	 In few communities	 In no communities
Conservation sites in Madagascar	 Improve	 Maintain	 No conservation sites
Alternative livelihoods	 Significant investment	 Limited investment	X No investment
Your donation (one off)	£ 20	£1	£0

Figure 2.5. Sample choice task, where respondents were asked to select their preferred option.

The first of the choice experiment attributes was a focus on threatened species populations. This was explained with images of Malagasy threatened species: the Alaotran gentle lemur; the Madagascar pochard; the Flat-tailed tortoise; and the Madagascar giant jumping rat. The attribute included the increase, maintenance or decline of these threatened species. The second attribute concerned the extent to which local communities are explicitly involved in the management the conservation project. This includes training and empowerment of local individuals and reflects the way in which Durrell operate in many of their sites (Andrianandrasana *et al.*, 2005; Earle, 2016). The third attribute focused on improving the condition of protected areas across Madagascar, levels included no sites, maintenance of sites or an improvement in the condition. The fourth attribute was the investment in alternative livelihoods for local communities as part of the conservation project. Examples given were: growing coffee, growing vanilla and providing bee keeping equipment. In addition, a payment attribute was selected. This was described as a one-off donation to contribute to the conservation project and ranged from £0 to £50. Note that the zero payment option was only included in the BAU option due to the fact that the management options all required payment.

The attributes are clearly not completely stand-alone; for example, threatened species populations and the condition of conservation sites are closely linked as the condition of sites will influence threatened species populations. However a project may focus on species-based actions (e.g. enforcing anti-hunting laws, removing invasive predators) without a focus on habitat so we treat these as separate attributes. Similarly, the provision of alternative livelihoods does not inherently involve active community participation and decision making in a conservation project (Amulen *et al.*, 2017) which is why these are included as separate attributes. In order to make sure respondents understood the task, each attribute, and the vocabulary used in the survey, a pilot study was conducted (n=14). This enabled us to further refine the design and to define the choke point for the payment attribute, where individuals would not be willing to pay above a certain amount (Mørkbak, Christensen and Gyrd-Hansen, 2010). In order to make sure respondents understood both the task, each attribute and the vocabulary used in the survey a pilot study was conducted (n=14). This enabled us to further refine the design and to define the choke point for the payment attribute, where individuals would not be willing to pay above a certain amount (Mørkbak, Christensen and Gyrd-Hansen, 2010).

A large number of unique conservation management scenarios can be constructed from this number of attributes and levels. Sawtooth software (V.3.2) and fractional factorial design

techniques were used to obtain a choice experiment design, which consisted of only the main effects. This resulted in 36 pair-wise comparisons of alternative management scenarios which were randomly blocked to 4 choice sets, each with 9 choice tasks. Each choice task contained two management scenarios and the BAU scenario with the corresponding zero donation. The BAU option is necessary to achieving welfare measures that are consistent with demand theory (Hanley, Mourato and Wright, 2002). If the BAU is omitted respondents may be forced to choose an option that they do not have any reference for and therefore could overestimate willingness to pay. Further details on the design of choice experiments can be found in Hanley et al (1988)(Hanley, Wright and Adamowicz, 1998)(Hanley, Wright and Adamowicz, 1998)(Hanley, Wright and Adamowicz, 1998)(Hanley, Wright and Adamowicz, 1998)(Hanley, Wright and Adamowicz, 1998).

2.2.3 Choice experiment data collection

The survey was conducted during July and August 2016 with face-to-face interviews and recorded on Android phones using Open Data Kit (ODK) (Hartung *et al.,* 2010). These were conducted over a 4 week period including a week before the school holidays began. Interviews were carried out by ARL and one research assistant. We aimed to obtain a representative sample of adult paying footfall through the ticket gates, visitors were approached opportunistically after entering the zoo, and only 11% of those approached refused to participate in the study. We do not believe respondents associated the choice experiment interview with the request for a donation at the gate as these were separate processes; one a formal zoo fund-raising activity and the other research conducted by researchers from a university. Interviews lasted 20 minutes on average and no longer than 30 minutes.

The choice experiment was introduced by explaining each of the attributes, as well as the financial constraints in delivering these conservation scenarios, and individuals were presented with a practice choice task and time to ask questions. Throughout completion of the choice tasks respondents were reminded to consider their household budgetary constraints. Following the choice tasks we asked a series of short questions to collect socio-economic characteristics such as age, income and previous donations to charities (and whether these charities focused on humanitarian work or were wildlife focused). These were included as explanatory variables to explore heterogeneity in preferences, as well as to analyse the sample against paying visitors to the zoo.

2.2.4 Revealed preference design and data collection

In addition to the choice experiment, we wanted to compare the preferences for the attributes based on a real conservation campaign. This was designed in collaboration with the Durrell marketing department, during its 2016 campaign to raise money for their conservation projects in Madagascar. The campaign was on the same population as the choice experiment sample and ran during the same period as the choice experiment. Visitors were asked at the tills for an additional one-off donation to raise money for a conservation project in Madagascar (all money did indeed go directly to support Durrell's work in Madagascar). The experimental campaign ran for four weeks, split equally between threatened species management and community involvement in management in Madagascar (alternating weekly, see Table A in Appendix 2.1).

The two campaigns were presented to visitors at the entrance to the zoo in the form of posters and leaflets. A £1 additional donation was asked for (though more could be given). The donation confirmation and amount was recorded within the till data which could then be extracted and linked to the choice experiment responses by scanning the till ticket bar code. All visitors were therefore exposed to either campaign (approximately half to each of the two formulations: a focus on threatened species or community involvement in management). Our experiment was only able to run for a period of four weeks therefore the revealed preference results were limited to a subset of visitors to the zoo during that period (n=1798). A small sub-set of visitors (n=244) then went on to complete the choice experiment. Unfortunately due to logistical constraints only some visitors were asked to give a donation, therefore not all those who completed the choice experiment had been asked to make a donation.

2.2.5 Ethics and data management

The research was scrutinised and cleared under the Bangor University Research Ethics Framework. During the interviews we introduced ourselves and the task involved. Respondents were reminded that they could stop at any time without giving any explanation. The oral consent script (See Appendix 2.2), ODK technical skills as well as interview techniques were practiced during the training period (1 week). We read a script explaining the purpose of the study, how data would be stored and used and highlighted that respondents could stop the interview at any time. We confirmed that the script was read and whether respondents gave consent to continue within ODK on the android phone. We did not ask for written consent as felt that this was not appropriate in the informal setting of the zoo, and would potentially put off respondents. No names of respondents were collected and all data was saved on a password protected computer. Individual respondents were not informed that the donation at zoo entrance

was linked to the choice experiment. Barcode information gave us only the ticket type (e.g. adult, concession) and donation amount, no personal details of the respondents could be obtained (e.g. no bank or card details or personal names).

2.2.6 Data Analysis

Final choice tasks were analysed using R (version 3.2.2) and included in a mixed multinomial logit model (MIXL) in the GMNL package (Sarrias *et al.*, 2015). To allow identifiability, the model was specified so that the probability of selecting a conservation management scenario was a function of attributes of that scenario and of the alternative specific constant (ASC). The ASC captures the effects of utility of attributes not included in the choice specific attributes (Birol, Karousakis and Koundouri, 2006). In this case the ASC estimates the utility for the baseline project relative to BAU and was coded 0 for BAU and 1 otherwise. When the parameter estimates are obtained by the use of the MIXL model, welfare measures, in the form of willingness to pay, can be determined by estimating the change in the conservation management attribute in question and the utility of income represented by the coefficient of the cost attribute.

While unobserved heterogeneity can be accounted for in the MIXL base model, the model fails to explain the sources of heterogeneity (Hensher and Greene, 2003). By including interactions with respondent-specific socio-economic data with choice specific attributes, the model can identify variations in random and conditional heterogeneity in choice preferences. Socio-demographic details of respondents were included as dummy variables into the final model. The income variable was adjusted for co-habiting respondents and was dummy coded for above average household income in the UK at £23,556 per annum (DWP, 2013). We created a dummy coded variable for high education, where respondents having a degree, or post graduate degree were given a 1, all others a 0. We also created dummy variables as to whether the respondent had previously donated to: any charity, a wildlife charity or a humanitarian charity (coded as a 1 for donate and 0 for not donating).

We then wanted to analyse the interactions between the revealed preference study and the choice experiment. Firstly we used a chi-squared test to test whether the proportions of individuals donating or refusing differed depending on campaign type. We then hypothesised that those exposed to the threatened species management campaign would have higher preference to the threatened species population attribute within the choice experiment. All respondents within the choice experiment survey had been exposed to one of the two marketing

campaigns, therefore we created a dummy variable for which marketing campaign the choice experiment was conducted under (related to the date of the survey). For "exposure to species campaign" those respondents that were exposed to the threatened species campaign were given a 1 and those exposed to the community involvement in management campaign a 0. This allowed us to analyse the effects of marketing exposure on preferences within the choice experiment. These exposure variables were only interacted with two of the attributes within the choice experiment: threatened species populations and community involvement in management.

Due to a limited number of respondents that ended up both specifically being asked for a donation, and participating in the choice experiment (due to the random sampling) we ran a donor base MIXL model using only those individuals that gave a real donation during either campaign. Finally we wanted to test two hypotheses on the difference between donors and refusers. The first hypothesis was that those that refused to give a donation, under either campaign would have a lower stated willingness to pay than those that gave a real donation for both the species populations attribute and the community involvement in management attribute. Secondly we tested the hypothesis that those that refused to donate in the real campaigns would have a more negative payment coefficient due to refusing to give a donation in real life.

We used the base MIXL model of all respondents to the choice experiment. We identified the responses of those individuals that had given a donation to either campaign, and those that had refused to give a real donation in either campaign. We extracted the individuals' conditional mean willingness to pay for the two attributes within the choice experiment and also extracted the parameter coefficient for the payment attribute using the conjoint package in R (B¸ak and Bartt, no date). We then conducted a series of t-tests to see if those that refused to donate had significant difference in their willingness to pay for either the threatened species populations attribute or community involvement in management attributes.

2.3 Results

2.3.1 Descriptive statistics.

A total of 244 choice experiment interviews were conducted with an additional 31 refusals and 10 individuals that dropped out during the interview. We have limited socio-demographic data of the paying footfall in the zoo but a comparison on the data we have from till sales during our study period suggests that we achieved a relatively similar proportion of student, adult and retired respondents (see Table B in Appendix 2.1). The results show a relatively even distribution across age groups, though more females were interviewed than males and results are skewed towards those with less children (Figure 2.2).

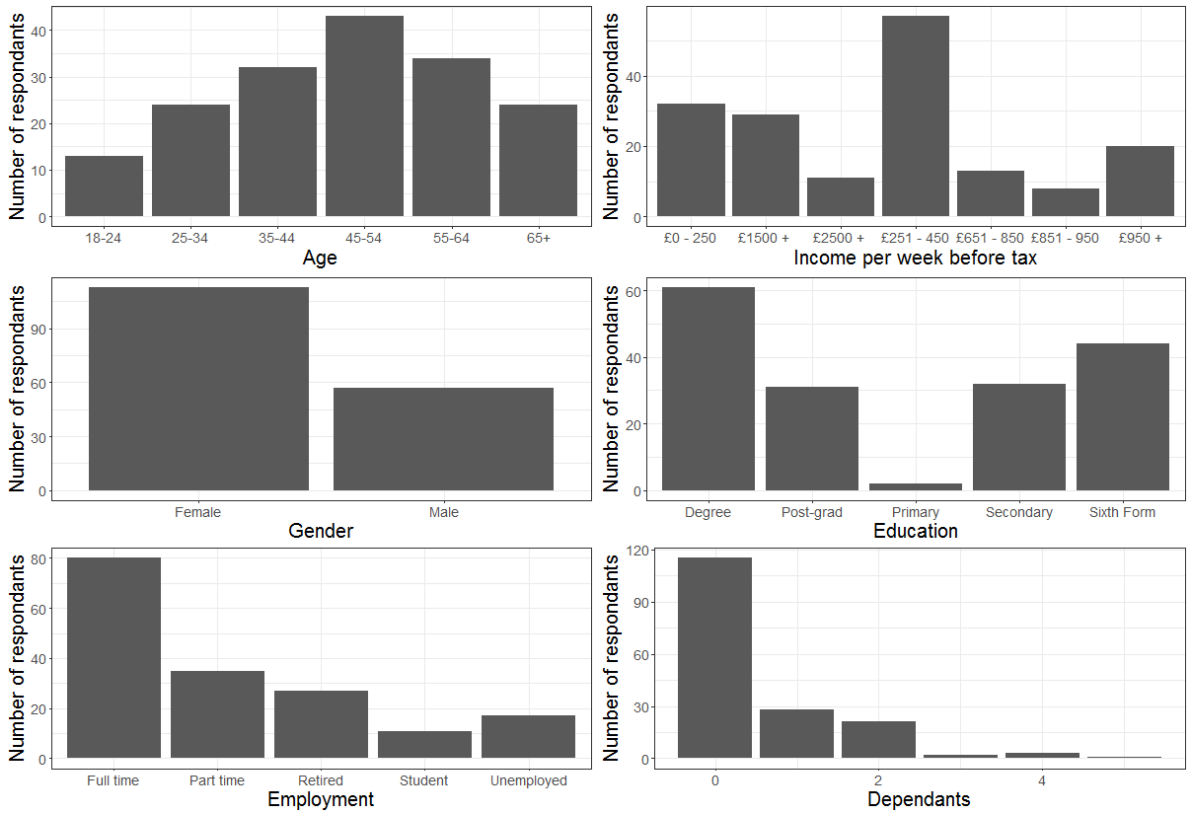


Figure 2.6. Descriptive statistics of the respondents within the choice experiment survey

2.3.2 MIXL model and interactions

From the 244 completed surveys, after non responses were excluded, 1505 choices were included in a MIXL base model (Table A in Appendix 2.3). The negative sign on the payment coefficient, shows that respondents prefer options that cost less, which is in line with expectations. The remaining attributes are positive and are all highly significant at the 1% level suggesting a focus on threatened species populations, community involvement in management, condition of conservation sites and alternative livelihood investment are all

valued as part of a conservation project by donors. The mean coefficients for the attributes threatened species populations and community involvement in management are much higher than the other attributes within the base model. Therefore, visitors to the zoo appear to derive particular utility from (and therefore have a stronger preference for) those conservation projects that improve threatened species populations in Madagascar and incorporate community involvement in management. The positive sign on the alternative specific constant (ASC) coefficient shows that respondents also prefer a project incorporating all the base level attributes compared to BAU.

Gender of respondent (n= 69 males) and having a child under the age of 18 (n= 42) had no significant effect on stated preferences for any of the attributes within the choice experiment. We also found that a respondent's previous donations to wildlife charities, humanitarian charities or both had no significant effect on which attribute was chosen. This implies previous charitable donation to a humanitarian charity had no impact on respondent stated preference for either providing alternative livelihoods or community involvement in management in Madagascar.

We tested a series of socio-demographic variables within the model, only three variables improved model fit: above average income, degree or graduate level education and exposure to the species campaign (Table B in Appendix 2.3), for results of the interacted MIXL model). These were interacted against all of the attributes in a series of models, but the best fit occurred when only interacted with the threatened species populations attribute. This increased the log likelihood from -972 in the base model to -968 and decreased the AIC value from 1967 to 1965. Those respondents with higher education had a significantly higher preference for threatened species populations improving than those with lower education. Those respondents with higher than average income also tended to have positive preferences for this attribute, though this interaction was not significant.

We tested the hypothesis that those exposed to the threatened species management campaign would have higher preference to the threatened species population attribute within the choice experiment. We interacted the dummy coded "exposure to species campaign" with the threatened species populations attribute (See Table B in Appendix 2.3). The sign for the interacted variable was negative. This implies that some respondents exposed to the threatened species management campaign tended to have lower preference for the threatened species

population attribute but this difference was not significant. The marketing exposure apparently had no effect on the preferences of respondents within the choice experiment itself.

2.3.3 Marginal willingness to pay

Once the MIXL has been estimated, the parameter estimates can be used to calculate marginal willingness to pay values for each attribute. Figure 2.3 shows mean willingness to pay (and 95% confidence intervals) for a conservation scenario with high levels of the attributes. The attribute with the highest mean willingness to pay is community involvement in management, followed closely by the threatened species populations attribute. Providing alternative livelihoods and improving conservation sites have similar (lower) support.

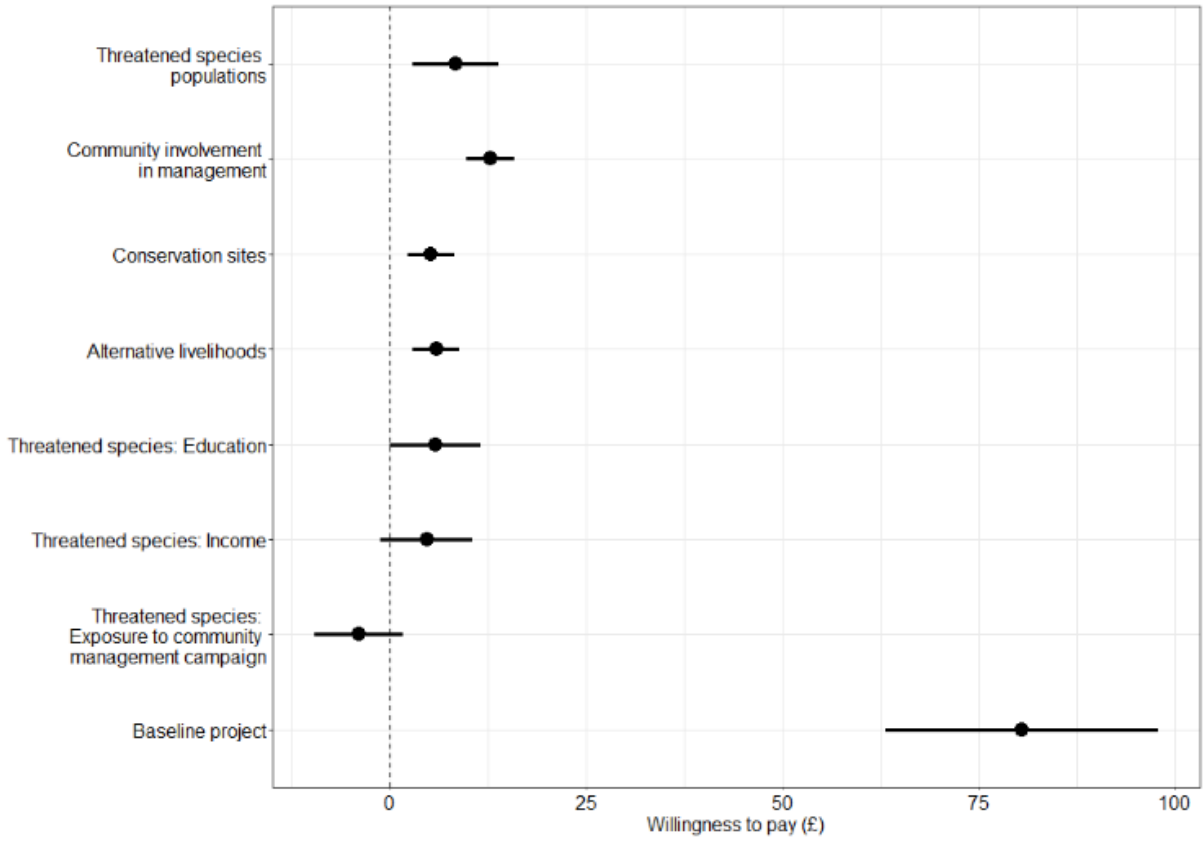


Figure 2.3. Mean willingness to pay (and 95% confidence intervals) for attributes and interacted socio-economic variables of respondents for conservation management scenarios in Madagascar.

Respondents are willing to pay, on average £12.83 (£9.82-£15.84 95% CI) for a community involvement in management programme in Madagascar, compared with the £8.41 (£2.96-£13.87) to improve threatened species populations. There was evidence for positive willingness to pay for both conservation sites (£2.36- £8.21) and providing alternative livelihoods (£3.01–£8.84). The interacted variables with a negative WTP imply that some respondents in that

demographic group had a negative preference for those attributes however, this was not significant.

2.3.4 Revealed preference results

A total of 14,116 paying visitors entered the zoo during the 4 week period. However, due to the volume of visitors entering through the tills, time and personnel constraints, only 13% of these were asked to give a donation (see Table 2.2 for a summary of the campaigns and the number of donators and refusers). The majority (88%) of those who were asked to donate did make the additional donation (see Table 2.2). However a chi-squared test showed that there was no significant difference between the proportions that donated or refused under the two marketing campaigns.

Table 2.2 Summary results of donators and refusers the two marketing campaigns run at Jersey zoo over a four week period of alternating campaign types during July and August 2016.

Campaign type	**Community (%)**	**Threatened species (%)**	**Total (%)**
Donation	797 (89)	778 (86)	1575 (88)
Refusal	98 (11)	125 (14)	223 (12)
Total	895	903	1798
Data Source: Durrell Marketing department July- August 2016. Chi squared =3.02 (P=0.074)			

Prior to approaching for interviewing we did not know who had been asked to make a donation at the tills, and with the relatively low proportion of visitors who were asked, this resulted in only 15% of the respondents that participated in the choice experiment having also been asked to give a donation. Of these 50 respondents that completed both elements of the experiment, 43 gave a donation and 7 refused. Of these, only 40 were included in the final analysis (36 donators, 4 refusals), due to drop outs and non-responses to the parts of the survey.

The MIXL donor base model (with only those individuals that gave a donation during either campaign) showed similar patterns to the model for all respondents but note that the number of observations dropped from 1505 to 318 due to the small sample size (See Figure 2.4). Individuals had a negative preference for an increase in the payment attribute and the two attributes for threatened species populations and for community involvement in management remained significant at the 1% level (See Table C in Appendix 2.3). The attribute for alternative

livelihoods remains significant, but is lower than the community involvement in management attribute or threatened species populations attribute. The attribute for conservation sites is no longer significant. This implies that those that gave a real donation have a stronger stated preference for those conservation projects that improve both threatened species populations and community involvement in management.

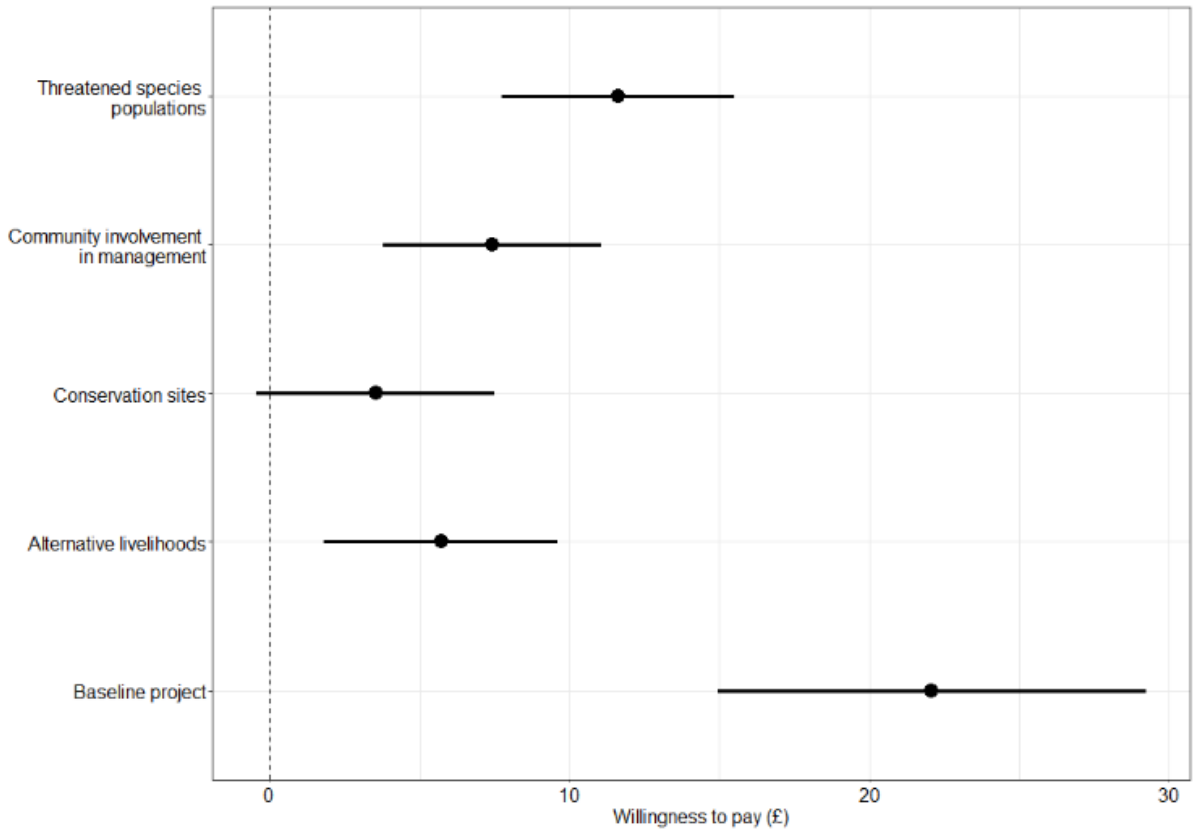


Figure 2.4. Mean willingness to pay (and 95% confidence intervals) for attributes within the choice experiment for those individuals that gave a real voluntary donation during either marketing campaign prior to participating in the choice experiment.

We tested the hypothesis that those that refused to give a donation, under either campaign would have a lower stated willingness to pay than those that gave a real donation for two of the attributes within the choice experiment; species populations and community involvement in management. The results of the t-tests showed that there was no significant difference between donators and refusers in their stated willingness to pay for either attribute, though the sample size is very small (see Figure 2.5a). Finally we tested the hypothesis that those that refused to donate in the real campaigns would have a more negative payment coefficient, due to refusing to donate in real life. The sample size was very small for this test and there was no significant

difference in the random utilities for the payment attribute within the choice experiment. However, we can see that some individuals refused to give a real donation had positive utilities for the payment attribute (Figure 2.5b). This implies that some individuals may not have given the payment attribute adequate consideration of their ability to pay and those individuals that gave a real donation tended to have a lower preference for the conservation projects with higher costs.

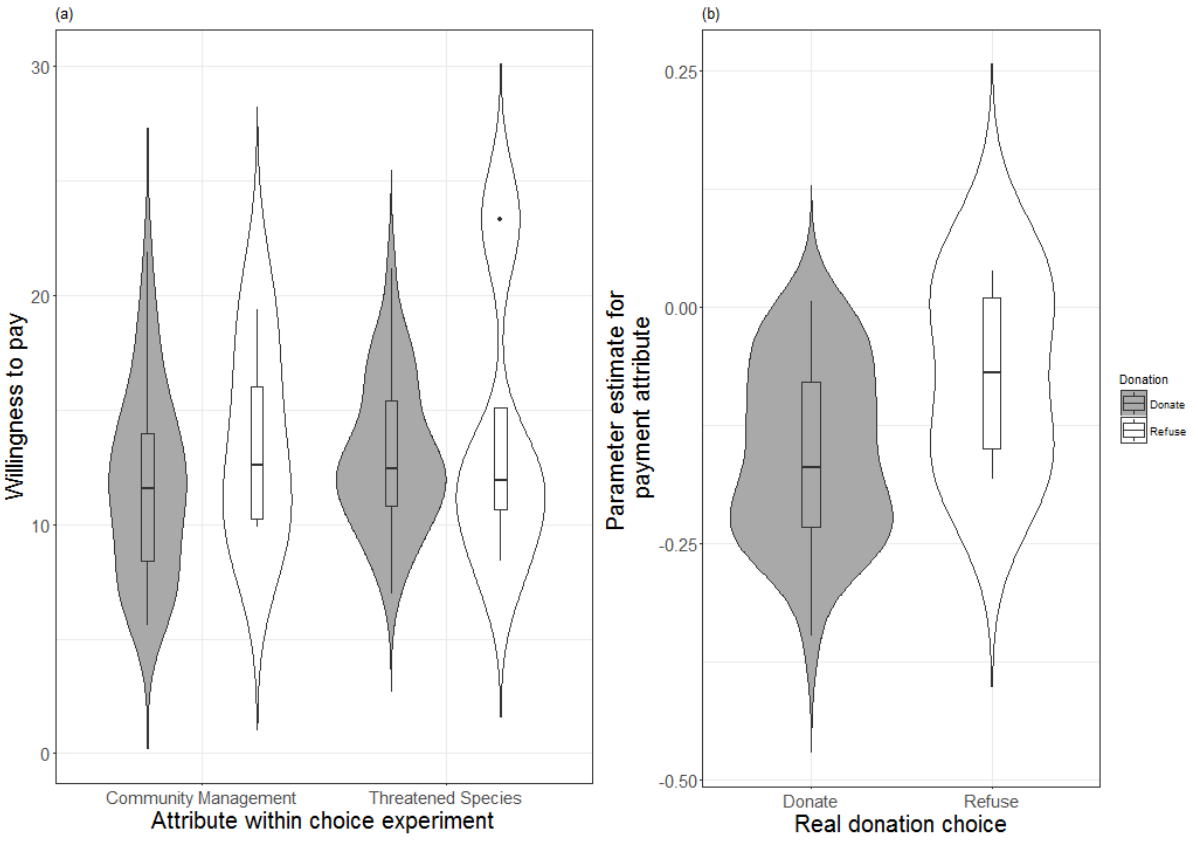


Figure 2.5. The difference between respondents that donated or refused during the real campaigns for both their willingness to pay and the payment coefficient within the choice experiment. Figure 2.5(a) Willingness to pay for respondents that refused or donated in the real campaigns for the corresponding attributes in the choice experiment. Donations and refusals are combined across the marketing campaigns as there was no significant effect of exposure on preference. The violin plots show median, upper and lower quartiles and the centred density. Figure 2.5(b) Individual coefficients for the payment attribute within the choice experiment for respondents that either refused or donated within the choice experiment. Donations and refusals are combined across the marketing campaigns as there was no significant effect of exposure.

2.4 Discussion and conclusions

Understanding what potential donors value in a conservation project is necessary to improve the marketing of conservation projects to attract funding, while also revealing insights into how the general public view conservation. We show that visitors to a zoo in Jersey, Channel Islands, have a positive willingness to pay for conservation projects in Madagascar whether focused on delivering improvements in threatened species populations, improving the condition of important sites, involving local communities in management, or providing support for alternative livelihoods. However there was a particularly strong willingness to pay for projects with community involvement in management. This preference was seen even on days when a threatened species-focused marketing campaign was running and when analysing the results of only those that gave a real donation. This implies that emphasising a participatory, community conservation approach to conservation is attractive to potential donors and could increase funding.

Socio demographic characteristics of respondents did not have a significant effect on our results. Our sample did however contain people with fewer dependants potentially undervaluing the attributes with associated bequest values (Peters and Hawkins, 2009). If the study had been done after the zoo visit, this may have increased both stated and revealed preference amounts. However the logistics (donations were requested at the cash desk as visitors paid to enter the zoo) meant it wasn't possible to ask for a donation after the visit and so while it would have been possible to conduct a choice experiment after a respondent's zoo experience to test for deliberative effects (Kenter *et al.*, 2011), this was not done as we wanted the revealed preference study and the stated preference study to be comparable.

Hypothetical bias is often present in choice experiment studies as respondents do not have to back up their statements with real commitments (Carlsson and Martinsson, 2001; List and Gallet, 2001; Murphy *et al.*, 2005). Many authors have suggested that the reliability and validity of choice experiments should be tested through comparisons with real or simulated markets (Hensher, 2010; O Sarobidy Rakotonarivo, Schaafsma and Hockley, 2016). We attempted to externally validate the findings from a choice experiment using a real marketing campaign on the same sample of respondents. We showed that exposure to the campaign types had no effect on the preference of respondents nor did the real donation to either campaign. We also looked at the effect of campaign type on the willingness to pay of those that donated. The amount of respondents that participated in both elements of the experiment was unfortunately too small to reliably estimate any difference between those that gave real

donations compared to those that refused. However, it is interesting that, if anything, those who donated tended to be those with a lower willingness to pay than those who refused. This lends tentative support to those who question the validity of choice experiment due to overstatement of willingness to pay due to the hypothetical nature of stated preference valuation techniques (List and Gallet, 2001; Murphy *et al.*, 2005).

Although we don't believe that respondents associated the revealed preference donation study (conducted by the zoo at their cash desk), with the choice experiment survey (conducted by researchers), there is of course the potential that those asked to make a donation have considered their willingness to pay more concretely, than those involved in the choice experiment alone without previously being asked for a donation. This could result in differences in hypothetical bias between those asked for a donation and those not asked. Unfortunately, the small number of respondents to the choice experiment who had been asked for a donation meant that we could not explore this effect.

Our sample was of members of the public visiting a particular UK zoo. It would certainly be valuable to carry out further studies exploring preferences for different conservation approaches among the general public both in donor countries, and the countries where such conservation projects are conducted. The insights presented here and the methodology (allowing validation of the choice experiment results with a revealed preference approach) suggest how such research could be carried out.

We collected no qualitative information which might help explain the preferences we observed. However conservation involving community management may be viewed as more legitimate and fair (Markova-Nenova and Wätzold, 2017). It may also reflect pragmatic views that conservation which includes local people in management will be more effective, though evidence to support this is mixed (Stephen R. Kellert, Jai N. Mehta, S, 2000).

The pilot indicated that respondents considered the attributes as independent of one another and the clear ranking of WTP for the attributes enabled us to treat them as distinct. Conservation projects often are faced with trade-offs and may not able to prioritize all potential approaches at the same time; for example tackling illegal hunting to address reductions in a threatened species may be prioritized over general habitat protection. Choice experiment design requires a trade-off between eliciting the maximum information from respondents, without overburdening them with multiple attributes and choice tasks. Further understanding

of what donors prefer in community conservation projects would benefit charitable marketing campaigns.

Areas of high biodiversity often overlap with areas where poverty is widespread (Fisher and Christopher, 2007) and there is also a growing body of research which supports the idea that conservation should be participatory and involve local communities in management (Ancrenaz, Dabek and O'Neil, 2007; Dyer *et al.*, 2014; Boissière *et al.*, 2017). Our choice experiment suggested there was overwhelming support for conservation projects in Madagascar incorporating community involvement in management. There is widespread agreement among conservationists working in the country that conservation should include local people as full partners (Andrianandrasana *et al.*, 2005; Pollini *et al.*, 2014; Dolch *et al.*, 2015). It is encouraging that this approach is valued by potential donors.

3. Using a capitals-based approach to investigate multidimensional aspects of capacity for community conservation in Madagascar.

Abstract

Many community-based conservation projects seek to build community capacity to enable the co-management of natural resources. However there is little agreement on definition of community capacity and how it should be measured which poses challenges for the monitoring and evaluation of capacity building activities. We use a capitals approach (considering human, social, organisational and economic capital) to develop a set of indicators to quantify these foundational assets underpinning community capacity. Using 198 household surveys in 17 communities in northern Madagascar, we investigate the relationship between the indicators within each capital and select a subset to characterise each capital. We explore the relationship between each of the foundational capitals and between these and poverty (as measured by a multidimensional poverty index). We find that single indicators for each capital may not be appropriate to represent the multidimensionality of community capacity. The approach developed is a first step in applying multiple indicators to enable the evaluation of the efficacy of capacity building interventions. Improved understanding of the strengths and weaknesses in community capacity can help in the development of effective capacity building initiatives to promote more successful conservation outcomes in community-based conservation projects.

3.1 Introduction

The need for capacity building has been recognised at the individual, community, organisational and national scales in order to achieve efficient and coordinated action to prevent biodiversity loss (Whittle, Colgan and Rafferty, 2012; O'Connell *et al.*, 2017). Alongside the rise in community-based conservation approaches have been calls for the strengthening of community capacity to in order to achieve both sustainable development goals, and successful conservation outcomes (Chaskin, 2001; Wells *et al.*, 2004; Balint, 2006; Cavaye, 2008; Mizrahi, 2009). However, despite significant investment in capacity building initiatives at multiple scales (Mizrahi, 2009), there remains a range of definitions of what capacity is and, therefore, what capacity building entails (Goodman *et al.*, 1998; Chaskin, 2001; Donoghue and Sturtevant, 2007; Cavaye, 2008; Mizrahi, 2009; Whittle, Colgan and Rafferty, 2012). One consequence of this is that there is a deficit in the measurement, monitoring and evaluation of capacity and capacity building activities in conservation (Beckley *et al.*, 2008; Wilder and Walpole, 2008; O'Connell *et al.*, 2017).

Beckley *et al* (2008) define community capacity as "the collective ability of a group [the community] to combine various forms of capital within institutional and relational contexts to produce desired results or outcomes". They, and others, suggest that capitals (human; social, economic, organisational and natural) form the asset base of a community's capacity (Chaskin, 2001; Beckley *et al.*, 2008; Mountjoy *et al.*, 2013). These foundational assets can be strengthened and mobilized over time given the right socio-political environment and support (Balint, 2006; Donoghue and Sturtevant, 2007; Beckley *et al.*, 2008). A number of conceptual models of community capacity exist that vary which capitals are included as foundational assets (Chaskin, 2001; Moore, Severn and Millar, 2006; Donoghue and Sturtevant, 2007; Beckley *et al.*, 2008; Mountjoy *et al.*, 2014). In this study we focus on human, social, organisational and economic capital in order to undertake co-management of a community-based conservation project.

Community-based conservation projects place demands on stakeholders and require a range of knowledge, skills, leadership capacity and motivation to act (Pretty and Ward, 2001) all of which are considered as human capital. For example the monitoring of biodiversity outcomes requires a basic knowledge of survey techniques and knowledge of local flora and fauna. Involvement in a conservation project also places demands in terms of social capital which has been defined as the "norms and networks that facilitate collective action" (Woolcock, 2001).

For example, in order to mobilise collective action in the face of an environmental problem, there requires a sufficient communication network both within the community, and to external agents. Social capital capacity building involves both enhancing existing internal relationships within communities "bonding" as well as external relationships with, for example, other communities, NGOs and government officials "bridging" (Woolcock and Narayan, 2000). This study includes both bonding and bridging social capitals and we refer to both "bridging social capital" and "bonding social capital" throughout this thesis.

Organisational capital in the context of community based conservation projects can be considered as the "governance within the community groups undertaking biodiversity activities" (Moore, Severn and Millar, 2006). For example, a functioning local environment group requires adherence to agreed rules and procedures. Organisational capital may include the procedures, roles, responsibilities, guidelines and objectives of groups (Foster-Fishman *et al.*, 2001), while recognising the broader policy and institutional settings which can mobilize community capacity (Moore, Severn and Millar, 2006; Beckley *et al.*, 2008). Economic capital refers to financial resources and equipment to enable community based conservation activities to achieve their goals (Moore, Severn and Millar, 2006). For example, in order to have sustainable fishing, correct net-gauges are required for the fisher groups, as well as equipment to enable the monitoring of natural resources. Sufficient community level infrastructure such as schools, roads and healthcare facilities are clearly pre-requisites for a successful community-based conservation project (Beckley *et al.*, 2008; McClanahan *et al.*, 2008).

We have adapted Beckley et al's (2008) figure of community capacity and applied it to the context of community capacity for natural resource conservation (Fig 3.1). Each of the capitals (human social, organisational and economic) can be characterised by a series of indicators (as summarised in Table 3.1). Various threats and opportunities can act as catalysts to develop community capacity, this may be the establishment of a community based conservation project, or as a reaction to an environmental problem. Beckley *et al*. (2008) also note that community capacity cannot happen within a social vacuum, it is also reliant on the relations of the community such as the bureaucratic rules and regulations in which the community exist. Community capacity is also enabled by the associative and communal relations, which are based on shared interests and shared identity respectively. The foundational capital assets therefore require both catalysts and relations to set the right socio-political environment and

support to enable efficient and coordinated action within a community (Balint, 2006; Donoghue and Sturtevant, 2007; Beckley *et al.*, 2008).

Previous studies have attempted to either qualitatively or quantitatively score indicators in relation to community capacity for various outcomes; adaption to climate change (Ruiz-Mallén, Fernández-Llamazares and Reyes-García, 2017; Whitney *et al.*, 2017), tourism development (Bennett *et al.*, 2012; Khosravi, Mohamed and Nair, 2015; Ghaderi, Abooali and Henderson, 2017) and natural resource management (Brinkman *et al.*, 2012; Cinner *et al.*, 2015). These studies vary widely in the number of indicators and methods used to assess the state of each capital asset. For example some studies simply use one indicator for social capital (such as membership to community groups (Cinner et al. 2015), while others use focus group discussions to score each capital more broadly (Leith *et al.*, 2012). Despite the popularity of community capacity building and the need to quantify the impact of community-based conservation projects, there is a lack of studies that use a rationalised set of indicators of the four capitals which serve as foundational assets for community capacity.

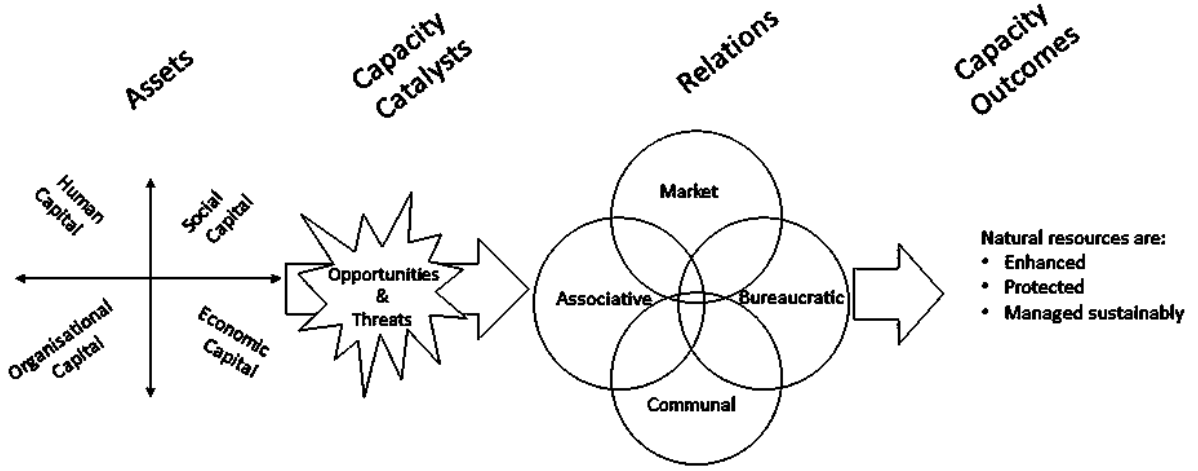


Figure 3.1. Community capacity model adapted from Beckley et al. (2008) showing assets, catalysts, relations and capacity outcomes for community based conservation.

In this study we develop a rationalised set of measurable indicators for each capital, which can be used to characterise community capacity through a household survey. Using the case of a proposed community-based conservation project in Northern Madagascar we develop a questionnaire to quantify performance in these indicators using carefully chosen questions based on the design of the conservation project concerned. This study includes both bonding and bridging social capitals and we refer to both "bridging social capital" and "bonding social capital" throughout this chapter. Capacity building activities within this case study focused on

both forms of social capital, as such we treat these capital assets as separate capitals within our analysis to better understand the attributes of the networks both within the communities and external to them.

We explore the relationship between each of the foundational capitals by investigating how performance in each of the capitals is related. Finally, we explore the relationship between these and poverty (as measured by a multidimensional poverty index; Alkire *et al.*, 2015). This study therefore focuses on the baseline levels of capacity assets prior to and capacity building activities as part of the community based conservation project (an opportunity catalyst). Measuring the capacity outcomes in terms of conservation outputs are therefore beyond the scope of this study.

Table 3.1 Summary of foundational capital assets for community based conservation projects, with key sources describing these assets as used in studies of community capacity.

Capital	**Indicator**	**Key literature sources**
Human	*Skills*	Foster-Fishman *et al*. 2001; Moore *et al.* 2006; Cinner, Fuentes, et al. 2009; Davenport & Seekamp 2013; Raymond & Cleary 2013
	Knowledge	Foster-Fishman *et al.* 2001; Pretty & Ward 2001
	Leadership	Raymond *et al.* 2009; Gruber 2010; Brinkman *et al.* 2012; Davenport & Seekamp 2013
	Motivation	Pretty & Ward 2001
	Attitudes	Mountjoy *et al.* 2014: Pretty *et al.* 2000
	Poverty & wellbeing *	Moore *et al*. 2006; Mountjoy *et al.* 2014
Social Capital Bonding	*Social network within the community*	Pretty & Ward 2001
	Collaboration	Cinner *et al.* 2015
	Communication	Foster-Fishman *et al.* 2001; Gruber 2010; Davenport & Seekamp 2013
	Trust	Foster-Fishman *et al.* 2001; Gruber 2010; Davenport & Seekamp 2013
Social Capital Bridging	*Social network outside the community*	Pretty & Ward 2001
	Collaboration	Cinner *et al.* 2009; Izurieta et al. 2011; Mountjoy *et al.* 2013; Raymond & Cleary 2013.
	Communication	Cinner *et al.* 2009; Izurieta *et al.* 2011; Mountjoy *et al.* 2013; Raymond & Cleary 2013.
	Trust	Foster-Fishman *et al.* 2001; Brinkman *et al.* 2012
Organisational Capital	*Goals*	Foster-Fishman *et al*. 2001; Davenport & Seekamp 2013.
	Governance structures	Cinner *et al*. 2009; Gruber 2010
	Responsibilities	Izurieta *et al*. 2011; Campbell & Shackleton 2001
Economic Capital	*Municipal infrastructure*	Beckley *et al.* 2008; McClanahan *et al*. 2008
	Financial resources	Beckley *et al*. 2008; McClanahan *et al.* 2008
	Equipment	Chapman 2014
	Employment	Brinkman *et al.* 2012
*Poverty is often included under human capital, however in this study we treat it separately in order to understand how poverty (broadly defined as a multi-dimensional concept) interacts with the foundational capital assets.		

3.2 Methods

3.2.1 Questionnaire design

This study explores community capacity in 17 communities surrounding two lakes (Sofia and Antafiandakana) in Northern Madagascar, Bealanana district (see section 1.7 for a description of the study context). We developed a household questionnaire based on the key capitals and indicators developed through the literature review. The household survey contained questions aimed at each of the key indicators within each of human, social, economic and organisational capitals (Table 3.1). This was designed to be able to quantitatively capture changes over time and the majority of questions conformed answers to a 7 point Likert scale (reverse scored for negatively phrased questions). Questions were based on previous household surveys and adapted to be relevant in a community-based conservation project context (see a full list of sources for each questionnaire item in Appendix 3.1). Additionally the questionnaire contained a standard household roster and a range of poverty indicators selected for a rural Malagasy context following Bidaud et al. (2017) and based on the Global Multidimensional Poverty Index (Alkire, Jindra, *et al.*, 2015).

Key informant interviews with 16 fokontany presidents, elders, and women's group leaders were used to adapt the indicators to the local context and develop suitable option lists for multiple choice answers. The final survey in English and Malagasy is freely available and can be downloaded onto from the open-source form hub website (Appendix 3.2).

The household questionnaire was translated by 1st language Malagasy speakers with a background in social research into Malagasy Offisialy (the national dialect) and back translated by Danielysa Razafindramavo (an MSc student associated with the project) to ensure meaning had been kept in the original text. The survey was then adapted for the Tsimihety dialect, the language spoken in both sites, by Danielysa Razafindramavo with help from two local field assistants. We then adapted the survey to enable us to record results on smart phones using Open Data Kit (ODK, Hartung et al. 2010).

A pre-test with 16 randomly selected individuals was conducted during July 2015 to ensure that the questions were locally relevant and that the Likert scale was understood. No major modifications were made to the structure of the survey. The questionnaires were conducted by Danielysa Razafindramavo and two local field assistants during July and August 2015. All were native speakers of Tsimihety and local to the region. Amy Lewis attended interviews every day, rotating around the four interview teams. The field team were trained in the

importance of consent as well as ODK technical skills and interview techniques during a week-long period involving role-playing as both interviewer and respondent. The training was also used to explore any technical issues arising with conducting the questionaire through the smartphone platform.

3.2.2 Sampling strategy

Interviews were conducted with household heads across the 17 fokontany between June and September 2015. Three villages were sampled in each fokontany as a maximum. Where a fokontany contained more than three villages, the villages were selected for sampling based on distance from the fokontany centre. We asked the fokontany president (or deputy when not available) to create a list of all villages and separate based on the fokontany centre, a close village (<30 minute walk) and a distant village (>30 minute walk). One from each group was randomly selected.

We defined households as: a person or group of persons, related or unrelated who live together and share a common source of food (Randall, Coast and Leone, 2011). At each village the leader or deputy was contacted and the list of household heads in that village was collected, assisted by the local electoral register. We defined household heads as the main decision maker within the household (Walle, 2006). Household heads were given a number, and selected at random. When an individual was not available, an appointment was made. Where individuals either did not wish to be interviewed, or a reasonable appointment could not be made another name was drawn. Note that this method is potentially limited in that only household heads on the electoral register or those recalled by the leader will be included in this analysis, potentially omitting more isolated households. At the end of the survey households were asked if they would like to participate in further studies and GPS coordinates were collected to enable the relocation of the household.

3.2.3 Ethics and data management

The research was scrutinised and cleared under the Bangor University Research Ethics framework. All respondents were over the age of 18 and were told that the research was about how households, communities and organisations work together to solve collective problems to deliver local community and environmental benefits. We explained that the results may be published, but their names would not. All data was saved on a password protected computer. An oral consent script was read out (see Appendix 3.3) and respondents were told that they

could stop the interview at any time without having to give a reason. Interviews lasted between 30 minutes and 1 hour. Interviews were conducted in the household or in their fields, as the respondent preferred. GPS coordinates were taken at the household, though these data were not shared.

3.2.4 Data Analysis

We used principal component analysis (PCA) to explore the results of the household survey. Similar to exploratory factor analysis (EFA), PCA is a dimension reduction technique. PCA uses a linear combination of variables to create a weighted average component score, as opposed to measuring a model of unobservable latent variables (Budaev, 2010). Factor analysis also enables subjectivity by the researchers who can search for multiple rotations of factors that are more easily interpretable, this has therefore "left many analysts sceptical of factor analysis, and may account for its lack of popularity in contemporary statistics" (Hastie, Tibshirani and Friedman, 2017, p. 560).

Some of the variables were phrased negatively, or reverse coded in the original file. We therefore had to create some "reverse" variables in order to have the same "direction" within the PCA. These variables are indicated with the suffix "_reversed". We also created some dummy variables from yes/ no answers, or where presence/ absence was the best interpretation (for example "presence of uncommon assets") again, these are denoted with the suffix "_dummy". Positive responses are coded 1 or and negative responses are scored 0. A full description of codes, transformations and relevant literature for each variable can be found in Appendix 3.1.

Due the presence of multiple missing values we also used the missMDA package (Josse and Husson, 2016) to impute those missing, which takes into account both the global similarity of individuals and the links between individuals using an iterative PCA. Number of components to extract was determined by the shape of the scree plot (Vyas and Kumaranayake, 2006). Variable loadings were calculated by dividing the variables coordinates on a dimension by the square root of the dimensions Eigen value.

In order to explore the relationship between each of the foundational capitals we inputted the results of each indicator into a pooled PCA using the Factominer package in R version 3.2.2 (Lê, Josse and Husson, 2008). This pooled PCA contained all indicators and allowed us to assess how well the indicators for each foundational capital grouped. In total 57 indicators were

put into the first pooled PCA. We then ran an individual PCA for each of the foundational capitals in order to reduce the number of variables and to prevent overlapping variables, and to prevent double counting. We used multiple rounds of PCA to reduce the variables within each of these capitals. Following Brinkman *et al.* (2012), variables were removed based on high numbers of missing values and low variable loadings. In order to avoid summing an individual's score for indicators within a foundational capital, we extracted the households' score for the principal components of that capital, based on the multiple indicators (which we will call capital components). We extracted household scores for each capital component (based on investigation of the scree plots, and explained variance). For the purposes of this analysis we analysed poverty indicators as separate from human capital. To enable further visualisation of foundational capitals we plotted the capital components within a final PCA.

Finally, we wanted to understand the relationship between poverty and foundational capital assets and other socio-economic variables. We extracted the capital component scores and put them into a linear model (lm package in R; Wilkinson & Rogers 1973) with socio-demographic variables. Our final analysis used a linear model to investigate the interaction between human capital, dimensions of poverty and other foundational capital assets using the capital component scores. Socio demographic variables were extracted from the household roster section of the questionnaire. This included continuous variables for household size, number of children and age of household head while gender of household head was dummy coded (1 for male).

3.3 Results

3.3.1 Socio-demographic results

In total, 198 household surveys were completed during July- September 2015. A total of 43 villages were sampled within 17 fokontany and across 4 communes. Between 7 and 15 household heads were interviewed per fokontany. The majority of our households were male-headed households and the sample showed normal distribution across age groups, household size and number of dependents (Figures 3.2a-d). Some poverty indicators are also shown in Figure 3.2 (Figures 3.2e-j). These highlight the poverty in which the majority of households are currently living in through multiple measures. For example, across the communities we see poor access to sanitation. The majority of household heads either have no access to a toilet or use a shared one (Figure 3.2g) and the household water source tends to come from a shared well or from a lake river or stream (Figure 3.2f). Despite a majority of households having a tin roof on at least one of their household buildings (Figure 3.2i), a significant number of households had one or more food insecure months in the last year (Figure 3.2j).

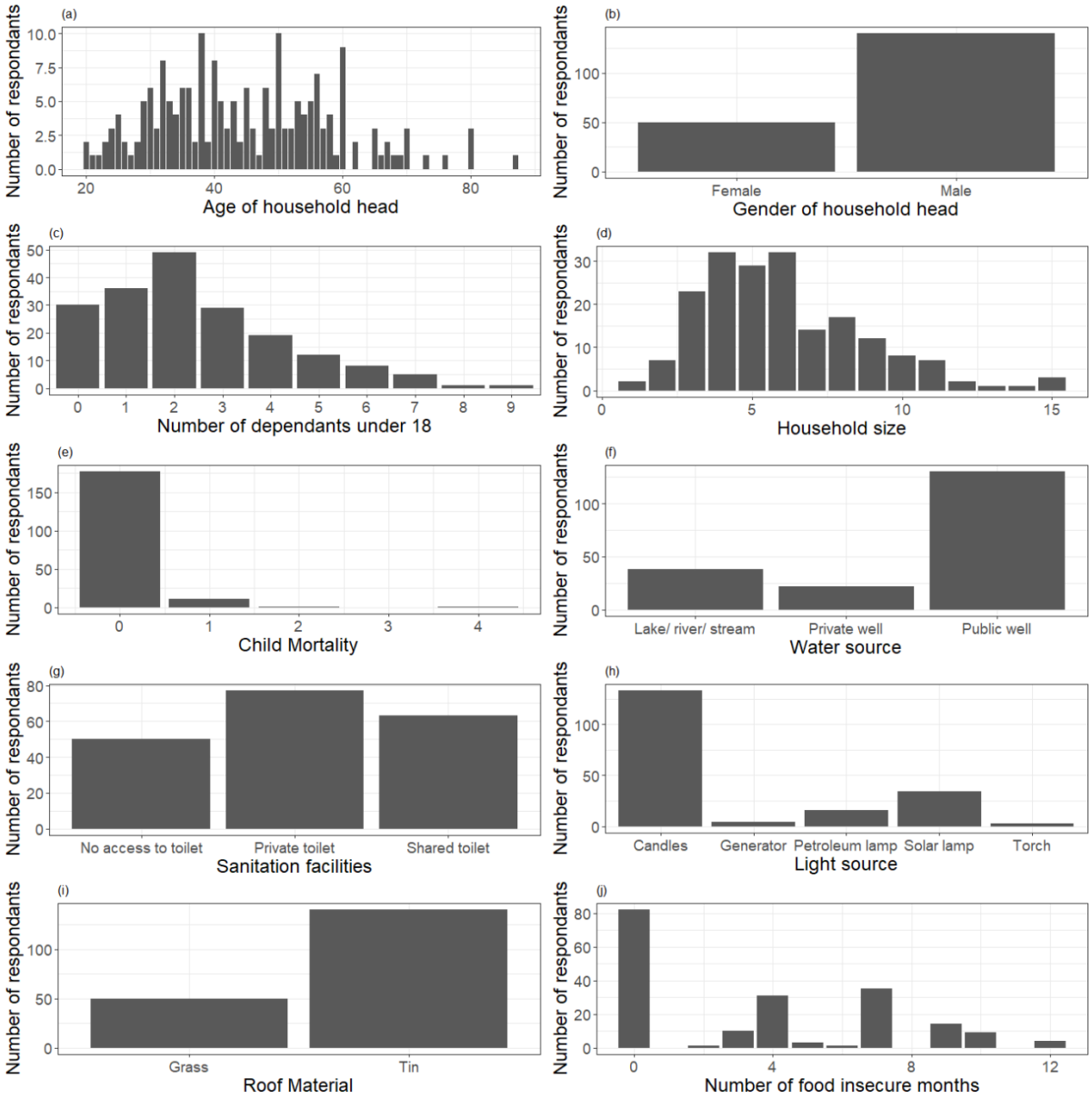


Figure 3.2. Figures 3.2a-d describe socio-demographic variables of household heads within the survey (n=198). Figures 3.2e-j describe some poverty variables collected within the household survey (see Appendix 3.1 for all poverty variables).

3.3.2 The relationship between foundational capitals and poverty

In total 57 indicators were included into the pooled principal component analysis (see Appendix 3.1 for a full list of all variables). The scree plot indicated a four component solution (see Appendix 3.4 for the scree plot figure). Figure 3.3 shows the four components plotted from the solution. These plots show the distribution of indicators and that there is considerable overlap between each capital. Contributions of indicators to the first component was largely dominated by bridging social capital indicators (indicators include trust and collaboration with external agents) which had higher values on the x-axis. The contributions to the second component were dominated by indicators of poverty with higher values on the y-axis. These figures highlight the need to reduce the number of underlying variables to fully represent each distinct capital.

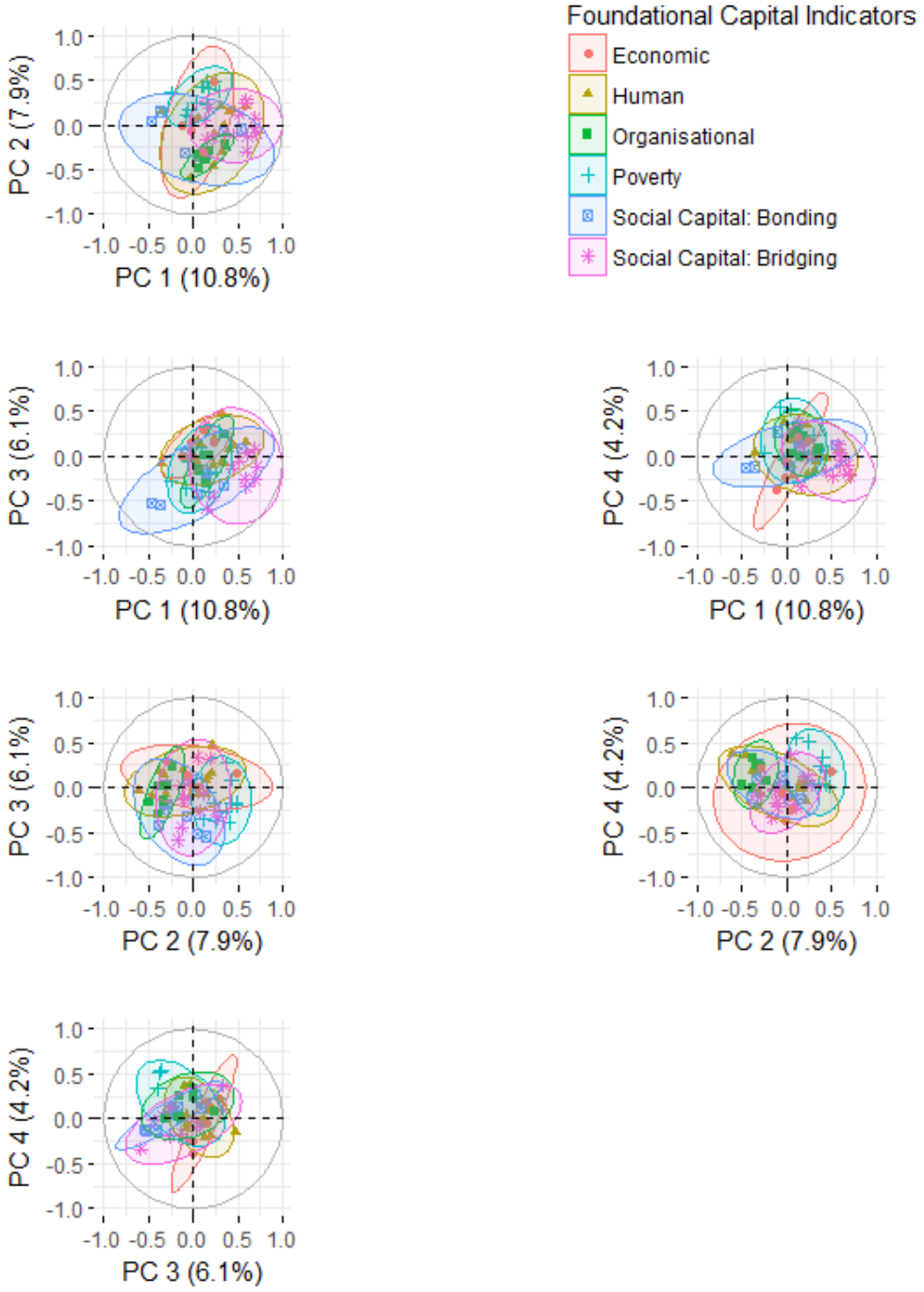


Figure 3.3. Loadings for the 4 principal components within the matrix for all indicators of foundational capitals showing considerable overlap. The points represent individual indicators and are grouped by colour and ellipse according to foundational capital. See Appendix 3.1 for a full list of all variables included in the PCA analysis.

3.3.3 Rationalising indicators for the four foundational capitals

We ran individual PCAs on each of the foundational capitals. In the case of each of the four capitals, we were able to reduce the number of indicators needed to charaterise the condition of the capital (see Table 3.2).

Table 3.2 The details of inputs and output of the principal component analysis on each of the foudational capital assets.

	Human Capital	**Social Capital (Bonding)**	**Social Capital (Bridging)**	**Organisational Capital**	**Economic Capital**	**Poverty**
Initial number of variables	13	8	13	6	5	12
Final number of variables	7	7	11	5	4	9
Percentage varience explained by first 2 components	40.6	43.7	40	52.2	55.4	35.8

In total six items were dropped from human capital, due to potential confusion in the questions and low variable loadings across multiple components. The remaining variables indicated a two component solution through scree plot. The remaining variables represented all the indicators of human capital in attitude, knowledge, skills, leadership and motivation. Interestingly the knowledge indicator (household education) did not correlate highly with other variables for human capital. Implying a one indicator solution is not sufficient to represent the full dimensions of human capital.

One item was dropped from bonding social capital as this was highly correlated with another variable and both were indicators of bonding social networks (one for the social network to solve environmental problems and the other to solve social issues). We removed the network for social issues indicator as this had a lower loading and was less targeted at community collaboration for conservation outcomes. Again a two-component solution was indicated by the scree plot. For bridging social capital two variables were removed, one due to potential confusion in results and one due to high correlation with another variable. Collaboration

indicators (working with NGOs or with government) were highly correlated, we removed the government collaboration indicator due to a lower loading across multiple dimensions and due to being less likely to change as a result of a community conservation project. Trust indicators for NGOs, government and other communities were all kept in the final two-component solution. In both bonding and bridging social capitals the indicators for the social network did not correlate highly with other indicators implying that a households social network in isolation may be a poor proxy for social capital.

One variable was removed from the list of indicators for organisational capital this was highly correlated with another variable and had a very low loadings across multiple components. This was one of multiple indicators of good organisational structure, so other indicators were able to represent this aspect of organisational capital. Only one variable was removed from economic capital (alternative livelihood in the region) as this had low loadings and employment was captured by another variable. Again, municipal infrastructure is often a proxy for economic capital, but this did not correlate with employment opportunities and other resources to deal with environmental change. In total three variables were removed from the indicators for dimensions of poverty. Food security "last year" and "in a normal year" were highly correlated and "normal" food security was dropped due to lower loadings. Type of floor and type of roof were also highly correlated, we dropped flooring type as an indicator for "living standard" due to the lower loadings.

All separate PCAs indicated a two component solution and the final indicators for each of the capitals are presented in Figure 3.4 (see Appendix 3.5 for all scree plots). Within all of these capitals there remains low correlation of variables within each of the capitals, while still explaining a high percentage of variability. This implies that single indicator solutions to each of these capitals could fail to capture the full dimensionality of each of the capital assets required for community-based conservation activities. After the removal of process decsribed above to rationalise the variables, we then put the final variables into the pooled PCA again. The scree plot did indicate a three component solution however there was an increase of only 1% in the first principal component. As such we only explored the first two components.

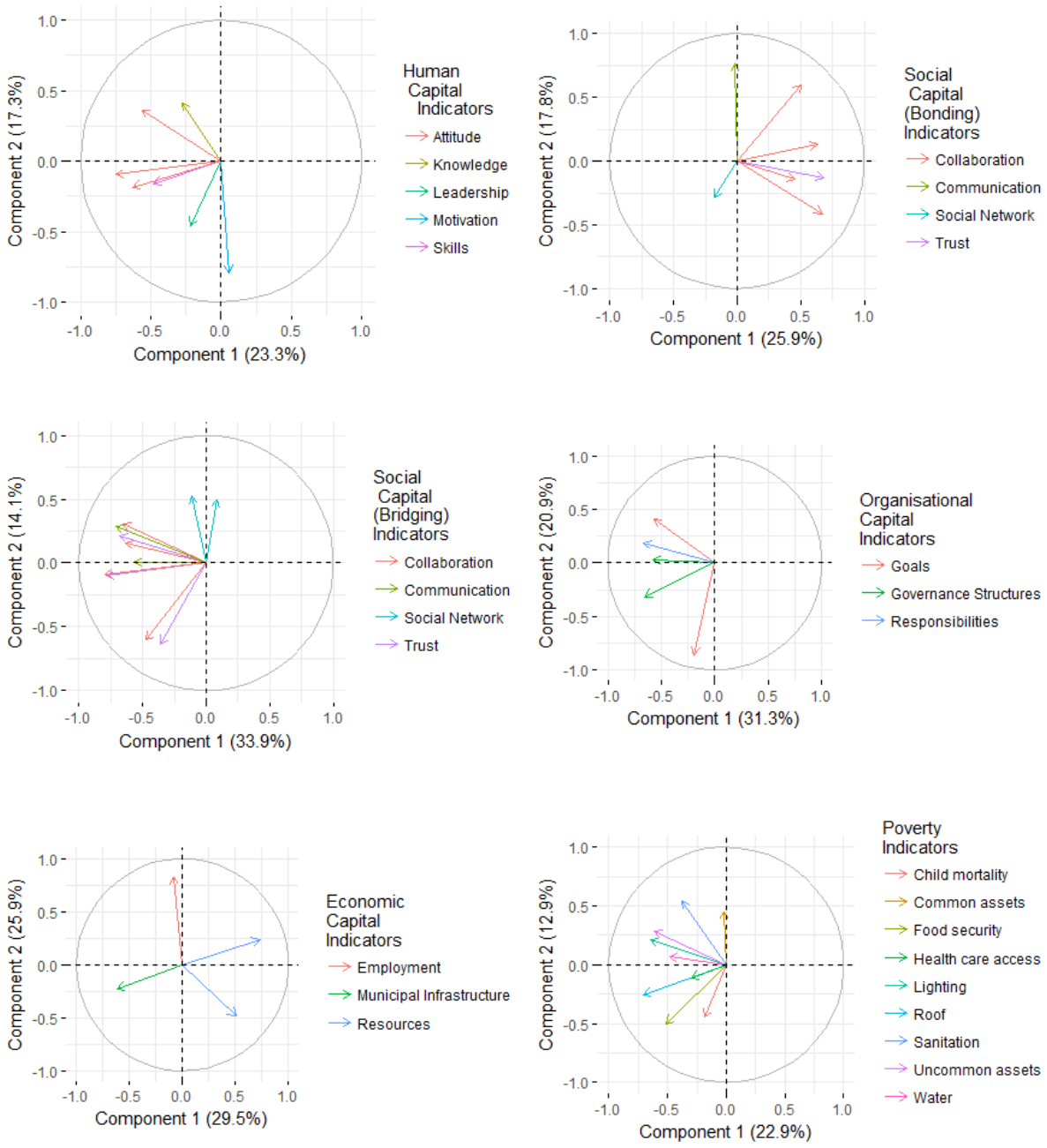


Figure 3.4 Loadings for each variable within the capacity assets for the first two principal components. Indicators are presented by arrow colour. See Appendix 3.1 for categorisation of indicators.

3.3.4 Extraction of household loadings to the principal components of foundational assets

For each capital asset we extracted each housholds' scores for the first two principal components as these were indicated as most important by the scree plot of eigen values for each asset. This was opposed to summing up their scores for each variable, to determine the strength of their individual capital assets. These capital components were included into a final summary PCA to more clearly show the multidimensionality of capacity (Figure 3.5). These show dimensions of each capital more clearly clustering, though dimensions of poverty do not follow this pattern. Both components for human and bridging social capital are correlated and poverty (component 1) fails to correlate with the majority of foundational asset components. We further explore these relationships through linear models.

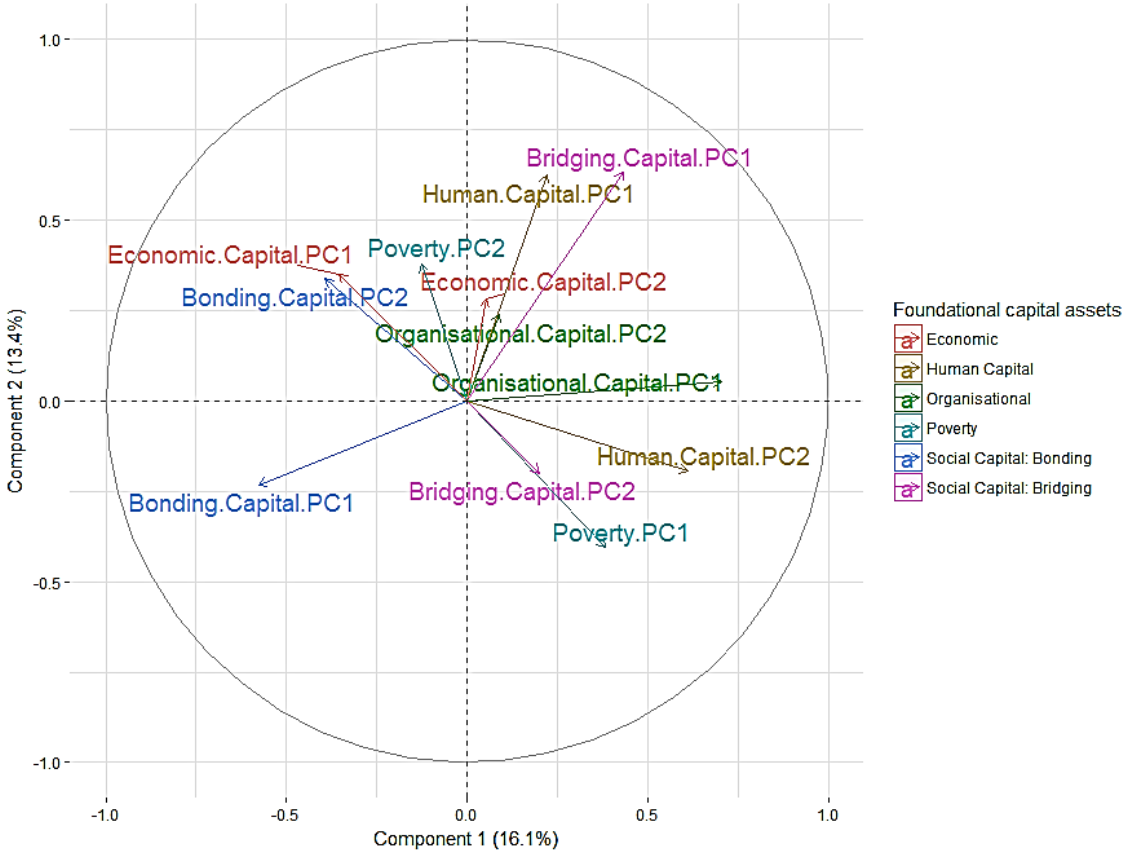


Figure 3.5. We extracted each household's first 2 primary loadings for each capacity asset and plot to show correlations for the first two principal loadings. This figure shows each capital more clearly clustering, though dimensions of poverty does not follow this pattern.

3.3.5 Interactions of poverty with foundational capital assets

We wanted understand the relationship between poverty and the composite scores of each foundational asset. These scores were derived from the first 2 principal component loadings for each household for each capital (see Table 3.3). Households with high levels of poverty (as measured by PC1) are less likely to have high economic capital as measured by PC1 (this relates to municipal infrastructure, financial resources and employment opportunities). They are more likely to have higher organisational capital in the form of setting goals, taking responsibilities and compliance with governance structures. Further investigation of the second component of poverty (PC2) showed that households headed by younger individuals were more likely to be poorer, however there was no significant interaction of gender or household size.

Table 3.3 Interactions of the first 2 principal components of poverty with foundational capital components and socio-demographic variables.

Variables	**Poverty PC1 Linear model estimate (S.E)**	**Poverty PC2 Linear model estimate (S.E)**
Intercept	1.013 (0.535).	1.126 (0.482)*
Human Capital (PC 1)	-0.310 (0.166).	0.140 (0.149)
Human Capital (PC 2)	0.347 (0.208).	-0.027 (0.187)
Economic capital (PC 1)	-1.003 (0.383)**	0.533 (0.345)
Economic capital (PC 2)	-0.327 (0.333)	0.069 (0.299)
Bridging social capital (PC 1)	-0.066 (0.130)	0.060 (0.117)
Bridging social capital (PC 2)	-0.062 (0.181)	-0.015 (0.164)
Bonding social capital (PC 1)	0.026 (0.133)	0.183 (0.119)
Bonding social capital (PC 2)	0.044 (0.154)	-0.005 (0.138)
Organisational capital (PC 1)	0.476 (0.186)*	0.015 (0.168)
Organisational capital (PC 2)	-0.099 (0.148)	0.379 (0.133)**
Male headed households	0.130 (0.302)	0.069(0.271)
Age	-0.005 (0.010)	-0.018 (0.009)*
Household size	-0.113 (0.070)	-0.052 (0.063)
Number of children	-0.062 (0.102)	-0.032 (0.092)
Adjusted R^2	0.111	0.053
Observations	197	197
Note: *** 1% significance level, ** 5% significance level, *10% significance level with two-tailed tests.		

3.3.6 Interactions of human capital with other dimensions of community capacity

Capacity building activities often focus on building on human capital. We wanted to understand how human capital interacts with the other foundational capital assets required for successful community conservation activities. Human capital is significantly correlated with bridging social capital (see Table 3.4) as was shown in Figure 3.5. This could be due to the fact that environmental education and skills may be associated with higher degrees of trust and collaboration between a household and NGOs (often providing such training). The second dimension of human capital was significantly correlated with organisational capital dimensions, and again interaction with NGOs and other communities may correlate with increased governance of environmental resources. The relationships however remain weak as within these communities there had been little training provision prior to the implementation of the questionnaire.

Table 3.4. The interaction of the first two dimensions of household's human capital with other foundational capital assets.

Variables	**Human Capital PC1 Linear model estimate (S.E)**	**Human Capital PC2 Linear model estimate (S.E)**
Intercept	0.016 (0.055)	0.0118 (0.045)
Poverty (PC 1)	-0.050 (0.032)	0.034 (0.026)
Poverty (PC 2)	0.035 (0.036)	-0.002 (0.029)
Economic capital (PC 1)	-0.002 (0.170)	-0.108 (138)
Economic capital (PC 2)	-0.112 (0.144)	-0.146 (0.117)
Bridging social capital (PC 1)	0.271 (0.052)***	-0.002 (0.042)
Bridging social capital (PC 2)	-0.229 (0.077)**	-0.022 (0.063)
Bonding social capital (PC 1)	-0.037 (0.0582)	-0.025 (0.047)
Bonding social capital (PC 2)	0.035 (0.064)	-0.241 (0.052)
Organisational capital (PC 1)	0.079 (0.080)	0.213 (0.065)**
Organisational capital (PC 2)	-0.122 (0.064).	0.135 (0.052)*
Adjusted R^2	0.192	0.187
Observations	198	198
Note: *** 1% significance level, ** 5% significance level, *10% significance level with two-tailed tests.		

3.4 Discussion

3.4.1 The need for indicators of capacity for devolved management of natural resources

There is pressure from funders for conservation projects to deliver on at least some aspects of community-based conservation (Calfucura, 2018). These projects place demands on the stakeholders capacity to undertake such activities (Pretty and Ward, 2001). Some community-based programmes such as co-management or participatory management projects devolve some level of authority over the natural resources to the control of the local community. Some evidence suggests increased conservation success when some level of control over natural resources was given to local communities (W. M. Adams and Hulme, 2001; Waylen *et al.*, 2010). It is widely recognised that devolved authority requires the building of community capacity to undertake co-management of natural resources (Chaskin, 2001; Wells *et al.*, 2004; Cavaye, 2008; Mizrahi, 2009). Yet there remains limited empirical evidence to suggest the relative effectiveness of such community-based interventions (Nilsson *et al.*, 2016). We set out to use a conceptual framework of community capacity developed by Beckley *et al.* (2008) to establish a set of indicators to enable the measurement of a communities capacity to undertake co-management within a conservation project in Madagascar. Indicators within each capital, focused on key capacity building activities and measurable outcomes of the project. This means that the indicators selected were relatively site specific, though the methods used to develop the indices are applicable to other community-based conservation projects aiming to create an evidence base for capacity building activities.

3.4.3 Capacity building must focus on multiple capitals

The focus of capacity building activities within conservation projects is often directed at improving human capital in the form of environmental education (Vaughan *et al.*, 2003; Trewhella *et al.*, 2005). Our results indicated that while higher scores in human capital were associated with bridging social capital, it did not strongly correlate with any other the other capitals (including bonding social capital). This implies that we need a holistic approach to capacity building activities which strengthen each element of a community's capacity to undertake community conservation. Involvement in a conservation project places multiple demands on many aspects of a communities capital assets. For example many community-based conservation projects require collaboration between different stakeholders and social capital is the "norms and networks that facilitate collective action" (Woolcock, 2001).

3.4.2 Each capital should be considered as multidimensional

We found that capacity, as defined by the foundational capital assets of human, social, organisational and economic capitals is multidimensional. This is contrary to other research that typically uses a single indicator to measure capital assets (Cinner *et al.*, 2015). Within each foundational capital asset we showed that the use of a single indicator for each capital may not be sufficient in exploring and measuring community capacity. For example membership to a community group did not highly correlate with other indicators of "social capital". A single indicator solution for human capital was also not appropriate. For example educational attainment did not correlate highly with other indicators of human capital. While using single indicator solutions may be cheaper and easier to roll out in terms of surveys these may not represent all dimensions of a community's capacity. We also identified some elements of the household questionnaire that were highly correlated and therefore could be dropped from the analysis using a careful process. Respondent burden is an important consideration of household surveys and identifying elements to minimise response-time can be used to better deliver more efficient household surveys in the future (Porter, 2004), while still capturing the multidimensionality of a communities capacity.

3.4.4 Capacity building activities cannot work in isolation

We have shown that capacity building activities cannot work in isolation of poverty reduction as poverty is negatively associated with multiple capital capacity assets. Our analysis indicted that households with higher degrees of poverty, as measured by our multidimensional poverty indicator, were significantly less likely to have economic capital in the form of municipal infrastructure, financial resources and employment opportunities. Capacity building might therefore also be a component of holistic approaches to poverty reduction (Sen, 1999; Agrawal and Redford, 2009; Brooks, 2017). As Beckley *et al*. (2008) noted, the foundational capital assets require both catalysts and relations to set the right socio-political environment and support to enable efficient and coordinated action within a community (Balint, 2006; Donoghue and Sturtevant, 2007; Beckley *et al.*, 2008). It was beyond the scope of this study to measure these dimensions and outcomes. This study therefore represents a first step in evaluating capacity building activities, and future studies should combine outcome monitoring as well as collecting baseline data on the strength of the foundational capacity assets. Future studies could include monitoring and the collection of qualitative data to measure catalysts and relations as well as defining measurable outcomes for capacity building activities in terms of conservation out-puts.

3.4.5 Final conclusions

Social sciences are now used to the concept of multidimensional aspects of poverty to reflect that poverty cannot be measured by a single indicator such as household income (Bibi, 2005; Alkire and Santos, 2010). We have shown that the building blocks required for successful community conservation programmes are also multidimensional and each capital asset needs to be measured using multiple indicators. Despite the challenges of measuring and handling multiple indicators, we argue that it is necessary for allowing meaningful evaluation of the effectiveness of capacity building investments and an understanding of what assets need to be strengthened to enable more autonomy in community-based conservation projects, and the successful management of natural resources.

4. Measuring the impact of capacity building for community based conservation using a Before-After-Control-Impact design

Abstract

Impact evaluation is essential to ensure informed decision making and efficient use of limited resources in the conservation sector. However, studies have been slow to adopt the rigorous methods required for empirical evidence of what does and doesn't work in conservation. We used a before-after-control-impact (BACI) approach to analyse the effect of capacity building activities in a community-based conservation project in Northern Madagascar. We used an asset-based approach to define community capacity as being built of human, social (both bridging and bonding), economic and organisational capitals. We measured these foundational capitals using a combination of indicators through a household survey with 120 households across 9 treatment and 8 control communities in 2015 (before the intervention) and 2017 (after two years of a community-based conservation intervention). We explored the composite measures of each of the foundational capitals, which comprised of scores for multiple indicators derived through PCA analysis. We did not find a significant effect of the intervention on our composite measures of each capital (though human and both bridging and bonding social capital showed positive improvements). We then explored selected individual indicators within social capital (both bonding and bridging) where we anticipated the capacity building activities would have the greatest impact over the short timescale studied. We found that there were significant effects of the intervention positively enhancing external social networks; this may suggest improved ability for communities to engage with other external projects such as development projects. Finally, we explored the extent to which the capacity building programme suffered from elite capture. We analysed individual indicators that we hypothesised would be most at risk to elite capture; those under human, organisational and economic capitals. We found that there were significant effects of the intervention recruiting more leaders of local groups as members of local environment groups. We found some evidence that the capacity of richer individuals (particularly with respect to human capital) was increased more significantly than that of others. Following a BACI design and careful indicator selection provides unusually robust evidence about the impact of an intervention on outcomes of interest. These results imply that relatively short-term capacity building programmes may not have a measurable impact on capacity across a wide community but may have specific impacts on

certain targeted elements. This data can inform the design of improved capacity-building activities in future.

4.1 Introduction

There is a growing awareness of the importance of impact evaluations for conservation to ensure that lessons can be learnt from what works and what doesn't work in terms of delivering conservation goals (Sutherland *et al.*, 2004; Ferraro and Pattanayak, 2006; Margoluis *et al.*, 2009; Fisher *et al.*, 2014). However, despite reocognition of the need for empirical evidence, conservation science has been slow to adopt the robust methods of impact evalution which allow for the credible constructions of a counterfactual scenario (Baylis *et al.*, 2016). For example, in a major review of the evidence of the effectiveness of Community Forest Management at delivering environmental and welfare outcomes, Bowler and colleagues (2012) found that the vast majority of studies lacked the methodological quality to allow conclusions to be drawn. Low adoption rates of robust methods may be due to limited resources and short project lifespans which pose challenges to constructing robust evaluations (Ferraro and Pattanayak, 2006; Margoluis *et al.*, 2009). However there are multiple challenges to robust impact evaluation in conservation: many conservation interventions are interested in their impacts on multiple outcomes some of which lack clear indicators; random allocation to an intervention is seldom possible, outcomes may spill over to areas not exposed to an intervention and there are many potentially confounding factors (Baylis *et al.*, 2016).

The Before-After-Control-Impact (BACI) approach involves data collection at both control and intervention sites, both before and after the project, to allow comparisons of outcomes (Smith, 2013). Control sites are selected to be as similar as possible to intervention sites, and difference-in-difference analysis controls for both observable and unobservable differences in characteristics, assuming these don't change over time (Wooldridge, 2001). A fundamental assumption is that the trend in outcomes of interest for the control group is the same as the expected trend for the intervention group in the absence of the intervention (Clements and Milner-Gulland, 2015). In the absence of a true BACI design, studies wanting to conduct the most robust impact evaluation possible will retrospectively match control sites to intervention sites using a quasi-experimental approach; but lack of data of baseline conditions is a common problem (Macura et al. 2015; Clements & Milner-Gulland 2015; Rasolofoson *et al.* 2017). While a BACI design cannot overcome all challenges in impact evaluation; it is often seen at the best option when treatment sites cannot be chosen at random (a full randomised control trial; Conner *et al.*, 2015).

To halt rapidly declining biodiversity in low income countries, there has been a push towards community-based conservation initiatives from multilateral, national, regional and local stakeholders (Calfucura, 2018). Community-based conservation involves a broad suite of approaches but the underlying principal is that local communities are involved in conservation decisions; this may or may not involve the devolution of management responsibility over natural resources (Adams and Hulme, 2001; Nilsson *et al.*, 2016). A number of authors have highlighted the importance of a community's capacity to engage in and manage activities to ensure the long-term and sustainable use of natural resources (Balint and Mashinya, 2006; Lammers *et al.*, 2017).

Community capacity is the collective ability of a community to combine various forms of capital (human, social, economic, organisational and natural) to produce desired outcomes (see Chapter 3: Table 3.1, Chaskin 2001; Beckley *et al.* 2008; Mountjoy *et al*. 2013). These capital assets are the foundations of community capacity (hereafter foundational capital assets) and can be strengthened over time, given the right support (Balint, 2006; Donoghue and Sturtevant, 2007; Beckley *et al.*, 2008). Community-conservation projects sometimes actively seek to build community capacity (Chaskin, 2001; Wells *et al.*, 2004; Cavaye, 2008; Mizrahi, 2009; O'Connell *et al.*, 2017) by focusing on building community empowerment, promoting equal benefit distribution and developing the community's social network (Brooks, Waylen and Mulder, 2013; Calfucura, 2018).

Despite significant investment in capacity building initiatives at multiple scales (Mizrahi, 2009), there is limited quantitative evidence of the efficiency and effectiveness of such initiatives (Goodman *et al.*, 1998; Chaskin, 2001; Donoghue and Sturtevant, 2007; Cavaye, 2008; Whittle, Colgan and Rafferty, 2012). Conservation projects have been shown to occasionally exacerbate social differences, with wealthier, more powerful members of a community accruing more benefits through elite capture (Holmes and Cavanagh, 2016) while costs may disproportionately fall on marginalized community members (Platteau, 2004; Persha and Andersson, 2014; Poudyal *et al.*, 2018). Elite capture has been shown to affect mostly economic and human capital, with key individuals securing more training or project resources (Poudyal *et al.*, 2016; Bidaud *et al.*, 2017).

Madagascar receives significant investment for conservation and development activities but questions have been raised about the effectiveness of this investment (Waeber *et al.*, 2016).

Over the past two decades there has been a rapid spread in the use of community-based approaches for biodiversity conservation (Raik and Decker, 2007; Rasolofoson *et al.*, 2015). We use a BACI design to evaluate the impact of an intervention to build community capacity at a site without previous conservation involvement in Northern Madagascar over two years. The site has been identified as a suitable wetland habitat for the reintroduction of a Critically Endangered duck, the Madagascar pochard, *A. innotata,* previously thought to be extinct. The focus of capacity building within this wetland conservation project aims to build social capital through the establishment of local environment groups and collaboration with NGOs and government. These represent elements of social capital including bonding (internal community relationships) and bridging (external community relationships). There have also been educational and training programmes aiming to develop the human, organisational and economic capitals within the intervention site (see Chapter 3, section 3.1 for a full description of each capital assets).

Baseline data collection via a household survey on a wide range of indicators of the foundational capital assets was collected in 2015 in 9 intervention communities and 8 control communities, and end line data collection in all communities in 2017. We explore the extent to which capacity building activities have a measurable impact on community capacity as measured by composite foundational capitals and specific indicators (refined and reduced according to the process described in Chapter 3). We hypothesised that the capacity building activities within the project mainly focused on social capital activities (both bridging and bonding) therefore we took a deeper look at its impact on individual indicators within those capitals. We also explore the extent to which elite capture may have occurred: we hypothesized that those identified as leaders of local groups were more likely to benefit from capacity building activities and that a higher poverty score would act as a barrier to the development of capacity. We believe this is the first attempt at rigorously evaluating the impact of the effectiveness of community capacity building activities using a BACI design.

4.2 Methods

4.2.1 Study Context

This study explores community capacity in nine intervention communities and eight control communities surrounding two lakes (Sofia and Antafiandakana) in Northern Madagascar, Bealanana district (see section 1.7 for a description of the study sites and an overview of the project). We selected Lac Antafiandakana, using the short-list of suitable lakes for the reintroduction of *A. innotata*, as a control catchment hosting a similar number of fokontany and a similar sized lake. Community capacity building activities took place in the 9 fokontany around Lac Sofia (the intervention site) between 2015 and 2017 (Young *et al.*, 2014). These included: training on livestock and agricultural techniques (including teaching how to reduce pesticide load in rice fields); environmental education activities (highlighting human impacts on the environment); and support to develop local natural resource management committees (see Table 4.1 for full details). These natural resource management committees (known locally as Vondrona Olona Ifotony or VOI) are established to enable local governance of natural resources through a management transfer agreement from the state under the GELOSE law (1996), a legal framework for community-based natural resource management in Madagascar (Rasamoelina *et al.*, 2015).

We selected Lac Antafiandakana, a neighbouring lake and its surrounding communities also in the Bealanana district, as a control site. This was selected as the matched control site due to it being on an initial shortlist of potential release site of the pochard, containing a similar sized lake and number of communities with similar socio-economic characteristics (Woolaver *et al.*, 2015; see Table 4.2 for a summary of both sites).

Table 4.1. The actions within the community-based conservation project completed during 2015-2016 organised by foundational capitals, showing the indicators we selected for each capital. Further analysis of individual indicators was conducted analysing the PCA results from Chapter 3.

Capital	**Capacity building actions***	**Composite indicators within capital**	**Key indicators analysed**		**Hypothesised impact by elite capture**
Human	Training on biodiversity monitoring Livestock vaccination training Livestock husbandry techniques training Training on natural pesticide use Sustainable farming techniques Teacher training Environmental education	Attitudes Knowledge Leadership Motivation Skills		Agricultural training (skills)	Yes
Social (Bridging & Bonding)	Creation of supportive parent groups Community meetings with fisher groups and environment groups Training on how to work with government Meetings with fisher groups Meeting with local environment groups	Collaboration Communication Social Networks Trust	Bridging	Social networks for environmental help (external agents) Trust with NGOS	No
			Bonding	Social networks for environmental help (within community) Trust within community	
Economic	Provide equipment to fishing groups Provision of new farming equipment Building primary schools Building fishing platform	Employment Infrastructure Resources		Resources for environmental work	Yes
Organisational	Formally establish local environment group (VOI) Teaching on how to vote, take minutes collect membership money & fines Set up local fishing group Decide and define no take zone	Goals Governance structure Responsibilities		Membership of group governing environmental resources	Yes

*Sources: Young et al. 2014; Woolaver et al. 2015; Pers comms Felix Razafindrajao

Table 4.2. Summary details of the control and intervention sites.

Site details	Intervention	Control
Lake	Sofia	Antafiandakana
Total area of lake	2.3km^2	3.4 km^2
Extent of Marshland	3.5km^2	17km^2 (fragmented)
Number of fokontany directly surrounding lake	9	8
Conservation status	Established as RAMSAR site in 2017 (site number 2301).	None

4.2.2 Questionnaire design

This study uses a household questionnaire that targets key indicators within each of human, social, economic and organisational capitals. The method for the questionnaire design is detailed in section 3.2.2 in the previous chapter. The survey was conducted by Danielysa Razafindramavo and two local field assistants during July and August 2015 (prior to interventions). The survey was repeated again during the same months in 2017 by Luna Angele and the same field assistants. All were native speakers of Tsimihety and local to the region. Amy Lewis attended interviews every day during both sampling years, rotating around the interviewer teams.

4.2.3 Sampling strategy

See section 3.2.1 in the previous chapter for a description of the baseline sampling methodology conducted in 2015. We selected the control site (Lac Antafiandakana) using the short-list of suitable lakes, At the end of the baseline survey, households were asked if they would like to participate in further studies and GPS coordinates were collected to enable the relocation of the household. Households were given a unique identifying number to allow merging of datasets. Households were re-contacted after a two year period (the end-line survey in 2017) if they had indicated they were happy to participate in future studies. If households were not happy to be interviewed for the second time, or a reasonable appointment could not be made, these households were excluded from the BACI analysis.

4.2.4 Ethics and data management

The research was scrutinised and cleared under the Bangor University Research Ethics framework. All respondents were over the age of 18 and were told that the research was about how households, communities and organisations work together to solve collective problems to deliver local community and environmental benefits. We explained that the results may be published, but their names would not. All data was saved on a password protected computer. An oral consent script was read out (see Appendix 4.2) and respondents were told that they could stop the interview at any time without having to give a reason. Interviews lasted between 30 minutes and 1 hour. Interviews were conducted in the respondent's household or field, whichever the respondent was more comfortable with. GPS coordinates were taken at the household to enable geographic characteristics of the household to be collected.

4.2.5 Data Analysis

We used a two-sample Kolmogorov-Smirnov test to analyse differences in socio demographic characteristics between the control and intervention site for the 2015 data. We used a Linear mixed effects (LME) modelling approach (lme4 package; Bates et al. 2015) to calculate difference-in-difference over time for both individual indicators and for composite measures of foundational capital assets between sites. The variable for intervention was a dummy variable (where households were given 1 if living within the intervention site) and fokontany was included as a random effect. We also included number of children, household size, age and sex of household head to account for other socio-demographic effects. Final models were selected step-wise based on the AIC value where terms were removes with AIC >2 (MuMIn package; Kamil *et al.* 2014). We explore the capacity building impact on three measures: (i) composite measures of capitals; (ii) key individual indicators; as well as the (iii) impact of elite capture.

i) Analysing impact on composite measures of foundational capitals

Firstly, we analysed the difference in differences between the control and intervention sites based on the foundational capital assets. Data from the 2015 household surveys (n=198) were analysed using principal component analysis (PCA) to finalise the variables to be included in the analysis for each foundational capital (see Chapter 3). Using the PCAs estimated for the 2015 data, scores for the 2017 data were calculated. Imputation of missing values, coding, component extraction and nomenclature was as described in Chapter 3, a full description of codes, transformations and relevant literature for each variable can be found in Appendix 3.1.

Household scores were extracted for the first two principal components for each foundational capital for both data sets. In order to estimate the difference-in-differences for each household, the difference between the 2017 PCA score and the 2015 PCA score was calculated to capture both magnitude and direction of change over time.

ii) Analysing impact on individual indicators

We hypothesised that the capacity building activities within the project mainly focused on social capital activities (both bridging and bonding) therefore we took a deeper look at its impact on individual indicators within those capitals (see Table 4.1). These individual indicators were hypothesised to be most affected by capacity building activities over the 2-year period, and also represented key directions within the PCA of each capital asset. These activities included positive changes in social networks in sourcing help for an environmental problem and improved trust with external agents such as NGOs. Within bonding social capital this included two items; (i) social networks for environmental help (within community); and (ii) trust within own community. Bridging social capital also included two items (i) social networks for environmental help (with external agents); and (ii) trust with NGOs. These reflect the project's focus on establishing and supporting local environment and other community groups and the potential impact of the presence of several NGOs in the intervention site over the two year period. We used the LME model to detect the difference-in-differences between the sites over time on these indicators as a result of the capacity building activities carried out by the project (the activities are also described in Table 4.1).

iii) Analysing the impact of elite capture & poverty

We also explore the extent to which elite capture may be detected by investigating both composite measures and individual indicators of human, organisational and economic capitals. Composite measures of these capitals are described above. Individual indicators were selected as key indicators potentially affected by capacity building activities as well as representing directions within the PCA of each composite measure. Indicators selected for human, economic and organisational capitals were respectively; access to agricultural training; resources for environmental work; membership to groups governing environmental resources (see Table 4.1). Elite capture was tested by using a dummy variable for "leader" within the LME model 1 indicates a household head was a leader). This was directly asked to household heads if they were a leader within their community, this was clarified by asking what group or organisation

they led. Deputies were not classed as leaders. The effect of poverty was tested using the poverty score from the 2015 household survey (the 1st axis of the Principal Component; see Chapter 3) as a continuous variable.

4.3 Results

4.3.1 Descriptive statistics.

Of the 198 individuals participating in the 2015 survey, 120 individuals completed the follow up survey in 2017. Those who did not complete both surveys were excluded from this analysis. The sample showed a broad range of household head age, size, and number of children while the large majority of household heads were male in both the control and intervention site (Figure 4.1). The results show no significant difference (K.S. test showed $P>0.05$ in all cases) in the control and intervention site for any of the socio-demographic characteristics; age and gender of household head, number of dependents and the 1st axis of the poverty PCA (see Chapter 3 for a description of the principal component analysis).

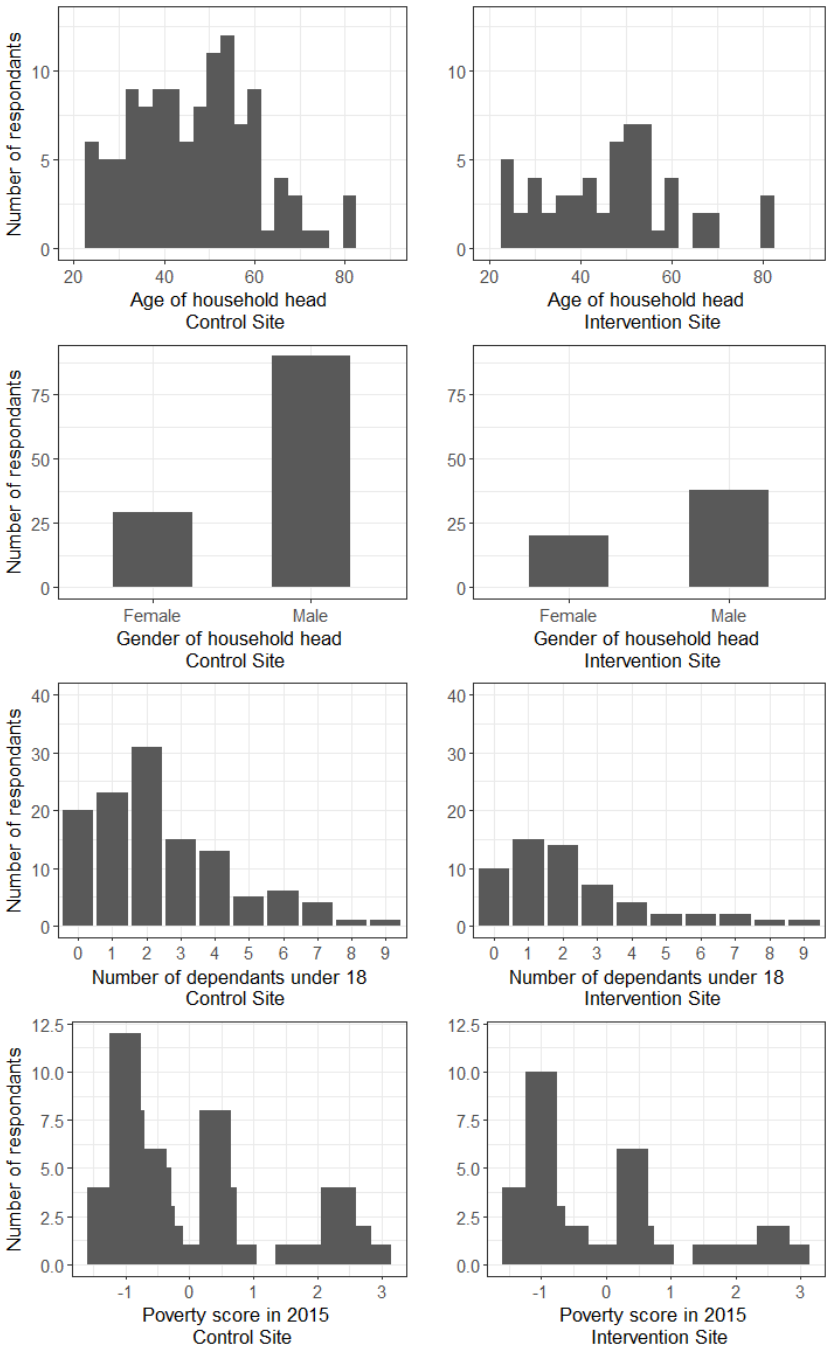


Figure 4.1 Descriptive statistics of the households completing both surveys in 2015 and 2017 (n=120), showing socio-demographic characteristics and dimensions of poverty in 2015.

4.3.2 Impact of the capacity building activities on composite measures of capitals

The LME model results show no significant difference in differences between the control and intervention site over the 2 year period as measured by the composite foundational capital scores using multiple indicators (see Table 4.3 & Figure 4.2; see Appendix 4.3, Table B for the results for the second component score). There was a slightly positive but non-significant effect

of intervention site on both human capital (P=0.146) and bonding social capital (P=0.219). Intervention site was dropped during model selection for organisational capital. This implies that there was no significant observed effect of capacity building activities on the combined measures of human, social, economic or organisational capitals as measured by multiple indicators. The lack of observed difference may be due to the spread of indicators within each of the composite measures of each capital (see Figure 3.4 in Chapter 3). We included several socio-demographic variables within the LME model (see Table 4.3) however we found no significant effects of age, sex of household heads or household size, however number of dependants was significantly correlated with higher organisational capital.

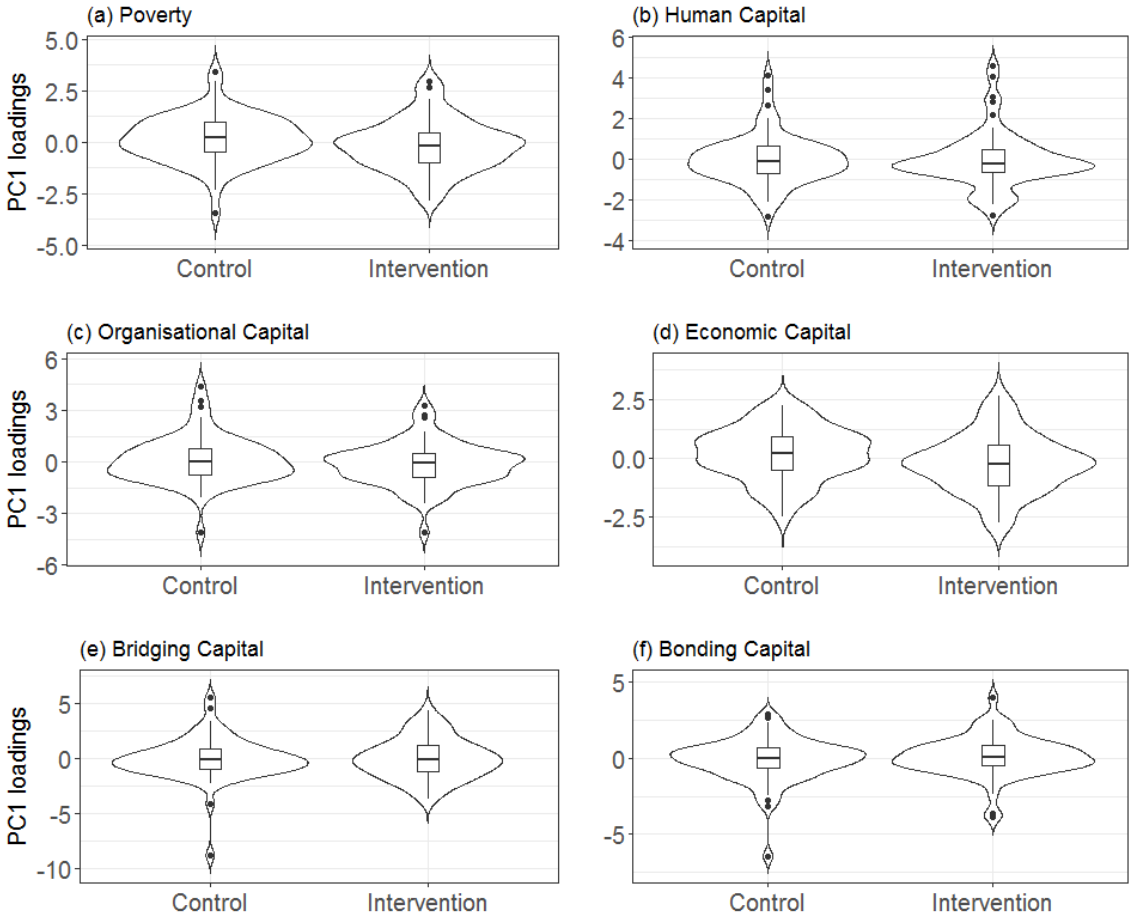


Figure 4.2 Violin plots for the differences in the multidimensional poverty score and each composite foundational capital asset score over time. Control and intervention sights are plotted for each model and the violin plots show median, upper and lower quartiles and the centred density of the household scores for the first principal component.

Table 4.3 Linear mixed effects model results for the difference in difference for foundational capitals over time based on the difference in the first principal component score between 2015 and 2017. Standard errors are shown in parentheses. A blank for a coefficient means that the variable was excluded from the model (which was determined by the AIC).

	Human	**Social**		**Organisational**	**Economic**
		Bonding	Bridging		
Intercept	0.332 (0.456)	-0.234 (0.220)	-0.838 (0.852)	0.068 (0.682)	0.202 (0.218)
Intervention site	0.466 (0.304)	0.476 (0.314)	-0.106 (0.611)		-0.411 (0.311)
Leader					
Poverty in 2015	-0.532 (0.121)***	-0.356 (0.128) ***			
Number of children				0.214 (0.100)**	
Male headed household	-0.452 (0.354)		0.718 (0.644)	-0.473 (0.465)	
Number of observations	120	120	120	120	120
AIC	469.23	481.550	606.744	539.321	476.853
Log likelihood	-228.610	-235.775	-298.372	-262.661	-234.426
Note: *** 1% significance level, ** 5% significance level, *10% significance level with two-tailed tests.					

4.3.3 Impact of the capacity building activities on individual indicators

The focus of many of the capacity building activities within the community-based project focused on social capital (see Table 4.1). We hypothesised that four specific indicators of social capital were more likely to be affected by the CBC activities; trust and social networks for both bridging and bonding social capitals. The difference in differences between the control and intervention site for the four key indicators of social capital shows both positive and negative impacts of the conservation project within the LME model (see Table 4.4 and Figure 4.3).

The social network indicator was found to have a significantly positive change in the intervention site in reference to external agents, a form of bridging social capital (see Table 4.4, Figure 4.3). This suggests that the project has increased the likelihood that people will turn to an NGO to solve a local environmental problem. However, there was no significant effect of the intervention site improving the connections between the resident communities when faced with an environmental problem (a bonding social capital indicator). Interestingly there was no detectable impact of the intervention on trust towards NGOs.

Table 4.4 Linear mixed effects model results for the difference in difference for specific variables based on expected changes between 2015 and 2017. Standard errors are shown in parentheses. A blank for a coefficient means that the variable was excluded from the model (which was determined by the AIC). The model shows no effect of the intervention on individual indicators except for bridging social networks with external agents.

	Bonding social capital		*Bridging social capital*	
Specific indicator	Bonding social networks for environmental help (within community)	Trust own community	Bridging social networks for environmental help (external agents)	Trust NGO
Intercept	-0.480 (0.373)	-2.206 (1.696)	0.504 (0.399)	-0.876 (2.342)
Intervention site			0.675 (0.270)**	-0.743 (1.521)
Leader		-1.831 (1.316)		
Male headed household	0.295 (0.301)	2.255 (1.486)	-0.599 (0.361)	1.476 (2.130)
Poverty in 2015		1.406 (0.698)		
Number of observations	120	120	120	120
AIC	36.491	87.374	41.227	101.908
Log likelihood	-14.246	-37.687	-15.614	-45.954
Note: *** 1% significance level, ** 5% significance level, *10% significance level with two-tailed tests.				

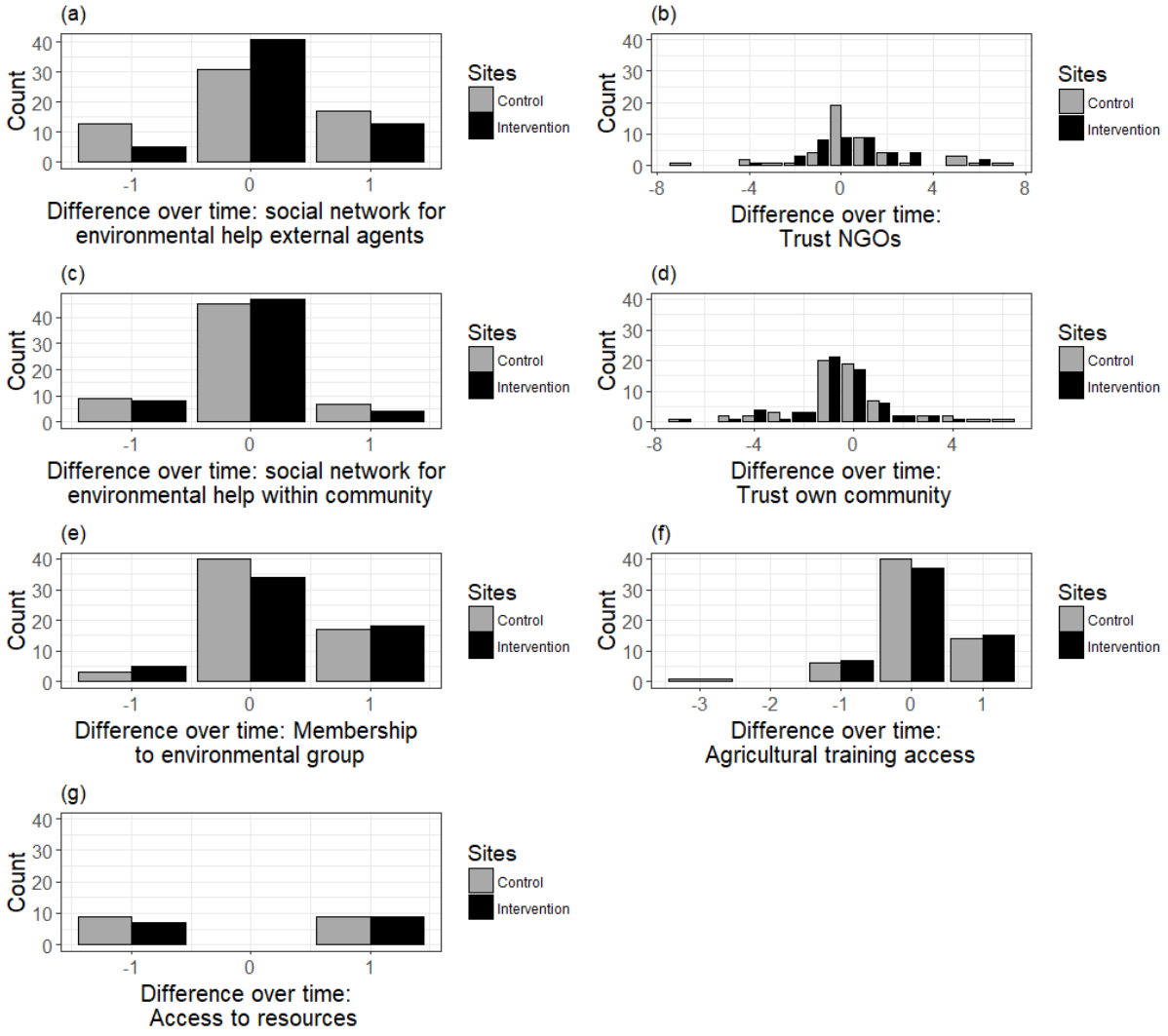


Figure 4.7. Difference over time for key indicators based on capacity building activities for a community conservation intervention site compared to a control site. Figures 4.7 a-d represent individual indicators for social capital (both bonding and bridging) predicted to show the greatest change over time due to the CBC activities. Within bridging social capital we analysed individual indicators for: social networks with external agents (4.7a) and trust with NGOs (4.7b). Within bonding social capital the indicators were the same: social networks within own community (4.7c) and trust within own community (4.7d). Figures e-g are individual indicators predicted to be at risk of elite capture: membership to environmental groups (4.7e); access to training (4.7f); and access to resources (4.7g).

4.3.4 Impact of elite capture on composite measures of capitals

We found no significant effect of leadership as an explanatory variable and was dropped from all models (see Table 4.3). Random selection of households meant that only n=25 leaders were included in the analysis, which may have been too small to detect a change within the composite score of foundational capital assets. We further explored the effect of poverty through the poverty score for each household from 2015 as an interacted variable. This showed that poorer individuals (across both the control and intervention site) were significantly less likely to show increased in both human and bonding capitals ($P<0.01$) suggesting there is some element of elite capture in who benefits from the capacity building activities.

4.3.5 Impact of the elite capture on specific indicators

We detected a significant impact of the intervention site in recruiting more members to local environment groups suggesting that the intervention resulted in increased membership of such groups (unsurprising as creating of such groups was one of the activities of the conservation project). Local leaders were more likely to join environmental groups over the two year period suggesting some element of elite capture by this measure (see Table 4.5). AIC model selection did not support the inclusion of the 2015 poverty score in any of the models suggesting poverty was not a barrier to becoming a member of an environmental group, accessing training or resources.

Table 4.5: Mixed effects model results for the differences in specific variables based on expected changes between 2015 and 2017. Standard errors are shown in parentheses.

	Membership of environmental group	Agricultural training	Access to resources
Intercept	0.575 (0.409)	0.249 (0.749)	0.100 (0.118)
Intervention site	0.633 (0.255)**		-0.3 (0.167)
Leader	1.029 (0.331)**		
Male headed household	-0.780 (0.409)	-0.301 (0.619)	
Poverty in 2015			
Number of observations	120	120	120
AIC	41.306	62.585	28.154
Log likelihood	-14.653	-27.292	-10.077
Note: ***1% significance level, **5% significance level, *10% significance level with two-tailed tests.			

4.4 Discussion

Community-based conservation initiatives have been used as a tool to halt rapidly declining biodiversity in low income countries (Calfucura, 2018). In order to have devolved management authority, there is often a call to build local capacity to ensure sustainable management of natural resources (Balint and Mashinya, 2006; Lammers *et al.*, 2017). There is growing interest in impact evaluations to assess the effectiveness of conservation initiatives (Sutherland *et al.*, 2004) yet clear definitions of capacity, and a structured approach to its measurement remains elusive. We used a framework of community capacity as being composed of human, social economic and organisational capitals (Beckley *et al.*, 2008) and designed a series of quantitative measures (both individual and composite) of these foundational assets to evaluate the impact of a conservation project over two years with a BACI design.

4.4.1 Did the intervention succeed in increasing community capacity in general?

When looking at foundational capital assets in terms of their composite scores we failed to find evidence of the effect of capacity building activities in the intervention communities. Initial analysis of the composite measures (in Chapter 3) highlighted the varying directions of indicators within each composite measure which may have prevented us detecting an overall significant effect. Given the small sample size and short timescale of the between our "before" and "after" measure of capacity, it is difficult to conclude much about the potential of the project to impact community capacity. It may simply be that insufficient time has elapsed for project activities to have had a measurable impact. It is interesting that bridging, organisational and economic capitals did not show a positive change over time, implying that capacity building activities targeting these capitals were not as strong and sustained as those targeting both human capital, and bonding social capitals (or these changes take longer to arise). An overreliance on building capacity within human capital may shadow equally important dimensions of capacity required for successful community based conservation projects, such as sufficient social capital to fall on in the face of problems and the organisational and managerial skills needed to both start and maintain the efficient running of a project.

4.4.2 Did the intervention succeed in increased social capital?

We found no significant effect of the intervention site on the composite measures of each of the foundational capitals, including bonding and bridging social capitals. We further investigated some of the key indicators predicted to have the most focus within the projects'

capacity building activities, which predominantly aimed to improve social capital. We found that the capacity building activities had a significant effect only on the social networks of bridging social capital i.e. a communities relationships with external agents. This implies that successful relationships were built, both between the NGOs working within the communities, but also between community groups. Efficient social networks are important to begin establishing trust and knowledge exchange between stakeholder groups (Woolcock and Narayan, 2000) and it is encouraging that sustained effort improving some aspects of social capital has provided measurable impact.

4.4.3 Is there evidence of elite capture in capacity building activities?

There is often significant investment in community based conservation projects but threats to effectiveness include elite capture which is considered to adversely affect conservation and development activities (Platteau, 2004; Persha and Andersson, 2014). This capture of training and resources combined with the inability of some of the poorest people to have a voice in the decision making processes means that community based natural resource projects often do not uphold the principals of social justice (Twyman, 2017). But there is little evidence as to how elite capture of training and capacity building activities may occur and there are calls for longitudinal studies of various forms of elite capture (Lund and Saito-Jensen, 2013).

We explored the impact of elite capture both on composite measures and key indicators. We found no evidence that those in leadership positions gained a greater amount of capacity over the 2 year period. This is likely due to the small number of leaders in our study which makes it difficult to draw conclusions. However we found that poorer households had significantly less human and social capital over time, regardless of whether they were in the intervention site or not. This implies that capacity building activities in the intervention site did not overcome the poverty barrier for the poorest individuals.

Bidaud *et al.* (2017) identified elite capture of training within a conservation project focusing on biodiversity offsets. Our analysis highlighted that leaders within the intervention site were more likely than the general community to be members of a group governing environmental resources. This would potentially give them more access to training, knowledge and resources in the long-term. However, we found no evidence that those in leadership positions had gained more agricultural training over the 2 year period implying that unlike Bidaud *et al* (2017) training had not been captured by those in elite positions. Understanding the role of elite capture and the multi-dimensions of poverty will improve outreach of community conservation

activities, and ensure that capacity building activities are fair, inclusive and accessible by all members of the community.

4.4.5 The benefit of a BACI design

BACI designs are in a small group of impact evaluation techniques that have the potential to robustly estimate a counterfactual (Margoluis *et al.*, 2009). Robust impact evaluation in conservation often faces a lack of clear indicators, difficulty in random allocation of control site, spill-over effects and accounting for confounding factors (Baylis *et al.*, 2016). Therefore BACI designs are inherently difficult, and are often a lengthy and costly process which makes it difficult to be taken up by conservation projects with limited funding (Baylis *et al.*, 2016).

By using Likert-based questions we were able to quantify difference in differences over time between the control and intervention communities using two surveys per household with the same individuals over a two year period. This study would have benefited from using more control sites to account for spill over effects as both lakes were in the same district (though multiple days walk apart from each other). Further replication would enable the determination of the longevity of capacity building effects over time as 2 years is relatively short. Despite this, we believe this is a first attempt at rigorously evaluating the impact of the effectiveness of community capacity building activities using a BACI design.

4.4.6 Conclusions

Having a clear definition of capacity and having quantifiable outputs can ensure that capacity building efforts are both focused and efficient in the face of limited conservation resources. In order to meet the growing demand for impact evaluations in conservation we need to produce empirical evidence derived through robust methods. We provide rigorous but tentative evidence that short-term capacity building programmes may not have a measurable impact on capacity across a wide community but may have specific impacts on certain targeted elements. We hope that this evidence can be used to inform the design of improved capacity building activities in the future as well as add to the evidence base of impact evaluations on community-based conservation projects.

5. Using an experimental game to explore stakeholder responses to wetland conservation interventions in Madagascar

Abstract

There is increasing interest in the extent to which social cooperation and information sharing can influence environmental behaviours and the extent to which external incentives (such as those provided through Payments for Ecosystem Services) can facilitate this and thus change behaviour. Using a case study of rice farmers in a catchment in Madagascar making decisions around pesticide use on fields surrounding a wetland of importance to conservation, we used an experimental game, to explore the impact of payments for habitat conservation, and facilitating communication between farmers on ecosystem service provision and coordination. The game allowed players (four play at a time) to make use decisions, such as planting crop (with differing levels of pesticide inputs) or providing ecosystem services though protecting habitat, on each of nine parcels of land. Each decision had consequences on the potential points scored both for themselves and their fellow players whose nine parcels are adjacent to theirs. A similar score could be achieved either through cooperative or non-cooperative land-use decisions but cooperative decisions resulted in better ecosystem outcomes. We found that incentives in the form of subsidies significantly increased co-operative behaviour and decreased non-cooperative behaviour. Facilitating communication did not significantly increase the provision of ecosystem services compared to the control, however it did increase the coordination of ecosystem service provision between players (wetland habitat was used to benefit both the player and their neighbours as opposed to just the player). Though game-playing simplifies real-life, we suggest that framed field experiments such as this can contribute to understanding the likely impact of interventions in advance, thus helping with decision making. However they also have real potential as a tool to facilitate communication between conservation projects and participating communities by promoting open and honest dialog about incentives and decision making.

5.1 Introduction

Wetlands support some of the world's poorest people who depend on them for fishing and agriculture and building materials (Rebelo, McCartney and Finlayson, 2010; Maltby and Acreman, 2011; Adekola, Mitchell and Grainger, 2015) and are also extremely important for biodiversity (Halls, 1997; Schuyt, 2005). Unfortunately the world's wetlands are being lost and degraded at an ever increasing rate (Davidson, 2014). Climate change and agricultural expansion (and intensification through the use of pesticides) are important drivers of this change (McCartney *et al.*, 2014; Langan *et al.*, 2018).

Synthetic pesticides are widely used to increase in crop yields through reducing in pests and diseases (Lobell, Cassman and Field, 2009). Accurate data on pesticide use at a national level in low income countries are rarely available but there is evidence that pesticide use is increasing, with over 10% of main season cultivators in sub-Saharan Africa using pesticides (Sheahan et al. 2017). However, despite improved production, some synthetic pesticides can have substantial negative externalities. The health impacts of pesticide use (felt by farmers and others using the environment) can be particularly high in low income countries where regulations may be weak, exacerbated by a lack of protective clothing and insufficient training on appropriate use (Wilson & Tisdell 2001; Wilson 2000). High pesticide use also has significant impact on ecosystem functioning, in particular affecting invertebrate abundance with consequences for nutrient cycling and decomposition of organic matter which has significant impacts for wetland conservation (Peters, Bundschuh and Schäfer, 2013; Chagnon *et al.*, 2015). Heavy and inappropriate use of pesticides can also harm populations of natural predators and lock farmers in a vicious cycle needing to use more and more pesticides (Wilson and Tisdell, 2001).

At the heart of the challenge to reduce landscape-level pesticide use is cooperation. Multiple farmers operate in a landscape where one farmer's strategy with respect to pesticide use has impact on the optimal strategy of others. In sub-Saharan Africa there has been a steady decrease in the land to person ratio since the 1960s (Jayne, Mather and Mghenyi, 2010). This implies there is a growing number of small-scale farmers operating within a given watershed in the region. These potential stakeholders are also subjected to multiple drivers that are increasing the uptake of pesticide which includes an increase in pest incidence and a growing informal market of 'discount' or unauthorised pesticides (Williamson, Ball and Pretty, 2008). Landscape level conservation mechanisms therefore have to contend with high perceived costs of switching to a more sustainable strategy and the need for cooperation amongst multiple farmers

at a landscape level (Wilson and Tisdell, 2001). Thus, pesticide reduction at the watershed scale presents a tragedy of the commons dilemma, where without external incentives rational actors should not cooperate even when it is in their common interest to do so (Hardin, 1968).

Behind many conservation interventions is the idea that to achieve conservation goals, human behavior must change (Nilsson *et al.*, 2016). Conservation interventions use various approaches to encourage behavioral change including; enforcement, economic substitution, and linked incentives (Salafsky and Wollenberg, 2000). For example Payments for Ecosystem Services (PES) use economic incentives to promote pro-conservation behavior, though there is concern that poor implementation can crowd out intrinsic motivations (Moros, Vélez and Corbera, 2017). However the monitoring and evaluation of these interventions in terms of their effects on behavior are limited (Brooks, Waylen and Mulder, 2013). As conservation interventions take time and money to implement, there is growing interest in how you can predict the impact of such interventions, particularly in relation to a common resource.

A variety of games have been developed to attempt to understand how individuals might behave in the context of managing natural resources where authority is devolved to the local community. A review by Redpath *et al.*, (2018) identify three approaches to using games to address conflicts in conservation; theoretical, experimental and constructivist. Each is designed to tackle different research questions from predicting behavior, testing the effects of interventions on stakeholder behavior, and reaching stakeholder led solutions (Redpath *et al.*, 2018). We use an experimental game to understand behavioral responses to two different interventions for wetland conservation. In the past, such games used university students as subjects; an approach which has been widely criticized for its limited applicability to the field (Levitt and List, 2007; Velez, Stranlund and Murphy, 2009). Recently there has been an increase in the number of framed field experiments where the experimental game involves local participants whose behavior the game seeks to explore, and where the context of the game more closely relates to real-life scenarios (Harrison and List, 2004; Anderies *et al.*, 2011). In the context of conservation, experimental games have focused predominantly on resource extraction: in the context of fisheries (Velez, Stranlund and Murphy, 2009; Travers *et al.*, 2011) or forests (Cardenas, 2004; Janssen *et al.*, 2013; Gatiso, Vollan and Nuppenau, 2015). More recently experimental games have been used to test the effects of payment mechanisms on motivational crowding out (Rode, Gómez-Baggethun and Krause, 2015; Moros, Vélez and Corbera, 2017). Other incentives have also been explored through game-playing such as:

group-based payments (Salk, Lopez and Wong, 2017); self-monitoring (Marrocoli *et al.*, 2018) and communication (Lopez and Villamayor-Tomas, 2017).

Despite the conservation value of the world's wetlands to our knowledge there has been little attention paid to understanding the behavioral effects of wetland conservation interventions on stakeholders through framed field experiments. A notable exception is Bell, Zhang and Nou, (2016) that applied an experimental game in Asia and found that payments discouraged coordination of wetland conservation activities amongst rice farmers. We use a common pool resource experimental game (hereafter "game") to understand how rice farmers in rural Madagascar respond to wetland conservation interventions. We explore the effects of two initiatives used in conservation projects: (i) economic incentives for pro-conservation behaviour and; (ii) communication through devolved authority and the establishment of local environment groups. We observed behaviours across communities in two catchments: one catchment in a recently established RAMSAR site which is part of a community-based conservation project supporting sustainable wetland use, and a second catchment as a control site. We conducted an adapted version of the tablet-based game developed by Bell *et al*. (2016) and looked at the within-game-effects of both subsidies and communication on heavy pesticide use and the provision and coordination of ecosystem services amongst players. By bringing together both the results of the game and responses to the household survey we could compare both in-game and on-farm decision making. Understanding the social context and incentives required to promote collaborative sustainable practices amongst farmers can give insights into improved approach for wetland conservation management in developing countries.

5.1.1 Madagascar's wetlands

Madagascar's wetlands provide valuable ecosystem services (ES), and are used to target biodiversity priority areas (Wendland *et al.*, 2010). The wetlands provide habitats for critically endangered species (Copsey *et al.*, 2009; Rabearivony *et al.*, 2010) as well as supporting livelihoods for natural resource dependent communities (Andrianandrasana *et al.*, 2005). Yet freshwater wetlands in Madagascar have received little conservation and research attention and remain highly degraded systems (Bamford *et al.*, 2017). Pressures include burning (Copsey *et al.*, 2009), clearing for rice farming (Ralainasolo *et al.*, 2009), invasive species and fishing (Bamford *et al.*, 2017). There is little evidence of the effect of the use of insecticides by farmers on wetlands but there is concern that heavy use may damage the communities of macro-invertebrates which are important food sources to threatened water birds (*pers comm.* A. Bamford). The rise in protected area establishment in Madagascar over the last decade has seen

an exploration of different management mechanisms to ensure biodiversity protection, from shared governance arrangements to multiple use management models (Gardner *et al.*, 2018).

5.1.2 The common pool resource game

The game used was an adapted version of the Netlogo game "NonCropShare" Bell, Zhang and Nou (2016) designed to evaluate the impact of different incentives on the willingness of players to cooperate to provide ecosystem services and associated benefits. Key changes included translation to Malagasy text, re-framing the game context to be relatable to Malagasy farmers (based on key informant interviews) and adjusting the game parameters to ensure that the control was always the first game to be played. The game was played in groups of four on separate tablet PCs linked via a mobile hotspot. Within the tablets a symmetric landscape is equally divided into four "farms", and within the game each player provides land-use decisions on a 3 x 3 cell grid of the 6 x 6 cell landscape (see Figure 5.1). In each cell, one of four land use decisions can be made, (see Table 5.1), each of which will bring different costs and benefits to the neighbouring squares (including those belonging to neighbouring players). For example, habitat provides bonus yields to surrounding cropland both on and off farm. However, heavy spraying on any cell cancels these benefits, but increases the production yield within that individual cell.

Table 5.1. Options for each cell on a 3 x 3 parcel of land with their associated costs and benefits.

Name	Description	Yield	Costs	Expected return	Benefits to neighboring land
Crop	Plant a crop, without doing anything else.	5	0	5	None
Habitat	Leave land as wetland habitat.	0*	0	5.5*	+2 yield for adjacent land shared in a perimeter of 2 squares
Crop & light spray	Plant a crop, with light, targeted application of pesticides.	7	-1	6	None
Crop & heavy spray	Plant a crop, with heavier application of pesticides.	13	-2	11	Cancels benefits from habitat on adjacent squares

*This represents mean expected return. In some treatments there are subsidies. Individuals can earn a random number of points (between 1 and 10). Source: adapted from Bell et al (2016a).

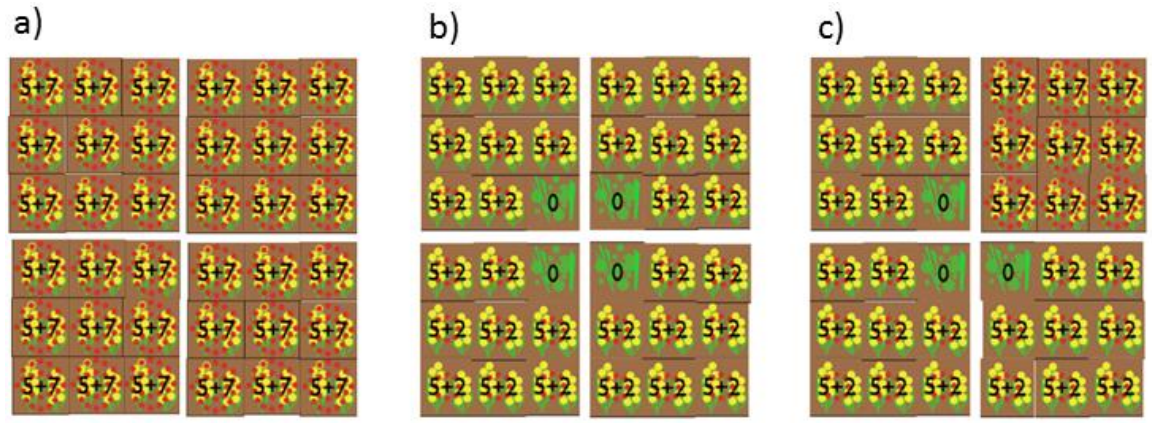


Figure 5.1. Strategies within the game (source Bell, Zhang and Nou 2016), each player controls land-use decisions on one of four 3 x 3 parcels of land within the tablet based game. Rice is depicted with the crop icon and habitat is represented by the green vegetation cells. Heavy and light spraying are depicted by the number of red spots on top of crop icon and over-laid numbers represent the cell yield based on table 5.1. The final score for each player represents yield minus costs plus subsidies. (a) The Nash equilibrium where each player scores 90 points, (b) An example cooperative solution where each player earns 90 points (without subsidies), (c) An example of defection from the cooperative solution, players earn (clockwise from top left); 72, 90, 72, 84 points respectively. In some treatments there are subsidies. Individuals can earn a random number of points (between 1 and 10) for planting habitat. In this case players can earn >90 points in a cooperative solution, maximum points per cell were capped at 15.

The game allows players to achieve similar outcomes either through the Nash strategy of heavy pesticide use (the best strategy with no knowledge of others' strategy), or the cooperative strategy of sharing ecosystem service benefits (Bell, Zhang and Nou, 2016). See Figure 5.1 for a depiction of the strategies. Each group of four players played four treatments for eight rounds each (i.e. 32 rounds in total were played by each player). A score for each round, and a cumulative score per treatment was calculated within the tablet, taking into consideration all costs and benefits on the cells within the players land. On-screen text was written in the local Tsimihety dialect and the use of images allowed accessibility for illiterate players. To incentivise playing to win, players were told that one of the four treatments would be selected randomly and a cash payment would be provided based on the total score across all rounds during that treatment (see section 5.2.4 for an estimation of scores and cash payments).

We analysed the effect of two incentives and their combined effects relative to a control. These were designed to reflect real-world interventions and followed the format presented in Bell and Zhang (2016). Each treatment was played eight times (n=8 rounds) amongst the four players and all players completed the four treatments (see Table 5.2 for a summary of each of the treatments) to reflect real life repeat interactions between community members. The rules of the game were explained via script to all of the players by LA in Tsimihety dialect. A practice game was played with all players and they were encouraged to ask questions and make different land use decisions, the practice lasted four rounds. The games were implemented by LA, supervised by ARL and assisted by two research assistants.

We adapted the game to ensure that the 1st game played was always the control treatment, where respondents were given no subsidies for planting habitat and were not allowed to communicate. The remaining treatments were played in a random order with each new group of four players. The other treatments varied in whether communication between players was allowed and whether there was a subsidy for habitat conservation. Allowing the players to communicate with each other reflected the collaborative local institutions set up in community-based conservation projects and the peer pressure of social (dis)approval. Players were allowed to talk to each other both within and between rounds. The subsidy was designed to imitate payments from conservation programmes such as PES. The subsidy ranged from 1-10 points, as habitat "yield" in addition to the ES bonuses that cell would already provide (in the control treatment habitat yields 0). Players were told what value the subsidy was prior to the game commencing. The four treatments were: control (no communication, no subsidy); no subsidy but communication allowed; subsidy but not communication allowed; both subsidy and communication.

Table 5.2. The four treatments completed by players, their descriptions and relevant real-life interventions.

Name	Description	Potential mechanisms to achieve behaviour change
1. Control (no incentive, no communication)	No subsidy; moves of other players shown at the end of the round.	No intervention, personal motivation only.
2. No incentive, communication allowed	No subsidy; moves of other players shown as soon as they confirm the square (so they can discuss).	Increased collaboration and communication (this may be achieved through the establishment of local environment groups).
3. Incentive, no communication	Subsidy of randomized value for habitat cells 1-10; moves of other players shown at the end of the round	Monetary incentives for wetland conservation (An example might include a PES scheme aimed directly at farmers, but with no community collaboration)
4. Incentive, communication allowed.	Subsidy of randomized value for habitat cells 1-10, moves of other players shown as soon as they confirm the square.	Monetary incentive for wetland conservation & collaboration (An example might include a PES scheme that works with a local community and organised through a local environment group)

Source: Adapted from Bell, Zhang and Nou (2016b).

5.1.3 Theoretical predictions

We ran a series of models with different response variables (three at the landscape scale and two individual scale) to test a range of hypotheses. The landscape scale models explored the effect of treatments on the delivery of Ecosystem Services in the game landscape. Firstly, we hypothesized that subsidies would increase the provision of ESs in the landscape (defined as the total number of habitat cells selected in the 6 x 6 grid). Secondly we hypothesised that the coordination of ES provision (shared habitat bonuses to neighbouring farms) would increase where communication was allowed between players. This would be because there was an expected social cost (fellow players' disapproval) of not coordinating if a player had asked you to. Finally, we expected the number cells with heavy pesticide spraying to be reduced with increased habitat subsidy.

The individual models explored individual actions taken within the game. We expected players to play the game more cooperatively if in the previous round the other players had been playing

the game cooperatively (i.e. players were acting rationally). Conversely we expected players to negatively affect neighbouring land through making a heavy pesticide land use decision the land borders if in the previous round other players had made land use decisions negatively affecting their neighbouring players.

To explore how behaviour in the game related to real farming practices, and the effect of the existing community-based conservation project in the area we included a range of explanatory variables in all of our models. In an attempt to relate behaviour in the game to real farming practices we included use of pesticides as an explanatory variable. We predicted that individuals using higher levels of pesticide on their rice crop in real life were more likely to select the option of heavy spraying within the game. To explore the effect individuals living within the community based conservation project compared to the control wetland we included this as an explanatory variable. We predicted that: living in the intervention site, being in receipt of agricultural training (more common in the community conservation project site), or being a member of a local environment group would reduce the amount of heavy spray cells throughout the game, compared to individuals living in the control site. We hypothesised that older and more educated individuals might be more likely to achieve a cooperative solution and thus achieving a greater number of points with less reliance on heavy spray cells (i.e. "solving" the game) and so included these as explanatory variables.

5.2 Methods

5.2.1 Study context

We conducted the framed-field experiment in Northern Madagascar during July-September 2017. Two catchments were selected as a control and intervention site for a community conservation project promoting sustainable wetland use (see section 4.2.1 and section 1.7 for a description of the control and intervention sites as well as further information of the community-based conservation project). Pesticide use, in the form of insecticides, is considered to be a significant factor in the decline of benthic invertebrates within the lake systems, which in turn has reduced food availability for water birds particularly the critically endangered Madagascan Pochard (*A. innotata; pers comm* A. Bamford). The current amount of pesticide within the lake is unknown, though some previous surveys indicated widespread usage of various forms of pesticide (*pers comm* A. Bamford and F. Razafindrajao). As part of a watershed-scale conservation programme to support the re-introduction of *A. innotata* multiple capacity building activities have taken place which include; training on natural pesticide use; sustainable farming techniques and environmental education (see Chapter 4, Table 4.1 for a full list of all capacity building activities). Understanding the motivations to participate in more sustainable farming techniques may help to solve the cooperative problem of land-scape level change required to reduce the pesticide load in these environmentally sensitive lake-systems.

5.2.2 Key informant interviews

In December 2016, 21 key informant interviews were conducted to support the development of the game. Key informants included elected leaders, elders and members of local environment and women's groups. The interviews were based on a framework of open ended questions (see Appendix 5.1) with space to follow up if different topics arose. Interviews focused on extent of insecticide use, intended purpose, perception of insecticide effects on crops and the wider environment, as well as collecting quantitative data on local sales of insecticides. Interviews were conducted in Tsimihety dialect by LA and directed by ARL.

5.2.3 Sampling strategy

The game was pretested amongst conservation practitioners, the research team as well as local household heads during December 2016. Players were randomly selected as part of the end-line interviews carried out for the before-after-control-intervention (BACI) household survey (see Chapter 4). Household heads were invited to participate in the end-line household survey and then invited to play the game either that afternoon or the following day. Where a household head did not agree to participate in the game a different household head was asked to participate

opportunistically to ensure there were four players in each game (note these individuals did not participate in the BACI study). The household survey (described in Chapter 3) included information on household socio-demographics, farm-level data such as land size and pesticide use, as well as data on whether the household head was a member of a group managing natural resources.

5.2.4 Ethics and data management

The research was scrutinised and cleared under the Bangor University Research Ethics framework. All respondents were over the age of 18 and were told that the research was about how households, communities and organisations work together to solve collective problems to deliver local community and environmental benefits. We explained that the results may be published, but their names would not. All data was saved on a password protected computer. An oral consent script was read out (see Appendix 5.2) and respondents were told that they could stop the interview or game at any time without having to give a reason. Interviews lasted between 30 minutes and 1 hour. Interviews were conducted in the respondent's household or field, whichever the respondent was more comfortable with. Games lasted between 1.5-3 hours and were played in a communal location such as a school or one of the players' house. During the game respondents were given drinks and snacks and the opportunity to win cash based on their game-level performance. To incentivise playing to win, players were told that one of the four games they participated in would be selected randomly and a small cash payment would be provided based on the total score across all rounds during that game. Cumulative points across the randomly selected game were rounded up to the nearest 100 points, and 100 Ariary (approximately 0.032 USD) was awarded for every 100 points scored, a maximum score of approximately 1000 (approximately 0.3 USD). Average points earned was 700 Ariary (approximately 0.21 USD). Daily wages in the area were approximately 5,000 Ariary (approximately 1.49 USD), and cash rewards were determined in consultation with the local NGOs.

5.2.5 Data Analysis

Statistical models were constructed for five different response variables (see Table 5.3). There were three response variables at the landscape scale: ES provision within the game landscape; heavy spraying across the game landscape; and coordination of ES provision across the game landscape. There were two individual models with the following response variables: intended cooperation (Individual shared ES efficiency) and intended non-cooperation (cancelled ES benefits). Each of these was calculated based on the total number of each land use decision,

and the placement of that decision within the game landscape, i.e. a central or outer placement within the landscape (see Table 3 for the calculation). All analysis was conducted using R version 3.4.3 (R Core Team, 2013). All of the calculated variables were divided by the maximum potential score and logit transformed due to the skew from the subsidy levels. These were analysed using linear mixed effects (LME) models within the lme4 package (Bates et al. 2015). Random effects were selected as group ID in the landscape level models. Within the individual models household ID was included as a nested random effect within group ID. Data was visualised as a function of round using the loess methods in R which uses a t-based method to estimate standard error (R Core Team, 2013).

Table 5.3. Calculation of each of the response variables within the models.

Level	**Response variable**	**Calculation**
Landscape	ES provision within the game landscape	∑ habitat cells in landscape
Landscape	Heavy spraying across the game landscape	∑ HS cells in landscape
Landscape	Co-ordination of ES provision across the game landscape.	(∑ individuals shared benefits to neighbours / number of habitat placed)/ max potential score
Individual	Intended cooperative behaviour: Individual shared ES efficiency	An individual's shared benefits to neighbours / number of habitat placed
Individual	Intended non-cooperative behaviour: Individual cancelled habitat benefits	∑ of affected cells on neighbouring land due to border placement of HS cells

A full list of all fixed effects explanatory variables explored, and their calculations can be found in Table A, Appendix 5.3. These included data from the household survey; age, year in education, number of children, annual pesticide use were included as integers. Dummy variables were constructed for intervention site (1= intervention site), gender (1= male), whether the player had received rice training (1= training received) and whether the player was a member of an environmental group (1= member). For the landscape models these variables were averaged across the players to provide group-level demographic data.

Treatment order was not included as an effect as game order was randomised across groups, however round order (and round order squared) was included as a continuous variable to determine slope of the learning effect between rounds. In the individual models two final variables were calculated to determine the reaction effect from the previous round's land use

decisions amongst other players. The sum of the three other players shared ES score (as calculated as individual shared ES efficiency), in the previous round was used to determine an altruistic reaction effect. The same principal was used to calculate the score for a negative reaction effect: the sum of the three other players' cancelled habitat benefits in the previous round. Treatments were categorised as either a dummy variable for communication (1= communication allowed) and subsidy was included as a continuous variable. Maximum potential score in any single cell was capped at 15, giving a maximum potential score of 135 for any player per round. Final models were selected based on the main research questions and compared using the corrected Akaike Information Criterion (AICc) value. Final models were selected step-wise based on the AICc value and terms were removed with AIC >2 (MuMIn package; Kamil et al. 2014).

5.3 Results

5.3.1 Demographics

In total 27 games were played with 108 players in groups of four (n=13 games in control site, n=14 games in intervention site) and all groups completed the 4 treatments. Demographic characteristics were similar across both the control and intervention sites, though there was a greater number of female players in the intervention site (see Figure 5.2). From the household survey we observed that players within the control site used, on average, a greater amount of pesticide litres per year on their land (a mean value of 0.416L yr^{-1} in the intervention site and 0.546 L yr^{-1} in the control site). The intervention site had higher numbers of players that were members of a group governing environmental resources, and had had access to more agricultural training.

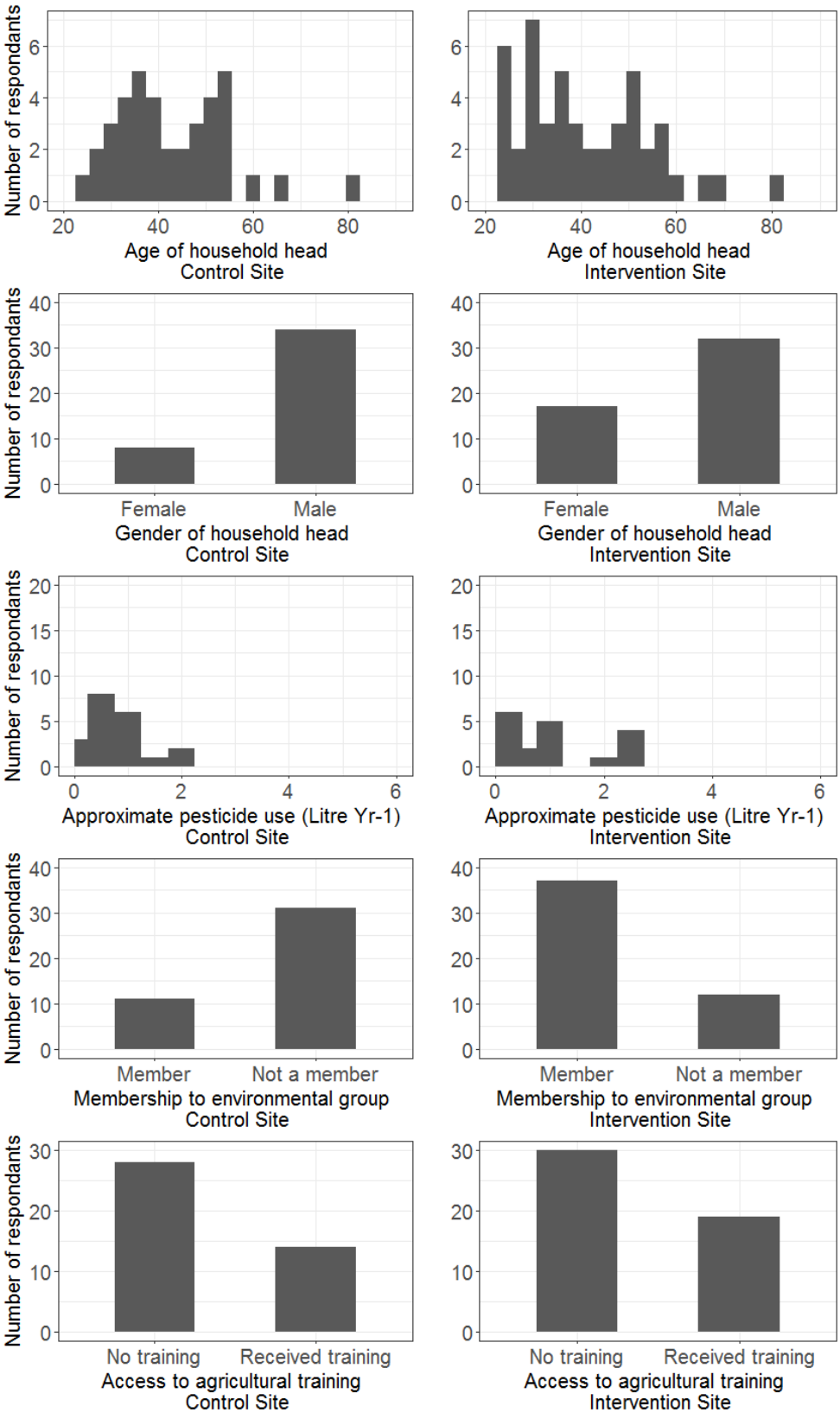


Figure 5.2 Descriptive statistics of the household heads participating in the game across both the control (n=52) and intervention site in 2017 (n=56). Demographic characteristics are shown as well as information related to pesticide inputs and access to agricultural training.

5.3.2 Pesticide use in study sites (Key informant results)

Results from key informant interviews (n = 21) conducted in December 2016 by ARL and LA indicated that a number of synthetic pesticides used within the region are pyrethroid based. Preliminary analysis of sediment in Lac Sofia has detected levels of cypermethrin, a more persistent generation of pyrethroids (*pers comm* A. Bamford). The majority of respondents said they used approximately 0.25L Ha^{-1} yr^{-1}, spraying 1-2 times per year. Most households began using pesticides in the last 3-6 years, before that it was not available in the area. Farmers note one reason for starting to use pesticides is the concern that if others use it and they don't, all the insects would go to their land. Respondents did perceive significant yield increased in rice before and after pesticide usage, reporting between 5-300% increases in rice yield. Approximately half of respondents noted negative consequences of pesticide use, primarily this included negative impacts on insects providing ecosystem services both on their land and that of neighbouring land.

"[Synthetic pesticide] *dries the soil because it kills useful insects like worms which muddy the soil"* Respondent 17.

"[Synthetic pesticide] *destroys the soil, the useful insects, if neighbours use it, it will destroy my soil insects"* Respondent 10.

Prior to using the insecticides, households stated that they typically used traditional natural pesticides, including citronella or chilli based sprays (collected from the local environment), and selective flooding of the rice fields (see Appendix 5.4 for a summary of the key informant results).

5.3.3 Round effects

Land use decisions within the control treatment are the baseline against which land use decisions in other treatments are compared. The land-use decisions were not stable across treatments over the 8 rounds, though tended to increase for the cooperative behaviour variables. This suggests that if the experiment had continued for longer than 8 rounds the conclusions would have been the same but the size of the effects may have varied. In the first round of the control treatment average number of heavy spray cells placed was 0.6 and this tended to increase with each subsequent round (Figure 5.3b). The average number of habitat cells placed within the first round of the control treatment (the ecosystem service provision within the landscape) was 1.8 and this tended to decrease across the 8 rounds (see Figure 5.3c). The coordination of ecosystem service provision between players was erratic across the games but tended downwards in the control treatment (Figure 5.3d).

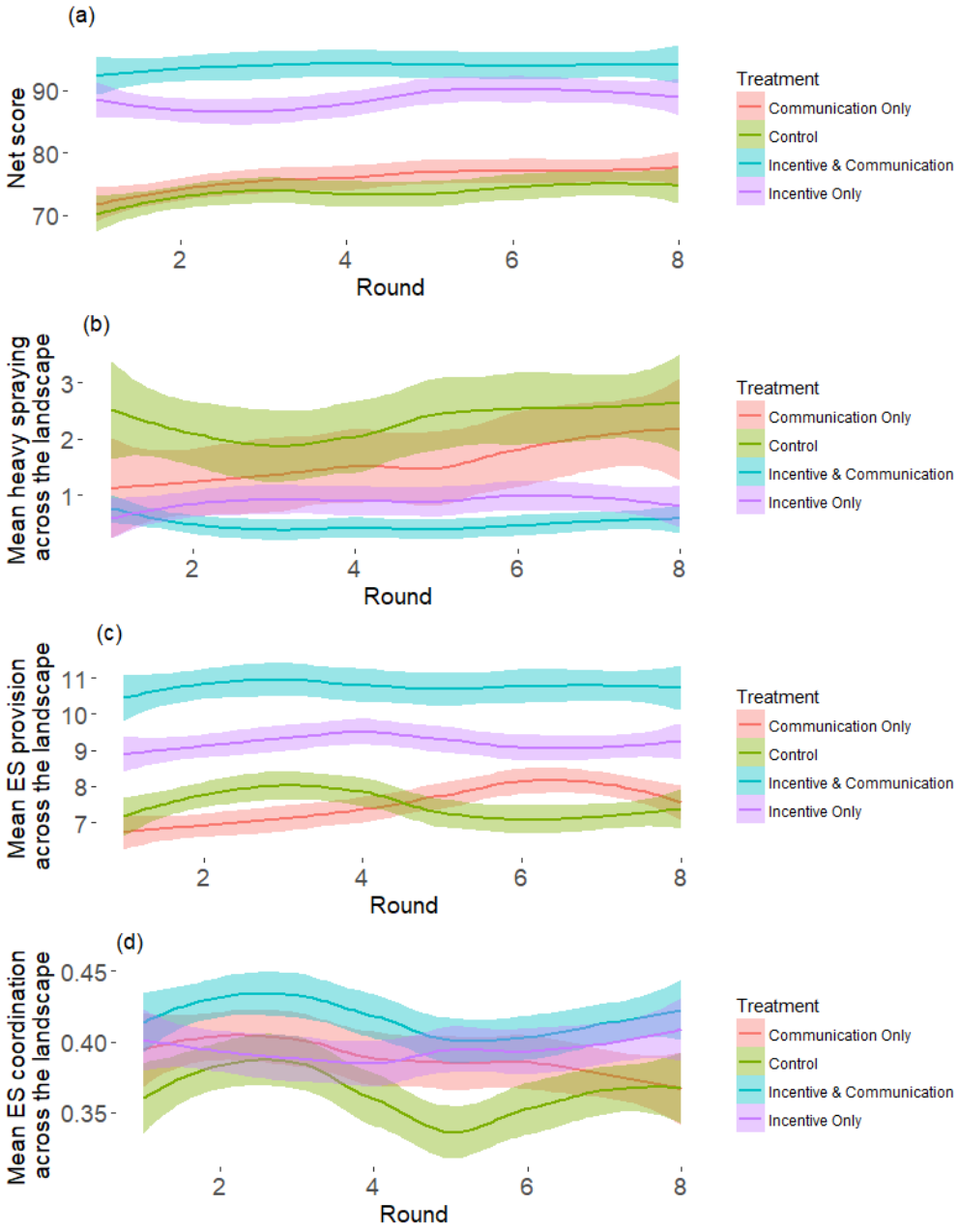


Figure 5.3 Mean land-use decisions across the game landscape for each of the rounds within the four treatments (standard errors are represented as shaded areas, computed using the loess method in R; R Core Team, 2013). Figure 5.3a shows net production score (yields minus costs plus benefits) relative to the. Figure 5.3b shows mean heavy spraying across the landscape, showing highest pesticide use in the control treatment. Figure 5.3c Shows mean ecosystem provision across the game landscape (number of habitat cells). Figure 5.3d shows the coordination of the ecosystem service provision as intended cooperative behaviour (the adjusted centralization of habitat cells).

5.3.4 Tactics to achieve maximum potential score

Players used a variety of methods to achieve the maximum potential points (net score). The mean score relative to the maximum potential score for each treatment was greater than 0.5 (see Figure 5.4) suggesting that players were playing to maximise points. We then tested the key strategies to achieve the maximum potential score per player i.e. acting cooperatively or selfishly.

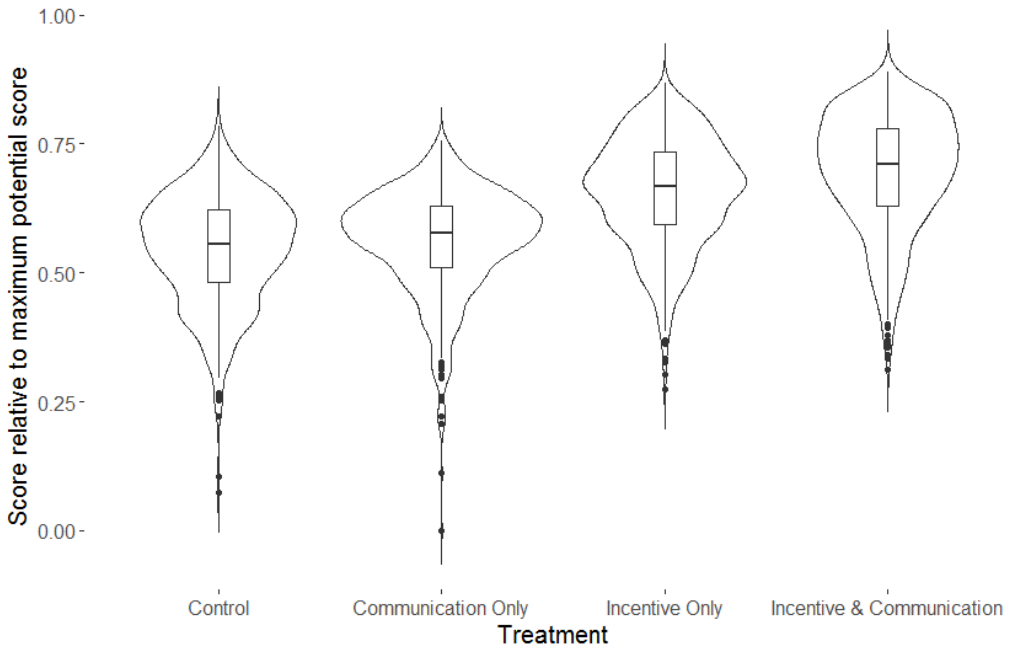


Figure 5.4. The players score relative to the maximum potential score that could have been achieved for each round based on a high return cooperative solution (calculated as the net cooperative strategy maximum = 15*9 as points earned per land square were capped at 15). Data shows differences between treatments. Treatment order (except control) was randomised so we expect no learning effects.

Strategies were analysed based on how many heavy pesticide cells contributed to the net production (the total score net of costs and subsidies). I.e. a player whose score was achieved by heavier spraying was acting more selfishly than a player with the same final score achieved through accruing habitat bonuses (see Figure 5.1 for an illustration of key strategies). Figure 5.5 shows a decreasing dependence on heavy pesticide cells due to the different treatments (the Nash strategy of "selfish behaviour" is observed more so in the control treatment; see Figure 5.5a). The combined treatment of incentive and communication shows the greatest shift

towards cooperative behaviour (achieving scores through shares habitat bonuses and less dependence on non-cooperative behaviour) compared to the control treatment: i.e. less reliance on pesticide to achieve the same score.

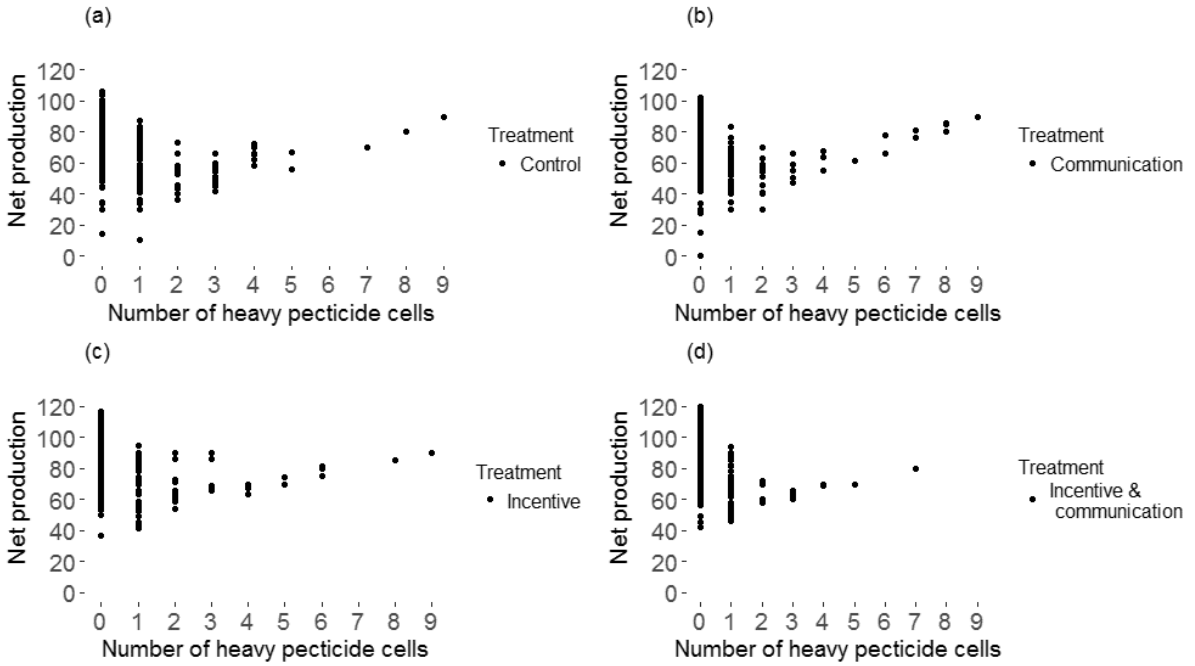


Figure 5.5. Net production (yield net of costs and subsidies) earned in the landscape for all game rounds, as a function of heavy spay cells for each treatment. A reliance on heavy pesticide cells (x-axis) to achieve a higher net score is reflective of a Nash strategy whereas a decrease in heavy spray cells to achieve the same or greater score (y-axis) implies players found a cooperative solution. Each figure shows treatment type: a) Control; b) Communication only; c) Incentive (including all subsidies); d) Incentive and communication (including all subsidies).

5.3.5 Effect of treatments on land-use decisions: landscape level models

The treatment where communication was allowed did not have a significant effect compared to the baseline control treatment on ecosystem service provision within the game landscape, i.e. did not increase a player's likelihood of setting aside more habitat due to peer pressure (see Figure 5.6a). However, communication significantly improved the coordination of ecosystem service provisions (i.e. if setting aside habitat, a player was more likely to set aside that habitat to benefit neighbouring lands), see Figure 5.6b. Communication also resulted in significantly less heavy pesticide across the game landscape. Incentives also had a significant effect on all response variables as predicted, where increased subsidies lead to a reduction in heavy pesticide use across the landscape, and an increase in ES provision and ES coordination. Model selection removed all other explanatory variables other than treatment: i.e. there was no significant effect of group level demographic variables, round or intervention site. See Appendix 5.5 (Tables A & B) for the full model results, and for the model selection table.

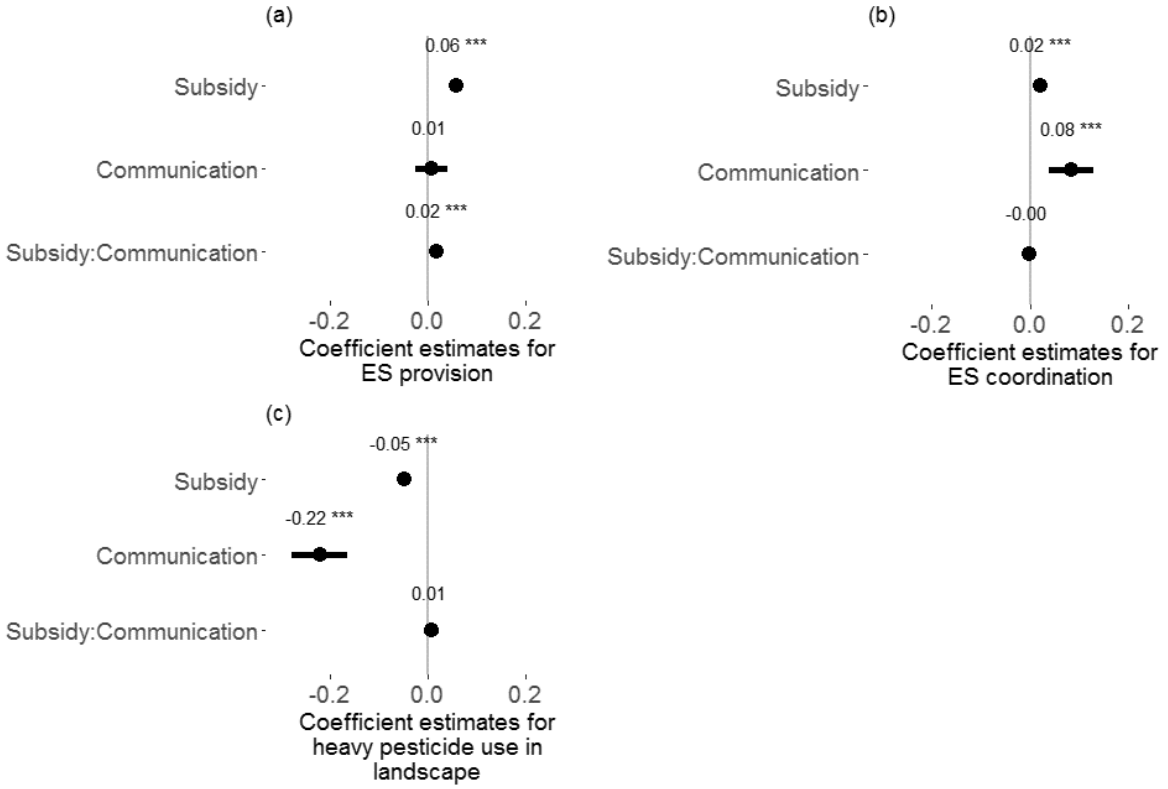


Figure 5.6 Coefficient plots for the results of the final linear mixed effects models. This shows treatment effects on several land-use decision response variables: ecosystem service provision across the landscape (Figure 5.6a), ecosystem service coordination (Figure 5.6b) and amount of heavy pesticide in the game landscape as a non-cooperative behaviour (Figure 5.6c). Group level characteristics were dropped as explanatory variables in the final model and Group ID was included as a random term in all models. Though the interaction between treatments is excluded from models in Figures b and c, these have been included for illustrative purposes. See Table A in Appendix 5.5 for a summary of the coefficient estimates. Note: *** 1% significance level, ** 5% significance level, *10% significance level with two-tailed tests.

5.3.6 Effect of treatment on land use decisions: individual level

We expected players to show rational behaviour by playing the game more cooperatively if in the previous round the other players had been playing the game cooperatively. We also expected players to make the rational choice of more heavy pesticide (non-cooperative) land use decisions if in the previous round other players had increased heavy pesticide land use decisions. Our results indicated that the players showed significant rational behaviour in response to the other players' land use decisions for both intended cooperative behaviour, and non-cooperative behaviour (see Figure 5.7). For example, the intended cooperative behaviour through shared ES benefits in the current round was significantly determined by the amount of

shared ES benefits seen in the previous round by other players (i.e. you scratched my back, I'll now scratch yours; see figure 5.7a). Conversely higher levels of heavy pesticide cancelling ES benefits by other players in the previous round, players were more likely to behave non-cooperatively and make land use decisions with heavy spray cells placed where they would negatively affect neighbouring lands (see figure 5.7b).

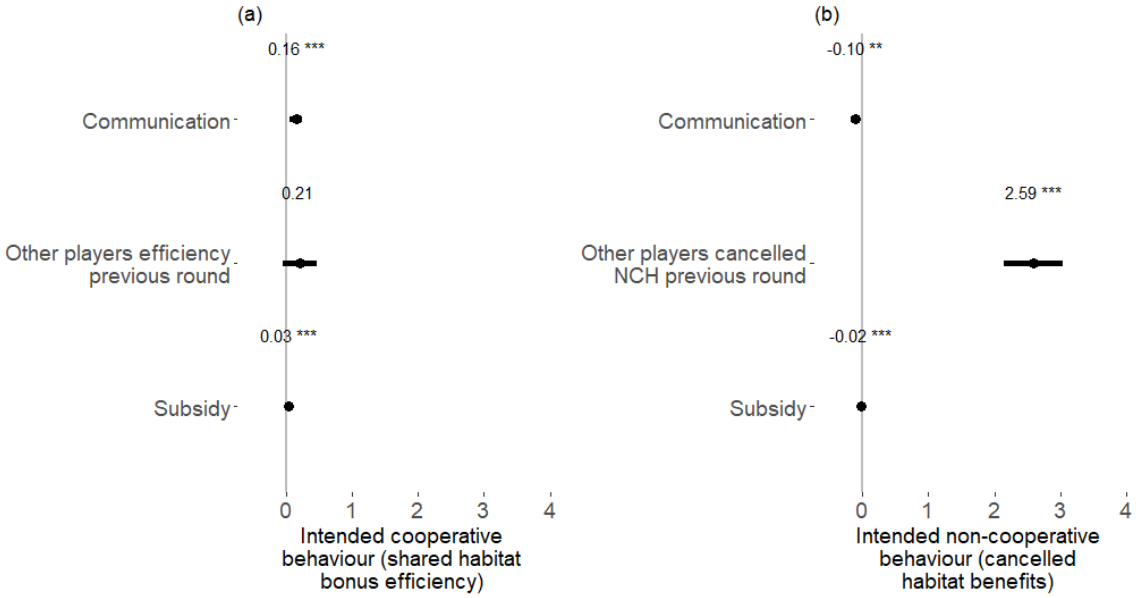


Figure 5.7 Coefficient plots for the results of the final linear mixed effects models. This shows treatment effects on two land-use decision response variables: intended cooperative (Figure 5.7a) and non-cooperative behaviours (Figure 5.7b). Cooperative behaviour was calculated through shared habitat bonus efficiency (i.e. ecosystem service coordination). Non-cooperative behaviour was calculated by the number of cancelled habitat bonuses in the game landscape. Individual level characteristics were dropped as explanatory variables in the final model and group ID was included as a random term in all models. See Table A in Appendix 5.6 for a summary of the coefficient estimates. Note: *** 1% significance level, ** 5% significance level, *10% significance level with two-tailed tests.

Within the individual models there was no significant effect of any individual characteristics as explanatory variables, and these were excluded from the final model (see model selection in Appendix 5.6). There were also no significant effects of the individuals living within the intervention catchment. However, we noted that the signs for pesticide use per year were as expected, heavier spraying within the game was positively associated with higher pesticide use in real life, though this was not significant and excluded from the final model. Across the

individual models and landscape models there was no significant effect of age, gender or number of children implying that demographic analysis will not determine cooperative behaviours.

5.4 Discussion

5.4.1 Impact of subsidy and communication on ecosystem service provision

We found that incentives in the form of subsidies that would mimic PES schemes by providing a subsidy significantly improved landscape level ES provision and decreased the level of heavy pesticide used across the game landscape. Communication, allowing social approval or disapproval amongst players, contributed to significantly higher coordination of ES provision. This corroborates other studies that advocate facilitation amongst stakeholders and local institutions to be formed to encourage pro-environmental behaviours (Clements *et al.*, 2010). The coordination of ecosystem service provision between players was erratic across the games but tended downwards in the control treatment. This follows the standard pattern for treatment with no incentives, i.e. decreased cooperative behaviour (Ostrom, 2000). We also observed tit-for-tat behaviour in terms of reacting to other players' land-use decision making, implying that positive reciprocal scenarios can occur given the correct starting incentives. Sustainable wetland management requires coordination amongst actors, where one stakeholder's strategy is reliant on another's. The use of local institutions to encourage communication and cooperation amongst stakeholders and PES schemes to directly incentivise ecosystem service provision have rarely been analysed in terms of their effectiveness to promote cooperative behaviour to ensure the continued provisioning of their ecosystem services.

5.4.2 Games as tools to predict and facilitate cooperative behaviour

We did not observe significant effects between the control and intervention catchments implying that the community-based conservation project has yet to have an impact on the decision making of local stakeholders. We also explored: mean annual pesticide use; whether the participant was a member of an environmental group; and whether the participant had been in receipt of agricultural training. There was also no effect of these household questionnaire variables and individual characteristics on decision making within the game landscape, but is more to do with the actions of neighbouring farms in previous rounds. As Bell, Zhang and Nou (2016) identified, this may imply that traditional household surveys may be inadequate at predicting appropriate interventions.

The value of these common pool resource games does not only lie in research. As Redpath *et al.* (2018) noted, games can be used to identify and manage conflicts in conservation settings. We found that there was a positive response to the game playing both by the participants and the collaborating NGO. The game can easily be adapted as a tool to facilitate discussions between stakeholders in wetland catchments under conservation intervention.

5.4.3 Game constraints

Real-life experiments are costly and raise ethical concerns, whereas common pool resource games, in the form of framed-field experiments are designed to mimic real-life decision making in game format for players. Of course in real life there are many constraints on land-use decision making such as available income, land-rights and cultural traditions (Förster *et al.*, 2015; Etongo *et al.*, 2018). Experimental games are necessarily simple and do not reflect the wider socio-ecological contexts in which these communities operate. There are inevitable questions about the external and internal validity of results meaning that the results must be treated with caution (Jackson, 2012).

Though there are some policy implications, these results must be taken within the limitations of the study, and of game-playing in general. For example the number of players was limited to four, though in real-life that land-use decision making would have to account for multiple neighbours (especially where fields are distributed across the landscape). Previous studies have shown that it is easier to achieve cooperative behaviour where there is a smaller number of stakeholders (Anderies *et al.*, 2011). In reality, there are thousands of stakeholders living and farming within catchments, and the consequences of losing a rice harvest is greater than the budget of most experimental studies which questions their external validity (Levitt and List, 2007). However we feel that the incentive to play the game for maximum points (to earn the monetary reward) as well as observed land-use decisions correlating with for example real pesticide use implies that these result may reflect some of the decisions undertaken by real farmers in a low-income country.

Equally important is the recognition that the clear link between action and outcome within the game may not be realised in reality. The differing time-scales of land use decision making and ecosystem service provisioning (Montoya-Tangarife *et al.*, 2017) mean that these results represent an upper bound of what may be possible within this wetland ecosystem context.

5.4.4 Final conclusions

Our results imply that management mechanisms that adopt both incentive mechanisms as well as encouraging communication amongst stakeholders will achieve the greatest outcomes in terms of ES provision. Conservation funding is limited, yet we have shown significant increase in ES provision with communication alone. This strengthens calls for the development of community-based environmental groups to ensure the sustainable delivery of natural resource management. Games can be used to determine the potential impact of conservation interventions though there are multiple constraints to their generalizability. Games may also be used as a facilitation tool amongst communities to explore the potential pros and cons of various interventions collaboratively, which is a principal of community-based conservation.

6. Discussion

In this chapter I summarise the key findings according to the original research aims, identify limitations, suggest areas for future research and highlight the applications for community-based conservation projects.

6.1 Key findings

In order to make the most of limited resources in conservation there are calls to: i) contribute to the empirical evidence base of community-based conservation projects and ii) predict the potential impacts of new conservation interventions. In this thesis I aimed to contribute to improving the design and implementation of community-based conservation projects by using impact evaluation and experiments relying on hypothetical scenarios. The overall aim was to add to the evidence base for the best way to design, promote and evaluate future community based conservation projects that benefit both people and wildlife. Below I present the main findings in relation to the original objectives of the thesis.

i) To understand the extent to which potential donors to a conservation project in Madagascar value the various aspects of conservation interventions.

Delivering the dual goals of conservation and development has led to a mix of strategies to deliver conservation objectives; from strict protected areas to community based conservation approaches which include local people in management (Salafsky and Wollenberg, 2000; Hughes and Flintan, 2001). Over-seas donors represent considerable funding for conservation projects in low-income countries (Hein, Miller and de Groot, 2013), though there is substantial unmet need (McCarthy *et al.*, 2012). Public attitudes to what conservation projects should fund is therefore important to consider (Booth, Gaston and Armsworth, 2009). In Chapter 2, we used a discrete choice experiment alongside a socio economic survey to establish hypothetical willingness to pay for multiple attributes of community conservation projects namely; threatened species populations, community involvement in management, the condition of sites of conservation concern and investing in the provision of alternative livelihoods.

Within the choice experiment we found that, hypothetically, participants were most willing to pay for conservation projects that included local community involvement in management. We also attempted to externally validate the choice experiment by running a simultaneous real-life fundraising campaign over a 1 month period for either a community-based conservation project or a project solely protecting threatened species. With the level of donation we requested, most

respondents made a donation so we were not able to demonstrate an effect of campaign type on real donations. However, we did identify potential hypothetical bias as some individuals that had refused to give a real donation participated in the choice experiment and had a positive willingness to pay. This research lends support to conservation campaigns that use and promote community-based approaches. Understanding the preferences of donors in high income countries is valuable for the marketing of future conservation campaigns.

ii) To evaluate the impact of capacity building interventions carried out as part of a community based conservation project on community capacity.

In Chapter 3, we explored the multiple dimensions of community capacity for co-management of natural resources. Many community-based conservation projects seek to develop community capacity to yet its definition and the quantitative measurement remains scarce (Beckley *et al.*, 2008; Wilder and Walpole, 2008; O'Connell *et al.,* 2017). We developed and refined a set of quantitative indicators to measure community capacity to undertake co-management of a conservation project in Madagascar. This was measured through the communities' assets of human, social, economic and organisational capitals (Beckley *et al.,* 2008). We found that the levels and changes in indicators differed, showing a requirement for capacity to be analysed in multidimensional space. By understanding the strengths and weaknesses in community capacity we can develop capacity building initiatives to promote more successful conservation outcomes.

Chapter 4 uses this set of indicators as a basis to evaluate the impact of capacity-building initiatives. Despite reocognition of the need for empirical evidence, conservation science has often been slow to adopt the robust methods of impact evalution (Baylis *et al.,* 2016). We used a before-after-control-impact (BACI) approach over a 2-year period to evaluate the impact of capacity building for a community-based conservation project in Madagascar. There was no evidence of impact in composite scores of capitals, though some specific indicators of social capital had improved over time. Efficient social networks are important to begin establishing trust and knowledge exchange between stakeholder groups (Woolcock and Narayan, 2000) and it is encouraging that sustained effort improving some aspects of social capital has provided measurable impact. There was some evidence of elite capture within the intervention site which is similar to other studies in Madagascar which identified elite capture of training and resources (Bidaud *et al.,* 2017). These results imply that relatively short-term capacity building programmes may not have a measurable impact on capacity across a wide community but may

have specific impacts on certain targeted elements. This data can inform the design of improved capacity-building activities in future.

iii) To explore the potential impacts of proposed wetland conservation interventions.

Fundamental to many conservation interventions is the idea that to achieve conservation goals, human behavior must change (Salafsky and Wollenberg, 2000; Nilsson *et al.*, 2016). The world's wetlands are being lost and degraded at an ever increasing rate (Davidson, 2014). Agricultural expansion (and intensification through the use of pesticides) are among some of the important drivers of this change (McCartney *et al.*, 2014; Langan *et al.*, 2018). In Chapter 5 we used a tablet-based game with Malagasy farmers to mimic land-use decision making amongst multiple stakeholders in a wetland ecosystem context as cooperative behaviour is at the heart of community-based conservation initiatives. The results show that while incentives in the form of subsidies can increase ecosystem service provision in the game landscape, facilitating communication can significantly increase the coordination of ecosystem service provision between neighbouring stakeholders. This adds to the calls by other studies that advocate facilitation amongst stakeholders and local institutions to be formed to encourage pro-environmental behaviours (Clements *et al.*, 2010). We also observed tit-for-tat behaviour in terms of reacting to other players' land-use decision making, implying that positive reciprocal scenarios can occur given the correct starting incentives. We did find that subsidies made the biggest difference in ecosystem service provision, though in real case studies there is concern that poor implementation can crowd out intrinsic motivations (Moros, Vélez and Corbera, 2017).

6.2 Study Limitations

6.2.1 Sampling methodology

There is a risk that our sampling methods resulted in a sample that did not fully represent the local population. Chapters 3, 4 and 5 use the same sampling methodology to select household head participants. We aimed to mitigate social bias by randomly selecting household heads using both the knowledge of the elected leader, and the electoral register. While we hoped that this would randomly select from the wide section of the communities in which we were conducting the studies, some people may be missed from the analysis. We made every effort to get and exhaustive list of household heads, however there is the possibility that those living in particularly remote locations with limited contact and participation within the fokontany may be excluded from this analysis. Other sampling methods, for instance using Google Earth to select buildings, may have identified more households. In addition, individuals under the age of 18 sometimes head households where, for example, other household members have passed away. We restricted our analysis to over 18s only to comply with ethical requirements set by the university but again, this may have led to the exclusion of some of the poorer members of the communities in which we were studying.

We were able to get a response rate of over 60% in the follow-up survey during the BACI method (Chapter 4). Given the dispersed villages and logistics, there was not always enough household heads in a given village or fokontany to fill all of the spots in the 4-player game (Chapter 5) that had completed both surveys. We therefore had to find additional players. While these household heads did complete the household survey we were not able to analyse the before-after effect alongside the game data.

6.2.2 Limitations in the BACI approach: exploring real impacts

Community capacity-building activities are often designed to have an impact over the long term (O'Connell *et al.*, 2017; Warren, Reeve and Arnold, 2017). It is well known that evaluations looking at socio-economic impacts over long timescales are rare (Ferraro and Pattanayak, 2006). Due to the restricted time of a PhD, we were only able to allow 2 years between the base line and end-line data collection in the BACI. The lack of impact of sustainable farming techniques and the formal establishment of the local environment group could be a result of this limited time for the interventions to have an impact. By using smart-phone technology and with our questionnaire open-access we have a methodological system in place to allow continued data collection within the study site.

6.2.3 Limitations in externally validating hypothetical behavioural experiments

Practitioners are increasingly turning to tools such as field experiments, derived from economic disciplines, to predict the potential impact of new conservation interventions. Tools such as discrete choice experiments and economic games place participants in hypothetical situations to determine behavioural responses to potential interventions. Fundamental critiques of these approaches is the reliance on hypothetical scenarios, and failure to validate the outcomes with independent data on real behaviour (Hensher, 2010; Araña *et al.*, 2013; Rakotonarivo, Schaafsma and Hockley, 2016). We attempted to externally validate the choice experiment (Chapter 2) and the experimental game (Chapter 5).

Choice experiment

Few choice experiments are able to externally validate their results as often there is no real market valuing the same attributes (Hensher, 2010). A recent systematic review by Rakotonarivo *et al* (2016) identifies 11 non market valuation choice experiment studies, published between 2003 and 2016, that attempt to validate their results (Rakotonarivo, 2016). Only one study compared preferences made in a hypothetical choice with a revealed preference field study and this was focused on carbon off-setting (Araña *et al.*, 2013). Within the choice experiment we hoped to have unlimited real-donation amounts for the real conservation campaigns in order to make a direct comparison with the choice experiment. We were only able to ask for a £1 donation on top of ticket sales as this was also a trial approach at a new fundraising mechanism, and as such the senior management team did not want to put off customers by asking for too much. While this raised over £2000 for the charity, it did not dissuade enough people, so we were not able to find the upper bounds of real donations as we could in the hypothetical choice experiment (by asking for a £20 or £50 donation, which was a rarer choice). Although we do not believe that respondents associated the revealed preference donation study with the choice experiment survey, there is the potential that those we asked to make a donation considered their willingness to pay more concretely than those we did not ask. There is the potential that there is differences in hypothetical bias between those respondents, but unfortunately, the small number of respondents to the choice experiment who had been asked for a donation meant that we could not explore this effect.

Experimental game

We combined the results of a detailed household questionnaire with in-game decision making. In the household survey we asked about socio-economic characteristics as well as information

on land-use decision making including: annual pesticide load on-farm; membership to environmental groups; access to agricultural training and; whether the participant resided in the control or intervention site. These variables had no significant effect on game-playing behaviour implying that the community-based conservation project has yet to have an impact on the decision making of local stakeholders. As expected if players were behaving rationally, the players' land-use decision making was more to do with the actions of neighbouring farms in previous rounds. As Bell, Zhang and Nou (2016) identified this may imply that traditional household surveys may be inadequate at predicating appropriate interventions.

In real life there are multiple constraints on land-use decision making including income, land-rights and cultural traditions. Experimental games are necessarily simple and do not reflect the wider socio-ecological contexts in which these communities operate. For example previous studies have shown that it is easier to reach cooperative solutions with fewer stakeholders (Anderies *et al.*, 2011), therefore our results may bias towards finding cooperative solutions.

6.3 Future developments

Given these limitations, the following areas of future research may compliment or improve the results of this thesis.

i) Further research into the impact of capacity building activities

We set up the before-after-control-impact study using an open source household questionnaire, which can be easily downloaded onto android devices. The questionnaire has details of the methodological approach used. We hope that this can contribute to continuing this study and lend support to other similar studies.

1) Of the household heads participating in the end-line survey, 95% indicated that they would be happy to participate in future studies. In order to get a longer-term view of capacity building impacts, additional surveys could be conducted.
2) Other community-based conservation projects can use our methodological approach and survey (which can be easily adapted to suit different contexts through ODK). This will also enable a comparison of capacity building techniques between different community-based conservation projects.

ii) Further research into donor willingness to pay for community-based conservation

Further studies could exploring preferences for different conservation approaches among the public both in donor countries and in the countries where such conservation projects are conducted. The methodology presented within the choice experiment in Chapter 2 (allowing validation of the choice experiment results with a revealed preference approach) suggest how such research could be carried out. In addition varying the donation amounts at the zoo-entrance will allow further external validation of results.

iii) Further research into cooperation amongst wetland stakeholders

In addition to using the household survey, the game could also be validated using farmer field schools, where real neighbouring farmers could participate in the game. The game could also be used as a tool to facilitate discussions between NGOs and stakeholders in the intervention site, for example by dropping the treatments and having more focused group discussions post-playing.

6.4 Applications for CBC projects

Annually, billions of dollars are spent on community-based conservation projects (Brockington and Scholfield, 2010). Community-based conservation approaches have been adopted by many large scale NGOs and are at the forefront of conservation approaches in low-income countries (Blaikie, 2006). Despite its popularity there are multiple critiques of the community-based approach one of which is the lack of systematic evidence with attributes causal factors to their success or failure (Berkes, 2004; Garcia and Lescuyer, 2008; Nilsson *et al.*, 2016). In the introduction we highlighted three key main mechanisms used to engage communities in conservation activities identified by Nilsson *et al.* (2016): (i) providing economic value through conservation livelihoods; (ii) providing socio-economic benefits in return for conservation behaviour; (iii) providing communities' devolved authority over their natural resources. We explore how the results of this thesis contribute towards providing an evidence base for each of these key mechanisms.

(i) There is willingness for conservation supporters to fund social aspects of conservation projects

The overseas donor market for biodiversity conservation in low income countries represents approximately between 3% and 12% of total funding (Hein, Miller and de Groot, 2013) meaning public attitudes to what conservation projects should fund is important (Booth, Gaston and Armsworth, 2009). In the first data chapter in this thesis, we explored the extent to which donors were willing to pay for community aspects of conservation projects including the involvement of local communities in management and decision making and providing alternative livelihoods. Community-based conservation projects are often carried out by environmental organisations and their current donor register may be unaware of the social impacts of the conservation project.

We have shown there is significant potential to generate additional funding by emphasising the community side of conservation projects. Respondents showed the highest willingness to pay for projects that have local community involvement in management. Results of the simultaneous donation campaign showed that respondents were very willing to donate the suggested £1 or above donation (88% made a donation); however, there was no effect of which of the two campaigns they were exposed to (threatened species management or community involvement in management). This implies that clearly highlighting the extensive conservation

work (both species and community based) that goes on outside of the zoo could generate considerable funding from members of the zoo-visiting public.

(ii) Farmers work together for wetland conservation when they are allowed to communicate (better than when they are being paid).

Chapter 5 in this thesis uses a hypothetical game to explore the role of subsidies and communication in providing wetland ecosystem services across a multi-stakeholder landscape developed by Bell, Zhang and Nou (2016). As Bell *et al.* (2016) found, we noted that while payments in the form of subsidies for natural habitat increased the total amount of ecosystem services provided, the coordination of those activities were not as strong as when there was communication allowed. Cooperation is at the heart of the challenge of wetland conservation. Multiple farmers operate in a landscape where one farmer's strategy with respect to pesticide use has impact on the optimal strategy of others. While the results of this study may represent what may really be possible within a wetland ecosystem context, we show that as within other common pool resources games, local institutions may greatly encourage pro-environmental behaviours.

In theory, providing economic benefits is a mechanism by which participants can reason that the benefits outweigh any losses from a prohibited behaviour (Nilsson *et al.*, 2016). The most widely acknowledged intervention in this category are PES schemes, which have received considerable attention over the last two decades (Chan *et al.*, 2017). There are concerns, however, that payments may crowd-out intrinsic motivations to participate on conservation projects (Moros, Vélez and Corbera, 2017). Setting up local-institutions may go some way to improving wetland conservation, without having to rely on market-based mechanisms.

The positive response of the game to both of Durrell staff, and of the players have shown that the game developed by Bell, Zhang and Nou (2016) can also be used as a tool to facilitate communication between conservation projects and participating communities by promoting open and honest dialog about incentives and decision making.

(iii) *The measurement and building of capacity for co-management of natural resources must focus on multiple capitals.*

Multiple scholars have highlighted that devolved authority requires the building of community capacity to undertake management of natural resources (Chaskin, 2001; Wells *et al.*, 2004; Cavaye, 2008; Mizrahi, 2009). However there is limited quantitative evidence as to the

effectiveness of this approach (Whittle, Colgan and Rafferty, 2012; Nilsson *et al.*, 2016). The third and fourth data chapters in this thesis represent a first attempt at rigorously evaluating the impact of the effectiveness of community capacity building activities using a BACI design in a community-based management project. Community-based conservation projects sometimes actively seek to build community capacity (Chaskin, 2001; Wells *et al.*, 2004; Cavaye, 2008; Mizrahi, 2009; O'Connell *et al.*, 2017) by focusing on building community empowerment, promoting equal benefit distribution and developing the community's social network (Brooks, Waylen and Mulder, 2013; Calfucura, 2018).

Within Chapter 3, we have shown that capacity, as defined by the foundational capital assets of human, social, organisational and economic capitals, is multidimensional (Beckley *et al.*, 2008). We found that each capital asset was not highly correlated to one another implying that capacity building should target each of human, social, economic and organisational capitals separately. Our analysis also highlighted that within each foundational capital asset, the use of a single indicator for each capital may not be sufficient in exploring and measuring community capacity. This is contrary to other research that typically uses a single indicator to measure capital assets (Cinner *et al.*, 2015). By analysing poverty separately, we have also shown that capacity building activities cannot work in isolation of poverty reduction, as poverty is negatively associated with multiple capitals which are important for the capacity of communities to undertake co-management of natural resources.

By using the rationalised set of indicators developed in Chapter 3, Chapter 4 analysed the impact of capacity building activities for a community-based conservation project. While we found no evidence of impact in composite scores we did find that there were significant effects of the intervention positively enhancing external social networks; this may suggest improved ability for communities to engage with other external projects such as development projects. These chapters provide rigorous but tentative evidence that short-term capacity building programmes may not have a measurable impact on capacity across a wide community (after a short period of time) but may have specific impacts on certain targeted elements. This highlights the need for practitioners to have clear, measurable objectives that link actions to outcomes in capacity building projects.

Our analysis also highlighted that leaders within the intervention site were more likely than the general community to be members of a group governing environmental resources. This would potentially give them more access to training, knowledge and resources in the long-term as

identified in Bidaud *et al.*, 2017. While capacity building efforts need to be focused to ensure efficient use of limited resources, there also needs to be mechanisms in place to ensure diverse representation of the community within any devolved authority over natural resources.

6.5 Final summary

Community based conservation projects have been promoted as a way of achieving both conservation and development goals. There are multiple critiques of this approach which include the lack of evidence for its successes (or failures). Robust impact evaluations, are being increasingly used to build an evidence base of environmental and social impacts of environmental projects and practitioners are also turning to tools derived from economic disciplines to predict the potential impact of new conservation interventions. Throughout this thesis we used a combination of methods which rely on hypothetical scenarios (choice experiments and experimental games), and an evaluation of self-reported impacts measured using a quasi-experimental design.

We have shown that while there is tentative support for some impact of capacity building activities, this remains weak and requires more targeted actions to produce measurable impacts. We have also shown that devolution of power to local communities may put some conservation activities at risk to exploitation by local elites. We have used a behavioural experiment in the form of a wetland catchment game and shown that facilitation may go some way to improving ecosystem services in complex multi-stakeholder environments, implying that economic substitution is not the only incentive for pro-conservation behaviour. We have also highlighted a potentially un-tapped market by determining donors' values for community aspects of conservation projects.

Community-based methods continue to be the prevailing approach for nature conservation. The intention of this thesis is to contribute the growing evidence base to ensure the better design and evaluation of community-based conservation projects.

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8. Appendices

Appendix 2.1 Campaign details

Table A. Campaign dates during the choice experiment field experiemnt during August 2016.

Week	Date in August 2016	Campaign type
1	01 - 07	Community involvement in management
2	08 - 14	Threatened species populations
3	14 - 21	Community involvement in management
4	22 - 28	Threatened species populations

Table B. Respondents and total paying visitors to the Zoo based on ticket sales the four week experimental period in August 2016.

Ticket type	Paying visitors (%)	Respondents (%)
Student	533 (4.6%)	15 (6.2 %)
Adult	8097 (69.4%)	172 (70.4%)
Retired	3031 (26%)	57 (23.3%)
Total	11661	244

Data source: Durrell Wildlife Conservation Trusts and DCE survey 2016.

Appendix 2.2 Oral consent script and attribute explanation

Oral consent form

[To be used for Jersey Wildlife Park visitors. Consent form should be read out at the start of the exercise and consent recorded.]

Introduction to the Research:

We are researching how conservation projects can best deliver their conservation strategy and what donors perceive as priorities for the areas in which they work. We hope to conduct questionnaires with visitors to the wildlife park to understand if there are any differences based on people's socio-economic backgrounds. Households are under no obligation to participate in our research. This research is being conducted by an MSc and PhD student at Bangor University, Wales. We are working with several NGOs on this project; Wildfowl and Wetlands Trust (WWT) and Durrell Wildlife Conservation Trust (DWCT).

The interview will take about 30 mins but you are free to stop it at any time. Before we start we want to make sure that you understand the research we are doing and what we will do with the information we collect.

Oral Consent Script

1. Did we make things clear? Do you want to ask us any questions about the study?

2. We will keep all the information you give us confidential as far as the law allows. Any notes or recordings we make will be kept on a password-protected computer. We will not share your personal details or personal views with anyone else. Is that okay?

3. Some of the information you give us may be published, but your real name will not be used in relation to any of the information you have provided us, unless you tell us clearly that you want us to use your real name. Is that okay?

4. You should know that even though we will avoid including identifying information in any publication, there is still a possibility that people will recognise you by the things you say. If at any time you feel concerned about what you are saying being disclosed, please feel free to stop and talk to us about it. If you say something that you later think should be deleted from our discussion notes, just let us know. Is that clear?

5. If you mention anything you do not want us to publish, please say so and we will follow your request. Okay?

6. You can stop this interview at any time, without giving us any reason. Okay?

7. We would like to record this interview with a digital audio recorder. That way we can listen to the recording afterwards and catch things you say that we might not fully understand during the interview, or might otherwise forget. Only people in our study team will be able to listen to the recording. Do you give us permission to record?

8. [If appropriate] If you agree, we would like to take some photos. We might use these in presentations or publications about this project. Is this okay?

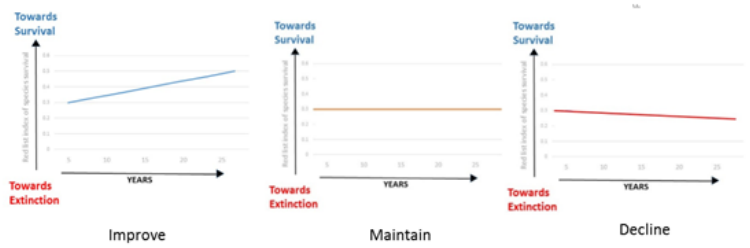
9. Do you have any further questions? Can we start the interview now?

Conservation Projects often vary their focus in several ways.

We would like you to consider four of these related to projects in Madagascar.

1) Threatened species populations.

The extent to which the conservation projects improves or maintains the populations of threatened species.



2) Community involvement in management.

The extent to which local people are trained and empowered to protect their local environment

3) Conservation sites

The extent to which the conservation project improves or maintains the condition of conservation sites.

4) Alternative livelihoods

The extent to which the conservation project invests in supporting alternative livelihoods for local communities living in and around conservation sites.

Donation

To support these campaigns these projects will require income from donors. This would be a one-off donation amount.

£0, £1, £5, £20 or £50

We would like you to consider how this would effect your household income as if you were giving a real donation of this amount

Figure A. Attribute explanation card.

This is a practice, each column represents a conservation project.

Which option do you prefer; A, B or None?

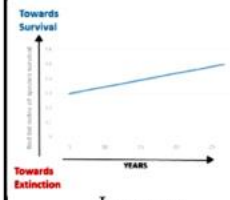
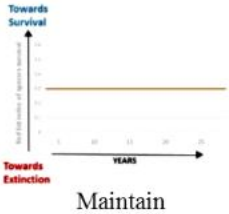
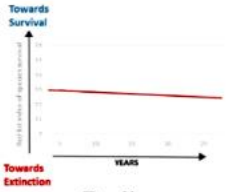
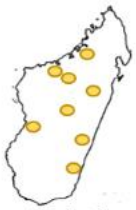
	Option A	Option B	None
Threatened species populations	 Improve	 Maintain	 Decline
Community involvement in management	 In few communities	 In many communities	 In no communities
Conservation sites in Madagascar	 Improve	 Maintain	 No conservation sites
Alternative livelihoods	 Significant investment	 Limited investment	X No investment
Your donation (one off)	£ 20	£1	£0

Figure B. Practice choice card.

Appendix 2.3 Further MIXL results

Table A. Results of the MIXL base model with all respondents

Attributes and Interactions	MIXL. Base model (S.E)
ASC	4.13 (0.444)***
Payment	-0.051 (0.004)***
Threatened species populations	0.608 (0.080)***
Conservation sites	0.270 (0.001)***
Alternative livelihoods	0.269 (0.076)***
Community involvement in management	0.655 (0.083)***
Log Likelihood	-972.31
AIC	1966.619
Observations	1505
Note: *** 1% significance level, ** 5% significance level, *10% significance level with two-tailed tests. The positive sign of the ASC shows that respondents prefer options that move away from the BAU scenario.	

Table B. Results of the MIXL model with socio- economic and marketing exposure interactions (standard error in parenthesis).

Attributes and Interactions	MIXL model with interactions (S.E)
ASC	4.07 (0.444)***
Payment	-0.05 (0.003)***
Threatened species populations	0.43 (0.143)**
Conservation sites	0.27 (0.076)***
Alternative livelihoods	0.30 (0.076)***
Community involvement in management	0.65 (0.082)***
Threatened species populations: education	0.30 (0.151)*
Threatened species populations: income	0.24 (0.151)
Threatened species populations: exposure to species campaign	-0.20 (0.146)
Log Likelihood	-968
AIC	1965
Observations	1505
Note: *** 1% significance level, ** 5% significance level, *10% significance level with two-tailed tests. Exposure was calculated based on the date the survey took place and which marketing campaign was running ("community involvement in management" or "threatened species management"). The positive sign of the ASC shows that respondents prefer options that move away from the BAU scenario.	

Table C. Results of the MIXL base model conducted only with the sample of respondents that gave a real donation during either marketing campaign.

Attributes and Interactions	MIXL Base model (S.E) with donators to either marketing campaign
ASC	2.490 (0.497)***
Payment	-0.113 (0.016)***
Threatened species populations	1.314 (0.307)***
Conservation sites	0.400 (0.224)
Alternative livelihoods	0.645 (0.234)**
Community involvement in management	0.839 (0.242)**
Log Likelihood	-177.59
AIC	377.19
Observations	318
Note: *** 1% significance level, ** 5% significance level, *10% significance level with two-tailed tests. Results from this model represent only those respondents that completed the choice experiment and that either donated or refused in the real campaigns. This is coded as 1 if donated to the community management campaign	

Appendix 3.1 Foundational capital assets details

Table A. This table shows: the foundational capital assets explored within this study; the indicators (derived from the literature review), relevant proposed capacity building activities (derived from project proposal), household questionnaire item (derived from the literature review and key informant interviews, more than one questionnaire item may have been developed as a result of this) and the name of the specific indicator measure used in the analysis (derived from the reduced PCA analysis).

Capital	Indicator	Capacity building interventions as part of the conservation programme*	Questions	Measures (bold indicates retained in analysis)
Human	Skills	Training on natural pesticide use Sustainable farming techniques	Have you or any member of your household received any agricultural training in the last THREE years? Specify by the training provider	**agri_train**
Human	Skills	Training on natural pesticide use Sustainable farming techniques	In the last two years have you or anyone in the household been given any training related to rice farming?	rice_train
Human	Skills	Livestock vaccination training Livestock husbandry techniques training	In the last two years have you or anyone in the household been given any training related to livestock farming?	livestock_train
Human	Skills	Training on biodiversity monitoring	In the last two years have you been involved in any community monitoring? Such as recording down birds, fish, papyrus, trees.	biodiv_train
Human	Knowledge	Environmental education	In the last two years have any children in your household been taught about the environment in school? (Such as playing games about wildlife)	Env_edu
Human	Knowledge		What is the highest level of education achieved by this household?	**head**
Human	Leadership		Community leaders motivate all the groups living in my community.	**Lead_motiv**
Human	Leadership		My community's leaders does a good job of informing residents about community issues.	**lead_inform**
Human	Motivation		In my village, the people look after the environment.	**Hum_pos**
Human	Motivation		In my village people sometimes damage the environment.	**Hum_neg**
Human	Motivation	Environmental education	My community is committed to protecting water resources.	community_protect_water
Human	Motivation	Environmental education	My community is committed to protecting other natural resources.	**community_protect_nature**

Human	Attitudes	Training on natural pesticide use Sustainable farming techniques Environmental education	Water quality can be improved if people change their farming practices	**WQ**
Human	Attitudes	Training on natural pesticide use Sustainable farming techniques Environmental education	Which practices should they improve?	wq_ek
Human	Attitudes	Environmental education	Burning forests improve the livelihoods of local people	**forest_invert**
Human	Attitudes	Environmental education Engage fishers to become a fishing group	We should catch the fish in the lake, no matter what size the fish is.	**fish_invert**
Human	Attitudes	Environmental education	Converting the marsh to agriculture improves the livelihoods of local people	**marsh_invert**
Human (Poverty)	Health		Have any children in your household died in the last 5 years?	**child_mort_invert**
Human (Poverty)	Living Standard		What is the household source of drinking water?	hh_water_invert
Human (Poverty)	Living Standard		What sanitary facilities does the household have access to?	**san_fac**
Human (Poverty)	Living Standard		What kind of light do you use in the house?	**light_highest**
Human (Poverty)	Living Standard		What material is used for the roof?	**roof**
Human (Poverty)	Living Standard		What material is used for the floor?	floor
Human (Poverty)	Living Standard		Does the household own any of the following?	**common_assets**
Human (Poverty)	Living Standard		Does the household own any of the following?	**uncommon_assets**
Human (Poverty)	Health		How many months did your household NOT have enough to eat normally throughout the year?	**sum_food_sec_lastyr_invert**
Human (Poverty)	Health		How many months did your household NOT have enough to eat during the last farming year?	sum_food_sec_normal_invert
Human (Poverty)	Health		Is there any problems with getting healthcare for your household?	**health_access_dummy_invert**
Human (Poverty)	Health		Why would you not be able to access health care? [select all that apply]	count_health_access_probs_invert

Social capital (Bonding)	Social Network (community)	Community meetings of project Formally establish local environment group, management transfer	If there was an environmental problem in my community (such as poor water quality, loss of firewood resources, and loss of papyrus), who would you work with to try to solve it?	**env_help_bond**
Social capital (Bonding)	Social Network (community)	Creation of supportive parent groups	Suppose a family in the village were impacted by an extreme event, such as crop failure. Who do you think they could turn to for help?	community_help_bond
Social capital (Bonding)	Collaboration (within community)	Meetings with fisher groups Meeting with local environment groups Formally establish local environment group, management transfer	Is anyone is the household part of the following community based group?	**sum_community_groups**
Social capital (Bonding)	Collaboration (within community)	NGO- community meetings of project	My community shares the same values of what is right and wrong.	**community_values**
Social capital (Bonding)	Collaboration (within community)	Formally establish local environment group, management transfer	I believe the decision making processes in my community are fair.	**fair_descisions_within_community**
Social capital (Bonding)	Collaboration (within community)	Formally establish local environment group, management transfer	The people who are most affected by community-level decisions are included in the decision making.	**inclusive_descisions**
Social capital (Bonding)	Communication	Meetings with fisher groups Meeting with local environment groups Formally establish local environment group, management transfer	The community is good at informing each other about important issues	**inform_each**
Social capital (Bonding)	Trust	Meetings with fisher groups Meeting with local environment groups Formally establish local environment group, management transfer	I am generally trusting when working with my own community.	**trust_own_community**
Social capital (Bridging)	Social Network (beyond community)	Teaching on how to work with government NGO meetings with fisher groups NGO with local environment groups	If there was an environmental problem in my community (such as poor water quality, loss of firewood resources, and loss of papyrus), who would you work with to try to solve it?	**env_help_bond**

Social capital (Bridging)	Social Network (beyond community)	Teaching on how to work with government	Suppose a family in the village were impacted by an extreme event, such as crop failure. Who do you think they could turn to for help?	community_help_bond
Social capital (Bridging)	Collaboration (beyond community)	Formally establish local environment group, management transfer	My community regularly works with other communities to solve problems.	other_community_working
Social capital (Bridging)	Collaboration (beyond community)	Teaching on how to work with government	My community regularly works with the government	work_with_gov
Social capital (Bridging)	Collaboration (beyond community)	Formally establish local environment group, management transfer Engage fishers to become a fishing group	My community regularly works with the NGOs to benefit the environment	**work_with_ngos**
Social capital (Bridging)	Collaboration (beyond community)	NGO meetings with fisher groups NGO with local environment groups NGO- community meetings of project Formally establish local environment group, management transfer Engage fishers to become a fishing group	When there is a project in my community working with external organisations such as NGOs everyone is encourage to participate (e.g. wealthy or poor, male or female, old or young) and not just an elite few. [if they do not work with NGOs etc. leave blank]	**external_inclusivenesss**
Social capital (Bridging)	Collaboration	NGO meetings with fisher groups NGO with local environment groups NGO- community meetings of project Formally establish local environment group, management transfer Engage fishers to become a fishing group	I believe the decision making processes between my communities and external agencies are fair	**external_fair_descision**
Social capital (Bridging)	Communication	Formally establish local environment group, management transfer Engage fishers to become a fishing group	Between my community and other communities there is regular communication or meetings to allow us to share information.	**other_community_comms**

Social capital (Bridging)	Communication	NGO meetings with fisher groups NGO with local environment groups NGO- community meetings of project Formally establish local environment group, management transfer Engage fishers to become a fishing group	Between my community and external organisations there is regular communication or meetings to allow us to share information	**external_communication**
Social capital (Bridging)	Trust	Formally establish local environment group, management transfer Engage fishers to become a fishing group	I am generally trusting of when working with other communities to solve problems.	**community.trust**
Social capital (Bridging)	Trust	Formally establish local environment group, management transfer Engage fishers to become a fishing group	Working with the government benefits the local area and community	**gov_benefits_community**
Social capital (Bridging)	Trust	Formally establish local environment group, management transfer	I am generally trusting of external agencies such as government.	**trust_external_gov**
Social capital (Bridging)	Trust	NGO meetings with fisher groups NGO with local environment groups NGO- community meetings of project Formally establish local environment group, management transfer Engage fishers to become a fishing group	I am generally trusting of external agencies such as NGOs.	**trust_ngo**
Organisational Capital	Goals	Formally establish local environment group, management transfer Engage fishers to become a fishing group Decide and define no take zone	As a community we are good at identifying the problems and needs in our area.	**id_needs_problems**
Organisational Capital	Goals	NGO meetings with fisher groups NGO with local environment groups NGO- community meetings of project Formally establish local environment group, management transfer	As a community we share the same goals for maintaining the natural environment	**shared_goals_env**

		Engage fishers to become a fishing group		
Organisational Capital	Governance structures	Teaching on how to vote, take minutes collect membership money & fines Formally establish local environment group, management transfer Engage fishers to become a fishing group	Within the community there is good compliance with institutions that govern natural resources.	**community_compliance_env_governance**
Organisational Capital	Governance structures	Formally establish local environment group, management transfer Engage fishers to become a fishing group	Is anyone is the household part of a group governing natural resources? [specify]	**environmental_group_governance_dummy**
Organisational Capital	Governance structures	NGO meetings with fisher groups NGO with local environment groups NGO- community meetings of project Formally establish local environment group, management transfer Engage fishers to become a fishing group	Last year, how often have you met with other members of this village to discuss resolving common problems?	meetings_community_probs
Organisational Capital	Governance structures	NGO meetings with fisher groups NGO with local environment groups NGO- community meetings of project Formally establish local environment group, management transfer Engage fishers to become a fishing group	In the last two years have you or anyone in the household attended a meeting related to the local environment (the forest, the lake, the hills)?	meetings_env_probs
	Responsibilities	Formally establish local environment group, management transfer Engage fishers to become a fishing group Teaching on how to vote, take minutes collect membership money & fines	When we need to work together people in my community are happy to take on responsibilities for the project.	**responsibilities**
Economic Capital	Municipal infrastructure	Building primary schools Building fishing platform	Does the village have any of the following?	**sum.vill.items**

	Resources	Membership and fines to local environment group & bank account establishment	As a community we are able to deal with any changes in the environment (loss of firewood, papyrus, water quality for fishing and drinking) [yes/ No]	**comm_env_change**
	Resources (finance)	Membership and fines to local environment group & bank account establishment	(why not, finance)	**deal_wchange_finance**
	Resources (equipment)	Provide equipment to fishing groups Provision of new farming equipment	(why not, equipment)	deal_wchange_equip
	Employment		What is the household head's main occupation?	**farmer_dummy**
*Source: Interview with Felix Razafindrajao, project manager and Darwin initiative project proposal				

Appendix 3.2: Survey Materials

Below is a link to the household capacity survey administered in Madagascar during 2015 and 2017. The form is freely downloadable and can be added to an ODK system on any android device.

http://formhub.redcross.org/forms/99e8403bfc9440e68c4016be11f21fda.

Appendix 3.3: Oral consent form used in the household survey

ORAL CONSENT FORM

[To be used for groups of community members participating in household interviews where informants are not literate or not comfortable with written consent forms. Consent form should be read out –or explained in a less formal way -at the start of the exercise and consent recorded on a Dictaphone or witnessed by another researcher.]

Introduction to the Research:

Thank you for your interest in the project. This document covers an outline of the research being conducted and also my contact details if you would like further information.

My name is Amy Lewis, a PhD student from the University of Bangor and I am collaborating with Danielysa Razafindramavo from Mahajunga University in Madagascar. Together, we are researching how households and communities work to solve collective problems. We would like to understand how the community works with NGOs and other external agencies to deliver both environmental benefits as well as benefits to local people.

We hope to conduct questionnaires with households in several fokontany to understand if there are differences in how people work together. Households are under no obligation to participate in our research. We will also be conducting interviews with different NGO managers to understand how they incorporate the views of local individuals as well as how they benefit local livelihoods and conservation.

We are working with several NGOs on this project; Wildfowl and Wetlands Trust (WWT) and Durrell Wildlife Conservation Trust (DWCT).

We would like to ask some questions about your household and the community that you live in.

The survey should take approximately 1 hour but you are free to leave at any time. Before we start we want to make sure that you understand the research we are doing and what we will do with the information we collect.

Is everything clear so far? We want to explain a few things:

1. We will keep all the information you give us confidential. We will not share your personal details or personal views with anyone else.

2. Some of the information you give us may be published, but your real name will not be used in relation to any of the information you have provided us, unless you tell us clearly that you want us to use your real name.

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5. You can stop this discussion at any time, without giving us any reason.

6. We may like to record this discussion with a digital audio recorder. That way we can listen to the recording afterwards and catch things you say that we might not fully understand during the discussion, or might otherwise forget. Only people in our study team will be able to listen to the recording. Do you give us permission to record?

7. [If appropriate] If you agree, we would like to take some photos. We might use these in presentations or publications about this project.

8. Do you have any further questions? Can we start the discussion now?

Appendix 3.4: Scree plot for pooled PCA

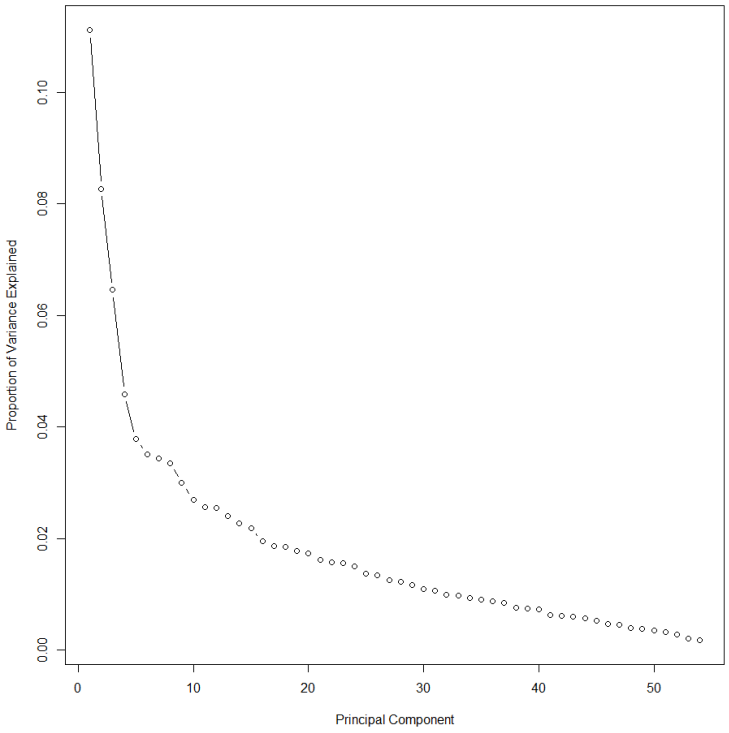

Figure A. Scree plot of full PCA. In total 57 indicators were included into the pooled principal component analysis. This indicates a 4-component solution.

Appendix 3.5. Scree plots for original capital indicators

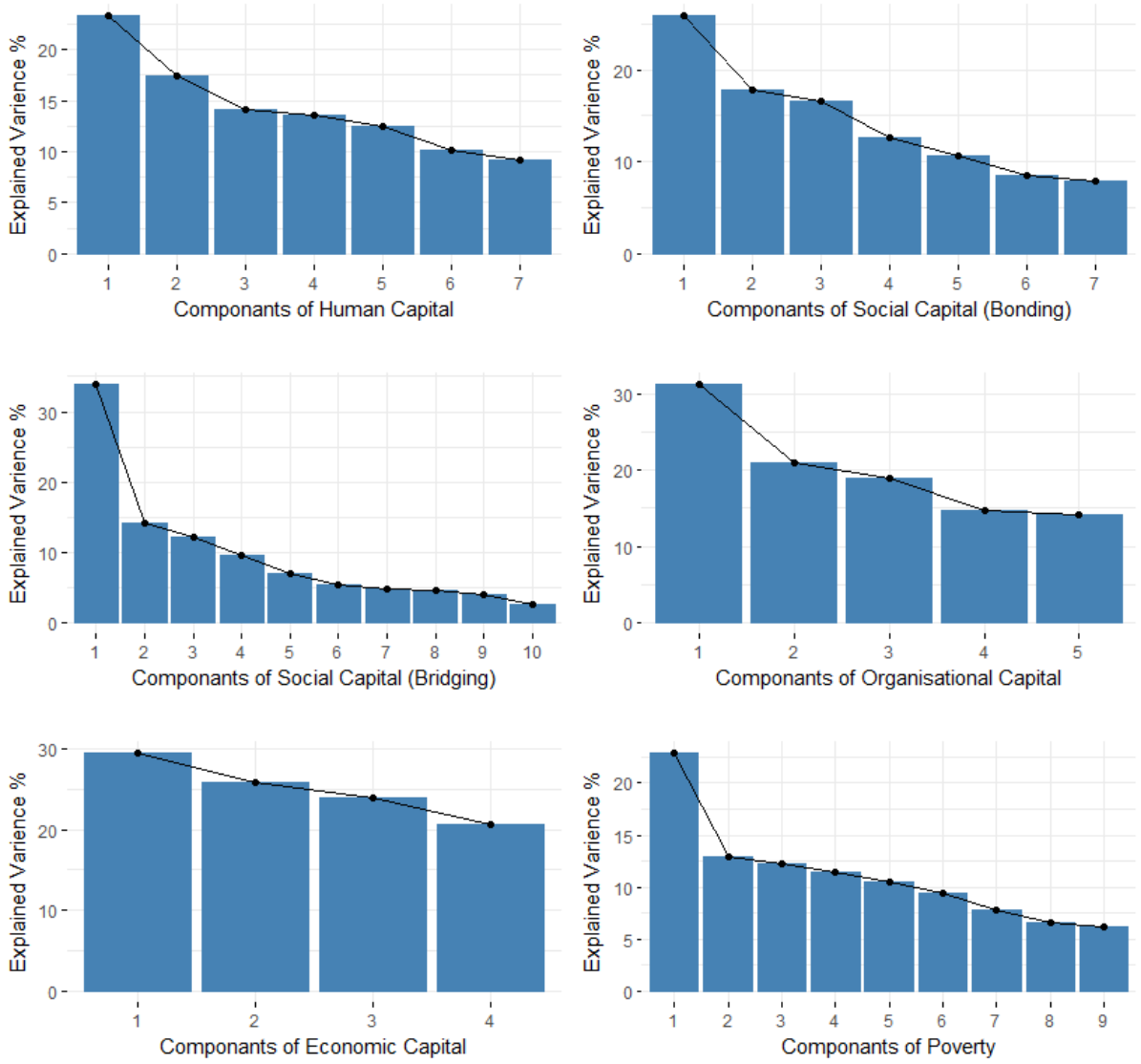

Figure A. Scree plots for the PCAs on each foundational capital asset and poverty. All indicate a 2 component solution.

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Introduction to the Research:

Thank you for your interest in the project. This document covers an outline of the research being conducted and also my contact details if you would like further information.

My name is Amy Lewis, a PhD student from the University of Bangor and I am collaborating with Danielysa Razafindramavo from Mahajunga University in Madagascar. Together, we are researching how households and communities work to solve collective problems. We would like to understand how the community works with NGOs and other external agencies to deliver both environmental benefits as well as benefits to local people.

We hope to conduct questionnaires with households in several fokontany to understand if there are differences in how people work together. Households are under no obligation to participate in our research. We will also be conducting interviews with different NGO managers to understand how they incorporate the views of local individuals as well as how they benefit local livelihoods and conservation.

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7. [If appropriate] If you agree, we would like to take some photos. We might use these in presentations or publications about this project.

8. Do you have any further questions? Can we start the discussion now?

Appendix 4.3: Model selection for component scores (PC1 & PC2)

Table A. Model selection table for each foundational capital asset for the 1st principal component scores: (a) Human capital (b) Social Capital: Bonding (c) Social Capital: Bridging (d) Organisational Capital (e) Economic Capital. The top four models for each selection are presented. Final selected model is in bold case and included variables are indicated by "YES" and shading.

(a) Human Capital (PC1)

		Explanatory variables						Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male headed household	Leader	Number of children	Random term	Df	LogLik	AICc	ΔAICc
A1	YES		YES				Fokontany	4	-229.833	468.0	0.00
A2	YES	YES	YES				Fokontany	5	-229.311	469.1	1.14
A3	YES		YES	YES			Fokontany	5	-229.517	469.6	1.55
A4	**YES**	**YES**	**YES**	**YES**			**Fokontany**	**6**	**-229.617**	**470.0**	**1.97**

(b) Social Capital: Bonding (PC1)

		Explanatory variables						Model properties			
Model name (selected model in bold)	Intercept	Intervention site	Poverty score in 2015	Male headed household	Leader	Number of children	Random term	Df	LogLik	AICc	ΔAICc
B1	YES		YES				Fokontany	4	-236.607	481.6	0.00
B2	**YES**	**YES**	**YES**				**Fokontany**	**5**	**-235.775**	**482.1**	**0.51**
B3	YES		YES	YES			Fokontany	5	-236.010	482.5	0.98
B4	YES		YES		YES		Fokontany	5	-235.427	483.40	1.85

(c) Social Capital: Bridging (PC1)

		Explanatory variables						Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male headed household	Leader	Number of children	Random term	Df	LogLik	AICc	ΔAICc
C1	YES			YES			Fokontany	4	-298.800	605.9	0.00
C2	YES			YES	YES		Fokontany	4	-299.264	607.1	1.11
C3	YES		YES				Fokontany	5	-298.405	607.2	1.21
C4	**YES**	**YES**		**YES**			**Fokontany**	**4**	**-298.380**	**607.3**	**1.34**

(d) Organisational Capital (PC1)											
		Explanatory variables						Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male headed household	Leader	Number of children	Random term	Df	LogLik	AICc	ΔAICc
D1	YES					YES	Fokontany	4	-264.037	536.4	0.00
D2	YES			YES			Fokontany	4	-264.247	536.8	0.42
D3	**YES**			**YES**		**YES**	**Fokontany**	**5**	**-263.366**	**537.3**	**0.84**
D4	YES				YES	YES	Fokontany	5	-263.667	537.9	1.44
(e) Economic Capital (PC1)											
		Explanatory variables						Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male headed household	Leader	Number of children	Random term	Df	LogLik	AICc	ΔAICc
E1	YES				YES		Fokontany	3	-233.847	476.0	0.00
E2	**YES**	**YES**			**YES**		**Fokontany**	**4**	**-233.250**	**477.0**	**0.90**
E3	YES	YES					Fokontany	4	-234.426	477.2	1.16
E4	YES		YES		YES		Fokontany	4	-233.615	477.8	1.71

Table B. Model selection table for each foundational capital asset for the 2nd principal component scores: (a) Human capital (b) Social Capital: Bonding (c) Social Capital: Bridging (d) Organisational Capital (e) Economic Capital. The top four models for each selection are presented. Final selected model is in bold case and included variables are indicated by "YES" and shading.

(a) Human Capital (PC2)											
		Explanatory variables						Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male headed household	Household size	Number of children	Random term	Df	LogLik	AICc	ΔAICc
A1	YES		YES	YES	YES		Fokontany	6	-229.199	471.1	0.00
A2	YES			YES		YES	Fokontany	5	-230.792	472.1	0.97
A3	YES			YES	YES		Fokontany	5	-230.822	472.2	1.03
A4	YES						Fokontany	3	-233.102	472.4	1.27
(b) Social Capital: Bonding (PC2)											
		Explanatory variables						Model properties			
Model name (selected model in bold)	Intercept	Intervention site	Poverty score in 2015	Male headed household	Household size	Number of children	Random term	Df	LogLik	AICc	ΔAICc
B1	YES						Fokontany	3	-236.648	479.5	0.00
B2	YES			YES			Fokontany	4	-236.117	480.6	1.08
NA											
NA											
(c) Social Capital: Bridging (PC2)											
		Explanatory variables						Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male headed household	Leader	Number of children	Random term	Df	LogLik	AICc	ΔAICc
C1	YES				YES		Fokontany	4	-267.683	543.7	0.00
C2	YES			YES	YES		Fokontany	5	-266.929	544.4	0.67
C3	YES						Fokontany	3	-269.285	544.8	1.06
C4	YES	YES			YES		Fokontany	5	-267.253	545.0	1.32

(d) Organisational Capital (PC2)											
		Explanatory variables						Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male headed household	Leader	Number of children	Random term	Df	LogLik	AICc	ΔAICc
D1	YES		YES				Fokontany	4	-241.417	491.2	0.333
D2	YES						Fokontany	3	-242.641	491.5	0.285
D3	YES	YES	YES				Fokontany	5	-241.220	493.0	0.136
D4	YES	YES					Fokontany	4	-242.414	493.2	0.123
(e) Economic Capital (PC2)											
		Explanatory variables						Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male headed household	Household size	Number of children	Random term	Df	LogLik	AICc	ΔAICc
E1	YES				YES		Fokontany	4	-235.666	479.7	0.00
E2	YES						Fokontany	3	-236.872	479.9	0.27
E3	YES	YES					Fokontany	4	-236.294	480.9	1.26
E4	YES			YES			Fokontany	4	-236.311	481.0	1.29

Appendix 4.4 Model selection for LME individual indicators

Table A. Model selection table for individual indicators: (a) Bonding social networks for environmental help (within community) (b) Bridging social network for environmental help (external agents) (c) Trust in NGOs (d) Membership of environmental groups. The top four models for each selection are presented. Final selected model is in bold case and included variables are indicated by "YES" and shading.

(a|) Bonding social networks for environmental help										
		Explanatory variables					Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male household	Leader	Random term	Df	LogLik	AICc	ΔAICc
A1	**YES**			**YES**		**Fokontany**	**4**	**-14.246**	**39.2**	**2.88**
A2	YES				YES	Fokontany	4	-14.795	40.3	3.97
A3	YES	YES				Fokontany	4	-14.812	40.3	4.01
A4	YES		YES			Fokontany	4	-15.215	41.1	4.81
(b) Bridging social network for environmental help (external agents)										
		Explanatory variables					Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male household	Leader	Random term	Df	LogLik	AICc	ΔAICc
B1	YES	YES				Fokontany	4	-16.822	44.3	0.62
B2	**YES**	**YES**		**YES**		**Fokontany**	**5**	**-15.614**	**45.5**	**1.83**
B3	YES			YES		Fokontany	4	-17.835	46.3	2.65
B4	YES				YES	Fokontany	4	-17.957	46.6	2.89
(c) Trust NGOs										
		Explanatory variables					Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male household	Leader	Random term	Df	LogLik	AICc	ΔAICc
C1	YES				YES	Fokontany	4	-47.364	105.4	0.00
C2	YES			YES		Fokontany	4	-47.403	105.5	0.08
C3	YES			YES	YES	Fokontany	5	-45.647	105.6	0.18
C4	**YES**	**YES**		**YES**		**Fokontany**	**5**	**-49.104**	**105.7**	**0.31**
(d) Membership of environmental group										
		Explanatory variables					Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male household	Leader	Random term	Df	LogLik	AICc	ΔAICc
D1	YES				YES	Fokontany	4	-16.674	44.0	0.00
D2	YES	YES			YES	Fokontany	5	-16.244	46.8	2.76
D3	**YES**			**YES**	**YES**	**Fokontany**	**5**	**-16.441**	**47.2**	**3.15**
D4	YES	YES				Fokontany	4	-18.494	47.7	3.64

(e) Trust within community										
		Explanatory variables					Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male household	Leader	Random term	Df	LogLik	AICc	ΔAICc
E1	YES		YES			Fokontany	4	-41.462	93.6	0.00
E2	**YES**		**YES**	**YES**	**YES**	**Fokontany**	**6**	**-37.687**	**93.8**	**0.25**
E3	YES		YES	YES		Fokontany	5	-39.819	93.9	0.33
E4	YES			YES	YES	Fokontany	5	-39.924	94.1	0.54
(f) Agricultural training										
		Explanatory variables					Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male household	Leader	Random term	Df	LogLik	AICc	ΔAICc
B1	**YES**			**YES**		**Fokontany**	**4**	**-27.292**	**65.3**	**2.08**
B2	YES				YES	Fokontany	4	-27.493	65.7	2.48
B3	YES	YES				Fokontany	4	-27.726	66.1	2.95
B4	YES		YES			Fokontany	4	-27.980	66.6	3.45
(g) Resources for environmental work										
		Explanatory variables					Model properties			
Model name	Intercept	Intervention site	Poverty score in 2015	Male household	Leader	Random term	Df	LogLik	AICc	ΔAICc
C1	**YES**	**YES**				**Fokontany**	**4**	**-10.077**	**30.8**	**1.80**
C2	YES			YES		Fokontany	4	-11.191	33.0	4.02
C3	YES				YES	Fokontany	4	-11.296	33.3	4.24
C4	YES	YES		YES		Fokontany	5	-9.898	34.1	5.06

Appendix 5.1 Semi-structured interview questions for farmers.

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Semi structured interview questions for farm-inputs.

Survey Information

Activity/Task	Date	Start time	End time	Person(s) Responsible	Remarks
Interview					
Checking Questionnaire					
Coding Questionnaire					
Data Entry					
Checking and Approving Data Entry					

Has the respondent/household given oral consent? [ ] YES [ ] NO

A. Identification

Name	
Age	
Sex	
Fokotany	
Village	_____ *years*
What is your role within the community? Are you yourself a farmer? How much land/ how many fields do you have?	

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Semi structured interview questions farm-inputs.

Understand input (fertilizers/ pesticide) types/ quantities to rice fields	
1. What fertilizer being used on your farm? NAME/ BRAND	
A. How much is used per year?	
B. What is it used for [and which crops]?	
C. How much does it cost (per kg/ per sachet)?	
D. Do you think this is typical of farming in your community? If not, how does it differ?	
E. How has the use of this changed over time?	
F. What are the positives and negatives to your field?	
G. Has it changed your yield? By how much?	
H. What are the positives and negatives to neigh-bouring fields & other areas?	
2. What pesticide being used on your farm? NAME/ BRAND	
A. How much is used per year?	
B. What is it used for [and which crops]?	
C. How much does it cost (per kg/ per sachet)?	
D. Do you think this is typical of farming in your community? If not, how does it differ?	
E. How has the use of this changed over time?	
F. What are the positives and negatives to your field?	
G. Has it changed your yield? By how much?	
H. What are the positives and negatives to neigh-bouring fields & other areas?	

Semi structured interview questions farm-inputs.

Birds and Agriculture	
1. How do domestic birds affect agriculture in Sofia?	
A. What are the benefits?	
B. What is negatively impacted?	
C. has there been a change over time in the number?	
[if yes] What has caused this?	
D. What would happen if there was an increase?	
E. What would happen if there was a decrease?	
1. How do wild birds affect agriculture in Sofia?	
A. What are the benefits?	
B. What is negatively impacted?	
C. has there been a change over time in the number?	
[if yes] What has caused this?	
D. What would happen if there was an increase?	
E. What would happen if there was a decrease?	

Appendix 5.2: Oral consent form used in the household survey

Oral consent form

[To be used for groups of community members participating in household interviews where informants are not literate or not comfortable with written consent forms. Consent form should be read out –or explained in a less formal way -at the start of the exercise and consent recorded on a Dictaphone or witnessed by another researcher.]

Introduction to the Research:

Thank you for your interest in the project. This document covers an outline of the research being conducted and also my contact details if you would like further information.

My name is Amy Lewis, a PhD student from the University of Bangor and I am collaborating with Danielysa Razafindramavo from Mahajunga University in Madagascar. Together, we are researching how households and communities work to solve collective problems. We would like to understand how the community works with NGOs and other external agencies to deliver both environmental benefits as well as benefits to local people.

We hope to conduct questionnaires with households in several fokontany to understand if there are differences in how people work together. Households are under no obligation to participate in our research. We will also be conducting interviews with different NGO managers to understand how they incorporate the views of local individuals as well as how they benefit local livelihoods and conservation.

We are working with several NGOs on this project; Wildfowl and Wetlands Trust (WWT) and Durrell Wildlife Conservation Trust (DWCT).

We would like to ask some questions about your household and the community that you live in.

The survey should take approximately 1 hour but you are free to leave at any time. Before we start we want to make sure that you understand the research we are doing and what we will do with the information we collect.

Is everything clear so far? We want to explain a few things:

1. We will keep all the information you give us confidential. We will not share your personal details or personal views with anyone else.

2. Some of the information you give us may be published, but your real name will not be used in relation to any of the information you have provided us, unless you tell us clearly that you want us to use your real name.

3. You should know that even though we will avoid including identifying information in any publication, there is still a possibility that people will recognise you by the things you say. If at any time you feel concerned about what you are saying being disclosed, please feel free to stop and talk to us about it.

4. If you mention anything you do not want us to publish, please say so and we will follow your request.

5. You can stop this discussion at any time, without giving us any reason.

6. We may like to record this discussion with a digital audio recorder. That way we can listen to the recording afterwards and catch things you say that we might not fully understand during the discussion, or might otherwise forget. Only people in our study team will be able to listen to the recording. Do you give us permission to record?

7. [If appropriate] If you agree, we would like to take some photos. We might use these in presentations or publications about this project.

8. Do you have any further questions? Can we start the discussion now?

Appendix 5.3 Details of model variables

Table A: Summary of all variables considered in the models, their description and calculation.

Level	Response variable	Calculation
Landscape	ES provision within the game landscape	(∑ Habi cells in landscape)
Landscape	Heavy spraying across the game landscape	∑ HS cells in landscape
Landscape	Co-ordination of ES provision across the game landscape.	(∑ individuals shared benefits to neighbours / number of Habitat cells placed)/ max potential score
Game	Round	Integer, round number
Game	Round 2	Integer, round number squared
Game	Intervention site	Households within intervention site = 1
Group	Mean household head education	∑ Years in education for all players / 4
Group	Number of players that are environmental group members	∑ of dummy variable for membership to environmental group (1= member)
Group	Mean age	∑ age of all group players/ 4
Group	Mean number of children	∑ children of all group players/ 4
Group	Number of players that received rice training	∑ children of all group players/ 4
Group	Mean annual pesticide use	
Individual	Intended cooperative behaviour: Individual shared ES efficiency	An individuals shared benefits to neighbours / number of habitat cells placed
Individual	Intended non-cooperative behaviour: Individual cancelled habitat benefits	∑ of affected cells on neighbouring land due to border placement of HS cells
Individual	Sex	Gender of respondent (dummy coded 1=male)
Individual	Age	Integer
Individual	Number of children	Integer
Individual	Household head education	Years in education, integer
Individual	Member of an environmental group	Dummy variable 1= membership
Individual	Received rice training	Dummy variable 1= training received
Individual	Annual pesticide use	Integer

Appendix 5.4 Summary of key informant interviews on pesticide use in Lac Sofia

i) Overview

The vast majority of farmers are subsistence rice farming in the Lac Sofia catchment, which is the staple crop for them and their families. There is a fear that without using pesticides this would have massive consequences on their harvest. We conducted key informant interviews to gain a greater understanding of the history of use of pesticides within the catchment.

ii) Methods

Interviews were conducted during December 2016 by AL and LA in Tsimihety dialect with 21 individuals in the 9 Fokontany surrounding Lac Sofia. Interviewees included Fokontany presidents, village elders and women's group leaders we also conducted interviews with local shop keeps and shopkeepers within the nearest market town, Antafiandakana, shop data were collected by LA and research assistants.

iii) Extent of pesticide use

The majority of people did not recognise the word pesticide but called it "*D6*", however we did not find any bottles labelled this, though we understand it may have been one of the first pesticides used in the region. D6 has therefore become synonymous with any pesticide used. There's only one shop in the catchment selling pesticide (Cyborg and Agrimatrine) but they only stock 2L and sell it 1cc at a time mostly for tomatoes, most people go to Bealanana or to Ambatoriha (the nearest market towns) to buy for the rice fields (as this is significantly cheaper than buying by the cc).

The majority of interviewees said they used about 0.25l Ha on average in rice fields[4], spraying 1-2 times per year costing around 10,000 ariary (equivalent to approx. 3.03 USD). Respondents' estimates for extent of usage ranged from "all" to half of people in their fokontany using pesticides. This implies a range of between 500l to 2000l yr^{-1} in the catchment based on the number of households, and the previous socio-economic survey conducted in 2014. The majority had started using pesticide about 3-6 years ago, with only 1 person saying longer "since [the year] 2000". Details from shop keepers estimates that pesticides have been stocked between 2002- 2010.

[4] We didn't measure out fields, this is based on respondent's estimation of acreage

iv) Motivations to use pesticides

Almost all users of pesticides had been recommended it by friends and neighbours. Prior to this most people used natural based pesticides such as chilli, citronelle or manasebe and draining/ re-flooding the land (but "*D6 is quicker*"). Key pests include: Mavebe, Sabaka, sababaka vopangeto, zazavery. When asked what would happen if someone didn't use it, most people feared that there would be negative consequences on crops:

"... All the insects would go to that [pesticide free] *land"*

"... [The insects would] *eat all the rice".*

Respondents' perception of the positive effects of using pesticides had a wide range. They reported yield increases of between 5-300% before and after pesticide use (based on number of bidons collected before and after using pesticide). There is not enough data to ground truth these claims, but it is interesting to hear what people think the benefits are. Many also mentioned that there were nutritional benefits to the crops:

"...Vitamins [in the pesticide bottles] *makes the rice strong".*

v) Perception of wider socio-environmental impacts

Approximately half of respondents perceived negative consequences to using synthetic pesticides, identifying the wider environmental impacts of killing beneficial insects which provide ecosystem services to the farmers:

"... D6 dries the soil because the D6 kills the useful insects like kankana [worms] *which muddy the soil, after we use D6 the kankana are dead and the soil is dry"*

"[D6 in water is] *bad because all dead including useful insects like sikobona and fish and worms, because they don't eat the rice they are just inoffensive… but people eat the fish"*

Some also identified negative consequences for neighbouring farmers:

"The chemical can go to the neighbour, because the smell is strong, D6 goes in the water. … [it's a] *problem because it can kill all the insects in the water... bad insects… fish and useful insects"*

"it destroys the soil, the useful insects, if neighbours use [D6], *it will destroys my soil insects"*

vi) Data from local shops

We also collected data on stocks in shops (n=3) in Ambatoriha (we did not have time to get this info from Bealanana). Akito-B seems to be the most common, there's a few entrepreneurs that bring multiple bottles back and sell in their fokontany. Some people also hire someone to spray the land for them, but do not know what chemical they use.

Sales data implies that in 2015: between 1-50l month^{-1} shop^{-1} was sold between September and October; 10-100l month^{-1} shop^{-1} in November to March; and 5-50l month^{-1} shop^{-1} from April to August. One shop stated that they sold over 1,000l per year.

Table X: A summary of the names of insecticides found in homes in Lac Sofia region, and those stocked in shops in the nearest market town (selling to multiple catchments).

Found in houses	Stocked in shops ***
Agrimatrine	Agrimatrine
Akito-B	Akito-B
Cyborg	Deltagri
Cyperol	Dimethobex
Spermatrine	Mathil-Dimex
	Mortak
	Novos
	Pyribex
	Tamega-topcarb

** Nb. Those stocked in shops do not necessarily get sprayed in the Lac Sofia catchment as this is a market town for several other catchments.

vii) Additional chemical use

We also found evidence that in 2008 a chemical was used to kill a rice eating bird called the fody *(Foudia madagascariensis).* The chemical is now banned within Madagascar and respondents noted that their domestic birds died. A source noted that it was still possible to buy this on the black market.

Appendix 5.5: Landscape level models

Table A. Full Linear mixed effects models for the landscape level. This shows treatment effects on several land-use decision response variables: ecosystem service provision across the landscape, ecosystem service coordination and amount of heavy pesticide in the game landscape as a non-cooperative behaviour. Mean group level characteristics are also included as explanatory variables.

		ES provision	**ES coordination**	**Heavy pesticide**
Game level attributes	Intercept	-1.442 (0.205)***	-0.410 (0.283)	-3.332 (0.674)***
	Subsidy	0.057 (0.003)***	0.021 (0.004)***	-0.048 (0.006)***
	Communication	0.008 (0.017)	0.084 (0.022)***	-0.221 (0.029)***
	Subsidy * Communication	0.019 (0.004)***	-0.001 (0.006)	0.008 (0.008)
	Intervention Site	-0.056 (0.102)	-0.198 (0.142)	0.034 (0.339)
	Round	0.043 (0.013)***	-0.028 (0.018)	-0.0289 (0.023)
	Round Squared	-0.004 (0.001)***	0.002 (0.002)	0.003 (0.002)
Group level characteristics	Mean age	0.002(0.005)	0.003 (0.006)	0.005 (0.015)
	Mean number of children	-0.015 (0.0367)	-0.021 (0.051)	0.120 (0.122)
	Mean education years	-0.027 (0.020)	-0.035 (0.028)*	0.047 (0.067)
	Mean membership to environmental group	0.166 (0.154)	0.465 (0.213)*	-0.734 (0.510)
	Mean rice training participation	0.024 (0.163)	-0.486 (0.044)	0.461 (0.540)
	AIC	2291.125	3955.071	5455.42
	BIC	2374.579	4038.525	5538.874
	Log Likelihood	-1131.562	-1963.535	-2713.71

Note: *** 1% significance level, ** 5% significance level, *10% significance level with two-tailed tests.
Nb: landscape-level random effects: Group. ID

Table B. Model selection table for landscape level models: (a) ES provision, (b) ES coordination and (c) Heavy pesticide use. The top four models for each selection are presented. Final selected model is in bold case and included variables are indicated by "YES" and shading.

(a) ES provision (number of habitat cells at the landscape level, logit transformed)

		Treatments			Additional explanatory variables				Model properties			
Model name (selected model in bold)	Integer	Comms	Subsidy	Comms:: subsidy	Intervention site	Mean_hhh_edu	Number of players received rice farming training	Random term	Df	LogLik	AICc	ΔAICc
A1	**YES**	**YES**	**YES**	**YES**				**Group ID**	**6**	**-1117.28**	**2246.6**	**0.00**
A2	YES	YES	YES	YES		YES		Group ID	7	-1118.40	2250.8	4.25
A3	YES	YES	YES	YES			YES	Group ID	7	-1118.74	2251.5	4.94
A4	YES	YES	YES	YES	YES			Group ID	7	-1118.96	2252.0	5.38

(b) ES coordination (mean landscape efficiency, logit transformed)

Model name (selected model in bold)	Integer	Comms	Subsidy	Comms:: subsidy	Intervention site	Round	Number of players received rice farming training	Random term	Df	LogLik	AICc	ΔAICc
B1	**YES**	**YES**	**YES**					**Group ID**	**5**	**-1945.78**	**3901.6**	**0.00**
B2	YES	YES	YES		YES			Group ID	6	-1946.96	3906.0	4.37
B3	YES	YES	YES			YES		Group ID	6	-1947.55	3907.1	5.54
B4	YES	YES	YES				YES	Group ID	6	-1947.57	3907.2	5.59

(c) Heavy pesticide use (number of heavy pesticide sprays within landscape, logit transformed)

Model name(selected model in bold)	Integer	Comms	Subsidy	Comms:: subsidy	Intervention site	Number of Environmental group members	Number of players received rice farming training	Random term	Df	LogLik	AICc	ΔAICc
C1	**YES**	**YES**	**YES**					**Group ID**	**5**	**-2697.40**	**5404.8**	**0.00**
C2	YES	YES	YES		YES			Group ID	6	-2697.65	5407.3	2.50
C3	YES	YES	YES			YES		Group ID	6	-2698.18	5408.4	3.56
C4	YES	YES	YES				YES	Group ID	6	-2698.71	5409.4	4.62

Appendix 5.6: Individual level models

Table A. Linear mixed effects models for individual effects. Response variables include both intended cooperative or non-cooperative behaviour in terms of costs or benefits to neighbouring land-users within the game

		Intended cooperative behaviour (shared habitat efficiency)	Intended non-cooperative behaviour (cancelled habitat bonuses)
Game level attributes	Intercept	-0.787(0.313)**	-2.866 (0.267)***
	Subsidy	0.035 (0.012)**	-0.029 (0.009)**
	Communication	0.166 (0.061)**	-0.129 (0.046)***
	Subsidy * Communication	-0.005 (0.015)	0.010 (0.011)
	Intervention Site	-0.225 (0.193)	-0.250 (0.189)
	Round	-0.105 (0.056)	-0.068 (0.035)
	Round Squared	0.009 (0.006)	0.007 (0.004)
	Mean score of other players' efficiency, previous round.	0.438 (0.169)**	
	Mean score of other players' pesticide impacts, previous round		2.608 (0.229)***
Individual level attributes	Sex	-0.058 (0.176)	-0.171 (0.143)
	Age	0.005 (0.006)	-0.004 (0.005)
	Number of children	0.075 (0.049)	-0.020 (0.039)
	Education years	-0.030 (0.022)	0.024 (0.018)
	Pesticide litres/ year	-0.013 (0.018)	0.015 (0.015)
	Membership to environmental group	0.085 (0.190)	0.077 (0.157)
	Received training in rice farming	-0.004 (0.175)	-0.149 (0.138)
	AIC	9738.866	8150.93
	BIC	9846.145	8258.262
	Log Likelihood	-4851.433	-4057.491

Note: *** 1% significance level, ** 5% significance level, *10% significance level with two-tailed tests.
Nb: individual-level random effects nested group id & individuals ID

Table B. Model selection table for individual level models: (a) Intended cooperative behaviour, number of shared ES points from centralising habitat cells and (b)

Intended non-cooperative behaviour (centralising heavy spray cells in the landscape). The top four models for each selection are presented. Final selected model is in bold case and included variables are indicated by "YES" and shading

(a) Intended cooperative behaviour (shared habitat efficiency)

		Treatments				Additional explanatory variables			Model properties			
Model name	Integer	Comms	Subsidy	Comms:: subsidy	Mean cooperative behaviour in other players (previous round)	Intervention site	Number of children	Random term	Df	LogLik	AICc	ΔAICc
A1	YES	YES	YES					Group ID	6	-4832.85	9677.7	0.00
A2	**YES**	**YES**	**YES**		**YES**			**Group ID**	**7**	**-4832.70**	**9679.4**	**1.71**
A3	YES	YES	YES			YES		Group ID	7	-4833.14	9680.3	2.61
A4	YES	YES	YES				YES	Group ID	7	-4833.30	9680.6	2.92

(b) Intended non-cooperative behaviour (cancelled habitat bonuses)

Model name	Integer	Comms	Subsidy	Comms:: subsidy	Mean non-cooperative behaviour in other players (previous round)	Intervention site	Rice training	Random term	Df	LogLik	AICc	ΔAICc
B1	**YES**	**YES**	**YES**		**YES**			**Group ID**	**7**	**-4034.92**	**8083.9**	**0.00**
B2	YES	YES			YES			Group ID	6	-4036.74	8085.5	1.64
B3	YES	YES	YES		YES	YES		Group ID	8	-4035.24	8086.5	2.66
B4	YES	YES	YES		YES		YES	Group ID	8	-4035.36	8086.8	2.89